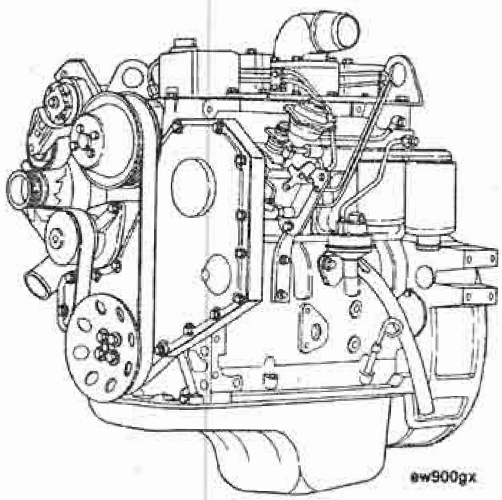
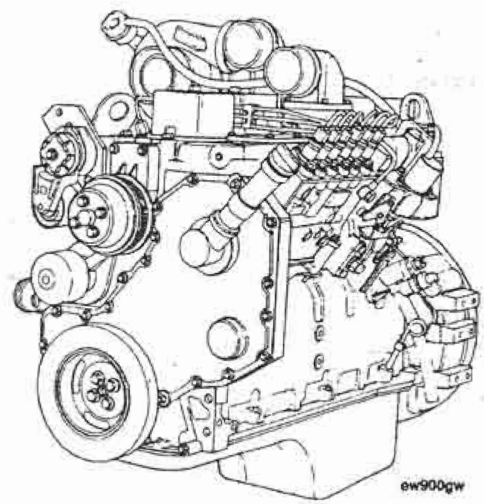
B Series Shop Manual 1991 and 1994 Certification Levels



Four Cylinder
4BT3.9



Six Cylinder
6BT5.9

Bulletin 3666017-01
Printed in U.S.A. 11/94 (996)

Foreword

This manual contains complete rebuild specifications and information for the B Series 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.

Read and follow all safety instructions. Refer to the WARNING in the General Safety Instructions in this section.

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.

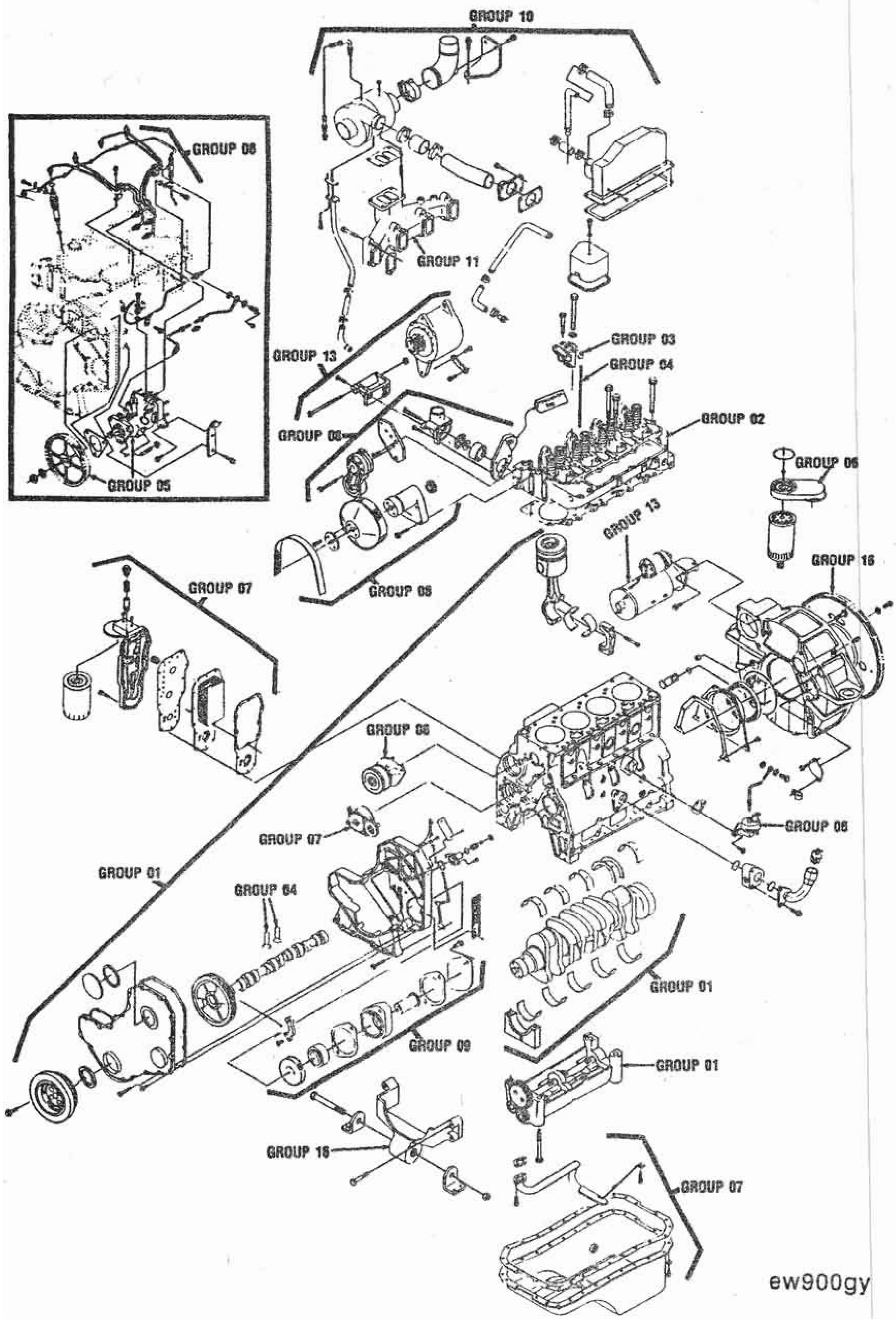
Reporting of errors, omissions, and recommendations for improving this publication by the user is encouraged. Please use the postage paid, self-addressed Literature Survey Form in the back of this manual for communicating your comments.

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:

Table of Contents

Cummins 22-Group System Exploded Diagram



How To Use The Manual

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 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 group index page at the beginning of each group to quickly aid in locating the information desired.
- 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

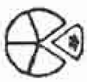
Both metric and U.S. customary values are used in this manual. The metric value is listed first, followed by the U.S. customary in brackets. An example is 60°C [140°F].

Generic Symbols

The following group of symbols have 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.

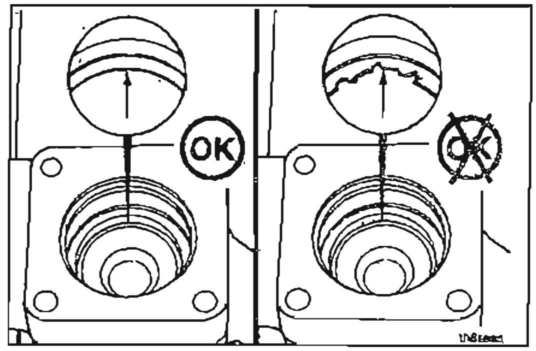
PERFORM an electrical **MEASUREMENT**

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

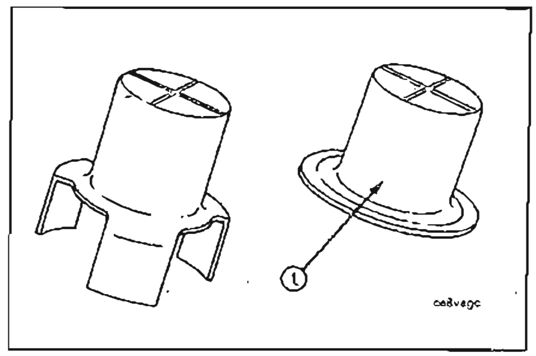
The component weighs 23 kg [50 lb] or more. To avoid personal injury use a hoist or get assistance to lift the component.

Illustrations

The illustrations used in the "Repair Sections" of this manual are intended to give an example of a problem, and to show what to look for and where the problem can be found. Some of the illustrations are "generic" and might **not** look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required, and an acceptable or **not** acceptable condition.



The illustrations are intended to show repair or replacement procedures. The illustration can differ from your application, but the procedure given will be the same.



Section I - Introduction

Section Contents

About the Manual

This manual contains information for 1991 and newer engines starting with ESN 44566920. For information on prior built engines refer to the B Series Shop Manual, Bulletin No. 3810206-02.

The procedures in this manual were developed for a shop environment with engine disassembly and assembly being performed on a rollover stand. A Group System has been used to subdivide the instructions by major components and systems. Refer to the Table of Contents (page i-1) for the various groups. The information is presented in very basic terms to make sure the instructions are easily understood. Wrench sizes and shop tooling are identified in the procedure when needed.

Each group contains the following in sequence:

- An Alphabetical Table of Contents (Index).
- Exploded view(s) of all the components in the group.
- General Information Section(s) containing the basic service, maintenance, and design information necessary to assist in the rebuild of the engine or a component.
- Procedural instructions for the disassembly, inspection, repair, and assembly that can be required to rebuild an engine. Additional repairs that are not essential during every rebuild, but can be necessary, are included. These repairs depend on the length of time an engine has been in service and the condition of the parts.

General Safety Instructions

Important Safety Notice

WARNING

Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation or other bodily injury or death.

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 dry, well lit, ventilated; free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) 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 crankshaft 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 protect the environment, liquid refrigerant systems **must** be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capture and recycling refrigerant.
- 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.
- 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.
- Do **not** perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.

General Repair Instructions

This engine incorporates the latest diesel technology at the time it was manufactured; 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 or death. 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. Some solvents and used engine oil have been identified by government agencies as toxic or carcinogenic. Avoid excessive breathing, injestion and contact with such substances. **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 or components will cause premature wear.

- **Perform the Inspections Specified in the Procedures.**
- **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 use again 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 rebuild instructions are available in the shop manual which can be ordered or purchased from a Cummins Authorized Repair Location. Refer to Section L, Literature, for ordering instructions.

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: Acid is extremely dangerous, 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 a good 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.

Glossary of Terms

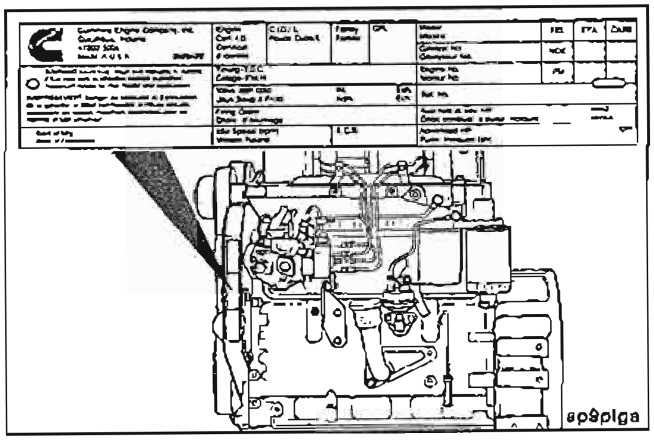
	Definition
A.C..	Alternating Current
AFC:	Air Fuel Control; a device in the fuel pump that limits the fuel delivery until there is sufficent intake manifold pressure to allow for complete combustion.
ATDC:	After Top Dead Center· refers to the position of the piston or the crankshaft rod journal. The piston is moving downward on the power stroke or 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 or 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. 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) TYPE1 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.

	Definition
Magnetic Particle Inspection:	A method of checking for cracks in **either** steel **or** iron parts. This method requires a Magnaflux or 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
TC:	Torque Converter· used when referring to the torque converter cooler.
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 Premijm 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.

Section E - Engine and Component Identification

Section Contents

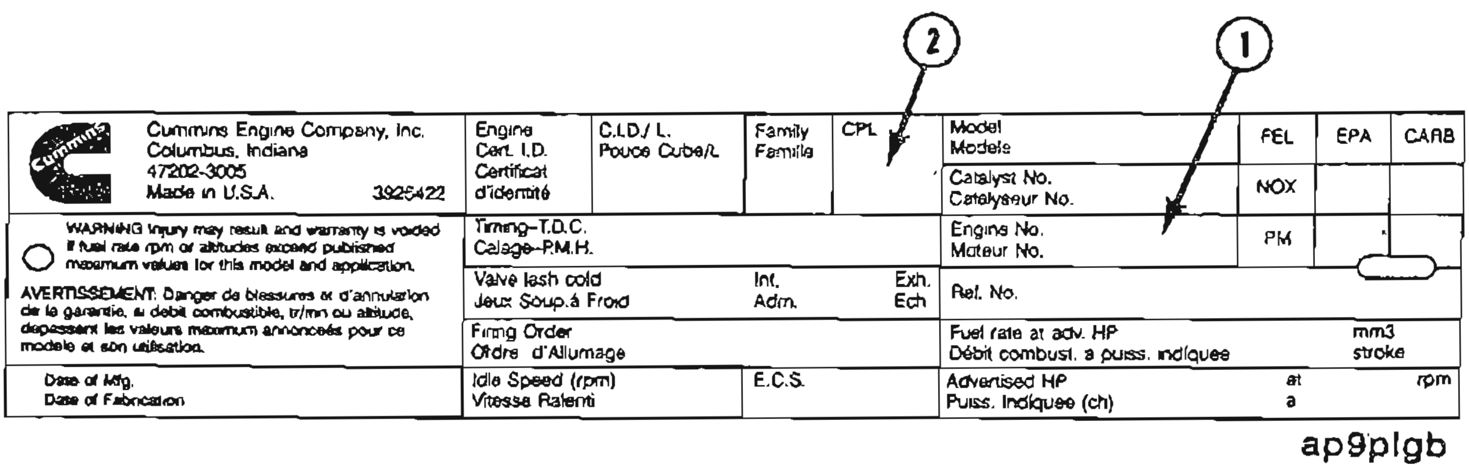
Engine Identification



Engine Dataplate

The engine dataplates show specific information about your engine. The engine serial number (1) and Control Parts List (CPL) (2) provide information for ordering parts and servicing the engine.

NOTE: The engine dataplate **must not** be changed unless approved by Cummins Engine Company, Inc.



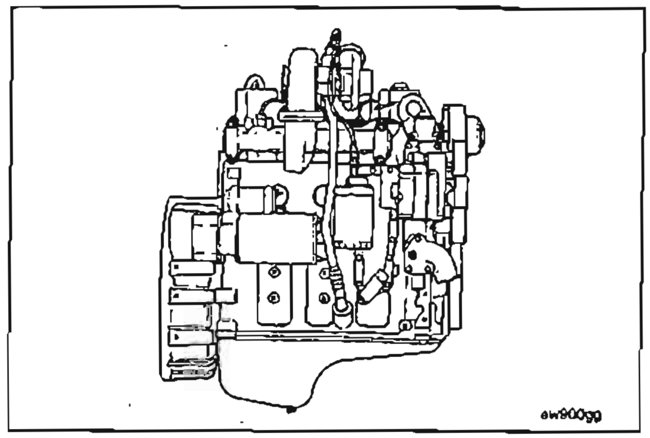
Automotive Engine Dataplate

Industrial Engine Nomenclature

The model name for Industrial engines provides the following engine data:

4 B T A 3.9

- 3.9 — Displacement in Liters
- A — Aftercooled
- T — Turbocharged
- B — Engine Series
- 4 — Number of Cylinders

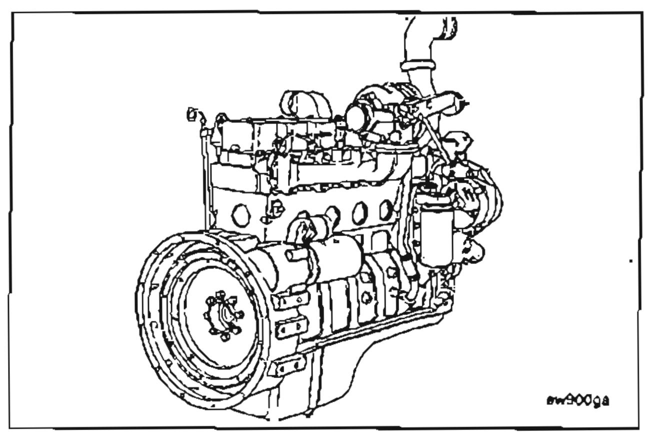


Automotive Engine Nomenclature

The model name for Automotive engines provides the following engine data:

B 5.9 190

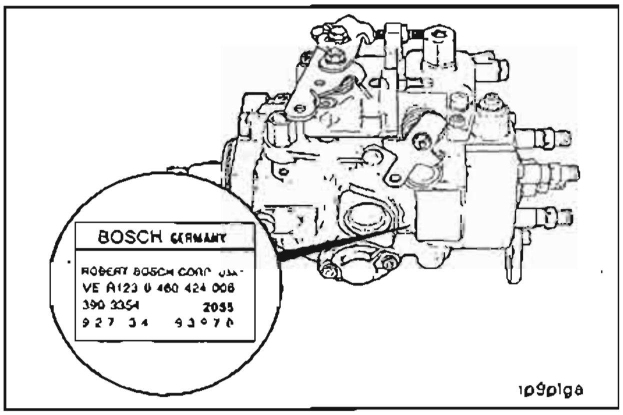
- 190 — Horsepower Rating
- 5.9 — Displacement in Liters
- B — Engine Series



Injection Pump Dataplate

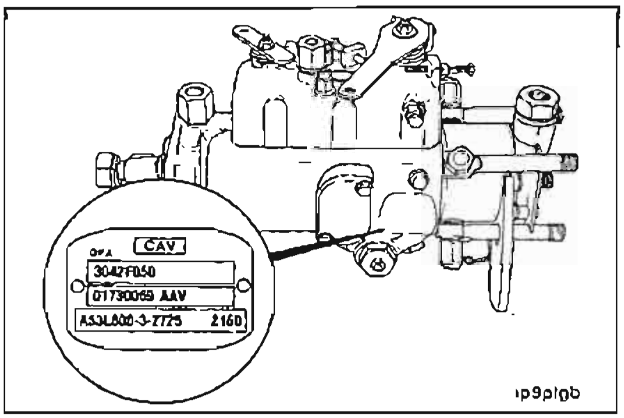
The injection pump dataplate is located on the side of the injection pump. It provides information for fuel pump calibration.

Robert Bosch VE dataplate location.



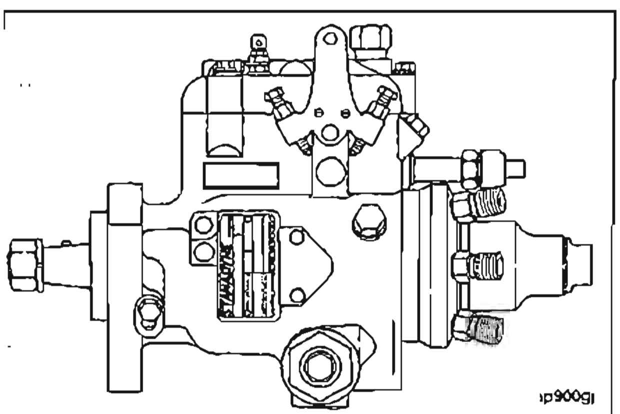
ip9plga

Lucas CAV DPA dataplate location.



ip9plgb

Stanadyne DB4 Dataplate Location



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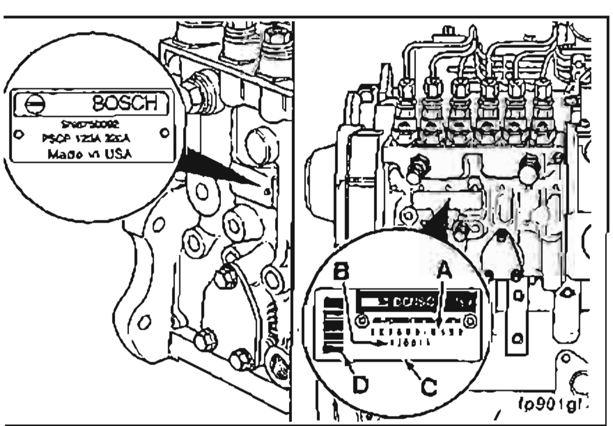
In-Line Injection Pump Dataplate Location

This illustration shows the dataplate location for the Bosch and Nippondenso in-line injection pump.



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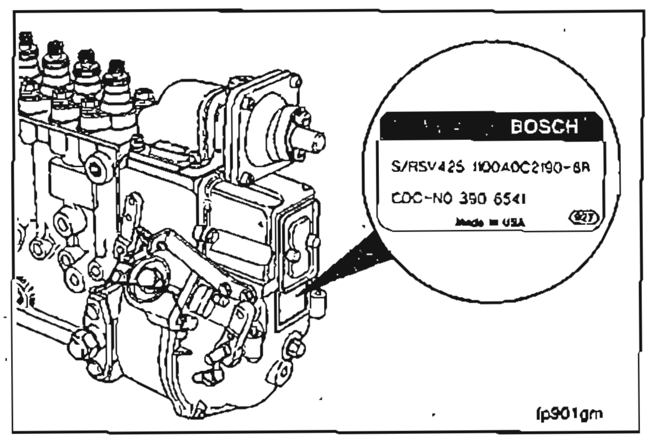
The Cummins part number for the fuel pump-governor combination is located on the governor dataplate.



General Engine Specifications

General Engine Data

Bore .... 102 mm [4.02 in]

Stroke .... 120 mm [4.72 in]

Displacement

4B .... 3.92 liters [239 in^3]

6B .... 5.88 liters [359 in^3]

Compression ratio

4B3.9/6B5.9 Industrial, naturally aspirated 18.5:1

4BT3.9/6BT5.9 Industrial, turbocharged 17.5:1

4BTA3.9/6BTA5.9 Industrial, turbocharged and aftercooled 16.5:1

B3.9/B5.9* Automotive, charge air cooled 17.6:1

Firing order

6 cylinder 1-5-3-6-2-4

4 cylinder 1-3-4-2

Valve Settings

Intake Valve Adjustment .... 0.25 mm [0.010 in]

Exhaust Valve Adjustment .... 0.51 mm [0.020 in]

Engine rotation (viewed from front of engine) .... Clockwise

Engine weight (with standard accessories)

4 cylinder engines .... 325 to 350 kg [715 to 770 lb]

6 cylinder engines .... 410 to 440 kg [910 to 970 lb]

Lubrication System

Oil pressure

At idle (minimum allowable) .... 69 kPa [10 psi]

At rated speed (minimum allowable) .... 207 kPa [30 psi]

Regulating valve opening pressure .... (1991) 449 kPa [65 psi]
(1994) 517 kPa [75 psi]

Differential pressure to open oil filter bypass valve .... (1991) 138 kPa [20 psi]
(1994) 172 kPa [25 psi]

Oil capacity of standard engine

4 cylinder engines .... 9.5 liters [10 U.S. Qts.]

6 cylinder engines .... 14.2 liters [15 U.S. Qts.]

Total system capacity

4 cylinder engines .... 11.0 liters [11.6 U.S. Qts.]

6 cylinder engines .... 16.4 liters [17.3 U.S. Qts.]

Cooling System

Thermostat

Begins to open .... 81°C [181°F]

Fully open .... 95°C [203°F]

Pressure cap for 99°C [210°F] system .... 50 kPa [7 psi]

Pressure cap for 104°C [220°F] system .... 103 kPa [15 psi]

Coolant capacity (engine only)

4 cylinder (non-aftercooled, charge air cooled)* .... 7.0 liters [7.4 U.S. Qts.]

4 cylinder (jacket water aftercooled) .... 7.9 liters [8.4 U.S. Qts.]

6 cylinder (non-aftercooled, charge air cooled)* .... 9.0 liters [9.5 U.S. Qts.]

6 cylinder (jacket water aftercooled) .... 9.9 liters [10.5 U.S. Qts.]

Intake Air and Exhaust System

Maximum allowable intake restriction at rated speed and load (with dirty air filter element)

Naturally Aspirated .... 50.8 cm H_20 [20 in H_20]

Turbocharged .... 63.5 cm H_20 [25 in H_20]

Maximum turbocharger outlet restriction at rated speed and load .... 76.2 mm Hg [3 in Hg]

Maximum exhaust restriction at rated speed and load

Automotive with oxidation catalyst........ 152.4 mm Hg [6 in Hg]

Automotive .... 114.3 mm Hg [4.5 in Hg]

Industrial .... 76.2 mm Hg [3 in Hg]

Fuel System

Fuel transfer pump maximum inlet restriction .... 100 mm Hg [4 in Hg]

Fuel transfer pump output pressure at rated speed

Distributor fuel injection pumps (maximum) .... 70 kPa [10 psi]

Inline fuel injection pumps (minimum) .... 172 kPa [25 psi]

Fuel filter restriction (maximum pressure drop across filters) .... 35 kPa [5 psi]

Fuel return restriction (maximum) .... 518 mm Hg [20.4 in Hg]

* All 1991 and 1994 automotive engines with charge air cooling are designated as B3.9 or B5.9.

Electrical System

Minimum Recommended Battery Capacity

Light accessories including alternator, power steering pump, and disengaged clutch

12 Volt System

4 cylinder engine .... 625 CCA

6 cylinder engine .... 800 CCA

24 Volt System*

4 cylinder engine .... 400 CCA

6 cylinder engine .... 400 CCA

Heavy accessories including hydraulic pump and torque converter

12 Volt System

4 cylinder engine .... 800 CCA

6 cylinder engine .... 950 CCA

24 Volt System*

4 cylinder engine .... 400 CCA

6 cylinder engine .... 475 CCA

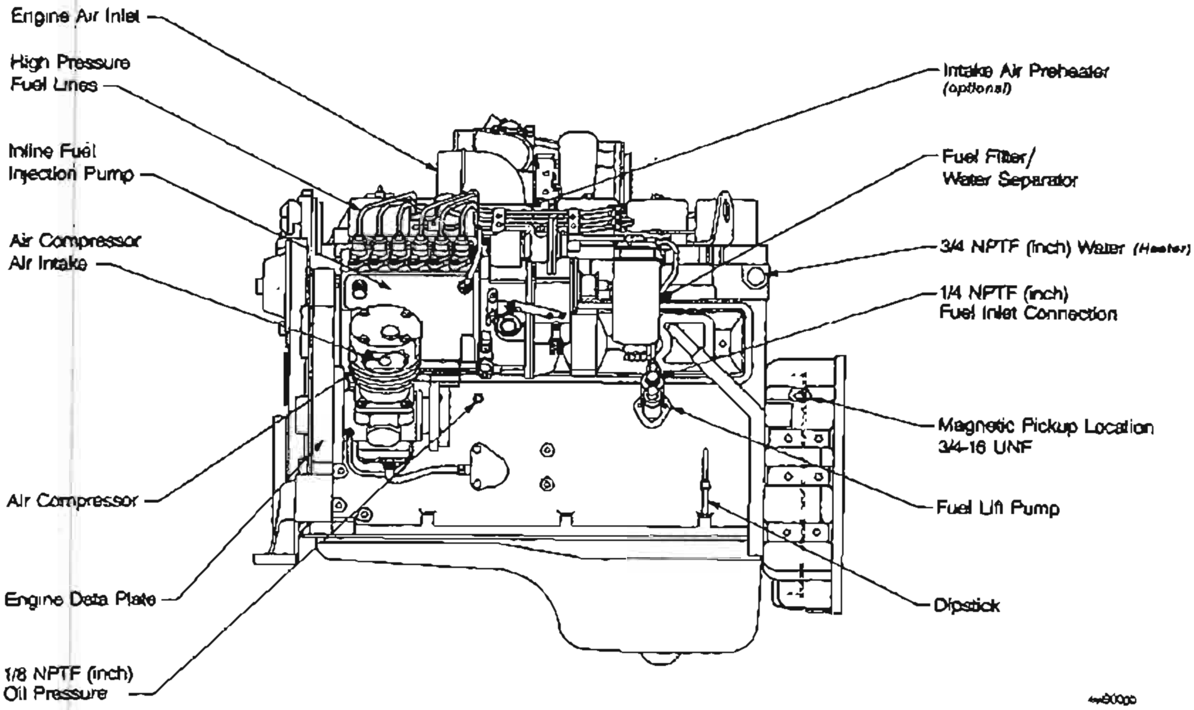
* Per battery (two 12 volt batteries in series) CCA Ratings are based on 18°C [0°F].

Batteries (Specific Gravity)

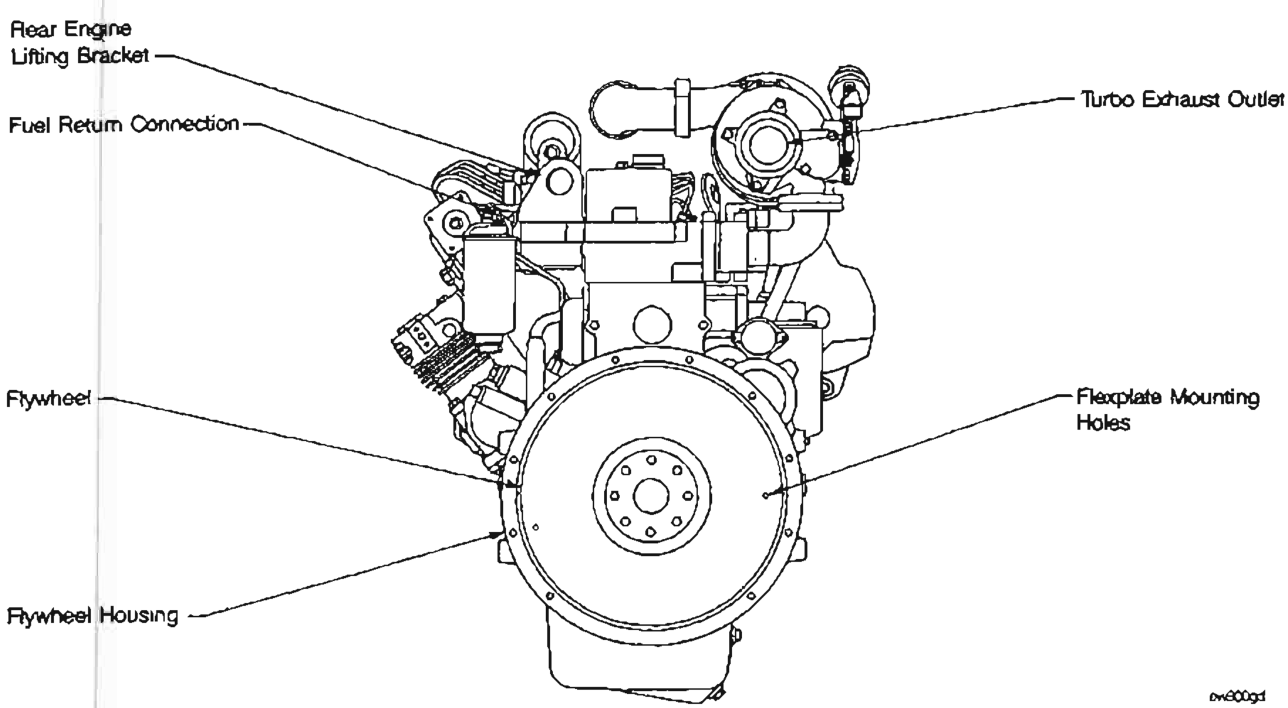
Specific Gravity at 27°C [80°F]	State of Charge
1.260 1.280	100%
1.230 1.250	75%
1.200 1.220	50%
1 170 1 190	25%
1 110 1 130	Discharged

Engine Diagram - Automotive Engine

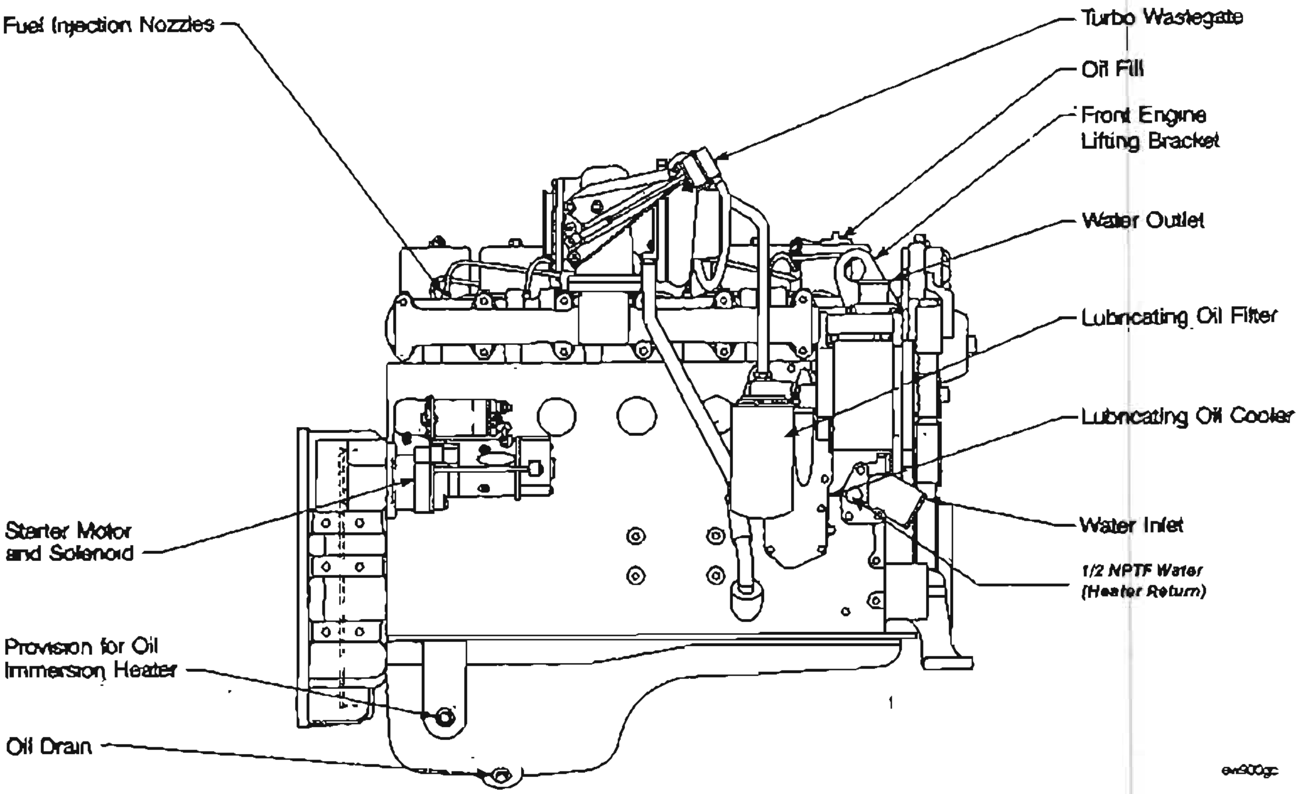
The illustrations which follow show the locations of the major external engine components, the filters, and other service and maintenance points. Some external components will be at different locations for different engine models.



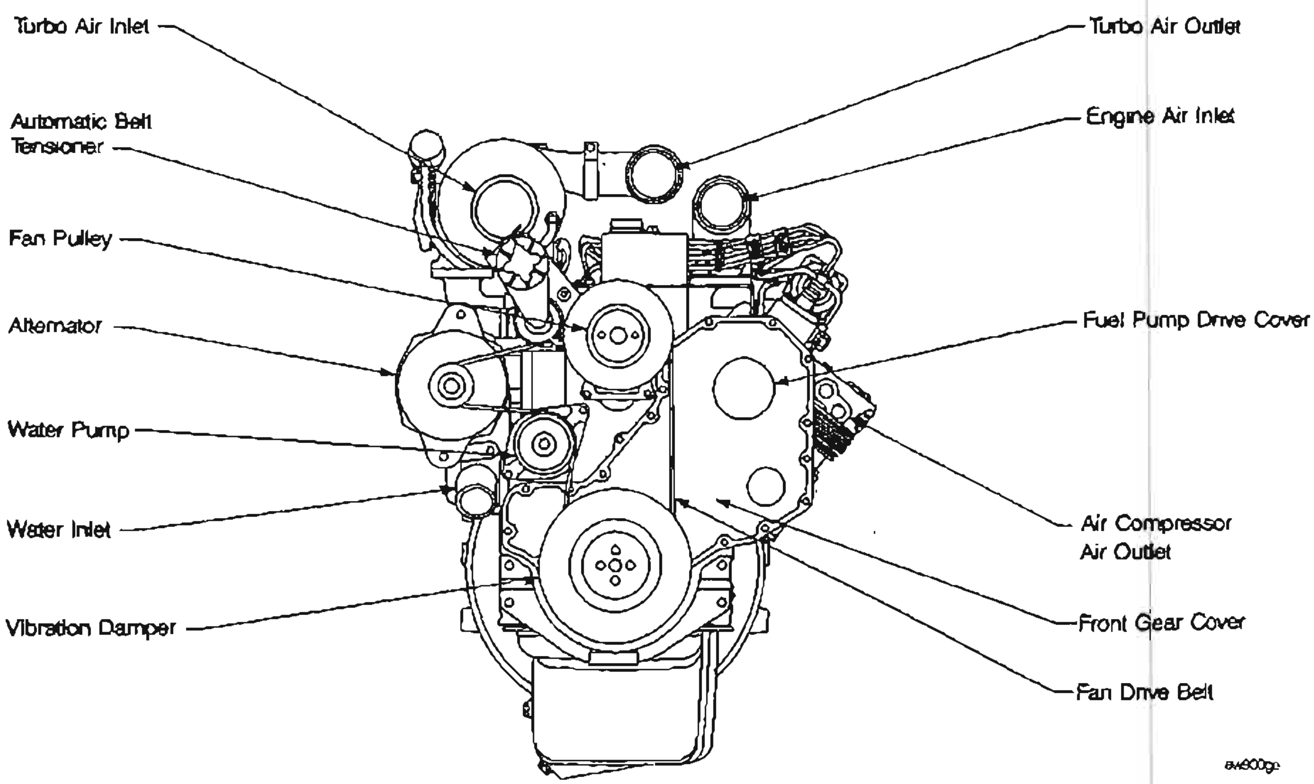
Inlet Side



Rear View



Turbocharger Side View



Front View

Section 0 - Engine Disassembly and Assembly - Group 00

Section Contents

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Engine Disassembly and Assembly

General Information

These procedures apply to all B Series 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.

Warning: 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 when **removing** or **installing** these parts.

Caution: All fasteners are specified in metric units. All fasteners have right-hand threads unless a **Caution** states that a fastener has **left-hand** threads.

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, 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. This will help identify the parts that can be involved in a failure and will 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.

Use a mallet when force is required to remove certain parts. Make sure all of the fasteners are 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

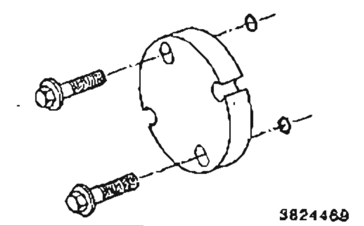
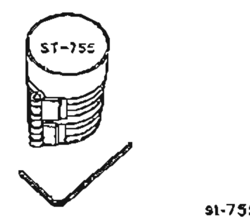
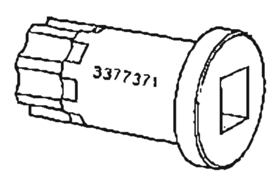
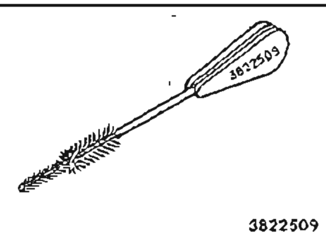
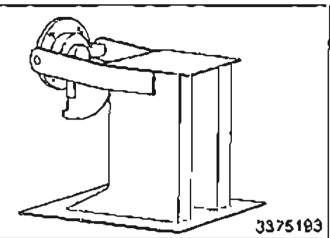
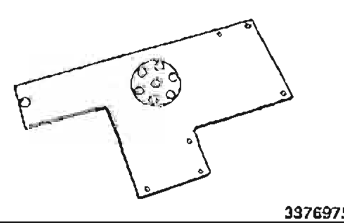
This procedure assumes that all of the components and assemblies have been cleaned, replaced, or rebuilt and are ready to be installed on the engine.

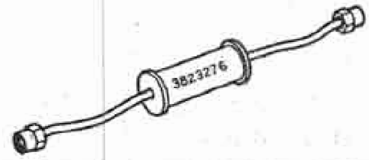
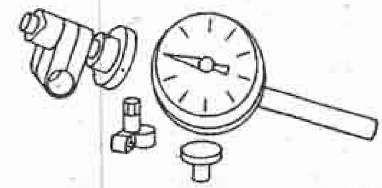
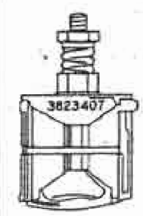
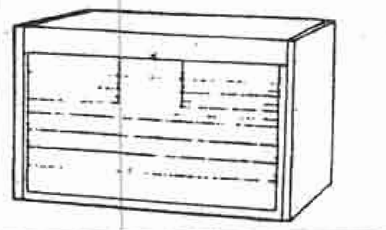
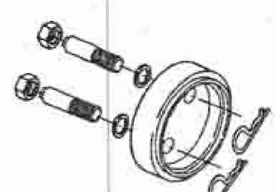
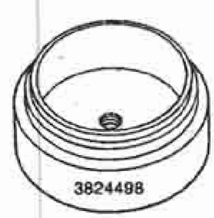
Torque values are listed in each step. If a torque value is **not** specified, use the chart listed in the Specifications, Group 18, to determine the correct torque value.

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.

Engine Disassembly and Assembly - Service Tools

The following special tools are recommended to perform procedures in Group 00. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

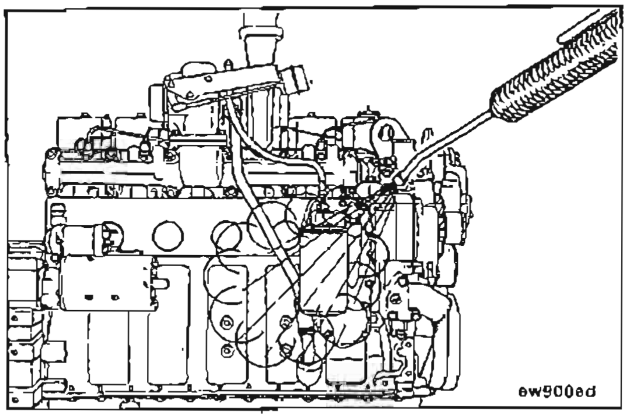
Tool No.	Tool Description	Tool Illustration
3824469	Fuel Pump Drive Gear Puller	
ST-755	Piston Ring Compressor	
3377371	Engine Barring Tool	
3822509	Injector Bore Brush	
3375193 3375194	Engine Rebuild Stand	
3376975	Engine Rebuild Stand Adapter	

Tool No.	Tool Description	Tool Illustration
3823276	**Flexible Injector Puller**	
3376050	**Dial Indicator & Sleeve Assembly** Use with Part No. ST 1325 Dial Gauge Attachment to measure flywheel and flywheel housing runout.	 3376050
3823407	**Ridge Reamer**	 3823407
3376593	**Mechanic's Tool Kit**	
3824078	**Wear Sleeve Installation Tool** Used to install the rear crankshaft lubricating oil seal wear sleeve.	 3824078
3824498	**Oil Seal Installation Tool** Used to install the front crankshaft lubricating oil seal in the front cover to a specified depth.	 3824498

Engine Disassembly Check List

The following is a checklist of recommended measurement to be made during disassembly to aid in determining the reuse of certain parts.

1 Injection pump drive gear backlash	0.076 0.330 mm [0.003 0.013 in]
2. Camshaft gear backlash (refer to page 0-26)	0.076 0.330 mm [0.003 0.013 in]
3. Lube pump gear backlash (refer to page 0-28)	0.076 0.330 mm [0.003 0.013 in]
4. Lube pump idler gear backlash (refer to page 0-29)	0.076 0.330 mm [0.003 0.013 in]
5. Balancer (Four Cylinder Only) (Refer to page 0-30)	
• idler gear to crank gear backlash	0.088 0.420 mm [0.003 0.017 in]
• shaft gear to idler gear backlash	0.088 0.420 mm [0.003 0.017 in]
• shaft gear to shaft gear backlash	0.153 0.355 mm [0.006 0.014 in]
6. Camshaft End Play	0.12 0.34 mm [0.005 0.013 in]
7 Crankshaft End Play	0.102 0.432 mm [0.004 0.017 in]



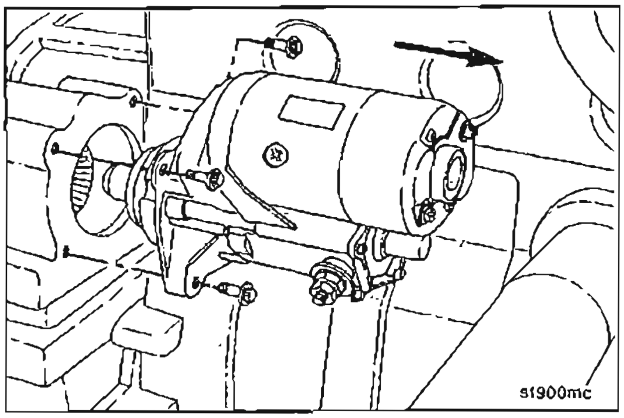
Engine Disassembly (0-1)

Steam Cleaning The Engine (0-2)

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

NOTE: Cover all engine openings and electrical components. This will prevent water damage.

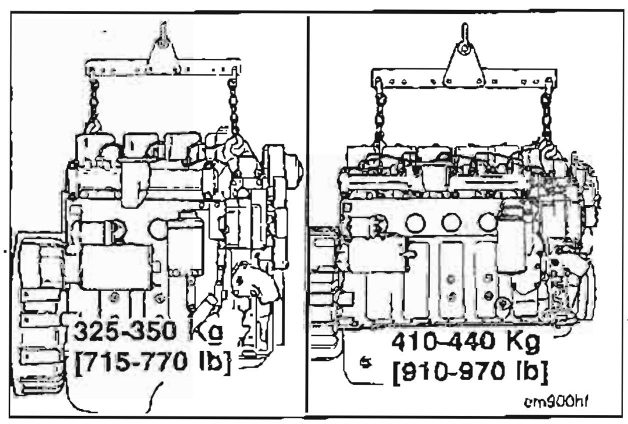
Steam clean the heavy dirt from the exterior of the engine.



Starter - Removal (0-3)

10 mm

Remove the starting motor.

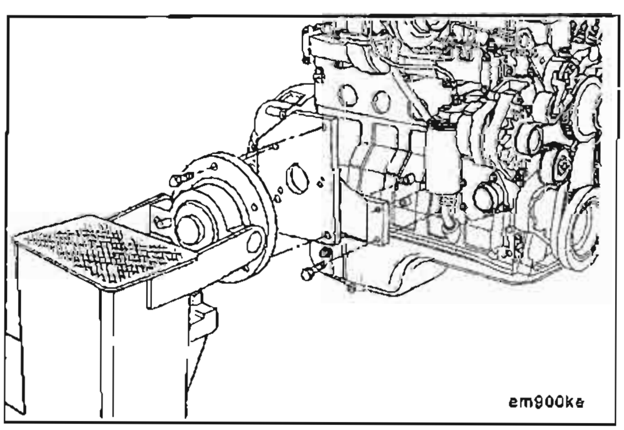


Engine Weight (0-4)

3822512 Engine Lifting Fixture

4B Engine (Wet) Weight: 325-350 Kg [715-770 lb]

6B Engine (Wet) Weight: 410-440 Kg [910-970 lb]



Rollover Stand - Engine Mounting (0-5)

18 mm, 3375194 Engine Rebuild Stand, 3376975 Adapter Plate

Mount the engine on the rebuild stand.

Torque Value: 77 N•m [57 ft-lb].

Mounting Hardware:

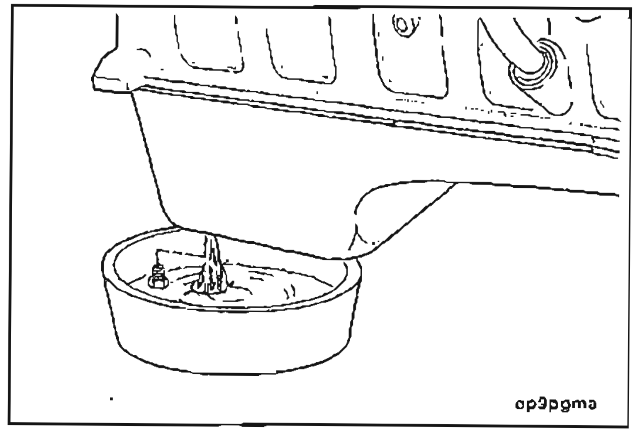
M12 x 1.75

Oil - Draining (0-6)

17 mm

Remove the drain plug.

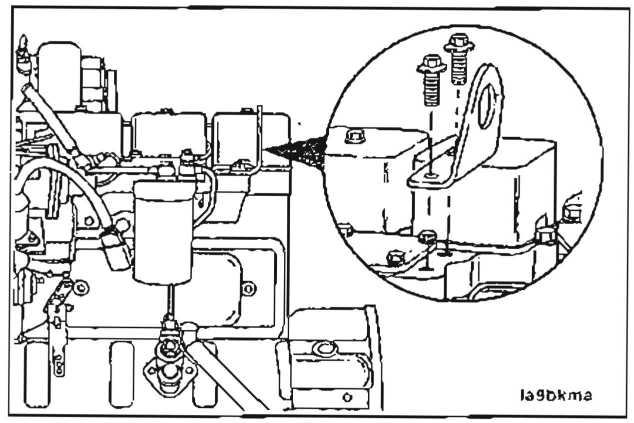
A drain pan with a capacity of 20 litres [5 U.S. gallons] will be adequate.



Lifting Bracket Removal - Rear (0-7)

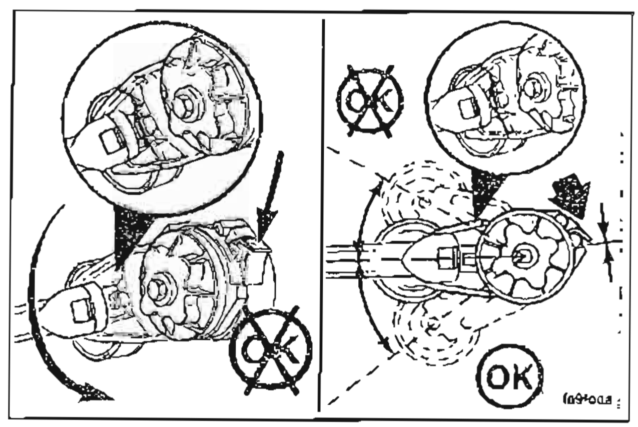
18 mm

Remove the rear lifting bracket from the cylinder head.



Drive Belt - Removal (0-8)

Applying excessive force to the tensioner in the opposite direction of wind-up or after the tensioner has been wound-up to the positive stop can cause the tensioner arm to break.

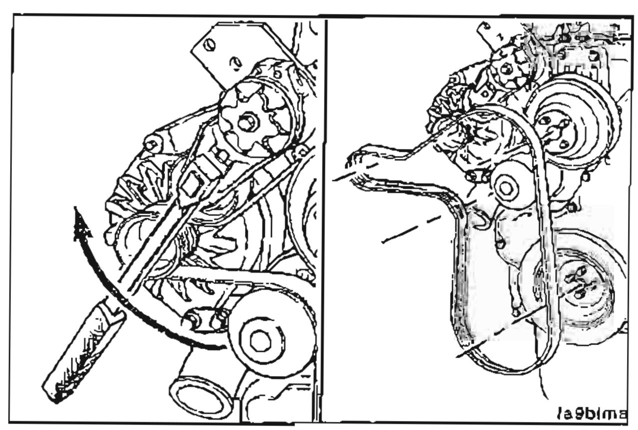


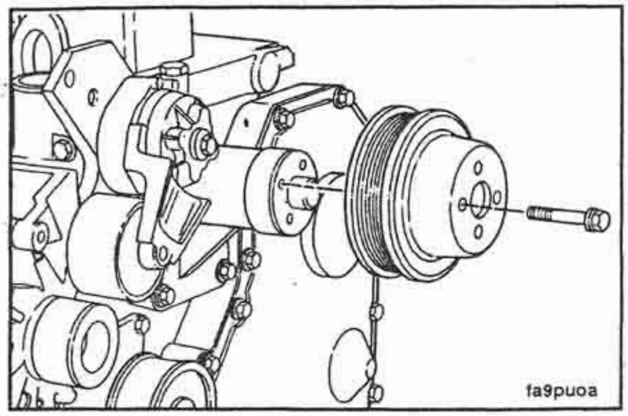
Caution: Keep hands out of the path of the spring-loaded tensioner.

1/2 inch or 3/8 inch Square Drive

Release the tension and remove the drive belt.

Service Tip: Loosen the vibration damper/crankshaft and fan hub pulley capscrews before removing the drive belt.

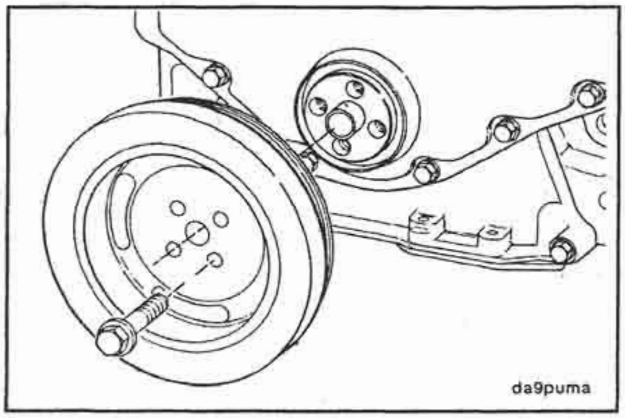




Fan Pulley - Removal (0-9)

13 mm

Remove the fan pulley and capscrews.

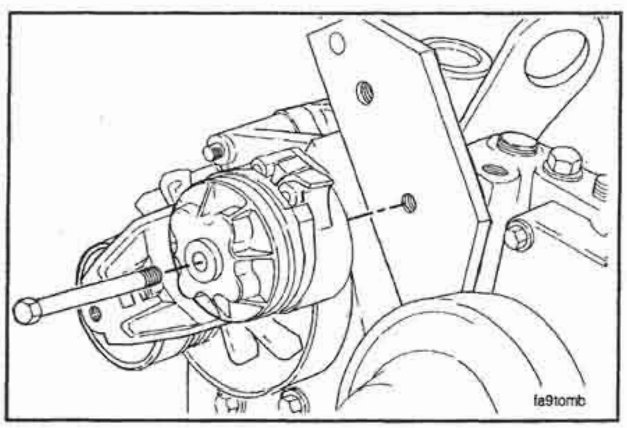


Vibration Damper/Crankshaft Pulley - Removal (0-10)

15 mm

Remove the vibration damper or crankshaft pulley and capscrews.

NOTE: Refer to Component Section 1 for the vibration damper inspection procedure.

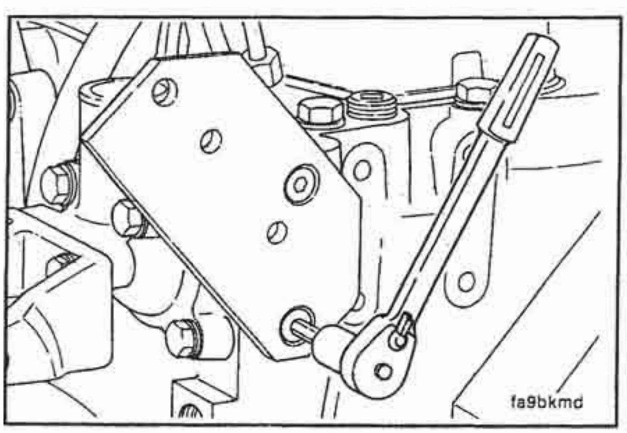


Belt Tensioner - Removal (0-11)

15 mm

Remove the belt tensioner from the bracket.

NOTE: Refer to Component Section 8 for the belt tensioner inspection procedure..



5 mm Allen

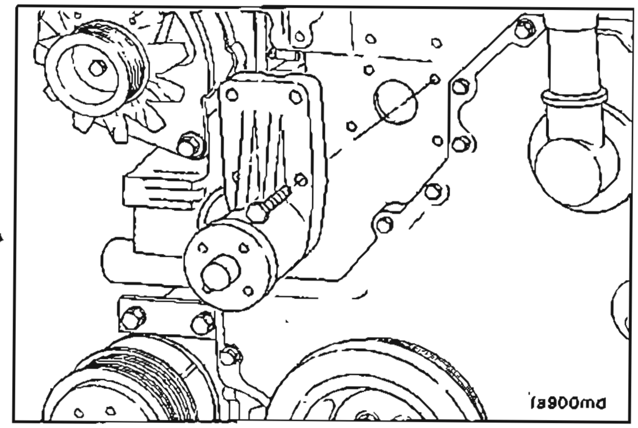
Remove the tensioner bracket.

Fan Hub - Removal (0-12)

10 mm

Remove the fan hub.

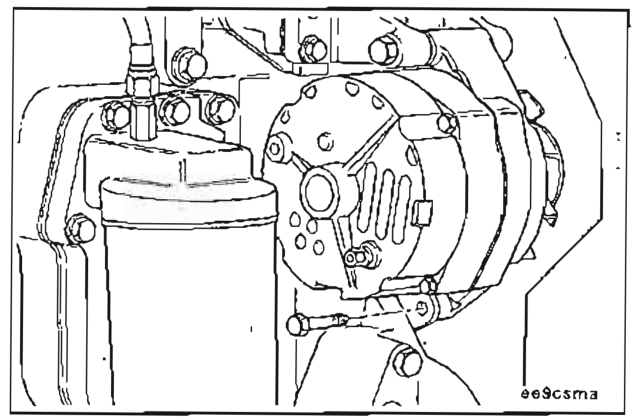
NOTE: Refer to Component Section 8 for inspection of the fan hub.



Alternator - Removal (0-13)

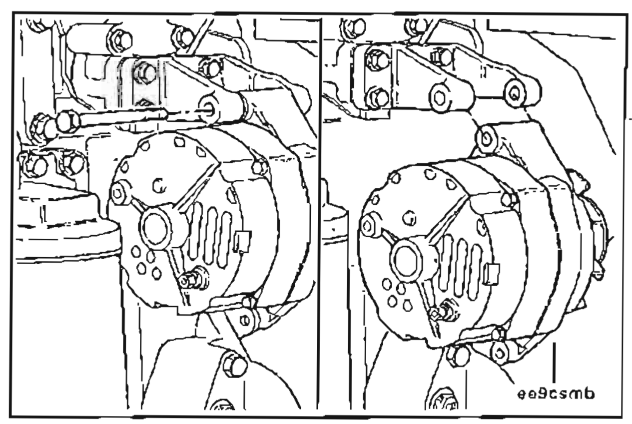
13 mm

Remove the alternator link.



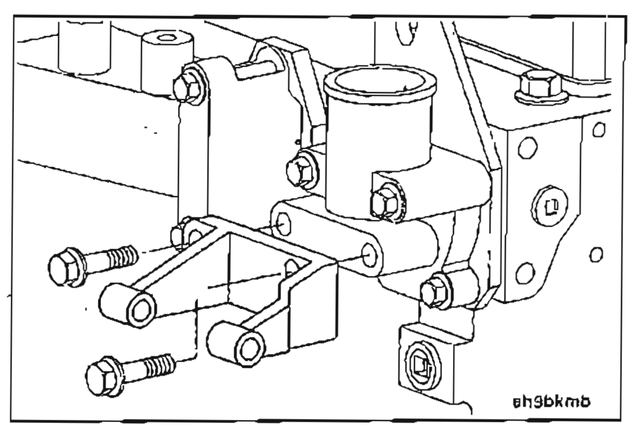
16 mm

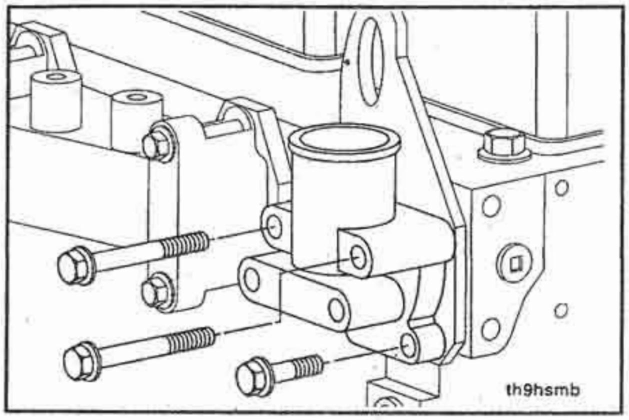
Remove the alternator mounting capscrew and alternator.



13 mm

Remove the alternator bracket.

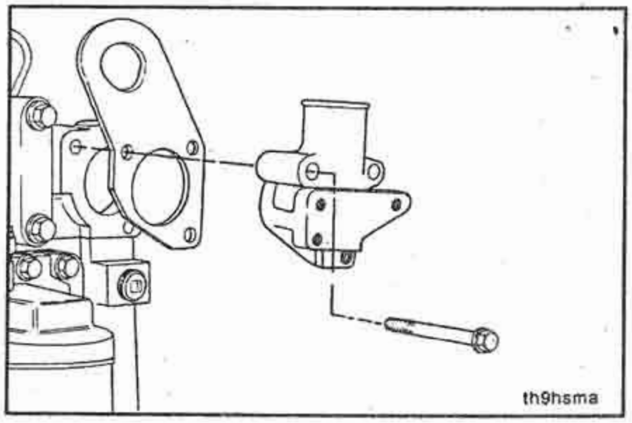




Thermostat - Removal (0-14)

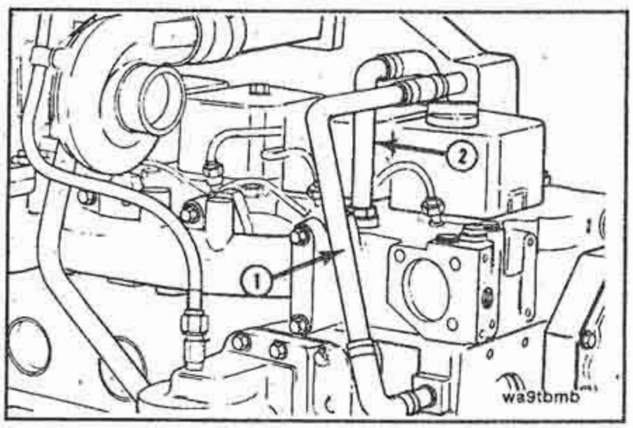
10 mm

Remove the capscrews from the thermostat housing.



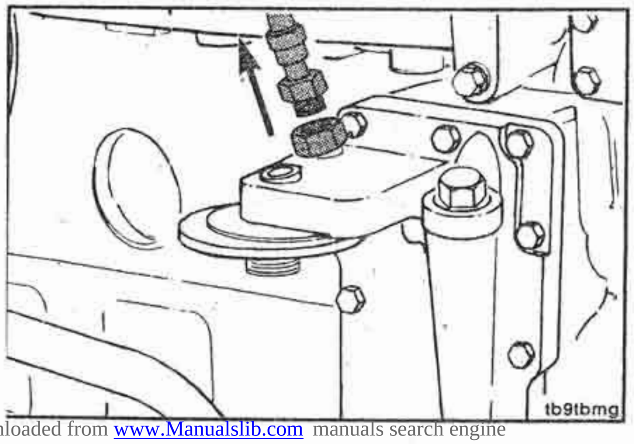
Remove the thermostat housing, gasket, thermostat and lifting bracket.

NOTE: Refer to Component Section 8 for inspection of the thermostat.



Screwdriver

If so equipped, remove the aftercooler supply tube (1) and the coolant return tube (2).



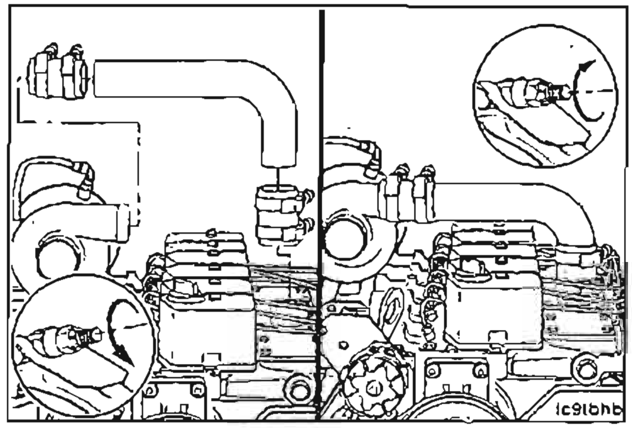
Turbocharger - Removal (0-15)

16 mm and 19 mm

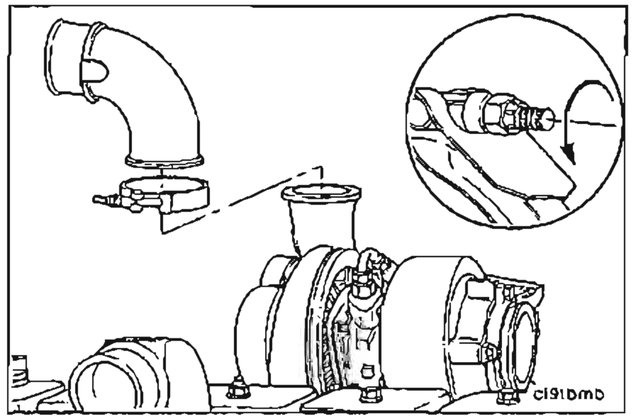
Remove the turbocharger oil supply line from the turbocharger and oil filter head.

8 mm, Screwdriver

Remove the air crossover tube.

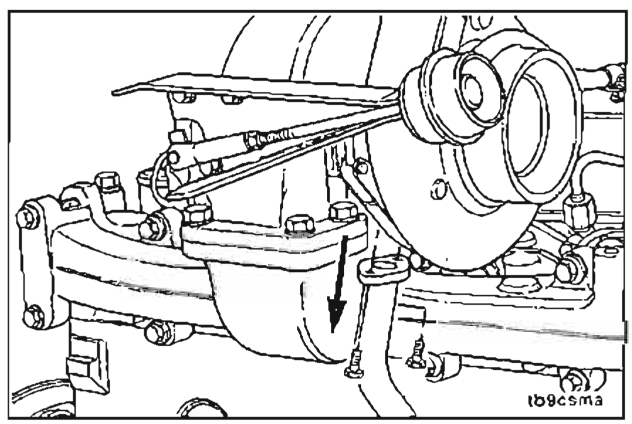


On Automotive engines, loosen the V-Band clamp and hose clamp and remove the charge air cooler inlet tube.



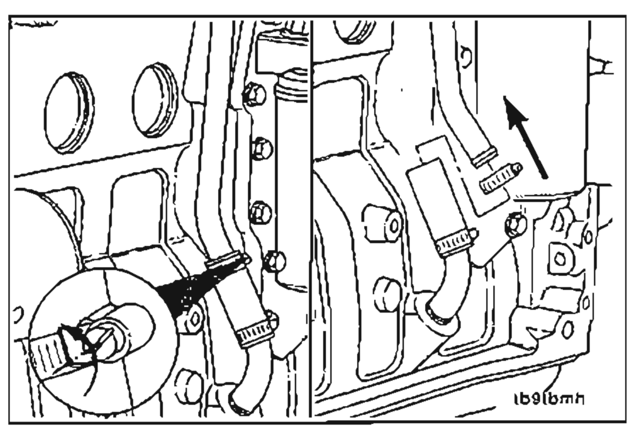
10 mm

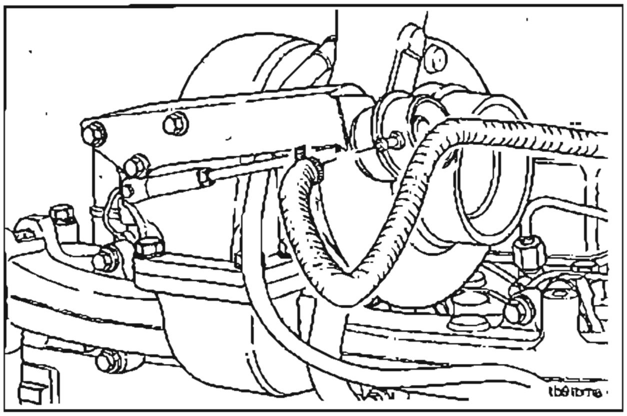
Disconnect the drain tube from the bottom of the turbocharger.



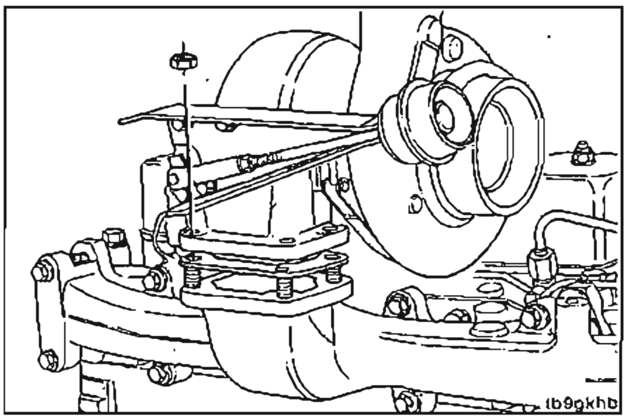
Screwdriver

Remove the turbocharger drain line from the drain tube in the cylinder block.





On engines equiped with wastegated turbochargers, remove the wastegate intake air hose.

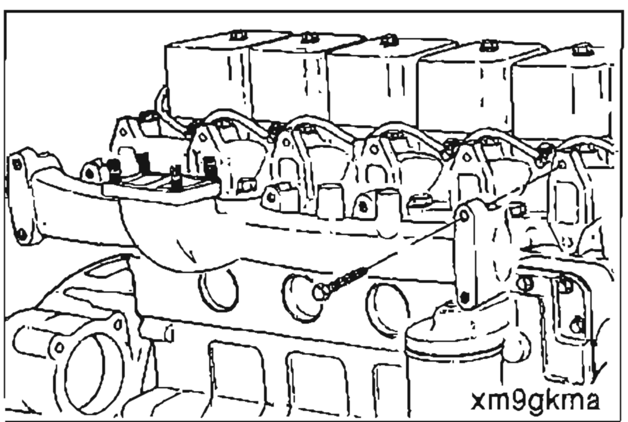


15 mm

Remove the turbocharger mounting nuts, turbocharger and gasket.

NOTE: Inspection of the turbocharger is described in Component Section 10.

Exhaust Manifold - Removal (0-16)

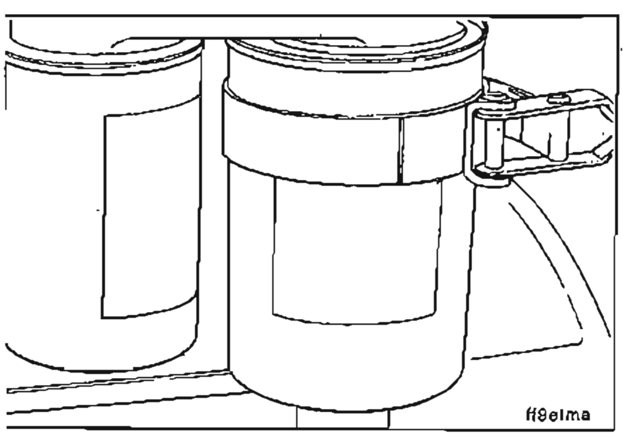


13 mm

Remove the capscrews, exhaust manifold and gaskets.

NOTE: Inspection of the exhaust manifold is described in Component Section 11

Fuel Filter - Removal (0-17)



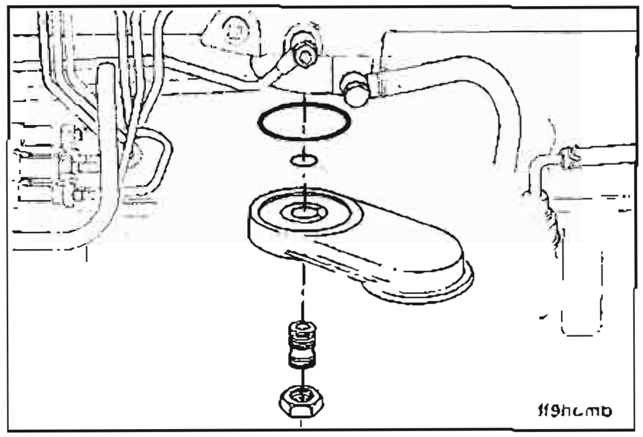
75-80 mm, 90-95 mm Strap Wrenches

Remove the fuel filter(s).

Fuel Filter Head - Removal (0-18)

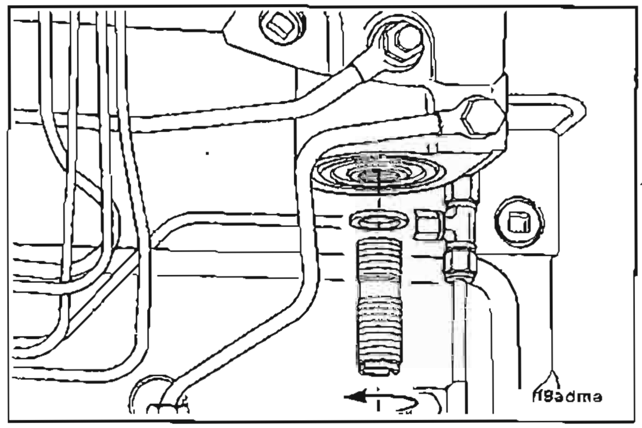
24 mm

If equipped with a dual filter head, remove the nut, dual filter head and o-ring.



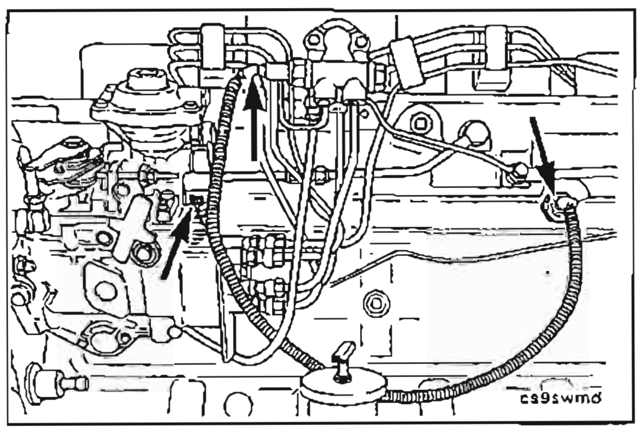
Screwdriver

Remove fuel filter adapter and o-ring.



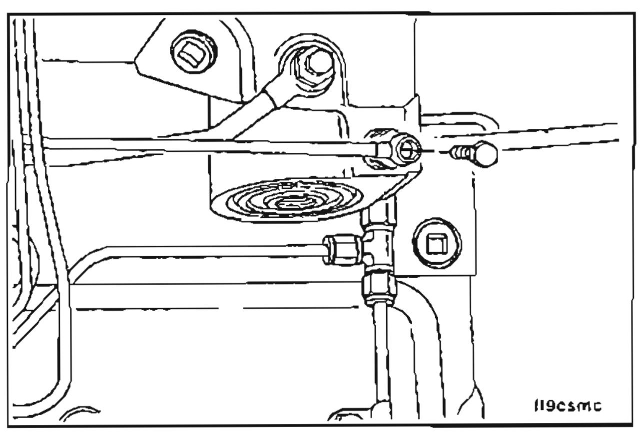
KSB (Remote Mounted) - Removal (0-19)

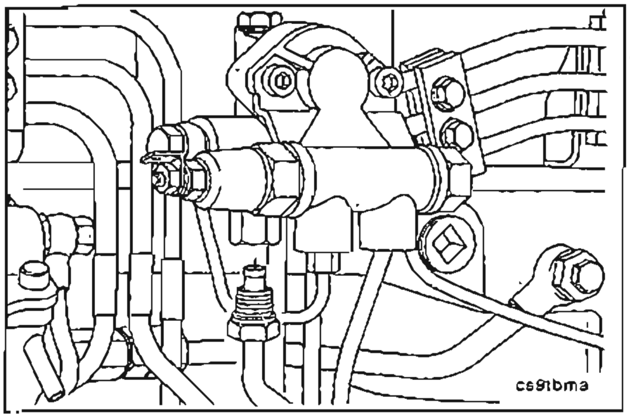
Remove the KSB wiring harness.



10 mm

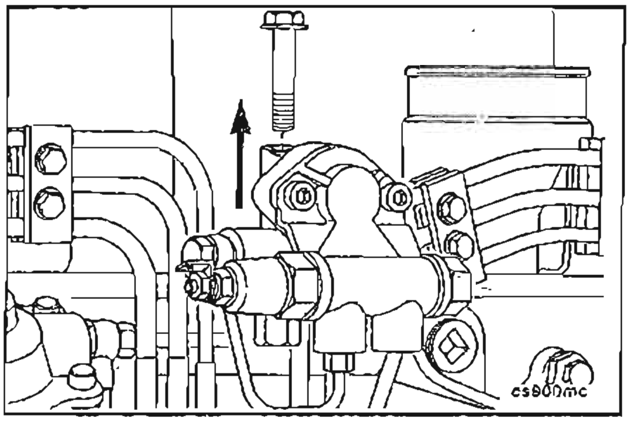
Remove the banjo screw securing the fuel transfer tube to the low pressure fuel supply banjo screw.





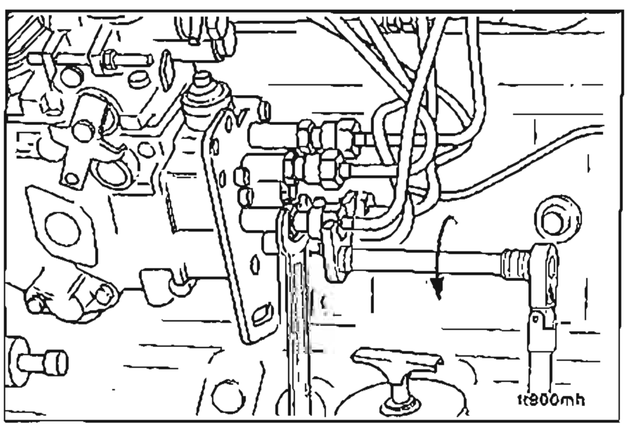
11 mm and 15 mm

Remove the flex hose from the KSB assembly. It is not necessary to remove the flex hose from the injection pump.



10 mm

Remove the KSB assembly from the intake manifold cover.



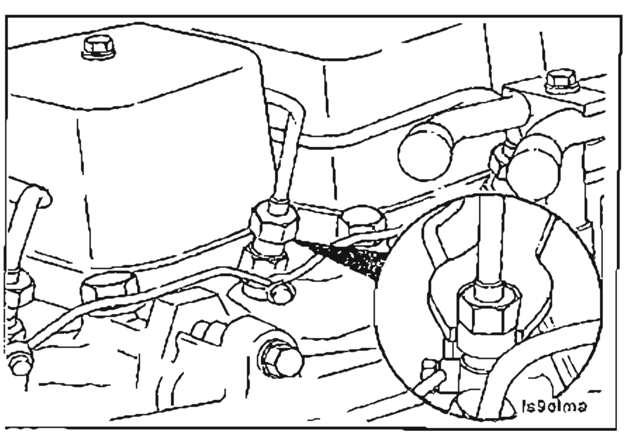
Fuel Lines - Removal (0-20)

High Pressure Fuel Line - Removal (0-21)

14 mm, 17 mm Crowsfoot Wrench, 19 mm Crowsfoot Wrench

Caution: Hold the fuel pump delivery valves securely when loosening the high pressure lines on the rotary pumps.

Remove the high pressure line fittings from the injection pump.



17 mm, 19 mm

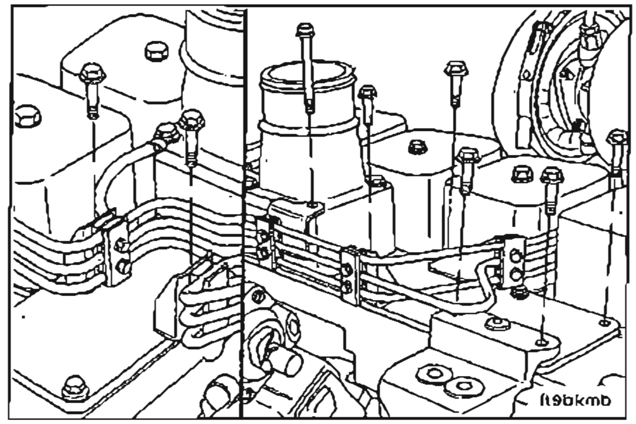
Remove the high pressure lines from the injectors.

NOTE: Refer to Component Section 6 for fuel line inspection.

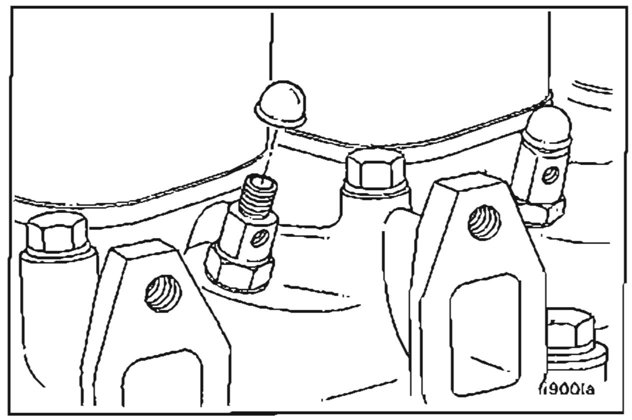
10 mm

Remove the manifold cover capscrews that secure the high pressure line support brackets.

Remove the high pressure lines as an assembly.

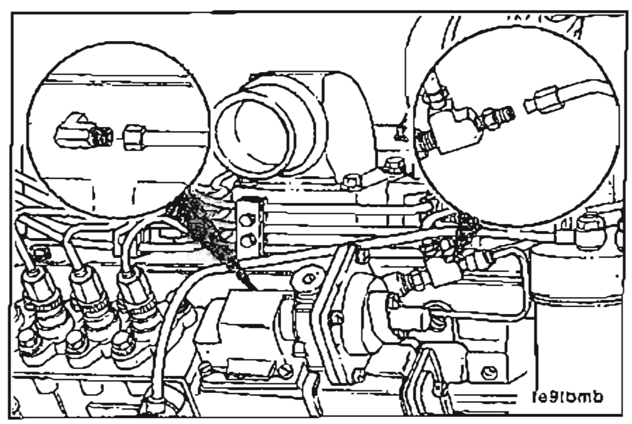


Cap or cover the injector openings.



12 mm and 13 mm

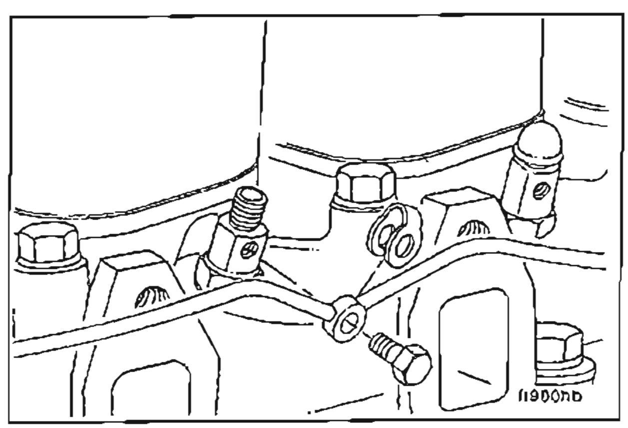
If so equipped, remove the air/fuel control tube and turbocharger wastegate line.

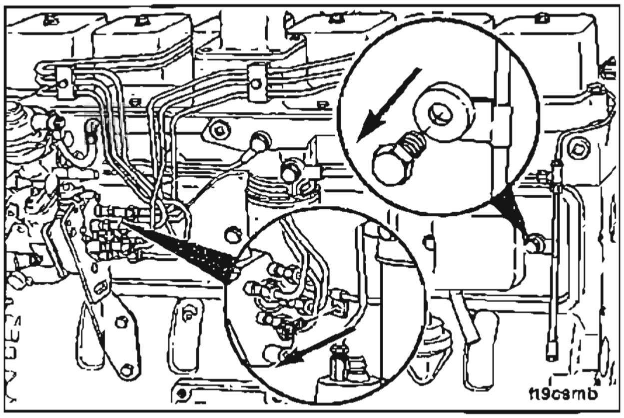


Fuel Drain Manifold - Removal (0-22)

10 mm

Remove the fuel drain manifold banjo fittings and sealing washers from the injectors.

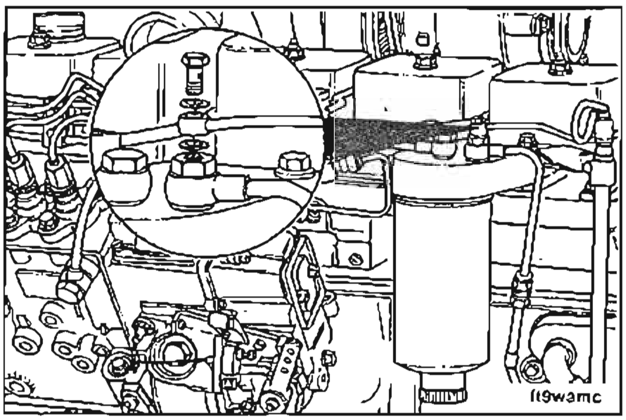




17 mm and 10 mm

Rotary Fuel Pump

Remove the fuel drain manifold support brackets and banjo fitting.

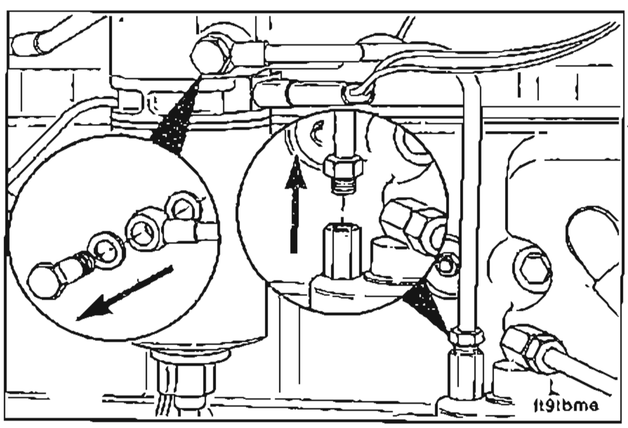


10 mm, 12 mm

In Line Fuel Pump

Remove the banjo capscrews and sealing washers at the filter head.

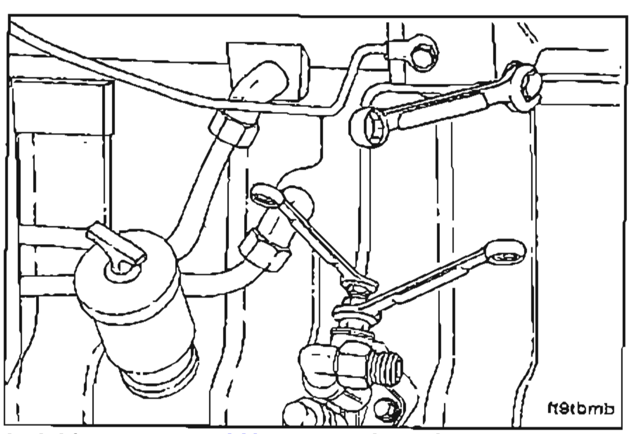
Remove the fuel line support bracket capscrew from the intake manifold.



Low Pressure Fuel Lines - Removal (0-23)

17 mm

Disconnect the two banjo fittings at the filter head.



14 mm and 17 mm

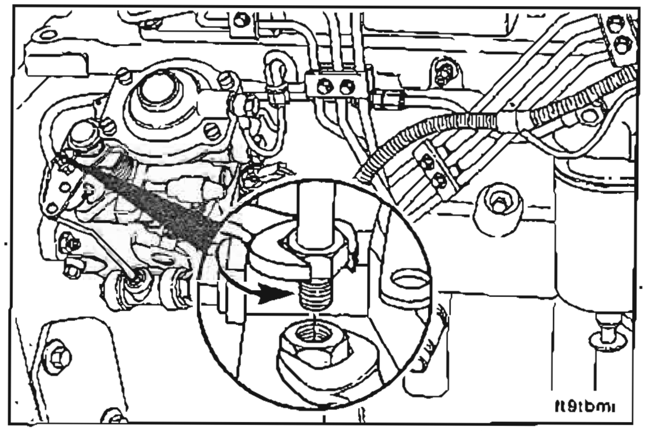
Caution: Be sure the fuel transfer pump connection is held securely when loosening the fuel line.

Loosen the nut and remove the fuel line from the lift pump.

14 mm and 17 mm

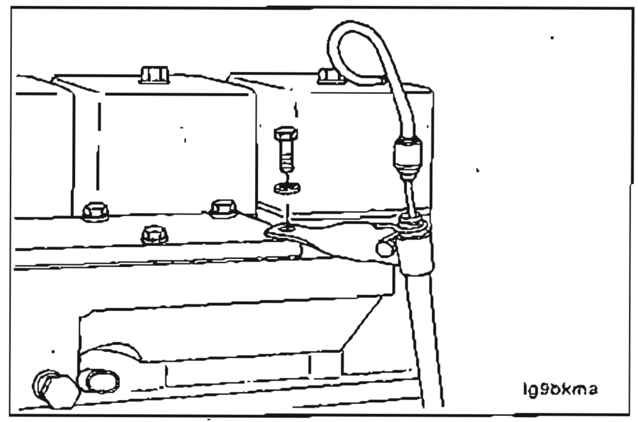
Caution: Be sure the fuel pump connection is held securely when loosening the supply line.

Remove the injection pump supply line.



Dipstick - Removal (0-24)

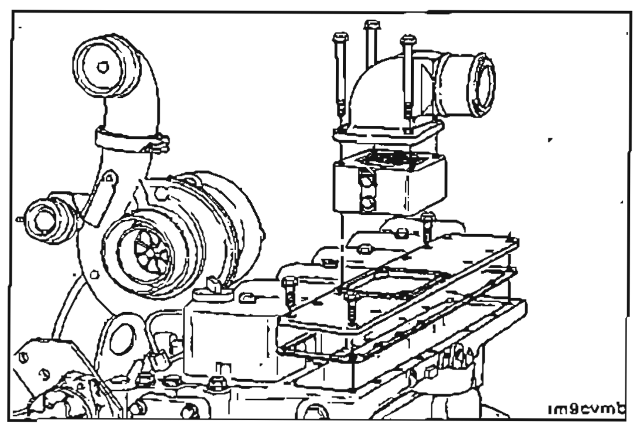
If equipped with a dipstick tube extension, remove the dipstick and extension.



Manifold Cover - Removal (0-25)

10 mm

Remove the manifold cover, gasket and grid heater if equipped.

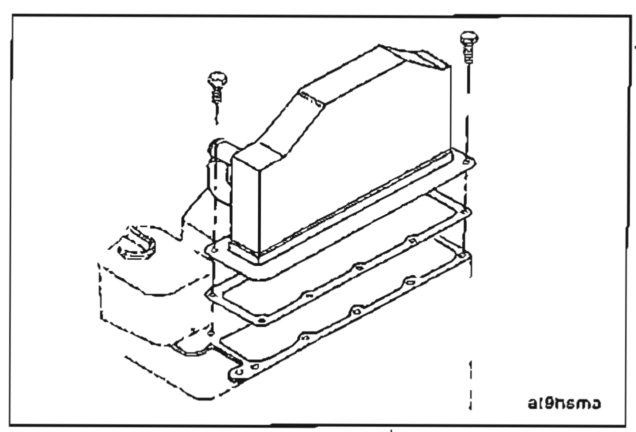


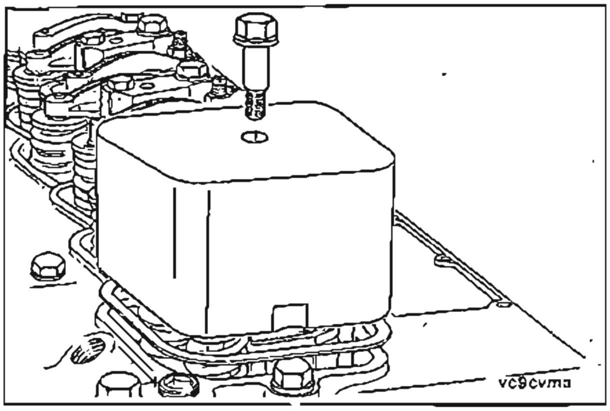
Aftercooler - Removal (0-26)

10 mm

If equipped, remove the aftercooler housing.

NOTE: Refer to Component Section 10 for the aftercooler inspection procedure.

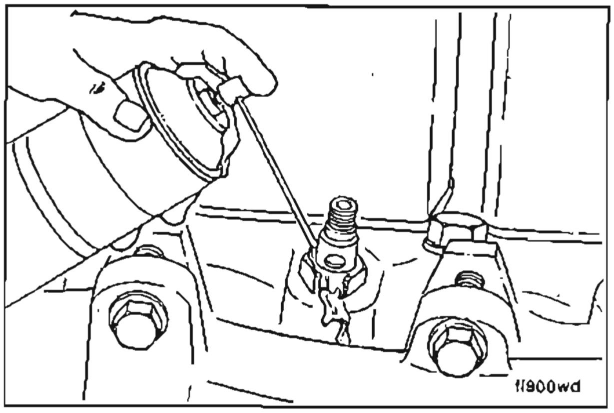




Valve Covers - Removal (0-27)

15 mm

Remove the special capscrews, o-ring seals, valve covers and gaskets.

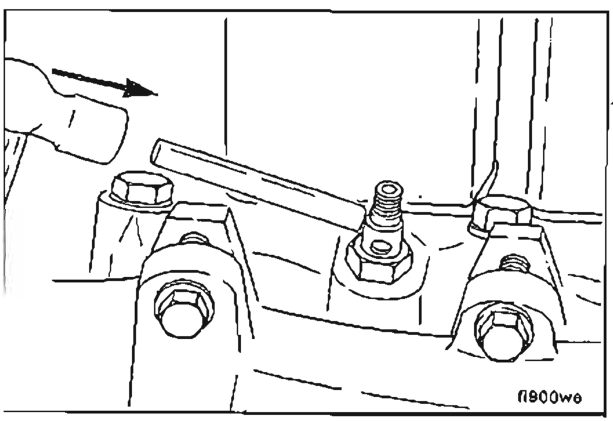


Injector Nozzles - Removal (0-28)

Rust Penetrating Solvent

Caution: When rust has formed on the hold down nut, the injector can turn in the bore when the nut is loosened. This will cause severe damage to the head by the injector locating ball cutting a groove in the bore.

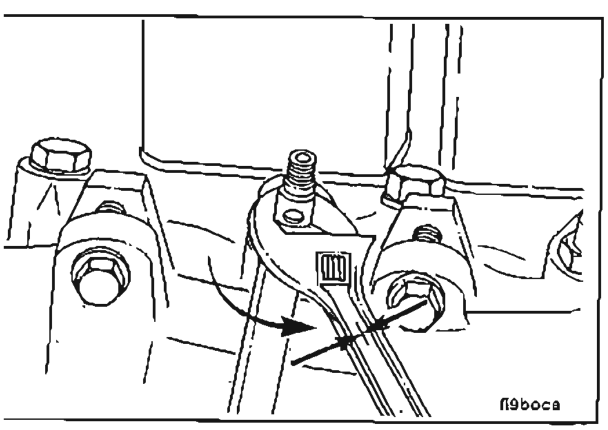
Soak the hold down nut with a rust penetrating solvent for a minimum of 3 minutes.



Brass Drift Pin, Hammer

Caution: Excessive force will damage the injector.

Tap the injector body with the hammer and drift pin to loosen any rust.



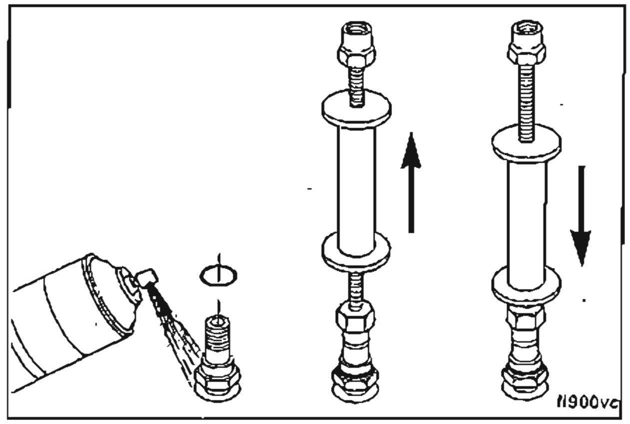
24 mm Box Wrench, Adjustable Wrench

Hold the injector body with an adjustable wrench while you loosen the hold down nut with a 24mm box wrench.

Injector Puller 3823276

Remove the injectors. If the injector is extremely difficult to remove, remove the injector o-ring and fill the bore around the injector with a penetrating solvent. Attach the injector puller and pull the injector out as far as possible, then use the injector puller slide hammer to tap against the puller nut and drive the injector into the bore. Repeating this procedure will allow the solvent to penetrate to the injector tip and loosen the carbon deposits on the tip.

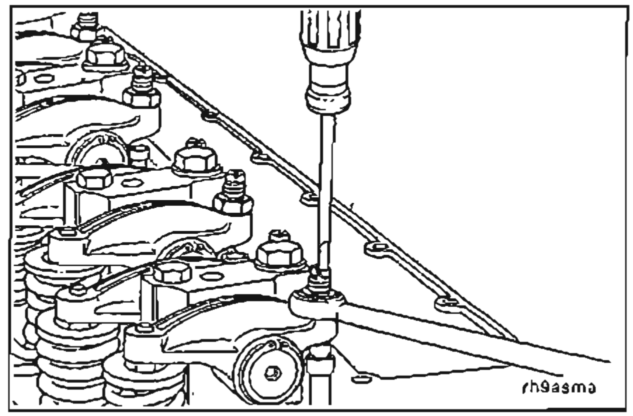
Refer to Component Section 6 for the injector test procedures.



Rocker Levers - Removal (0-29)

14 mm, Screwdriver

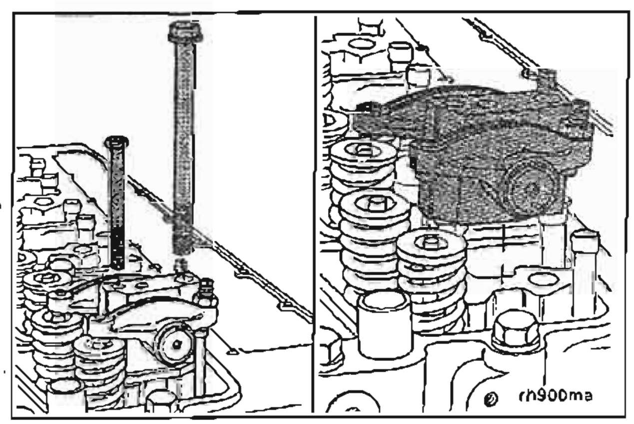
Loosen the nuts on the rocker lever adjusting screws and loosen screws until they stop.



13 mm, 18 mm

Remove the pedestal/head bolts from the rocker shaft pedestals and lift off the pedestal and rocker lever assemblies.

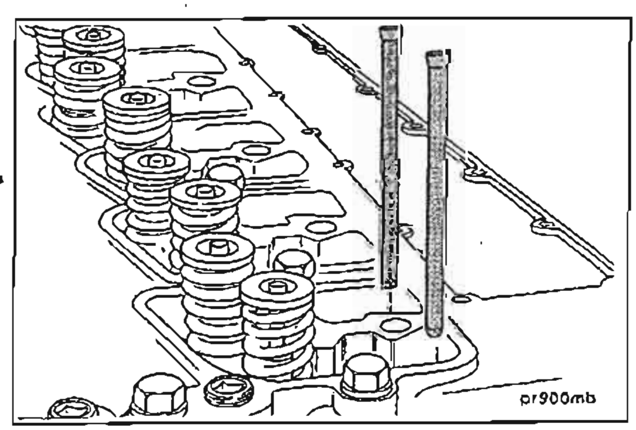
NOTE: Refer to Component Section 3 for disassembly of the rocker lever assemblies.

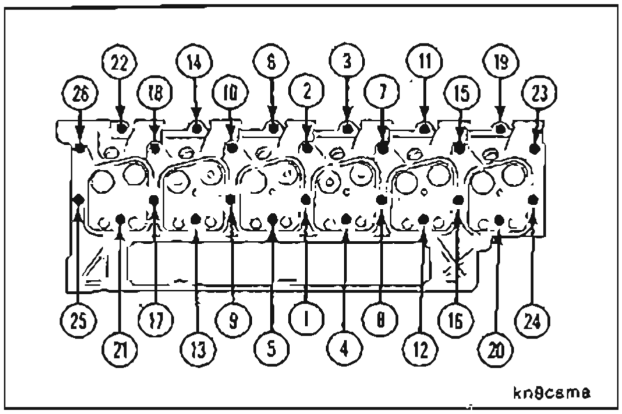


Push Rods - Removal (0-30)

Remove the push rods.

NOTE: Refer to Component Section 4 for the push rod inspection procedure.

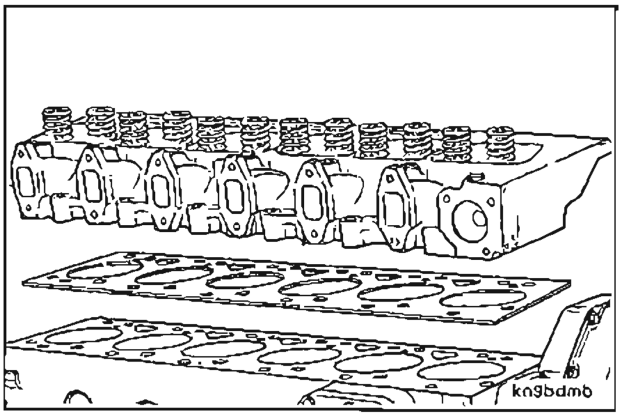




Cylinder Head - Removal (0-31)

18 mm

Remove the remaining cylinder head capscrews in the sequence shown.

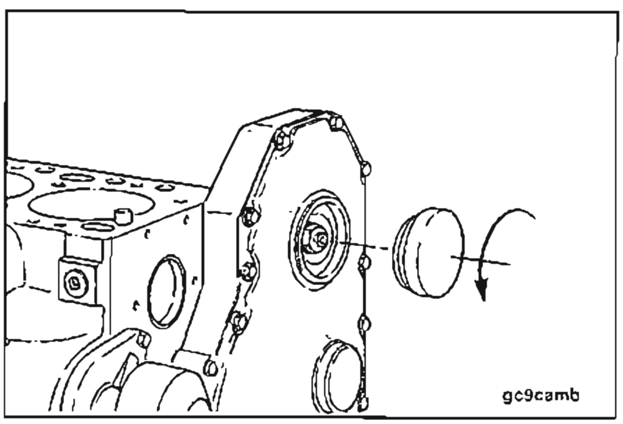


Remove the cylinder head and gasket from the block.

Cylinder Head Weight:

4 Cylinder 36 Kg [80 lb]
6 Cylinder 52 Kg [114 lb]

NOTE: Disassembly of the head is described in Component Section 2.

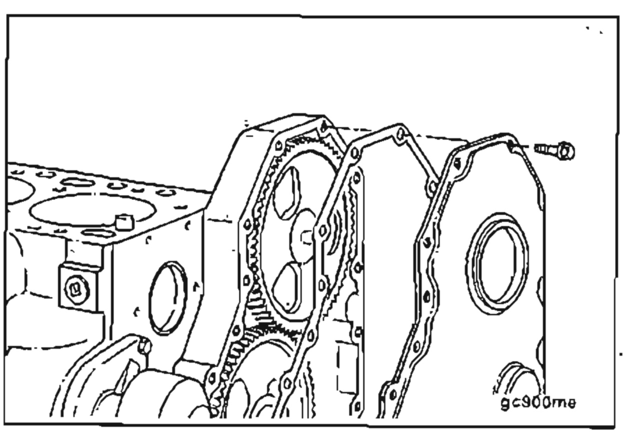


Front Cover - Removal (0-32)

90-100 mm Strap Wrench

Remove the front cover access cap.

Service Tip: A strap type filter wrench can be used to loosen access caps that have been excessively tightened.

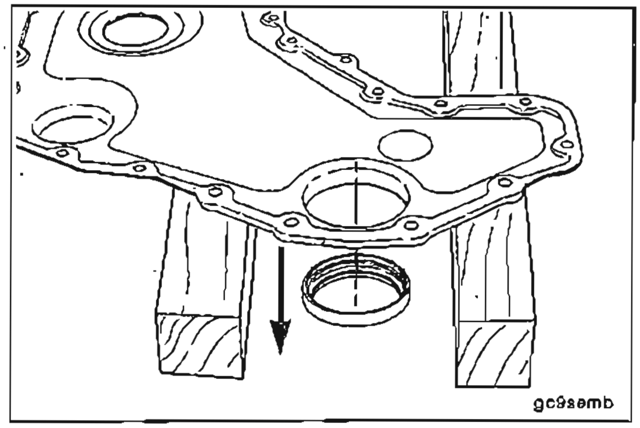


10 mm

Remove the front cover and gasket.

Hammer, Punch

Support the seal area in the front cover and drive out the seal.

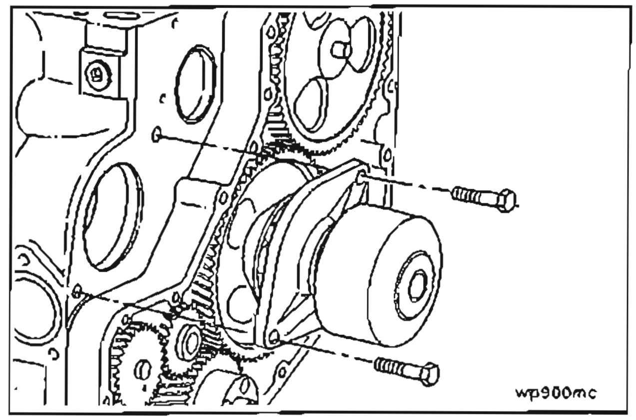


Water Pump - Removal (0-33)

13 mm

Remove the water pump and o-ring.

Refer to Component Section 8 for the water pump inspection.

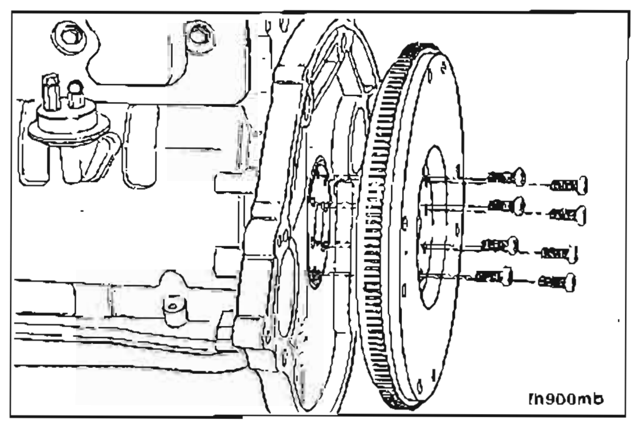


Flywheel - Removal (0-34)

18 mm

Lock the crankshaft and remove the capscrews, washers and flywheel.

NOTE: Refer to Component Section 16 for flywheel inspection.

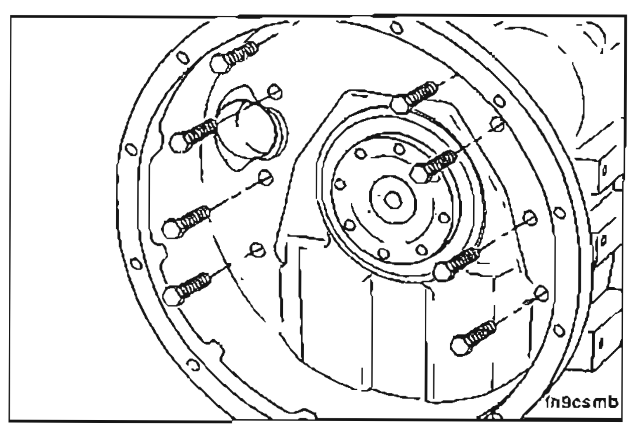


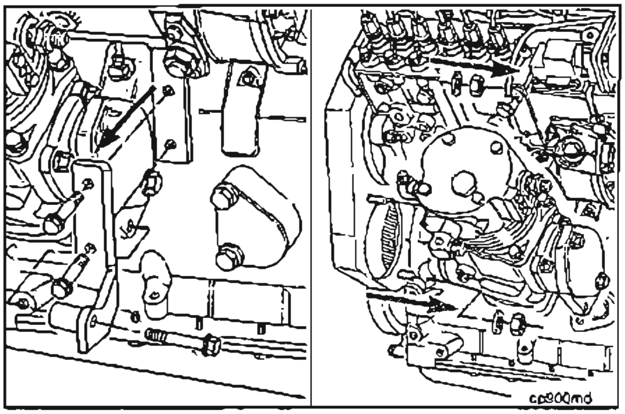
Flywheel Housing - Removal (0-35)

15 mm

Remove the flywheel housing.

NOTE: Refer to Component Section 16 for the flywheel housing inspection procedure.



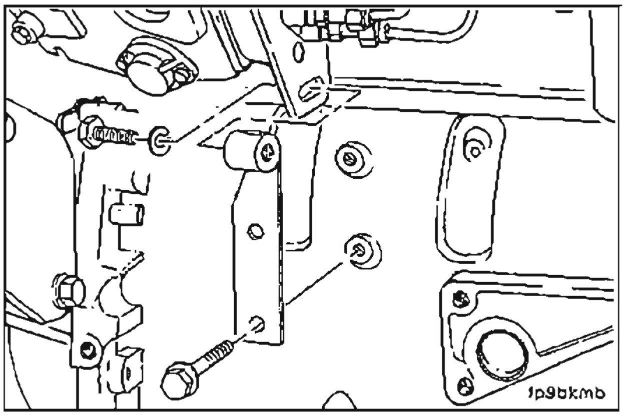


Accessories - Removal (0-36)

10 mm, 14 mm, 18 mm

If equipped, remove all additional gear driven accessories, (air compressor, hydraulic pump, etc.).

NOTE: Refer to the Manufacturer's Service Information for repair instructions.



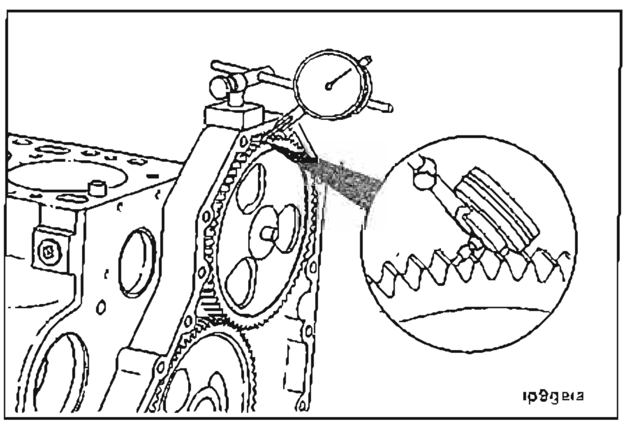
Injection Pump - Removal (Rotary Type Pumps) (0-37)

13 mm

Caution: A diesel engine cannot tolerate dirt or water in the fuel system. A tiny piece of dirt or a few drops of water in the injection system can cause damage to the system.

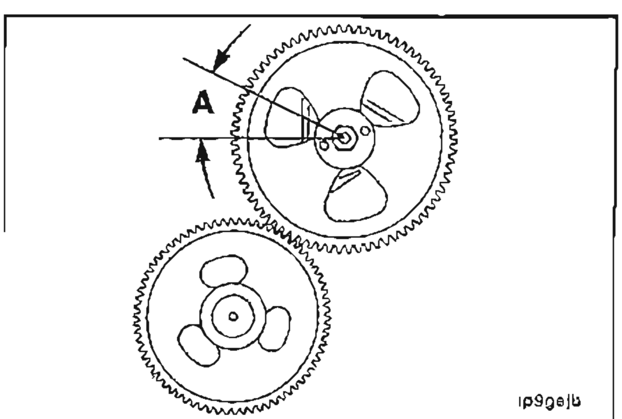
Clean all external surfaces of the injection pump, including all line connections and fittings that are to be disconnected. Clean the area around the injection pump gear cover to prevent dirt from entering the crankcase.

Remove the injection pump support bracket and capscrews.



Gear Lash - Check (0-38)

Position an indicator on the tooth of the injection pump drive gear.



Note the total indicator travel as injection pump drive gear backlash. Mark the pump drive gear and camshaft gear for further analysis if the backlash exceeds the limits.

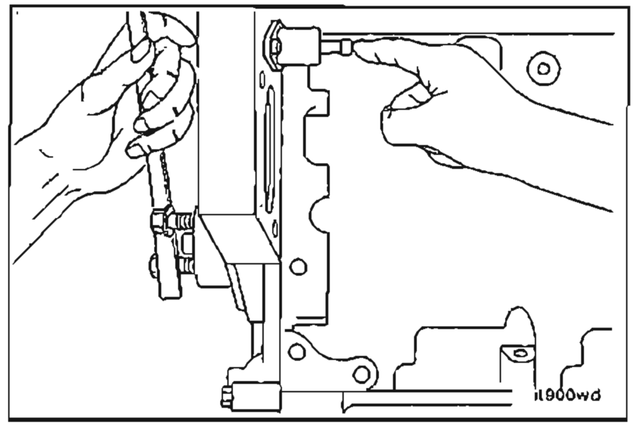
Injection Pump Drive Gear Backlash Limit (A)		
mm		in
0.076	MIN	0.003
0.330	MAX	0.013

NOTE: Prevent movement of adjoining gear when checking backlash or the reading will be the total of both gears.

Locking the Pump (0-39)

Locate TDC for Cylinder Number 1 by slowly barring the engine while pushing in on TDC pin.

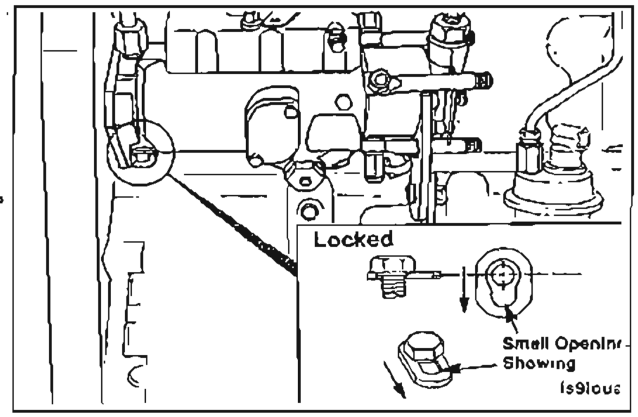
BE SURE TO DISENGAGE THE PIN AFTER LOCATING TDC.



14 mm

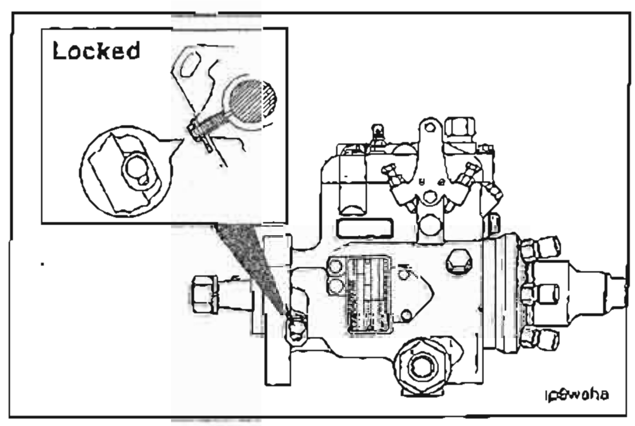
Loosen the CAV injection pump lockscrew, position the special washer with the small opening showing, then tighten the lockscrew against the pump drive shaft.

Torque Value: 7 N•m [5 ft-lb]



3/8 inch

Loosen the lockscrew for the Stanadyne DB4 fuel injection pump. Position the special washer behind the lock screen head. Tighten the lockscrew.



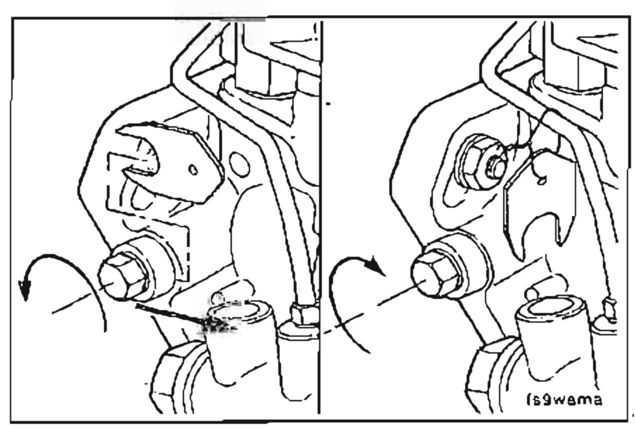
10 mm

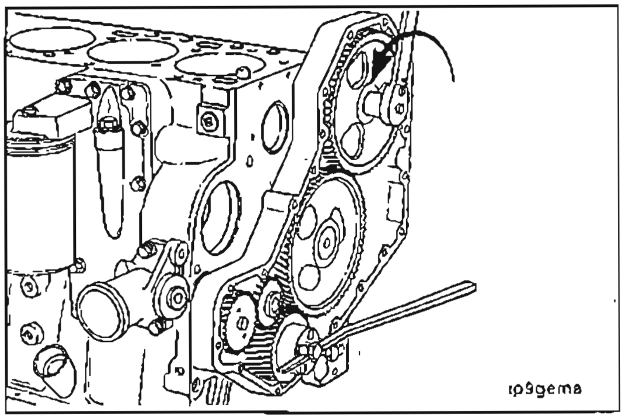
The special washer on the Bosch injection pump must be removed so the lockscrew can be tightened against the drive shaft.

NOTE: Before removing the Bosch pump, the pump must be locked with the No. 1 Cylinder in TDC position.

Torque Value: 30 N•m [22 ft-lb].

Wire the special washer to the Bosch pump.



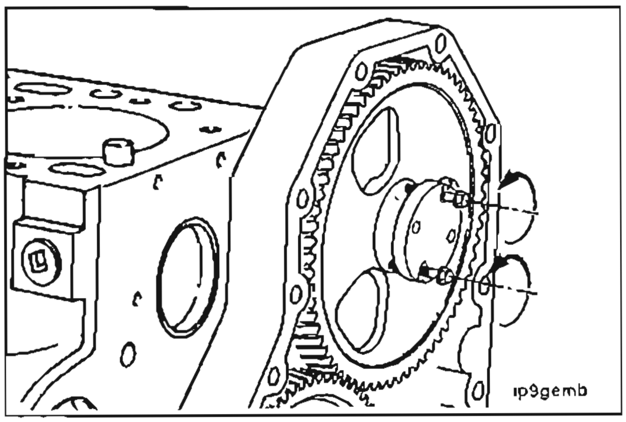


Drive Gear - Removal (0-40)

22 mm

Caution: Hold the crankshaft to prevent the rotation of the locked injection pump.

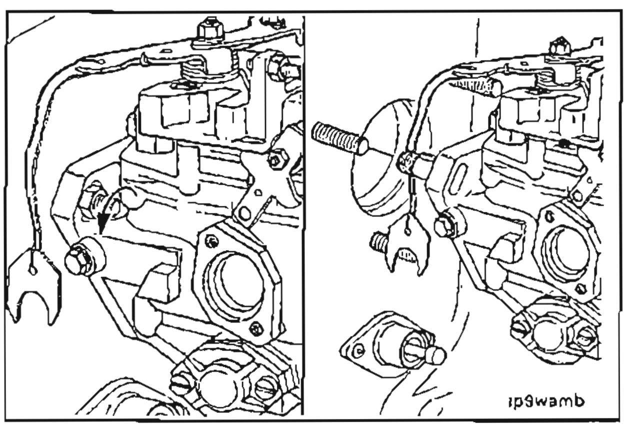
Remove the mounting nut and lock washer from the pump drive shaft.



75 mm T-Bar Puller or Fuel Pump Drive Gear Puller Part No. 3824469

Pull the pump drive gear loose from the drive shaft.

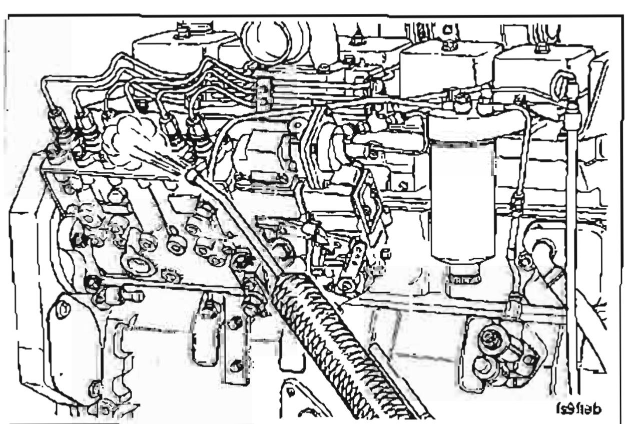
The puller hole threads are M8 X 1.25.



13 mm

Remove the three mounting nuts. Remove the injection pump.

NOTE: Refer to the applicable Manufacturer's Service Instructions for injection pump testing/repair. Minor repairs are described in Component Section 5.



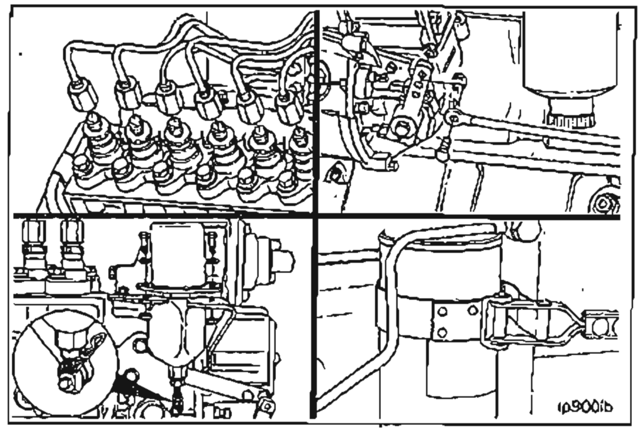
Injection Pump - Removal (In-Line) (0-41)

Caution: A diesel engine cannot tolerate dirt or water in the fuel system. A tiny piece of dirt or a few drops of water in the injection system can cause damage to the system.

Clean all external surfaces of the injection pump, including all line connections and fittings that are to be disconnected. Clean the area around the injection pump gear cover to prevent dirt from entering the crankcase.

Preparatory Steps:

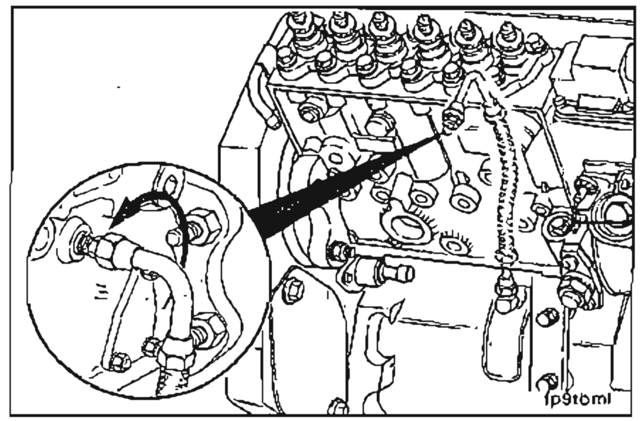
- Remove all fuel lines.
- Remove the control linkage.
- Remove the fuel shutoff solenoid.
- Remove the fuel filter.
- Remove the fuel pump support bracket.



14 and 15 mm

Disconnect the lubricating oil supply line from the fuel pump.

Disconnect the lubricating oil supply line from the engine block.

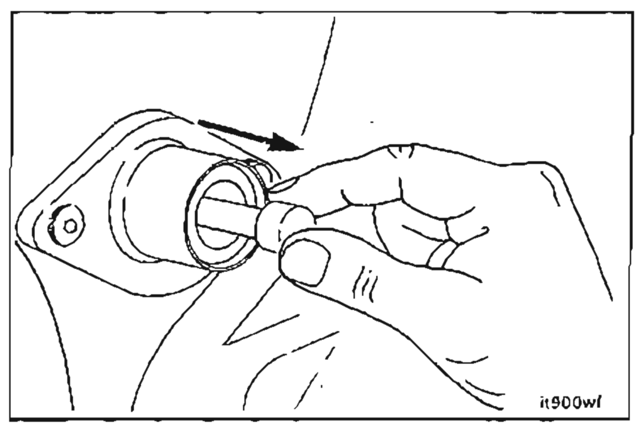


3377371 Barring Tool

Make sure the crankshaft has No. 1 cylinder at Top Dead Center (TDC).

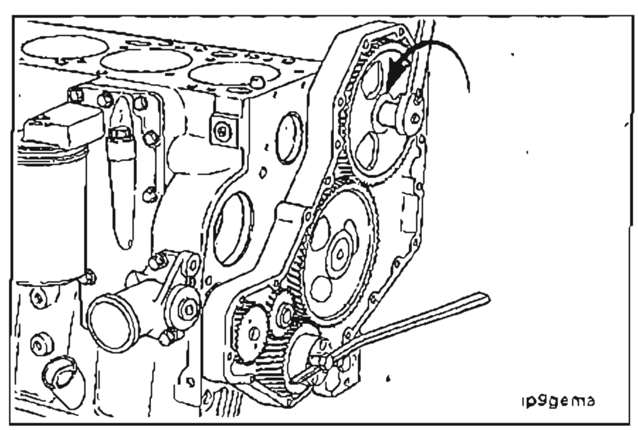
Rotate the engine until the timing pin engages.

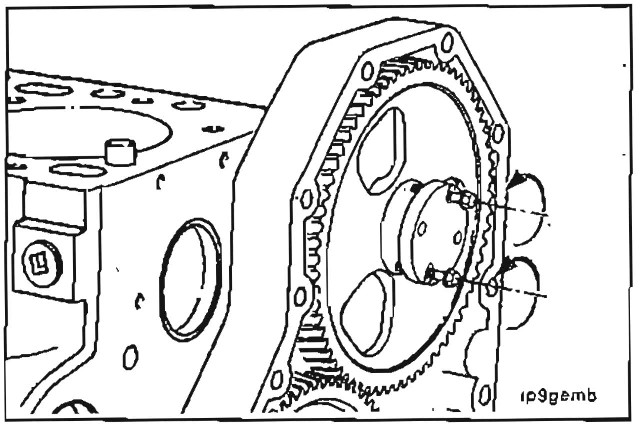
Be sure to disengage the pin after locating TDC.



22 mm

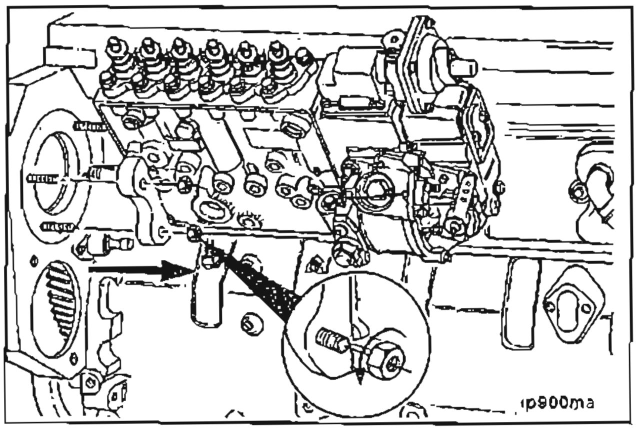
Remove the nut and washer from the fuel pump shaft.





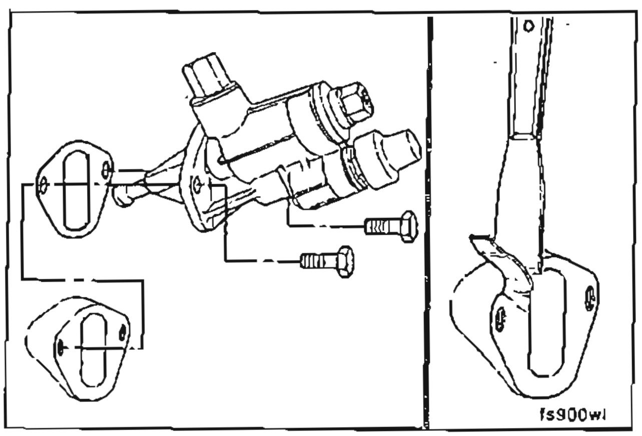
Two M8 x 1.25 Capscrews, 75 mm T-Bar, or Fuel Pump Drive Gear Puller 3824469

Pull the pump gear from the drive shaft.



15 mm

Remove the four mounting nuts and injection pump.

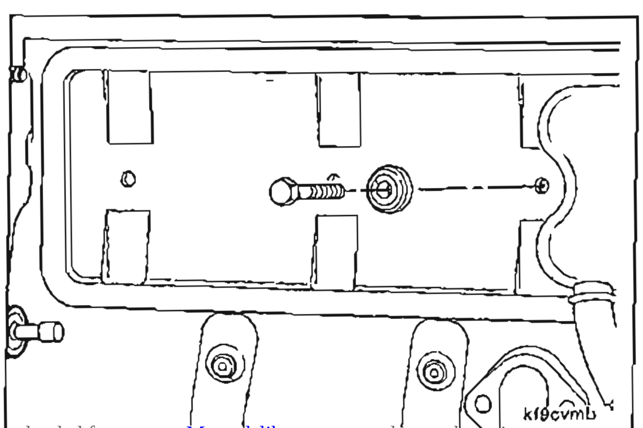


Fuel Transfer Pump - Removal (0-44)

10 mm

Remove the fuel transfer pump, spacer, and gaskets.

NOTE: Refer to Component Section 6 for fuel transfer pump test procedures.



Tappet Cover - Removal (0-45)

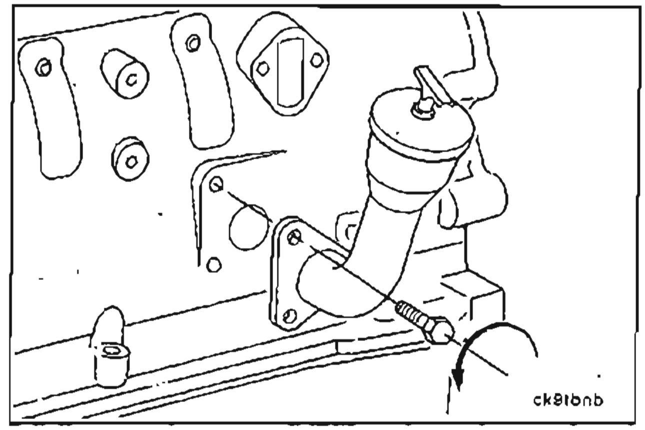
10 mm

Remove the tappet cover and gasket.

Side Oil Fill - Removal (0-46)

18 mm

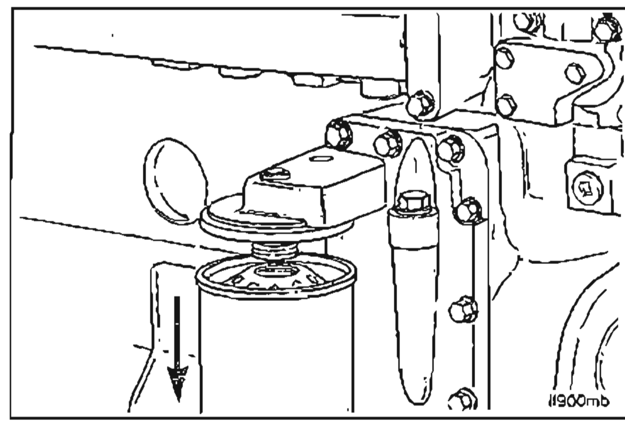
If present, remove the capscrews, side oil fill assembly and rectangular ring seal. Some engines may have an air compressor oil drain connection attached at this location. Remove the connection and rectangular ring seal.



Oil Cooler - Removal (0-47)

90-95 mm [3-1/2 to 3 7/8 in] Filter Wrench

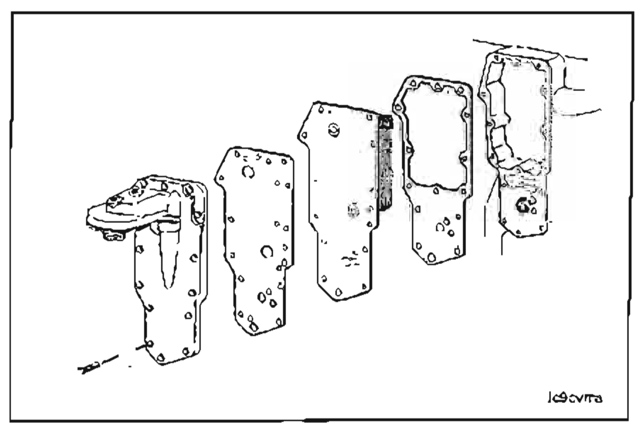
Remove the oil filter.



10 mm

Remove all the capscrews, oil cooler cover, cover gasket, oil cooler and cooler gasket.

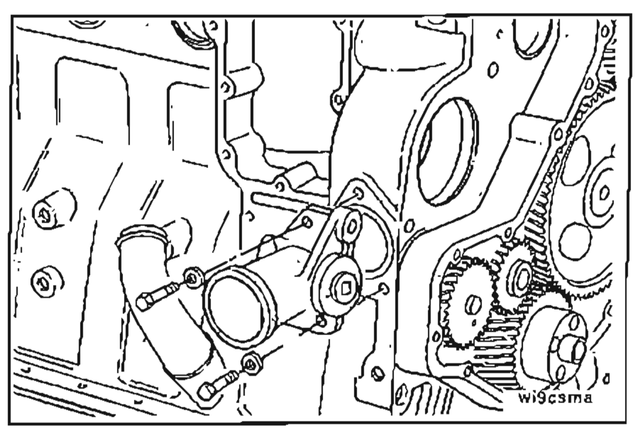
NOTE: Refer to Component Section 7 for inspection procedures.

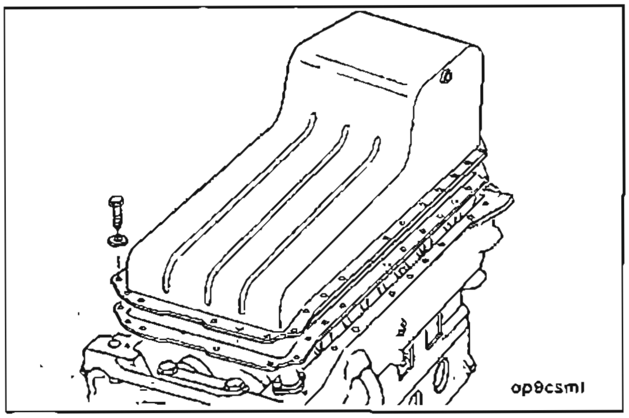


Water Inlet Connection - Removal (0-48)

13 mm

Remove the water inlet connection and rectangular ring seal.

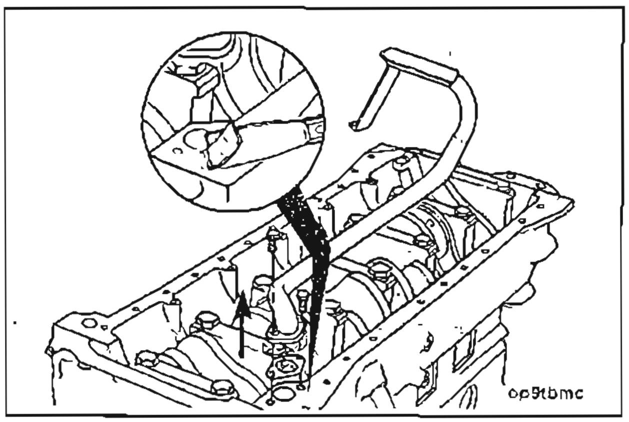




Oil Pan - Removal (0-49)

10 mm

Rotate the engine on the stand and remove the oil pan and gasket.

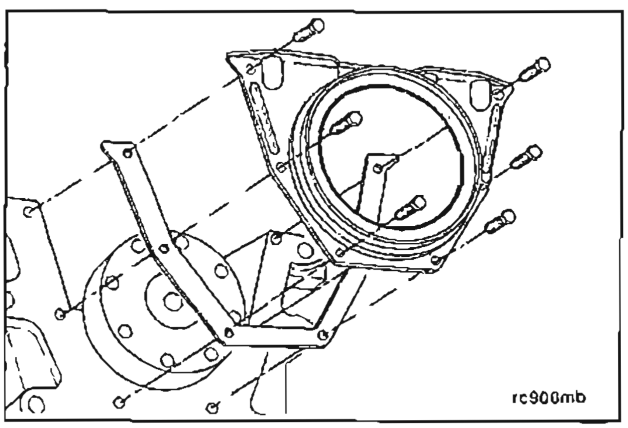


Suction Tube - Removal (0-50)

10 mm

Remove the suction tube and gasket.

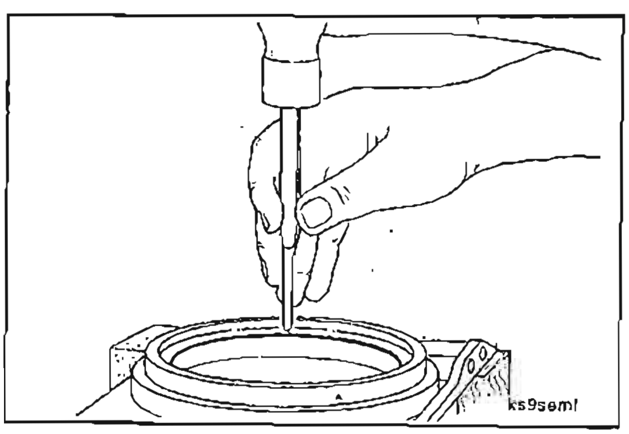
NOTE: Refer to Component Section 7 for the suction tube inspection procedure.



Rear Seal Housing - Removal (0-51)

8 mm

Remove the rear seal housing and gasket.



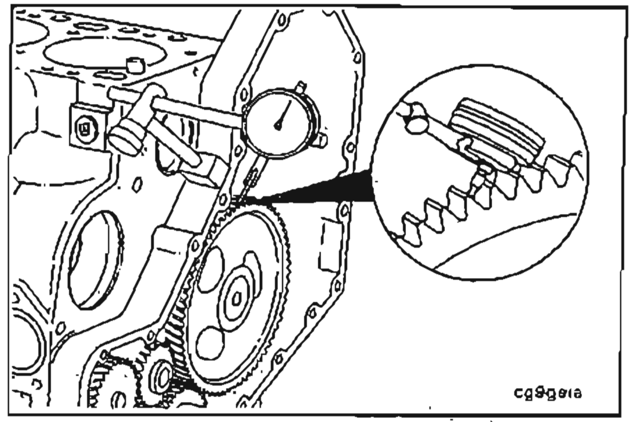
Support the seal area of the rear seal housing and press/ drive out the seal.

Camshaft - Removal (0-52)

Measuring Gear Lash (0-53)

Position an indicator on a tooth of the camshaft gear.

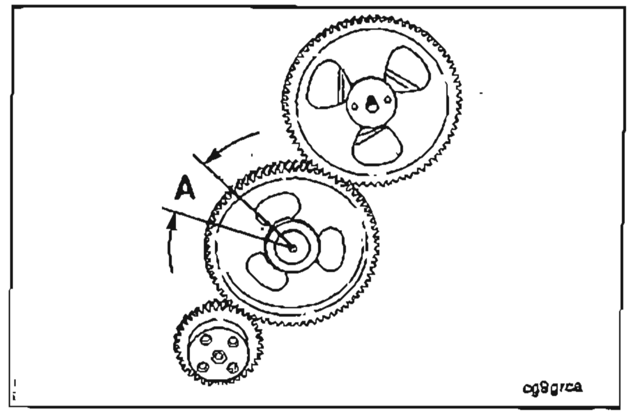
NOTE: The cylinder block position shown in the illustration is for clarity. The cylinder block must be positioned with the crankshaft on top to keep the tappets in the bores.



Note the camshaft gear backlash. Mark the camshaft gear and crankshaft gear for further analysis if backlash exceeds limits.

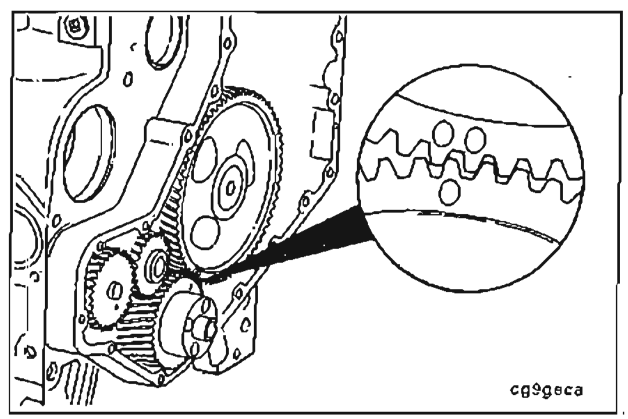
Camshaft Gear Backlash Limit (A)		
mm		in
0.076	MIN	0.003
0.330	MAX	0.013

NOTE: Prevent movement of adjoining gear when checking backlash or the reading will be the total of both gears.



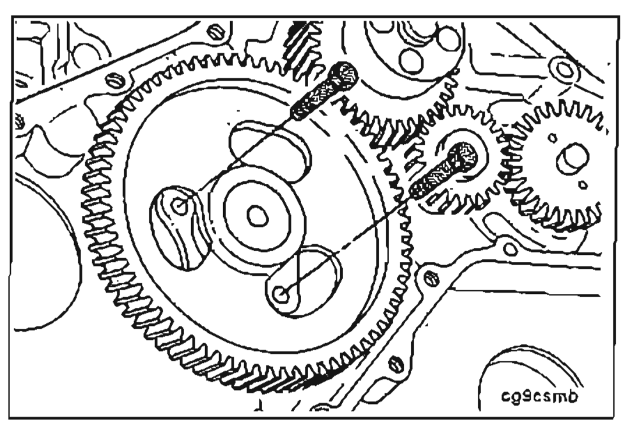
Rotate the crankshaft to approximately the TDC position for number one cylinder. Failure to do so will result in the camshaft catching on the connecting rods during camshaft removal.

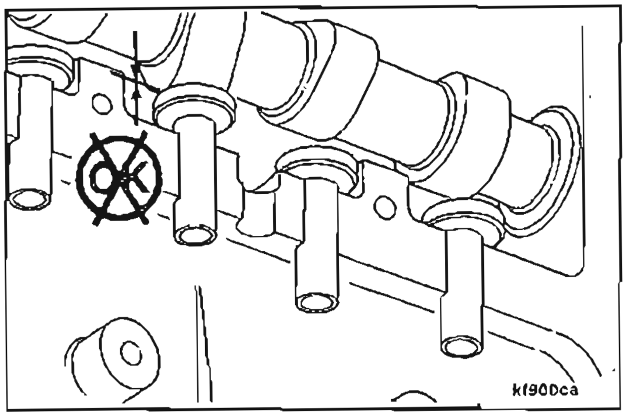
NOTE: The cylinder block is shown in an upright position in the illustration for clarity.



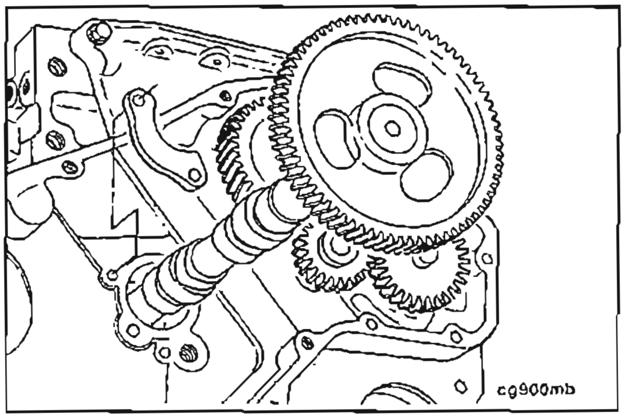
13 mm

Remove the thrust plate capscrews.





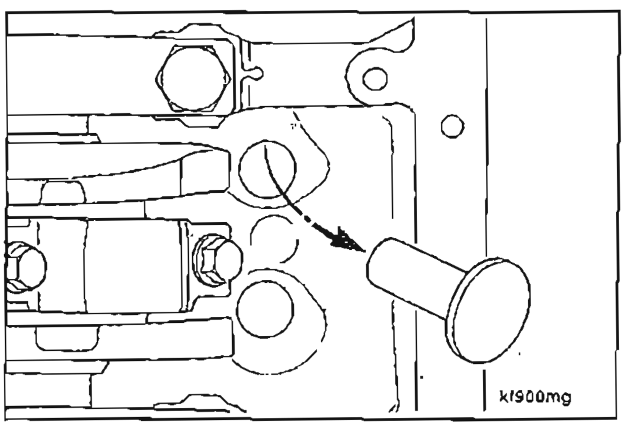
Visually inspect the tappets to make sure they are off the camshaft lobes.



Remove the camshaft and thrust plate from the cylinder block. Take care not to drop the thrust washer.

Service Tip: Rotate the camshaft while pulling outward with a steady pressure during removal.

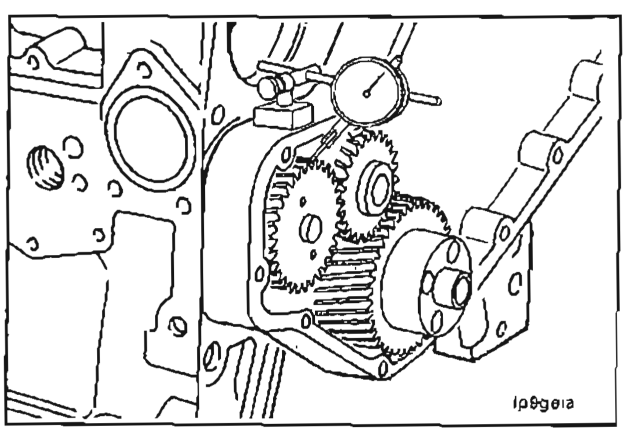
NOTE: Refer to Component Section 1 for disassembly and inspection.



Valve Tappets - Removal (0-54)

Remove the valve tappets. The engine can be rotated to allow easy access to the tappets.

NOTE: Refer to Component Section 4 for inspection proceures.

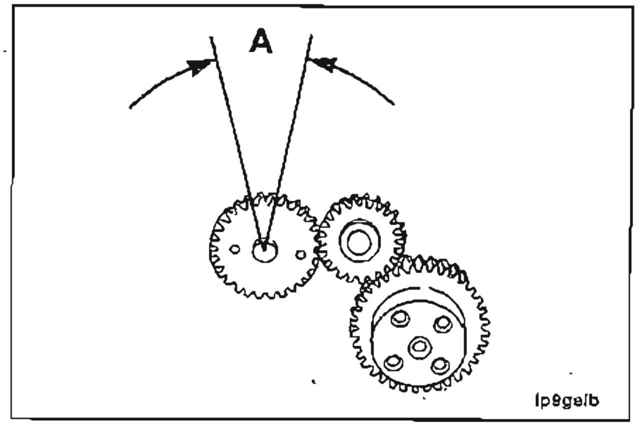


Lube Pump - Removal (0-55)

Measuring Backlash (0-56)

Position the indicator on a tooth of the lube pump gear.

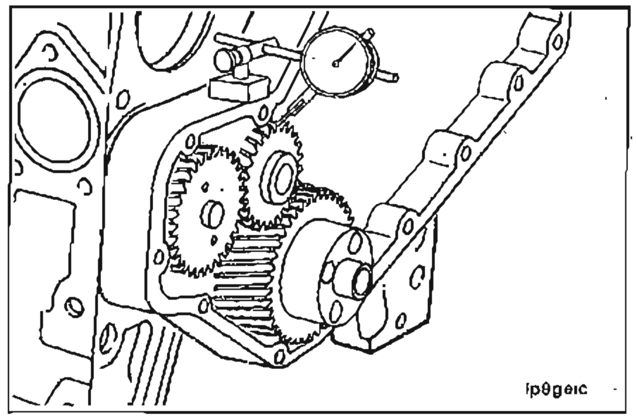
Note the lube pump gear backlash. Mark the lube pump gear and idler gear for additional analysis if the limits are exceeded.



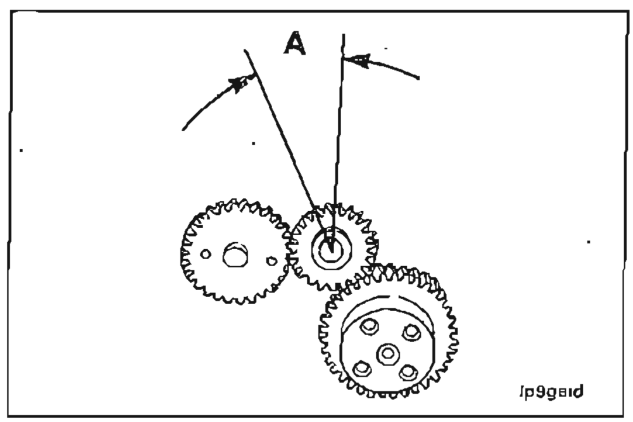
Lube Pump Gear Backlash Limits (A)		
mm		in
0.076	MIN	0.003
0.330	MAX	0.013

NOTE: Prevent movement of the adjoining gear when checking backlash or the reading will be the total of both gears.

Position the indicator on a tooth of the lube pump idler gear.



Note the idler gear backlash. Mark the idler gear and crankshaft gear for additional analysis if the limits are exceeded.



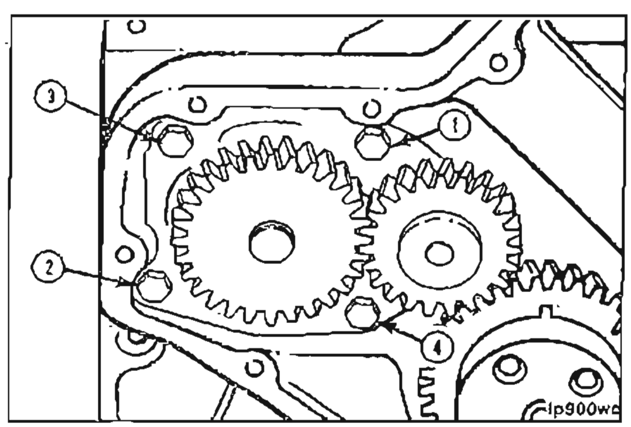
Lube Pump Idler Gear Backlash Limit (A)		
mm		in
0.076	MIN	0.003
0.330	MAX	0.013

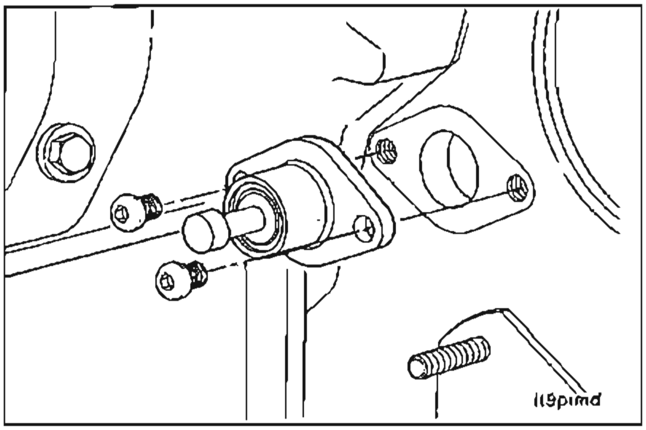
NOTE: Prevent movement of the adjoining gear when checking backlash or the reading will be the total of both gears.

13 mm

Remove the lube pump.

NOTE: Refer to Component Section 7 for inspection.

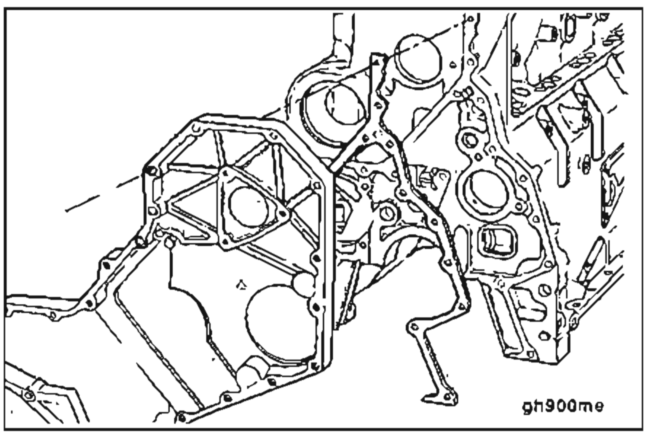




Timing Pin Housing - Removal (0-57)

T25 Torx

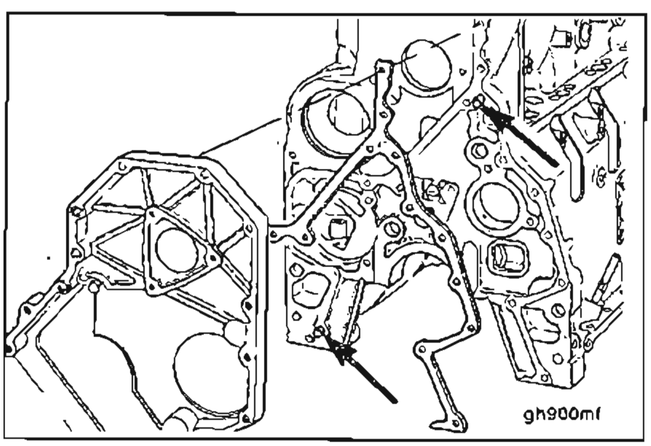
Remove the timing pin assembly.



Gear Housing - Removal (0-58)

10 mm

Remove the capscrews, gear housing and gasket.



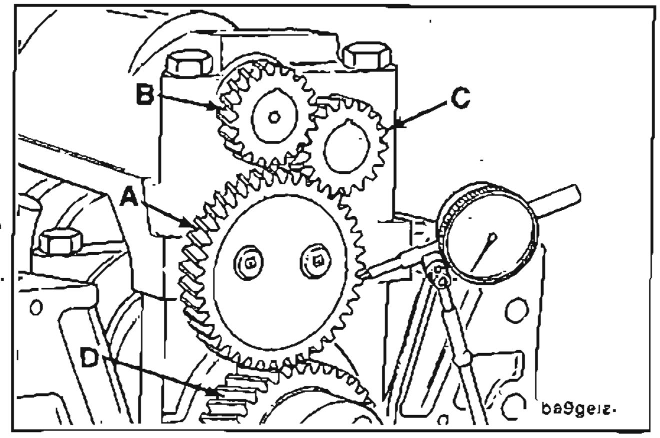
Plastic Hammer

The gear housing is positioned onto the cylinder block with two dowel pins. Tap in the area of the dowel pins with a plastic hammer if difficulty is encountered removing the housing.

Balancer - Removal (0-59)

Measuring Backlash (0-60)

Use an indicator to measure the backlash of the idler gear (A) upper shaft gear (B) and lower shaft gear (C).



NOTE: Prevent movement of the adjoining gear when checking backlash or the reading will be the total of both gears.

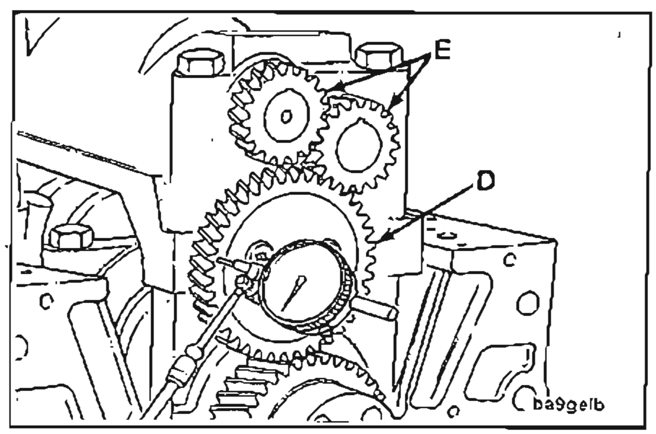
Balancer Gear Backlash

		mm		in
Idler	(A) to (D)	0.088	MIN	0.003
		0.420	MAX	0.017
Upper Shaft	(B) to (A)	0.153	MIN	0.006
		0.355	MAX	0.014
Lower Shaft	(C) to (B)	0.088	MIN	0.003
		0.420	MAX	0.017

Record for use during inspection. Refer to Component Section 1 for disassembly and rebuild instructions.

Measuring the End Play (0-61)

Use an indicator to measure the end play of the idler gear (D) and shaft (E).



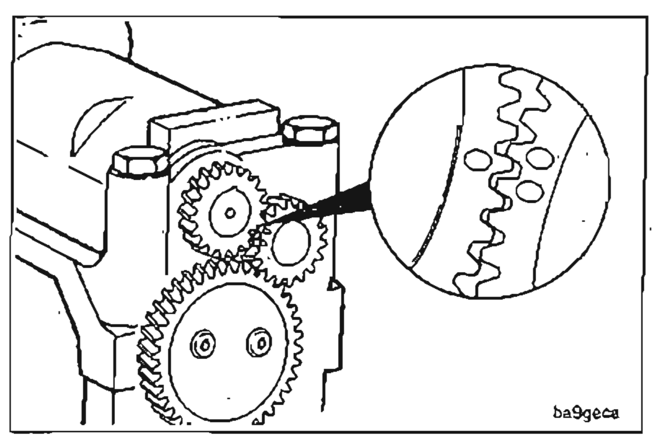
Balancer End Play

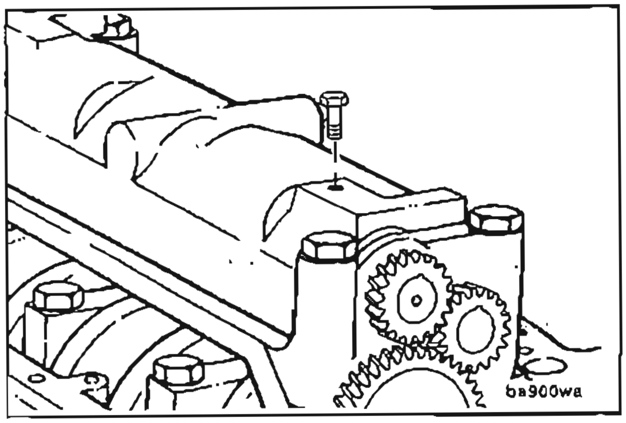
	mm		in
(D)	0.130	MIN	0.005
	0.630	MAX	0.024
(E)	0.075	MIN	0.003
	0.175	MAX	0.007

Record for use during inspection. Refer to Component Section 1 for disassembly and rebuilt instructions.

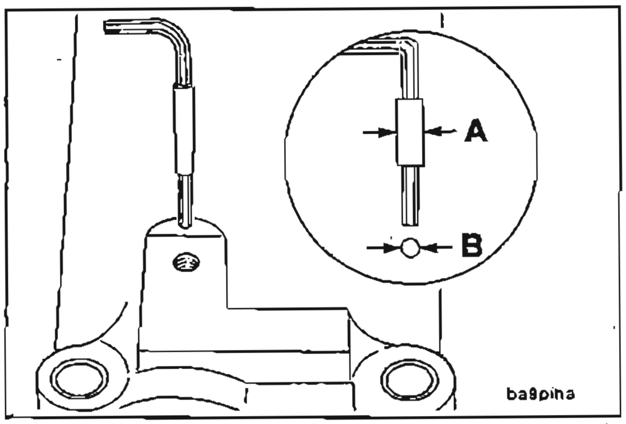
Locking the Balancer (0-62)

Rotate the balancer gears until the timing marks are aligned.





If the balancer shaft has a tapped hole, the shaft can be locked in position by temporarily installing a M8 capscrew through the housing and into the shaft.



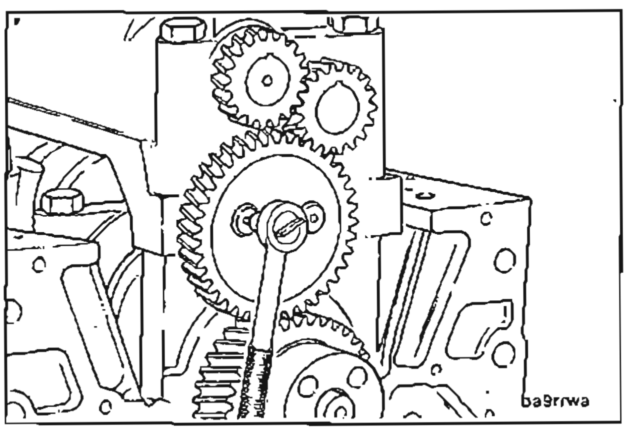
4.5 mm Allen, 1 inch Wide Masking Tape

Follow this procedure if the shaft does not have a tapped hole.

Wrap the 4.5mm allen wrench with masking tape until it has a snug fit in the hole in the balancer housing.

A = Approximately 10mm [0.4 inch]

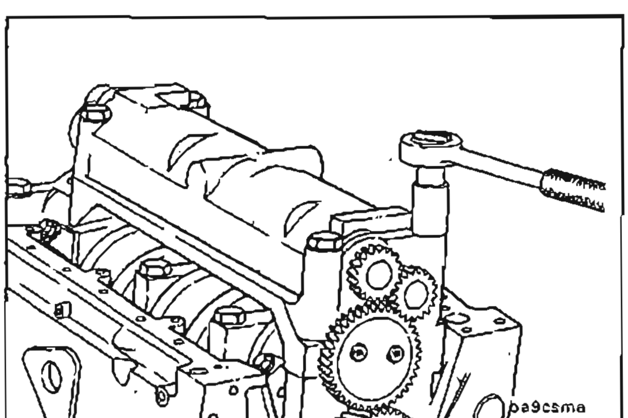
B = 10mm [0.4 inch]



Removing the Balancer (0-63)

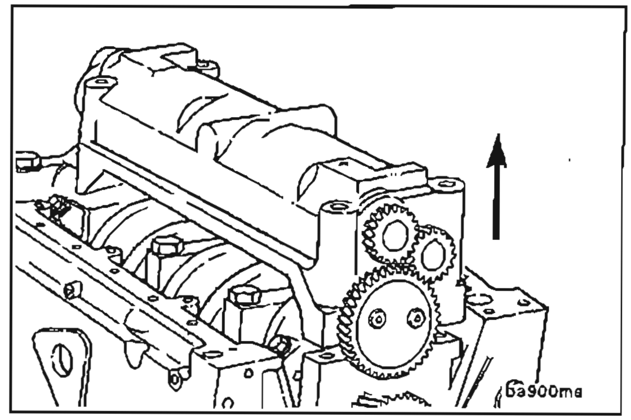
8 mm Allen

Loosen the socket head capscrews for the balancer idler gear retainer. DO NOT REMOVE THE CAPSCREWS.



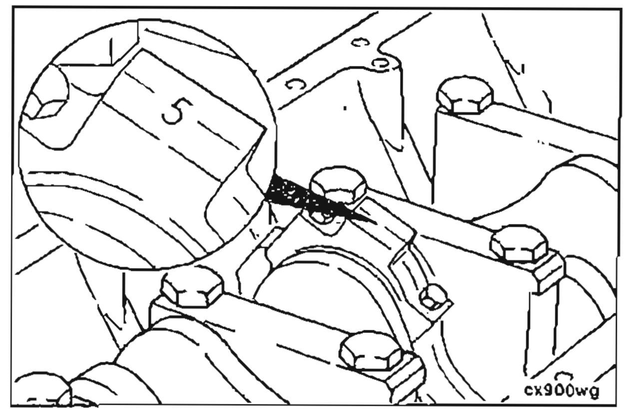
Remove the No. 1 and No. 4 main bearing capscrews.

Move the idler retainer until the pin in the No. 1 cap disengages the slot in the retainer. Remove the balancer assembly.



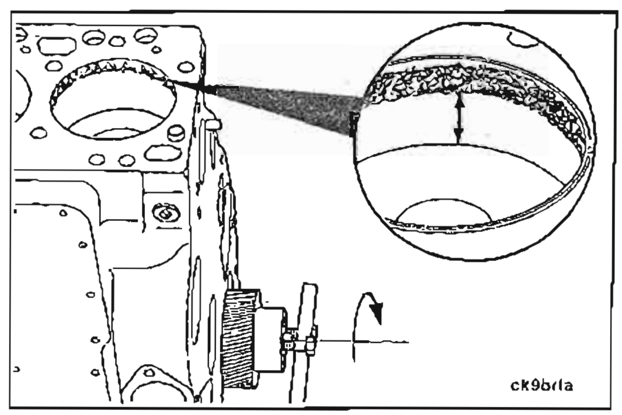
Piston and Rod Assemblies - Removal (0-64)

Mark each rod cap according to cylinder.

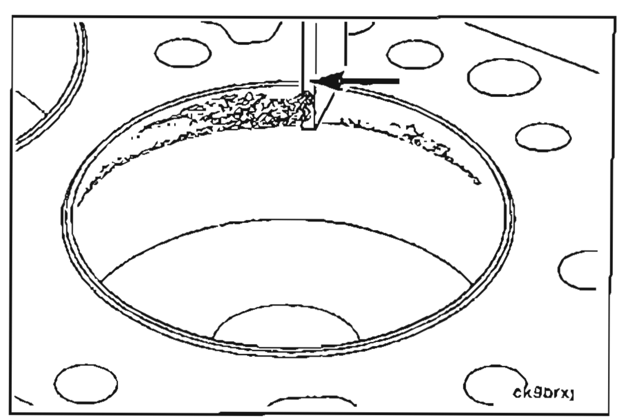


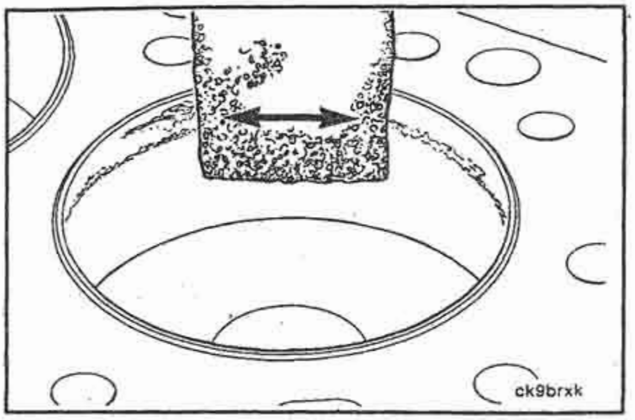
Rotate the engine on the rebuild stand so the cylinder bores are in a horizontal position.

Rotate the crankshaft so the pistons are below the carbon deposits above the ring travel area.

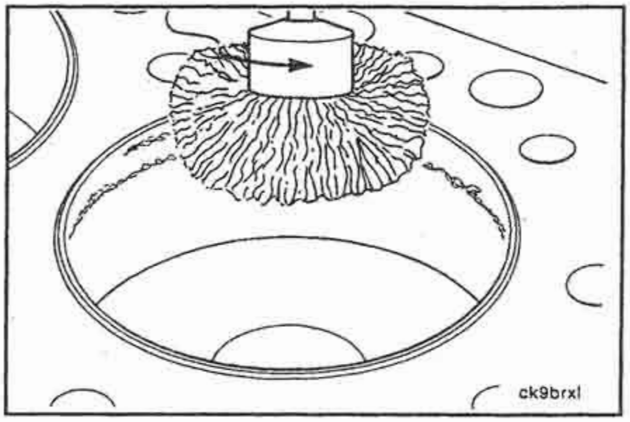


Use a scraper or a blunt edged instrument to loosen the carbon deposits. Do not damage the cylinder with the scraper.





Remove the remaining carbon with a Scotch-Brite® cleaning pad or equivalent.

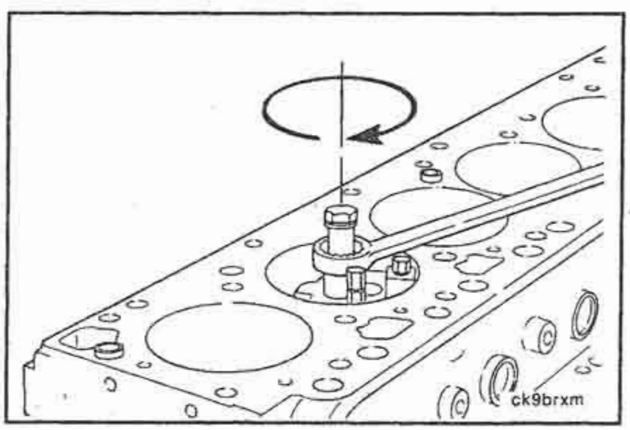


Warning: To prevent serious eye damage wear eye protection during this operation.

An alternative method to remove the carbon ridge is to use a high quality steel wire wheel installed in a drill or die grinder.

NOTE: An inferior quality wire wheel will lose steel bristles during operation, thus causing additional contamination.

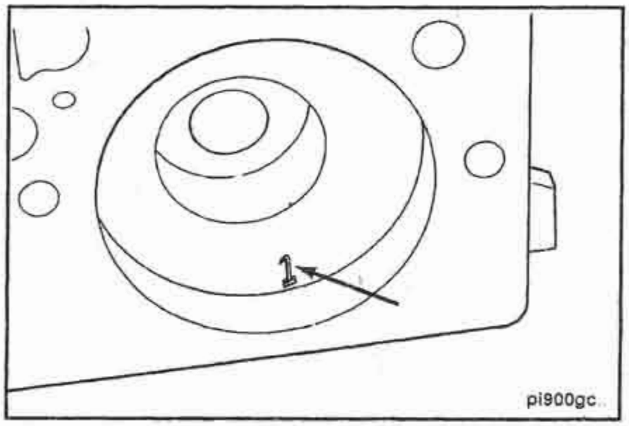
Do not use the steel wire wheel in the piston travel area. Operate the wheel in a circular motion to remove the deposits.



Ridge Reamer

If required, cut the ridge from the top of the cylinders.

Make sure ridge reamer does not gouge into the cylinder bore or remove more metal than needed.



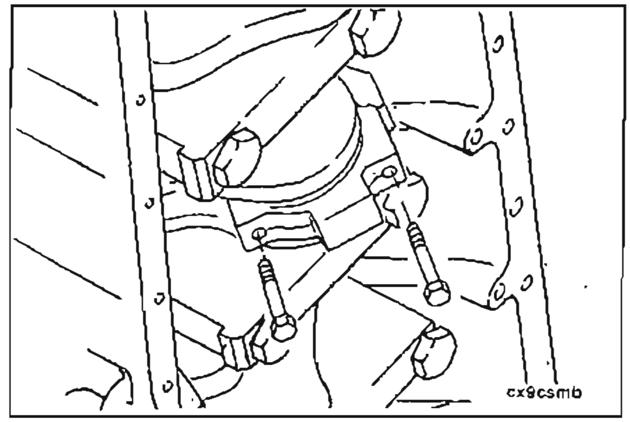
Mark each piston with the cylinder number.

During assembly, the piston **must** be installed into the corresponding cylinder number..

12 mm

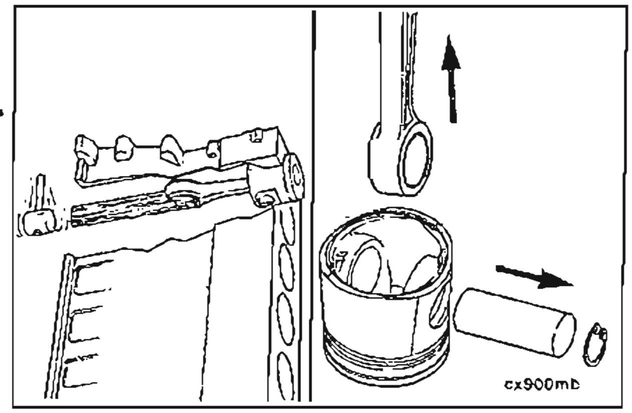
Remove the capscrews, rod cap and rod bearings.

Mark the cylinder number on the back side of the rod bearings.



Catch the piston with one hand while pushing the rod and piston assembly out of cylinder bore. Care must be taken not to mutilate the connecting rod or bearing.

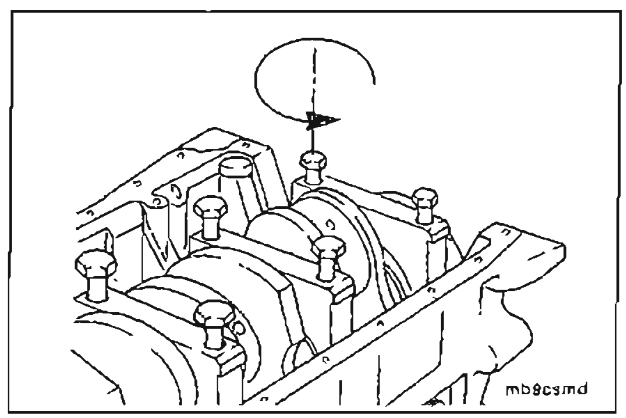
NOTE: Disassembly of the piston/rod assembly is described in Component Section 1



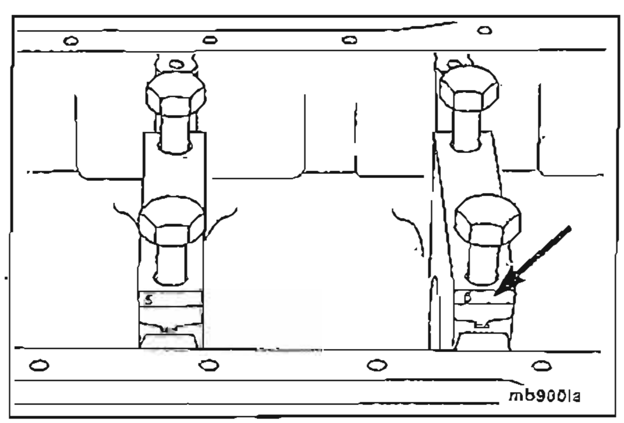
Crankshaft - Removal (0-65)

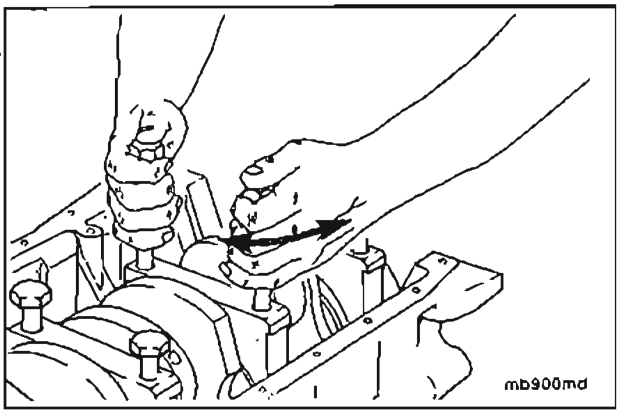
23 mm

Rotate the engine to a horizontal position so the main bearing caps are accessible. Remove the capscrews from the main bearing caps.



The main caps should be numbered. If they are not, mark them with the correct number.

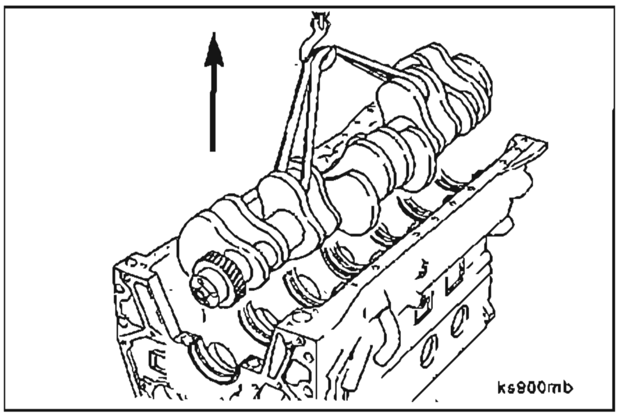




Remove the main bearing caps.

Do not pry on the main caps to free them from the cylinder block.

Use two of the main cap bolts to "wiggle" the main cap loose, being careful not to damage the bolt threads.

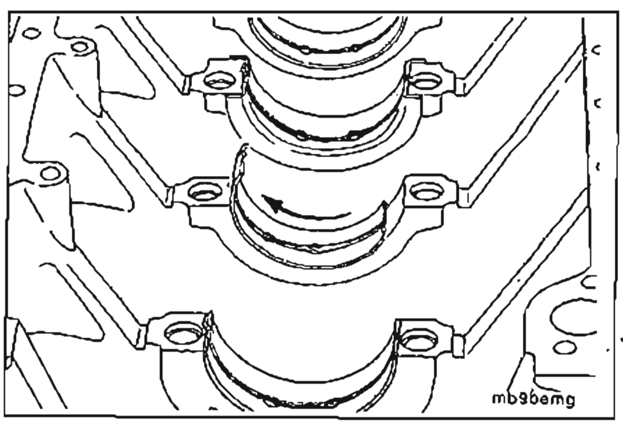


Crankshaft Weight:

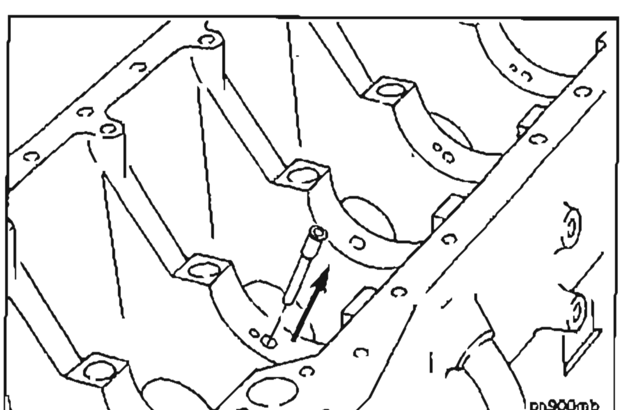
4 Cylinder 36 Kg [80 lb]
6 Cylinder 55 Kg [123 lb]

Lift the crankshaft and gear from the cylinder block.

NOTE: Refer to Component Section 1 for disassembly and inspection.



Remove the main bearings from the cylinder block and the main caps.

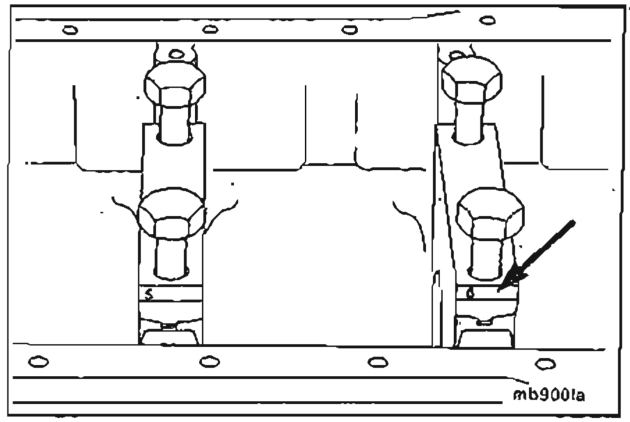


3/16 Inch Pin Punch

Remove the piston cooling nozzles.

Install the main caps in their corresponding positions. When correctly installed, the tangs (slots) should both be on the same side.

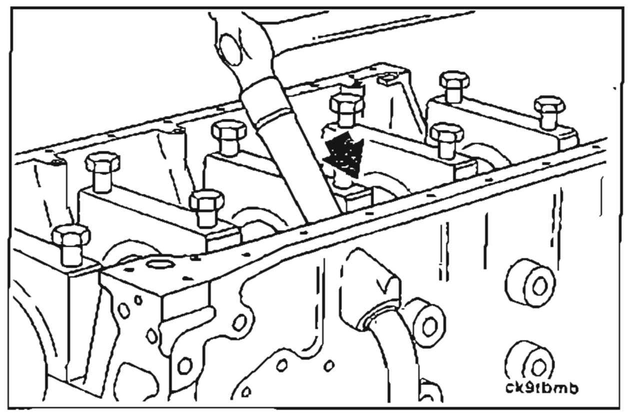
NOTE: #1 is to the front of the block.



Turbocharger Drain Tube - Removal (0-66)

3/4 Inch Drift & Hammer

Drive the drain tube out from the inside of the cylinder block.



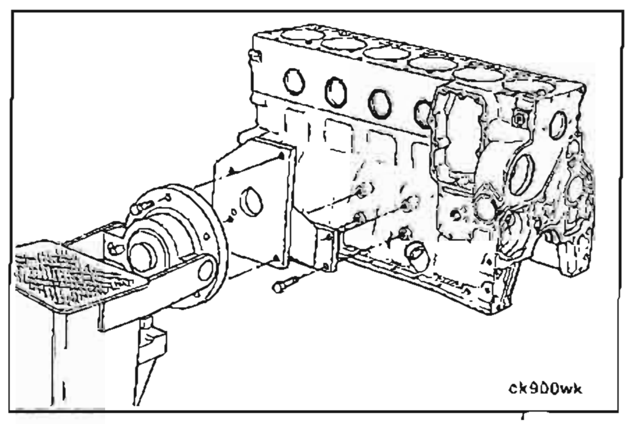
Cylinder Block - Removing From the Rollover Stand (0-67)

18 mm

Remove the cylinder block from the rollover stand.

NOTE: Refer to Component Section 1 for cleaning and inspection of the cylinder block.

4B Cylinder Block Weight:	91 Kg [201 lb]
6B Cylinder Block Weight:	124 Kg [275 lb]

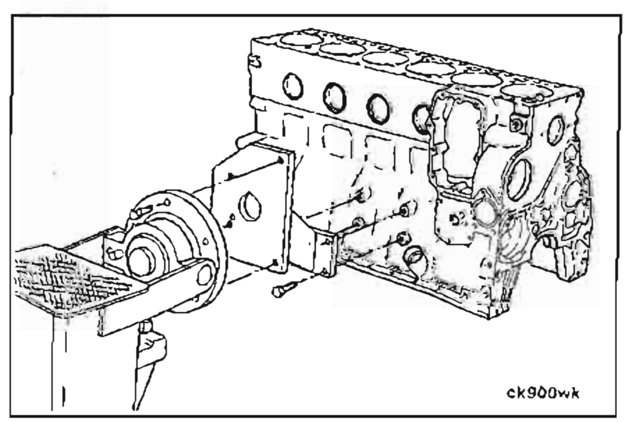


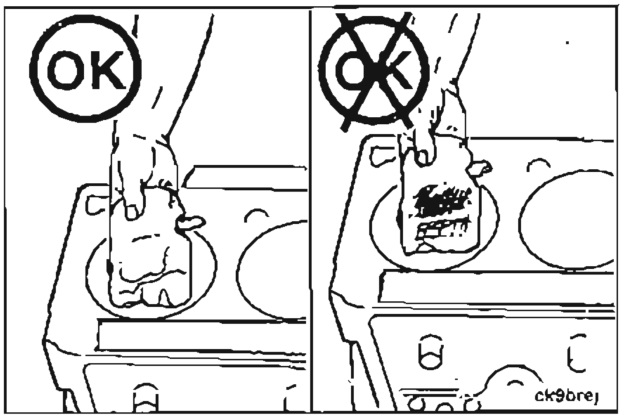
Engine Assembly (0-68)

Cylinder Block - Prepare for Assembly (0-69)

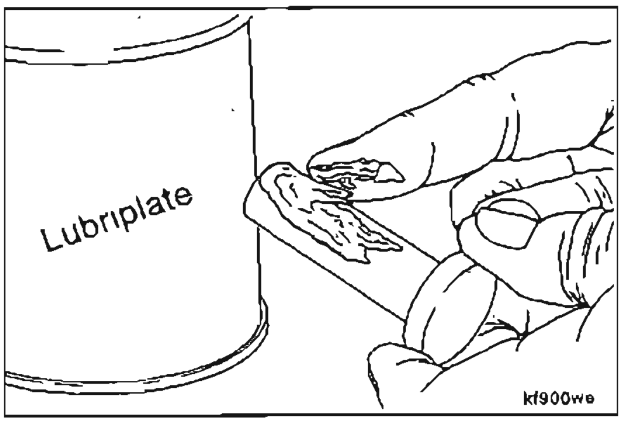
Install the cylinder block to the rollover stand.

NOTE: Make sure the cylinder block has been cleaned and inspected as described in Component Section 1



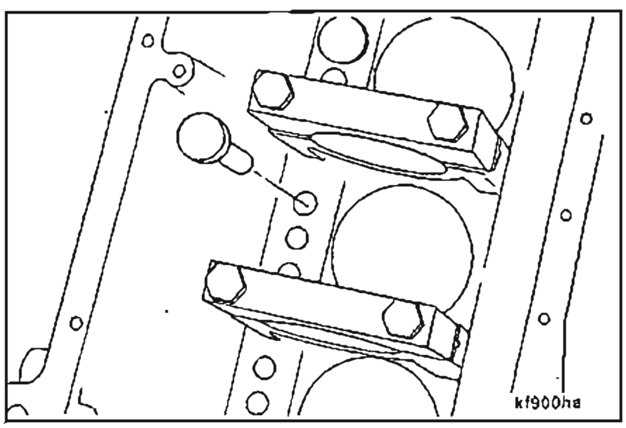


Caution: Be sure the cylinder bores are clean.

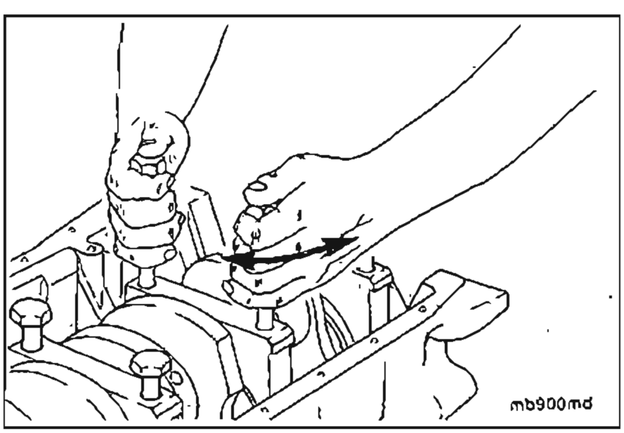


Valve Tappets - Installation (0-70)

Lubricate the tappets with Lubriplate 105®



Install the valve tappets.



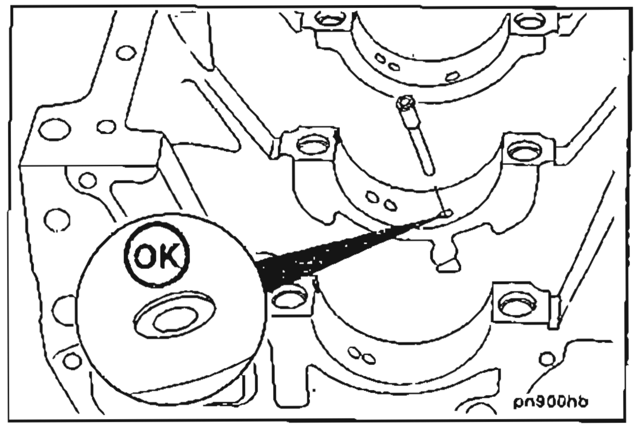
Crankshaft - Installation (0-71)

23 mm

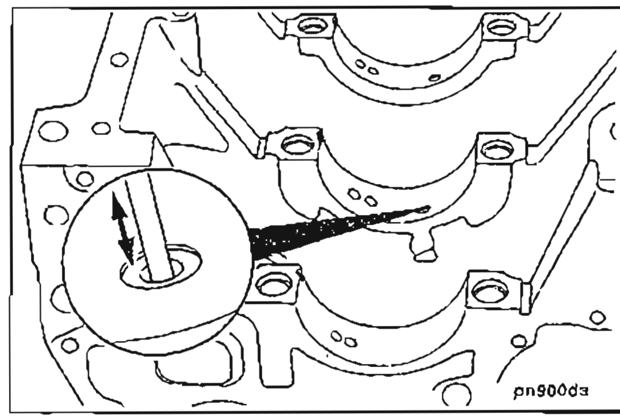
Remove the main bearing caps.

1/2 Center Punch

Install piston cooling nozzles even with or below the bearing saddle surface.

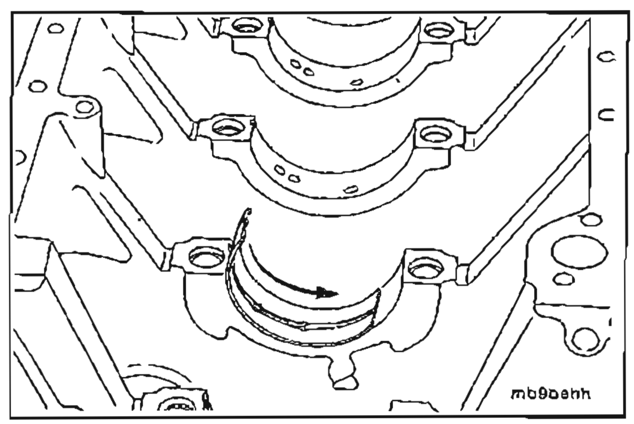


Caution: Be sure spray holes are clean and open.

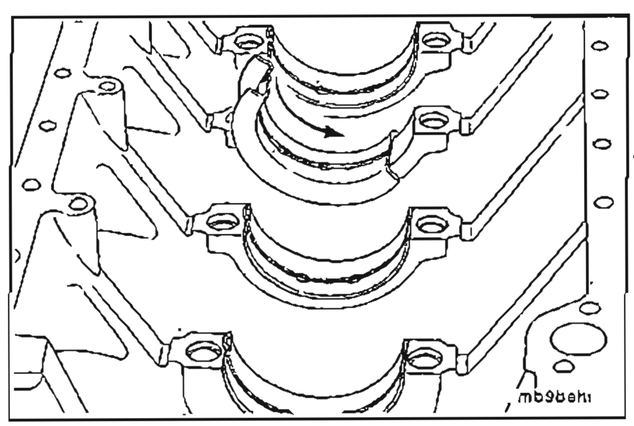


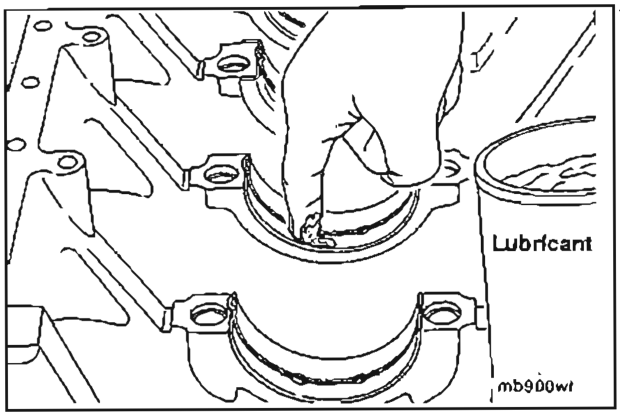
Install the upper main bearings.

Make sure the bearing tangs are in the notch in the bearing saddle.

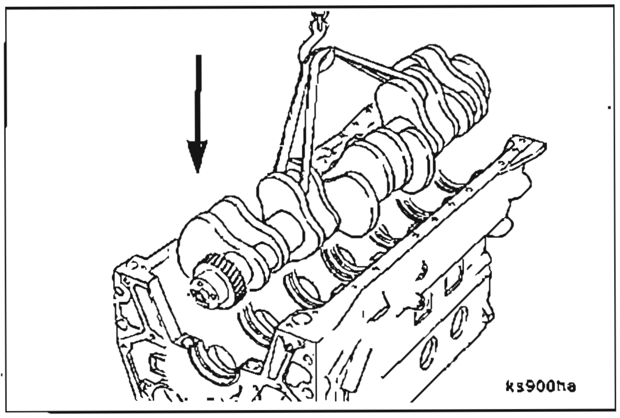


Install the combination thrust and main bearing in the second journal from the rear.





Lubricate the bearings with Lubriplate 105®

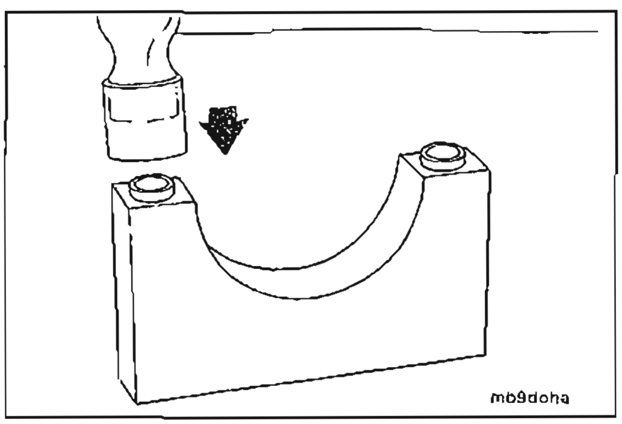


Caution: Carefully install the crankshaft to avoid damage to the crankshaft main bearings, especially the thrust/main bearing.

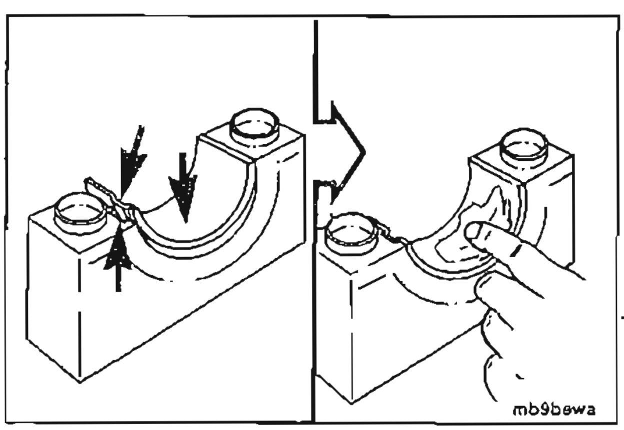
Install the crankshaft.

Crankshaft Weight:

4 Cylinder 36 Kg [80 lb]
6 Cylinder 55 Kg [123 lb]



Make sure the ring dowels have been installed into the caps.

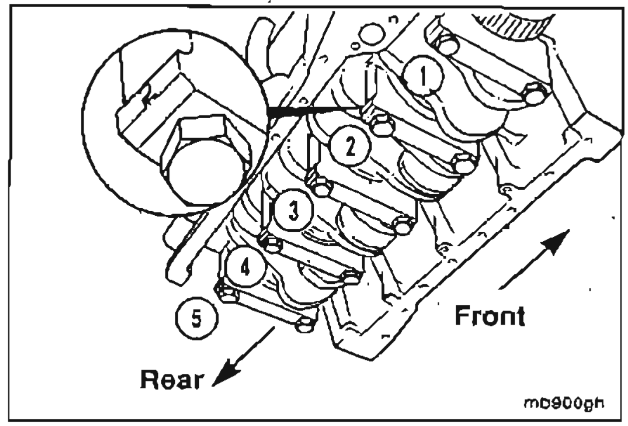


Install the lower main bearings into the caps.

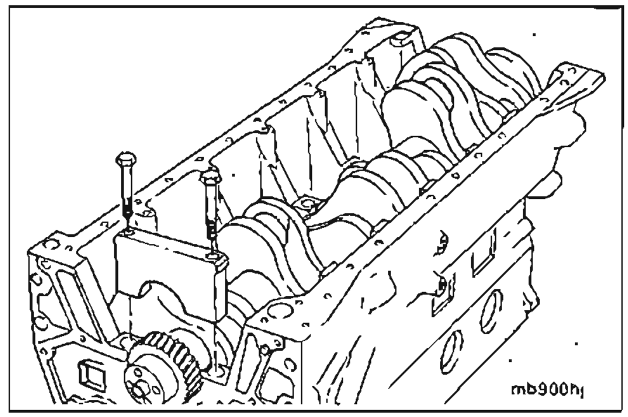
Lubricate the bearings with Lubriplate 105®

Make sure the bearing tangs are installed in the notch in the bearing cap.

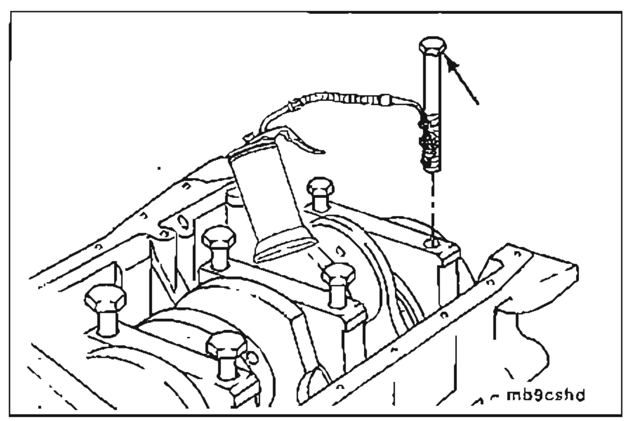
The main bearing caps are numbered for location. Number 1 starts with the front of the block, and the numbers face the oil cooler side of the engine.



Position the main bearings and caps.



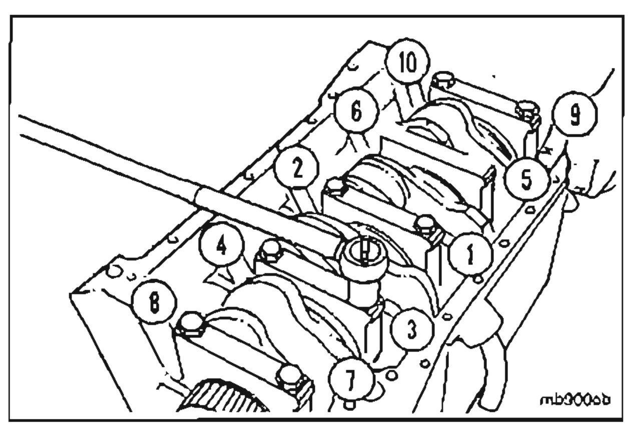
Lubricate the main bearing capscrew threads and underside of the head with clean engine oil.

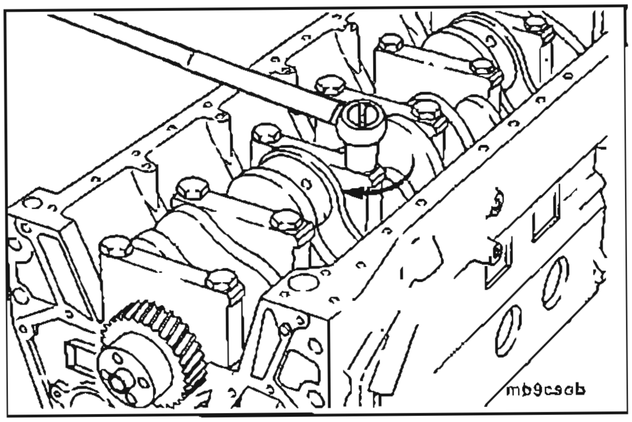


23 mm

Tighten the capscrews evenly following the illustrated sequence.

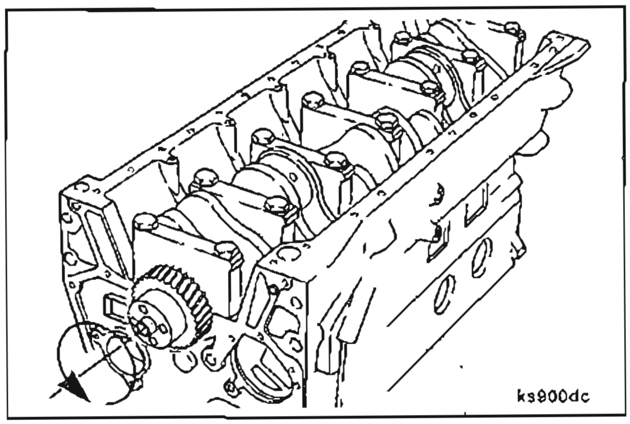
NOTE: When the engine is equipped with a balancer the main bearing caps cannot be torqued until the piston and rod assemblies are installed. It is also necessary to establish Top Dead Center before the balances can be installed. If a balancer is to be installed at a later procedure install and tighten No. 2, 3, and 5 main bearing capscrews until the main bearing caps are seated and proceed to procedure (0-72).





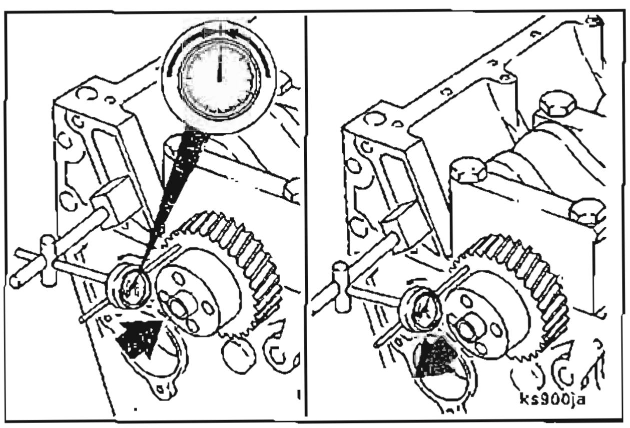
Follow these steps to tighten the capscrews.

Step	Torque Value
1	60 N•m [44 ft-lb]
2	119 N•m [88 ft-lb]
3	176 N•m [130 ft-lb]

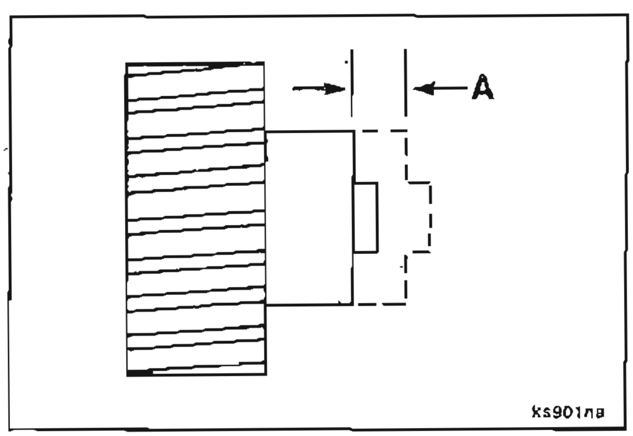


The crankshaft must rotate freely.

Check the bearing installations and the size of the bearings if the crankshaft does not rotate freely.



Position a dial indicator to measure crankshaft end play.

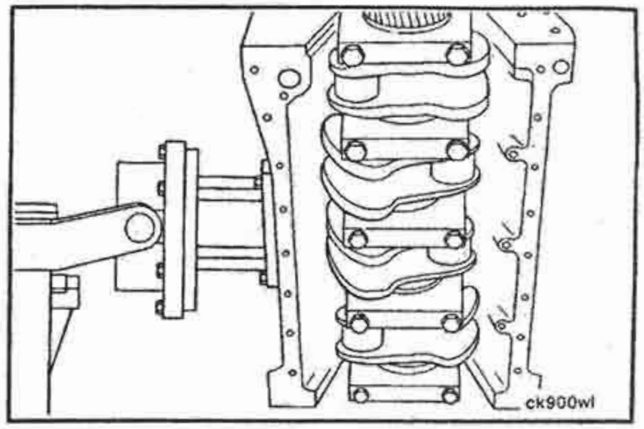


The dimensions of the thrust bearing and crankshaft journal determine end play.

Measure the end play.

Crankshaft End Play Limits (A)		
mm		in
0.102	MIN	0.004
0.432	MAX	0.017

Piston and Rod Assemblies - Installation (0-72)



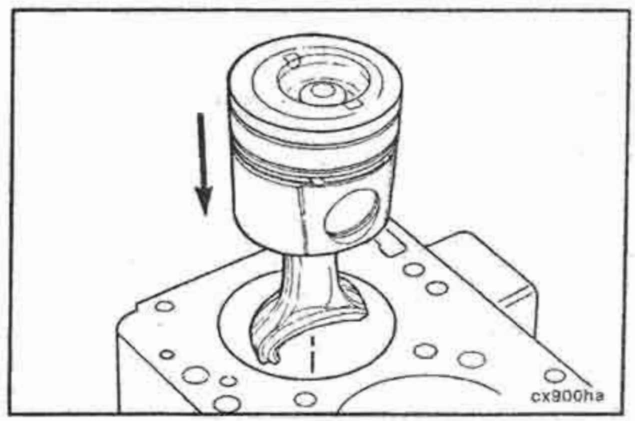
Rotate the engine on the stand until the crankshaft is vertical.

NOTE: If the engine is rotated more than 90 degrees, the tappets will fall out.

Piston Grading For 1994 Automotive Applications Only

When rebuilding an engine with the original cylinder block, crankshaft, and pistons, make sure the pistons are installed in the original cylinder. If replacing the piston(s), make sure the replacement piston(s) are the same grade as the original piston. If a new cylinder block or crankshaft is used, the piston grading procedure **must** be performed to determine the proper piston grade for each cylinder.

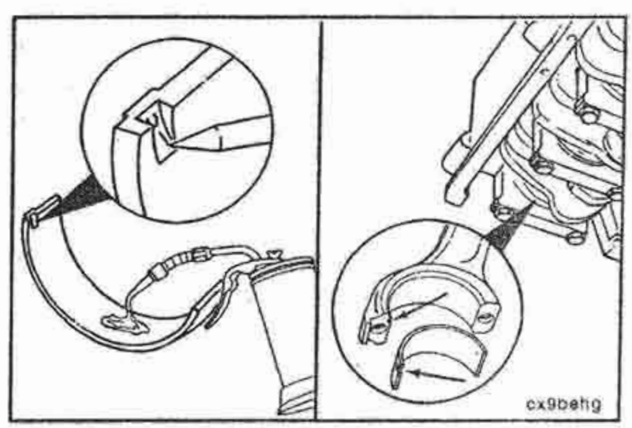
Install the connecting rod/piston assembly into the No. 1 cylinder without the rings installed. Make sure the word "Front" on the top of the piston is toward the front of the cylinder block.

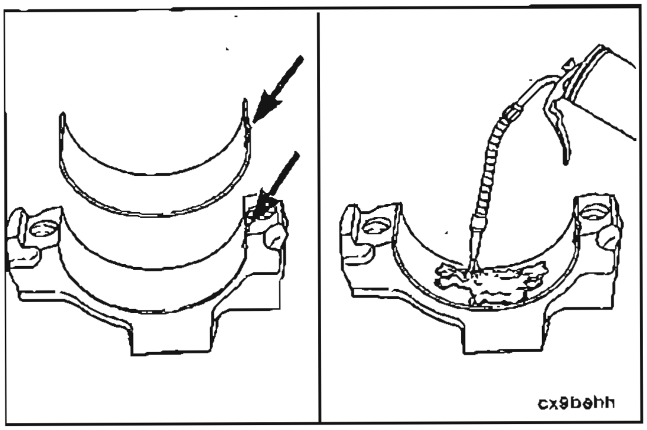


NOTE: The connecting rod bearing shells must be installed in the original connecting rod and cap.

Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the connecting rod.

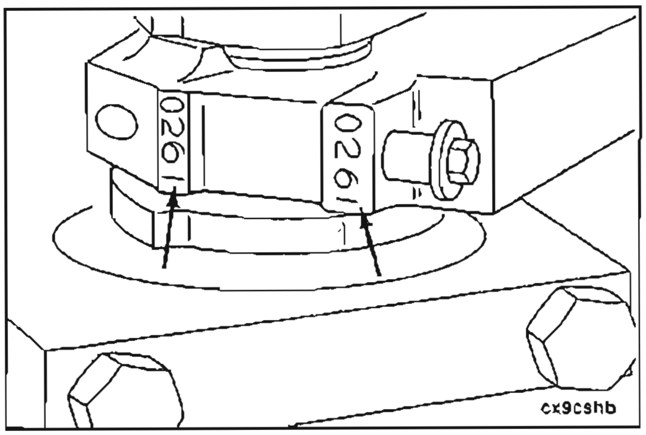
Use clean lubricating oil to coat the inside diameter of the connecting rod bearing shell.





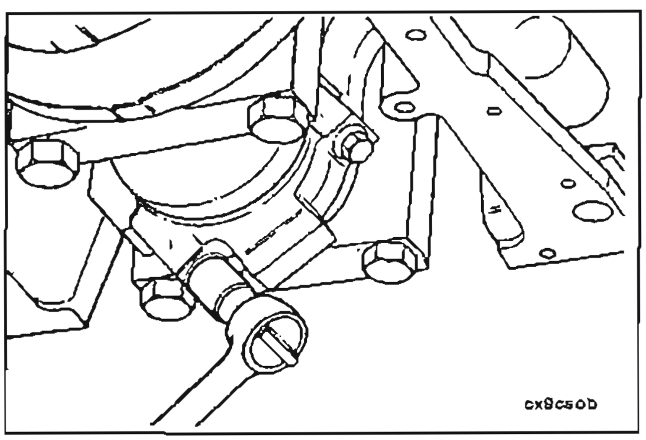
Install the bearing shell in the connecting rod cap with the tang of the bearing in the slot to the cap.

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



The four digit number stamped on the connecting rod and cap at the parting line must match and be installed on the oil cooler side of the engine.

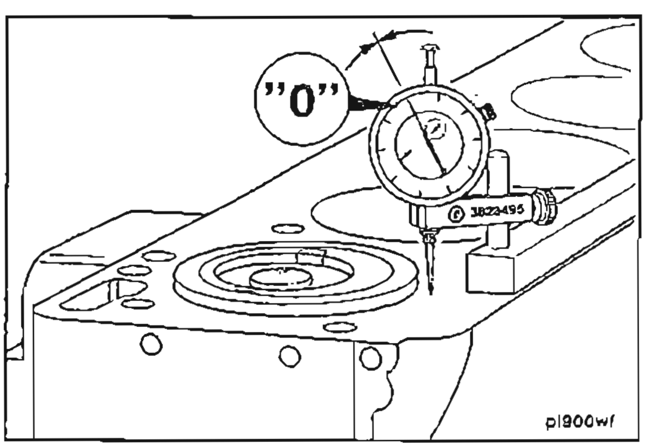
Install the connecting rod cap and capscrews to the connecting rod.



12 mm, Torque Wrench

Tighten the two capscrews.

Torque Value: 35 N•m [26 ft-lb]

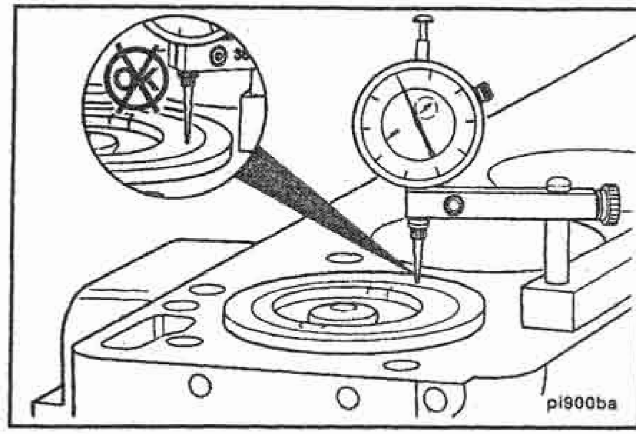


3823495 Dial Indicator

Use a fine grit stone to remove any burrs from the cylinder block head deck.

Zero "0" the dial indicator to the cylinder block head deck.

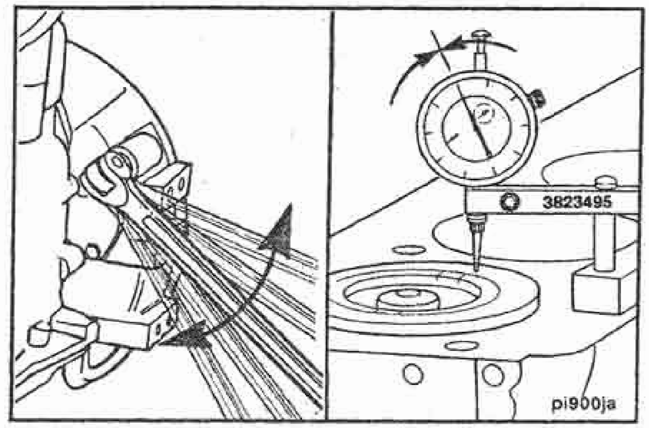
Move the dial indicator over the piston directly over the piston pin to eliminate any side-to-side movement. Do not place the indicator tip on the anodized area.



pi900ba

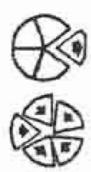
Rotate the crankshaft to top dead center (TDC). Rotate the crankshaft clockwise and counterclockwise to find the highest dial indicator reading.

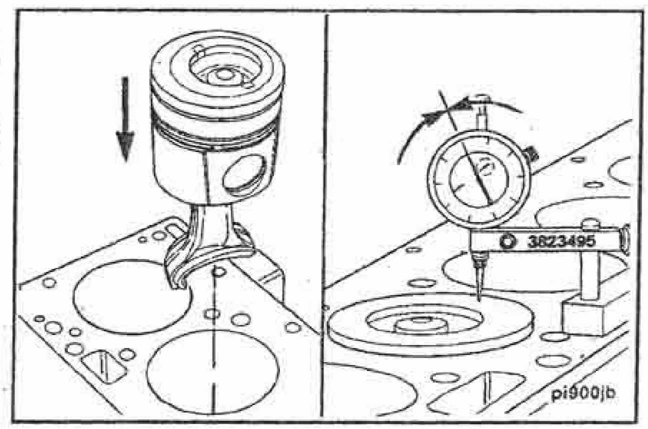
Record the reading.



pi900ja

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



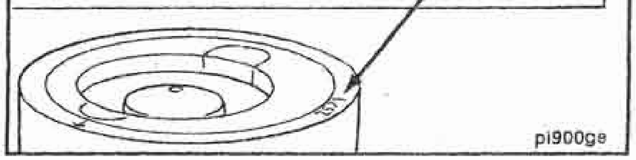


pi900jb

Determine the grade of the piston being used by referring to the chart.

Four digits on top of the piston are the last four digits of the part number.

NG	PROTRUSION	USE GRADE	PART NUMBER 160/175	PART NUMBER 190/230
	.024-.028 (.609mm-.711mm)	A	3922571	3922577
	.020-.024 (.508mm-.609mm)	B	3922572	3922578
	.016-.020 (.406mm-.508mm)	C	3922573	3922579
	.028-.032 (.711mm-.813mm)	A	3922571	3922577
	.024-.028 (.609mm-.711mm)	B	3922572	3922578
	.020-.024 (.508mm-.609mm)	C	3922573	3922579
	.032-.036 (.813mm-.914mm)	A	3922571	3922577
	.028-.032 (.711mm-.813mm)	B	3922572	3922578
	.024-.028 (.609mm-.711mm)	C	3922573	3922579



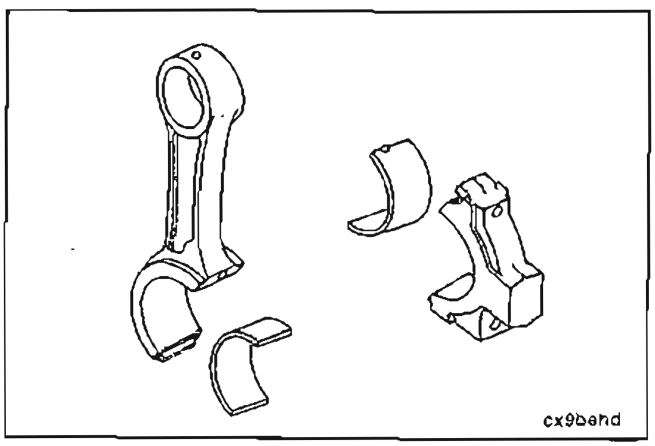
pi900ge

PISTON PROTRUSION

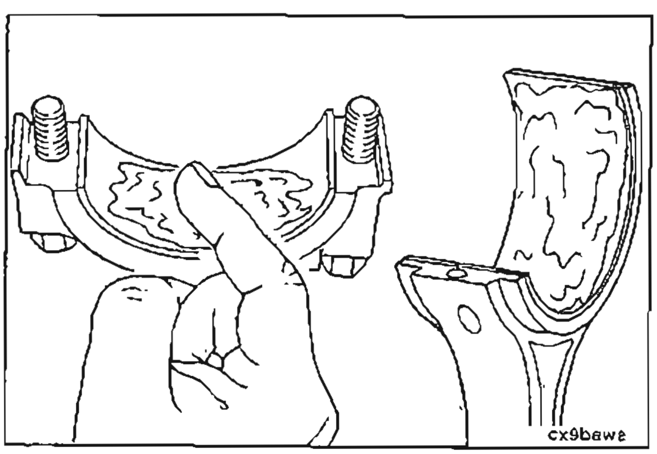
MEASURING PISTON	MEASURED PROTRUSION	USE GRADE	PART NUMBER 160/175	PART NUMBER 190/230
A	.024-.028 (.609mm-.711mm)	A	3922571	3922577
A	.020-.024 (.508mm-.609mm)	B	3922572	3922578
A	.016-.020 (.406mm-.508mm)	C	3922573	3922579
B	.028-.032 (.711mm-.813mm)	A	3922571	3922577
B	.024-.028 (.609mm-.711mm)	B	3922572	3922578
B	.020-.024 (.508mm-.609mm)	C	3922573	3922579
C	.032-.036 (.813mm-.914mm)	A	3922571	3922577
C	.028-.032 (.711mm-.813mm)	B	3922572	3922578
C	.024-.028 (.609mm-.711mm)	C	3922573	3922579

The specification for Piston Protrusion is 0.024 to 0.028 inch for emission controlled engines built after 1-1-94.

Piston and Connecting Rod Assemblies - Installation

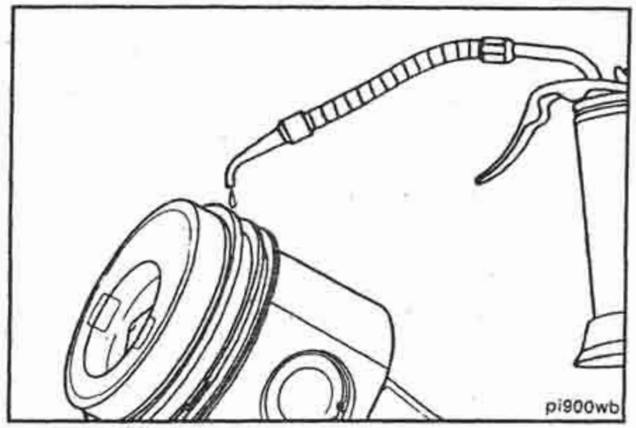

cx9bend

Install the bearing shells into both the rod and the cap. Make sure the tang on the bearing shells is in the slot of the cap and rod.


cx9bawe

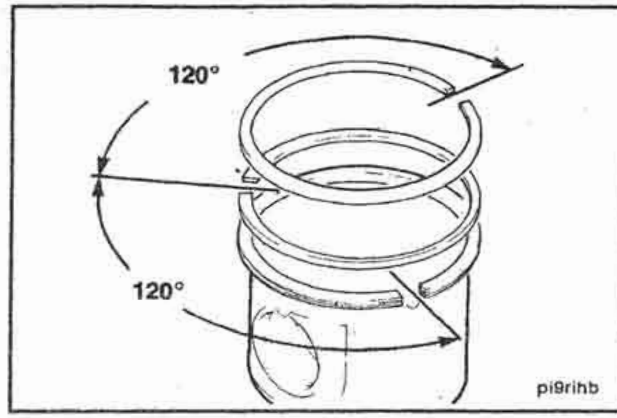
Lubricate the rod bearings with a light film of Lubriplate 105®

Lubricate the rings and piston skirts with clean engine oil.



Position the rings.

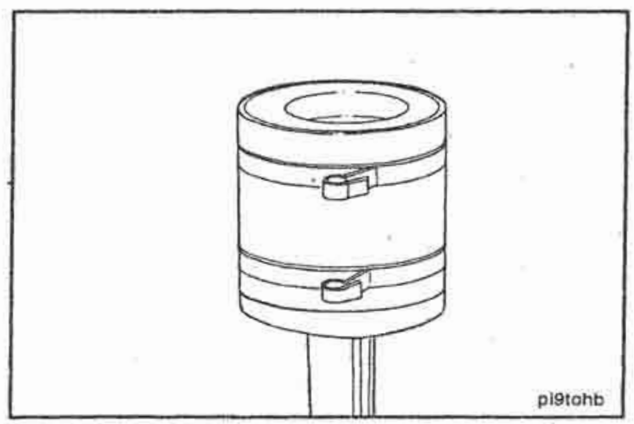
NOTE: Refer to component section 01 for installation of rings on pistons.



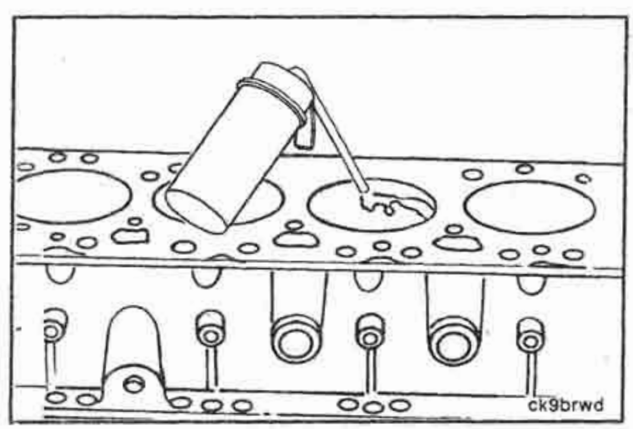
75 - 125 mm [3-5 inch] ring compressor

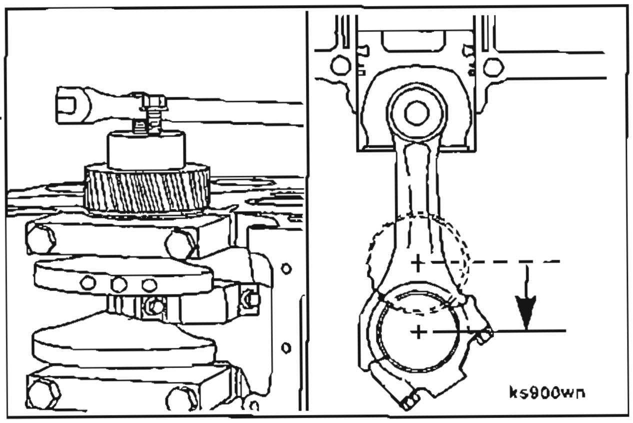
Caution: If using a strap type ring compressor, make sure the inside end of the strap does not hook on a ring gap and break the ring.

Compress the rings.

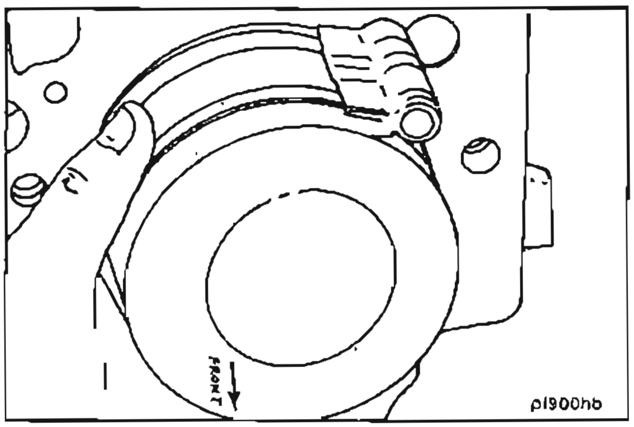


Lubricate the cylinder bore with clean engine oil.



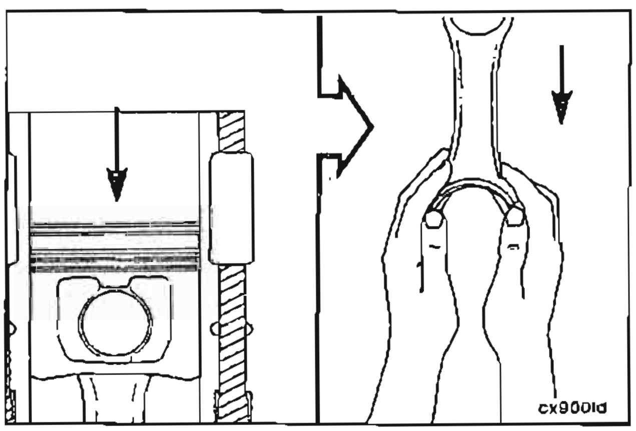


Position the rod journal for the piston to be installed to bottom dead center (BDC).

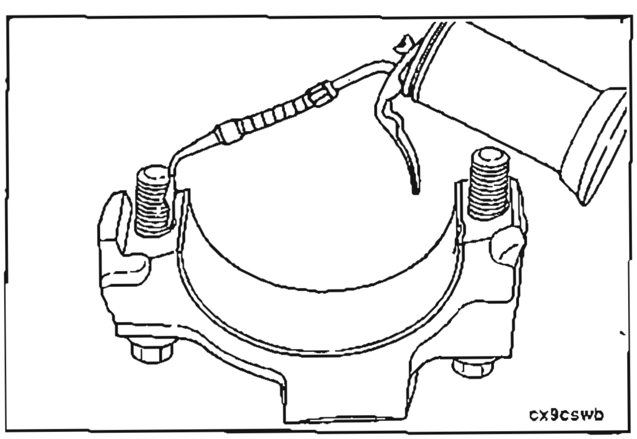


Caution: Take care not to damage the cylinder wall when inserting the connecting rod.

Position the piston and rod assembly into cylinder bore with the word "front" on piston towards the front of the cylinder block.



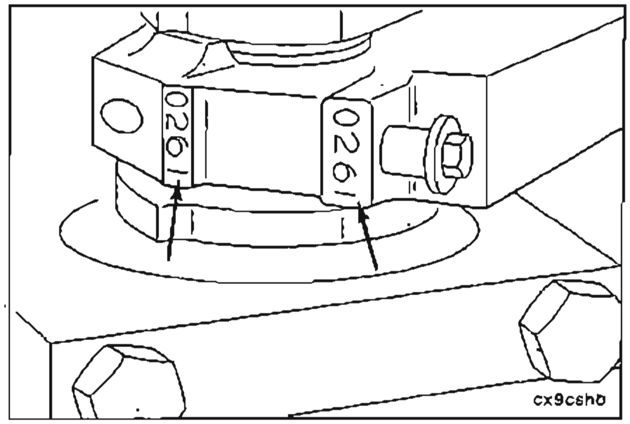
Carefully push the piston into the bore while guiding the connecting rod to the crankshaft journal.



Lubricate the threads and underside of the connecting rod capscrew heads with engine oil.

Caution: The four digit number stamped on the rod and the cap at the parting line must match and be installed on the oil cooler side of the engine.

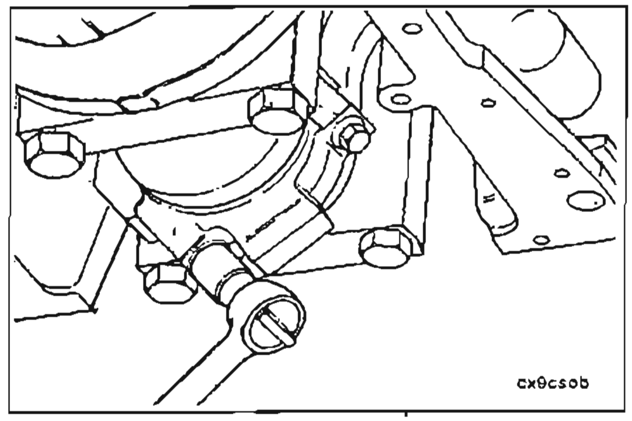
Install the rod cap and capscrews to the connecting rod.



12 mm, Torque Wrench

Alternately, tighten the two capscrews

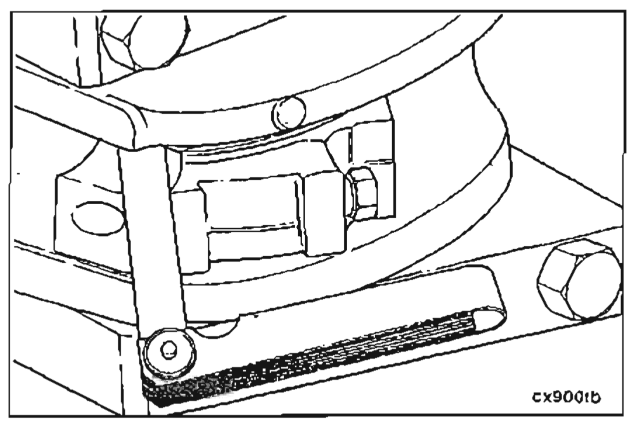
Step	Torque Value
1	35 N•m [26 ft-lb]
2	70 N•m [52 ft-lb]
3	100 N•m [74 ft-lb]



Measure the side clearance between the **connecting rod and crankshaft.**

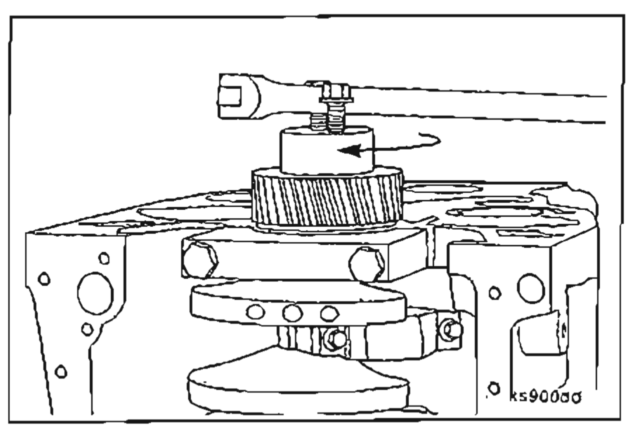
Do not measure the clearance between the rod cap and crankshaft.

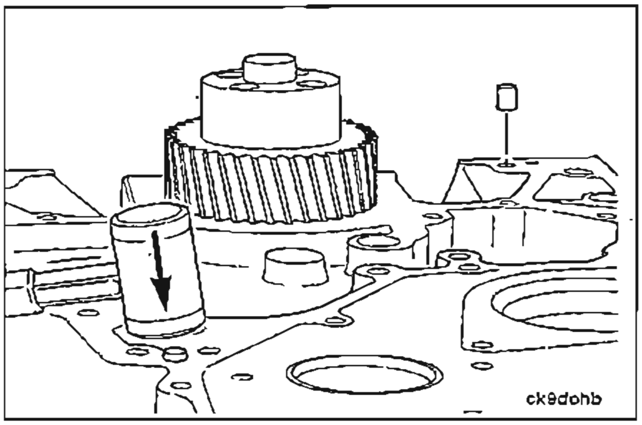
Side Clearance Limits		
mm		in
0.10	MIN	0.004
0.30	MAX	0.012



Caution: The crankshaft must rotate freely.

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



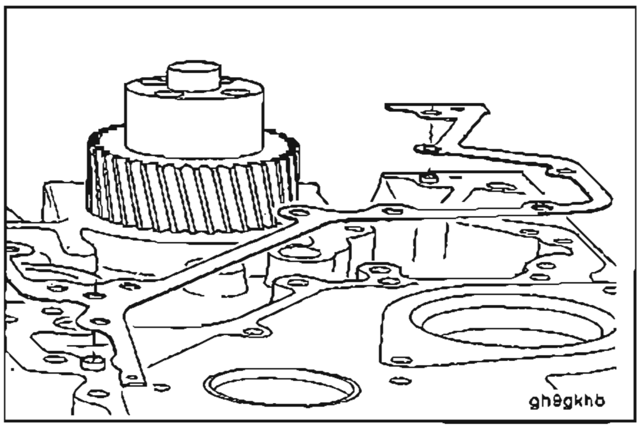


Gear Housing - Installation (0-73)

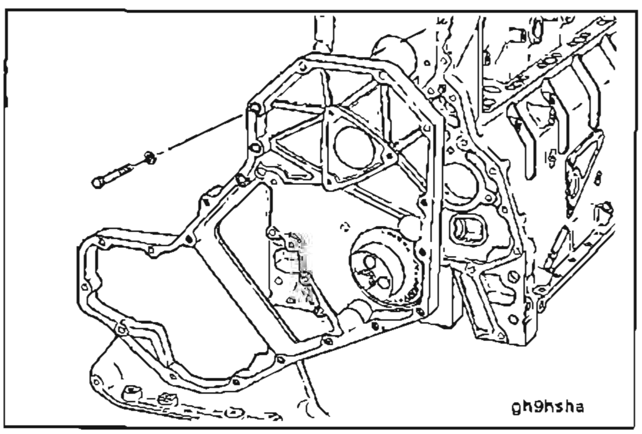
Mallet

If removed, install the two gear housing dowel pins.

The tapered end of the dowel fits into the cylinder block; install the pin to the bottom of the hole.



Install the gear housing gasket.

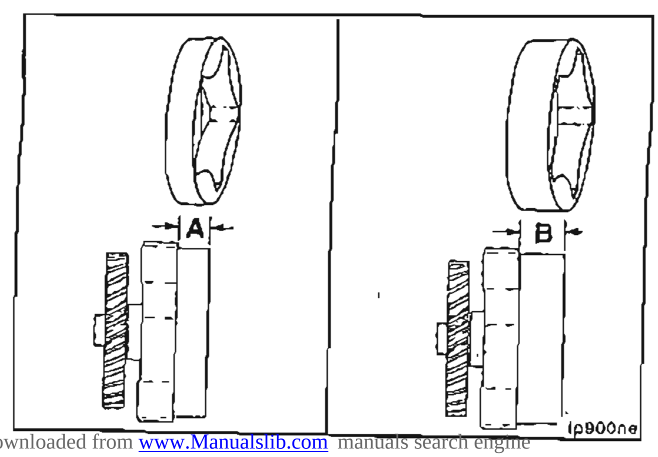


10 mm

Install the gear housing and capscrews.

Apply Loctite 205 to the capscrews.

Torque Value: 24 N•m [18 ft-lb]



Caution: Make sure the correct pump is installed. The 4 cylinder pump and 6 cylinder pump are not interchangeable.

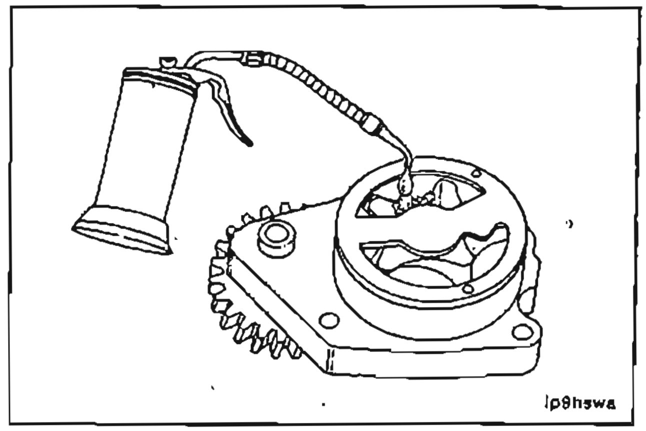
A = *Four cylinder gerotor size*
12.947mm [0.516 inch]

B = Six cylinder gerotor size
17.947mm [0.715 inch]

Lube Pump - Installation (0-74)

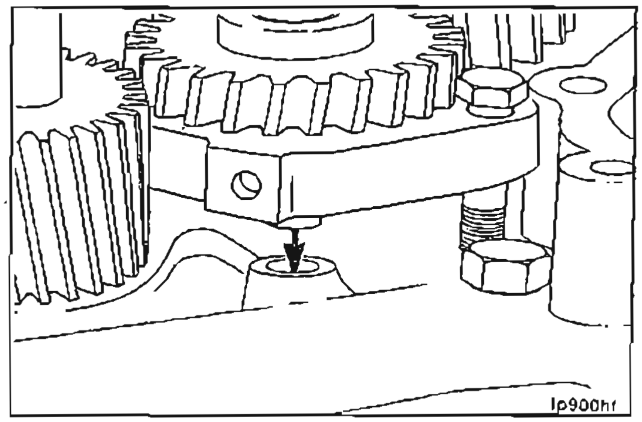
Lubricate the pump with clean engine oil.

Caution: Fill the lube pump before installation to aid with priming during engine start up.

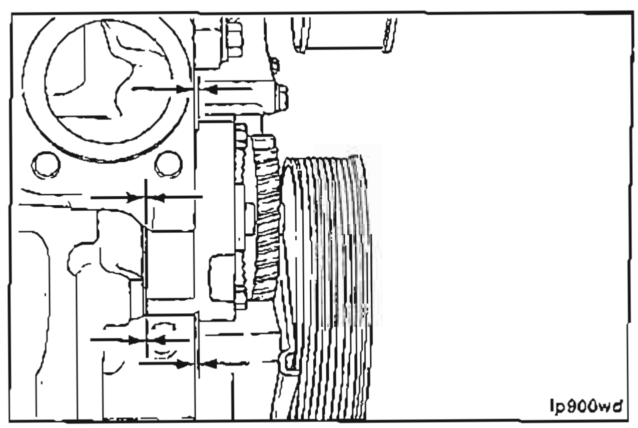


The idler gear pin fits into a locating bore in the cylinder block.

Install the lube pump.



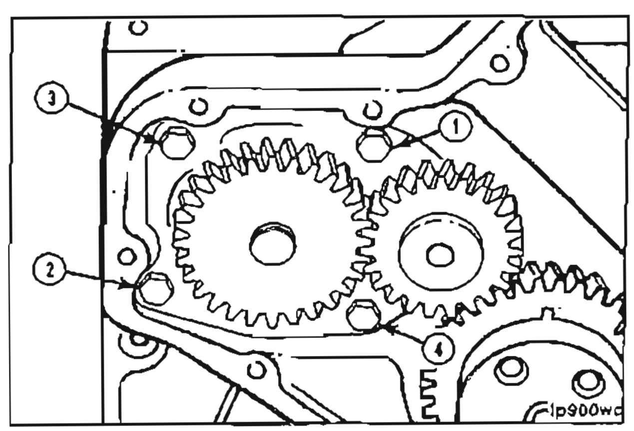
The sealing plate on the back of the pump will seat on the cylinder block and the capscrews **should not** draw the flange up to the block.

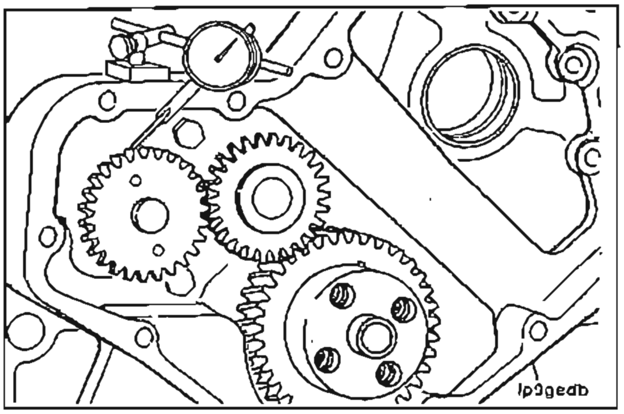


13 mm

Tighten the capscrews in the sequence shown.

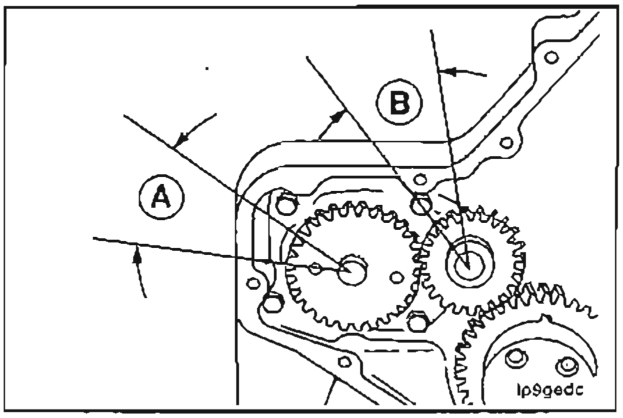
Torque Value: 24 N•m [18 ft-lb]





Caution: Be sure the gear backlash is correct if installing a new pump.

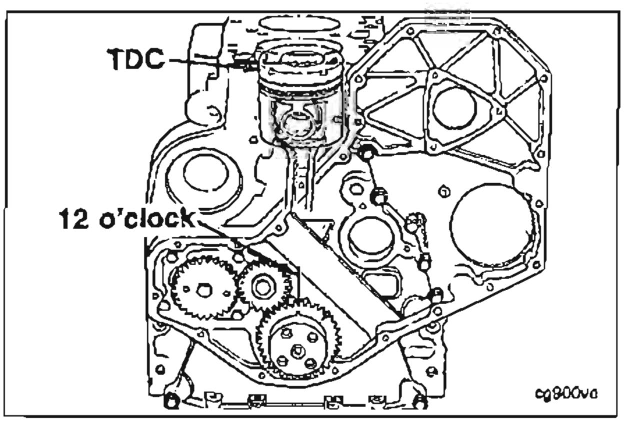
Use a dial indicator to measure gear backlash.



Measure gear backlash.

Backlash Limits	
A	B
0.08 to 0.33 mm	0.08 to 0.33 mm
[.003 to .013 in]	[.003 to .013 in]

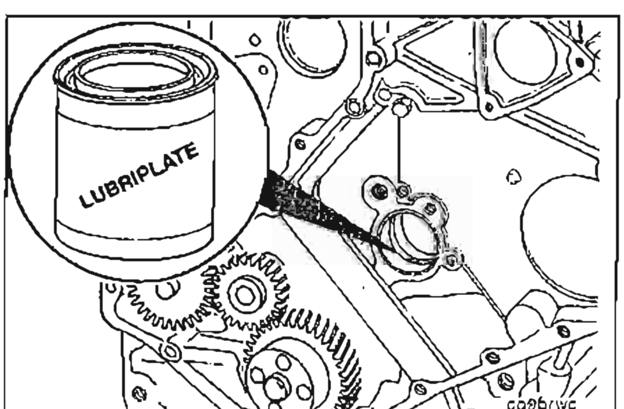
NOTE: Prevent movement of adjoining gears when checking backlash or the reading will be the total of both gears.



Camshaft - Installation (0-75)

Rotate the crankshaft until the number one cylinder is approximately at the TDC position. When properly positioned, the crankshaft gear alignment pin will be positioned in the 12 o'clock position.

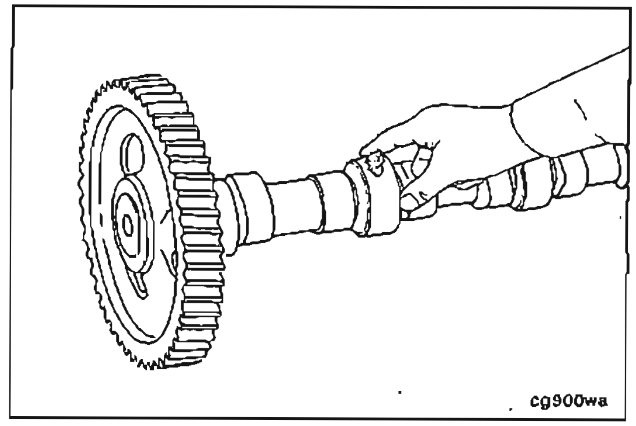
NOTE: If the crankshaft is not properly positioned, the camshaft may contact the connecting rods during installation.



Lubricate the camshaft bores with Lubriplate.

NOTE: If cam bushing has not been installed, refer to Component Section 1 for procedure.

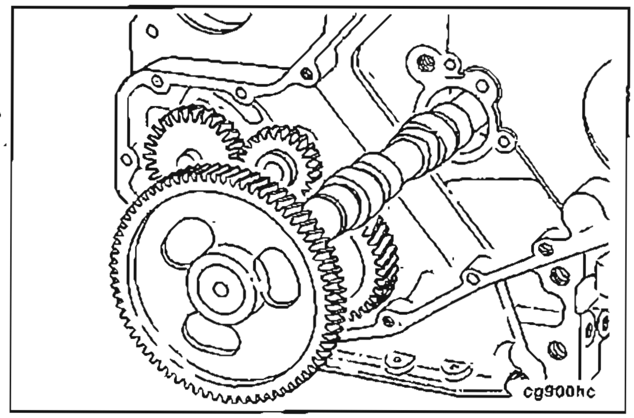
Lubricate the camshaft journals and lobes with Lubriplate 105®



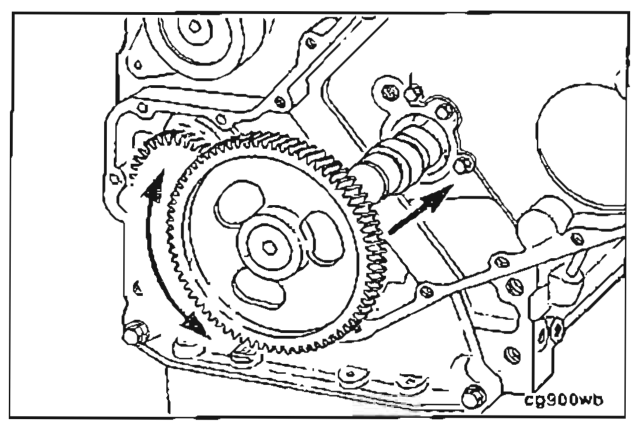
Position the camshaft/cam gear assembly into the cylinder block up to the last journal.

Refer to section 1 for assembly of cam gear on the camshaft.

Install the camshaft. While pushing in slightly, rotate the camshaft and carefully work the camshaft through the camshaft bushings. As each camshaft journal passes through a bushing, the camshaft will drop slightly and the camshaft lobes will catch on the bushings. Rotating the camshaft will free the lobe from the bushing and allow the camshaft to be installed.

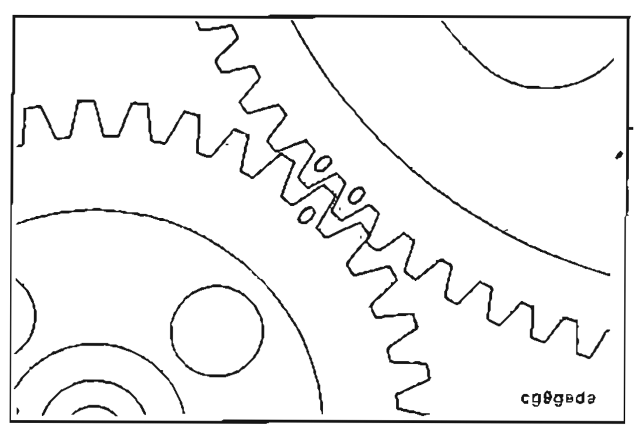


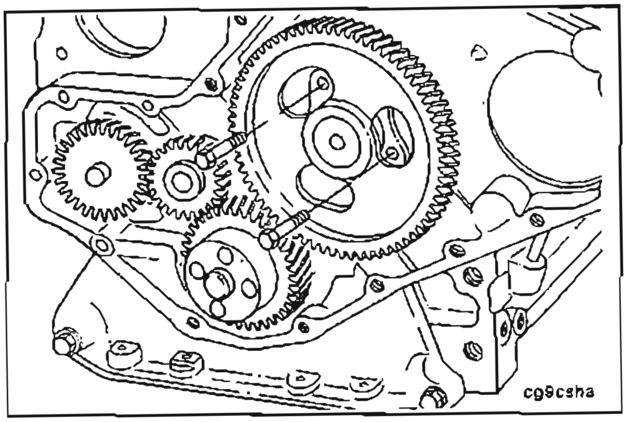
Before the camshaft gear is engaged with the crankshaft gear, check the camshaft for ease of rotation. When installed correctly, the camshaft will rotate freely.



Lubricate the thrust plate with Lubriplate 105®

Align the timing marks as illustrated and install the thrust washer.

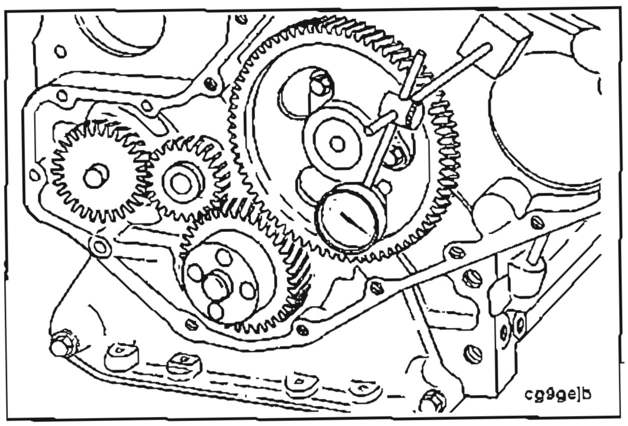




13 mm

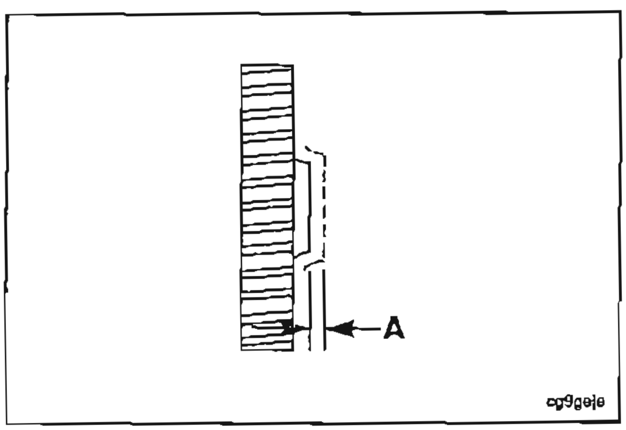
Push the camshaft into the cylinder block and install the thrust plate capscrews.

Torque Value: 24 N•m [18 ft-lb]



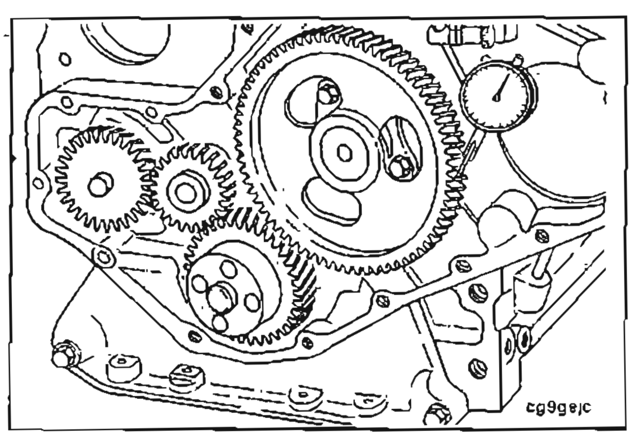
Measure the camshaft end play.

End play is controlled by the thickness of the thrust plate and the groove in the camshaft.



Camshaft End Play - Measuring (0-76)

Camshaft End Play Limits (A)		
mm		in
0.12	MIN	0.005
0.34	MAX	0.013

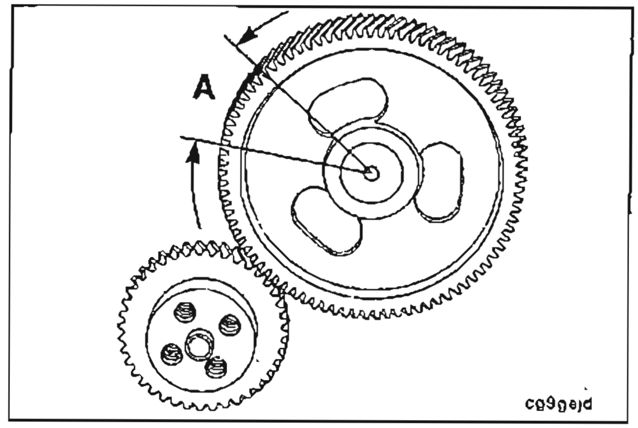


Caution: Be sure the backlash is correct for any replaced gears.

Use an indicator to measure backlash.

Camshaft Gear Backlash - Measuring (0-77)

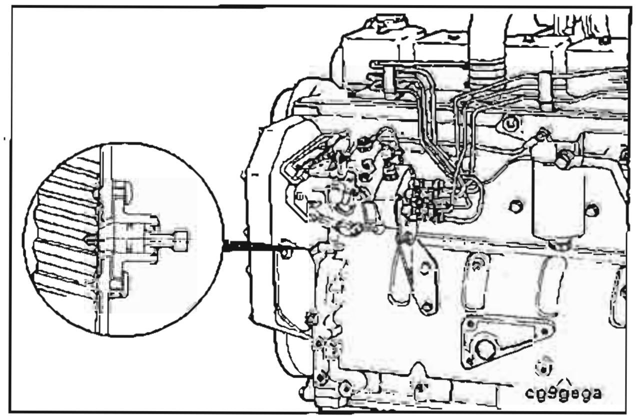
Camshaft Backlash Limits (A)		
mm		in
.076	MIN	0.003
.380	MAX	0.013



Timing Pin - Installation (0-78)

Caution: The timing pin assembly is precisely located on the gear housing to correspond to TDC for Cylinder Number 1

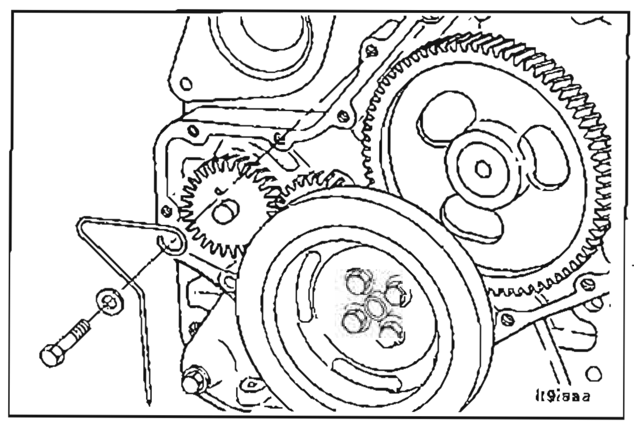
Caution: The timing pin assembly must be relocated if gear housings are interchanged.



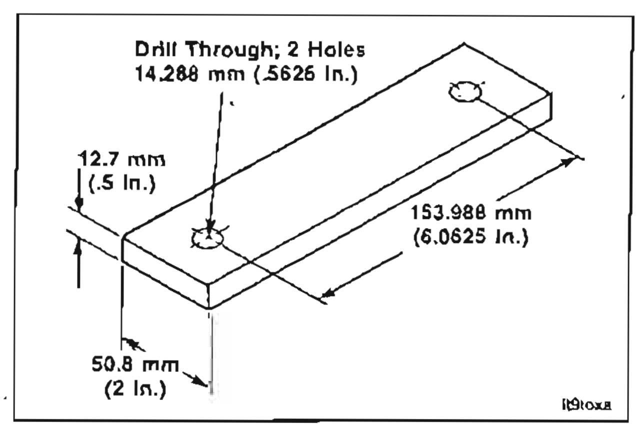
10 mm, 15 mm

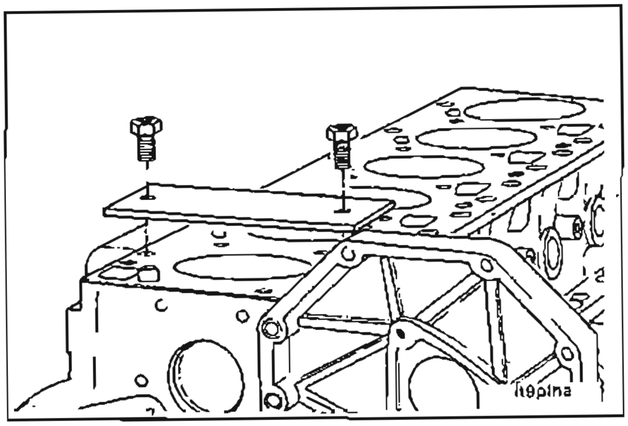
Rotate the cylinder block on the rebuild stand until the combustion deck is positioned at the top and parallel to the floor.

To relocate the assembly, temporarily install the crankshaft pulley and a fabricated wire pointer. Put a flat washer between the pointer and gear housing to prevent damage to the gear housing.



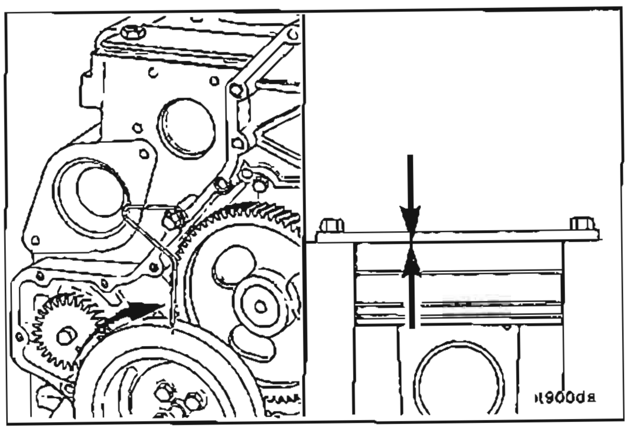
Fabricate a steel plate as shown in the illustration.





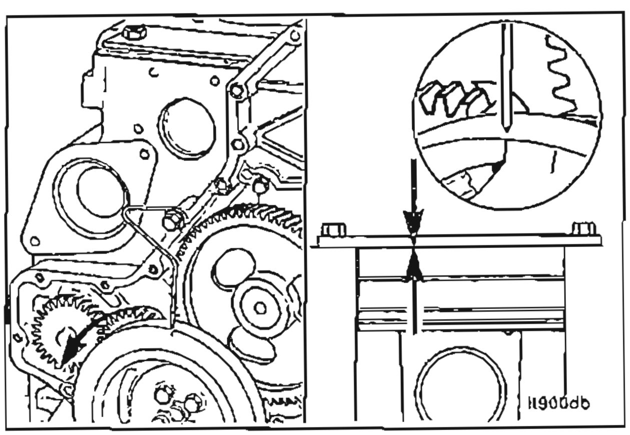
15 mm

Use two flywheel housing capscrews to assemble the plate over Cylinder Number 1



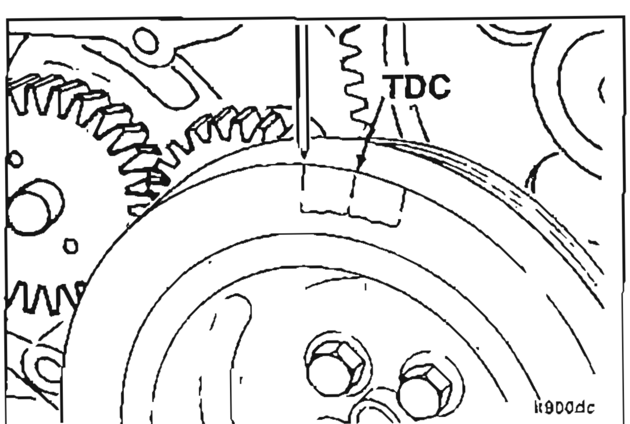
Rotate the crankshaft until the piston contacts the plate.

Mark the pulley.



Rotate the engine in the opposite direction until the piston contacts the plate.

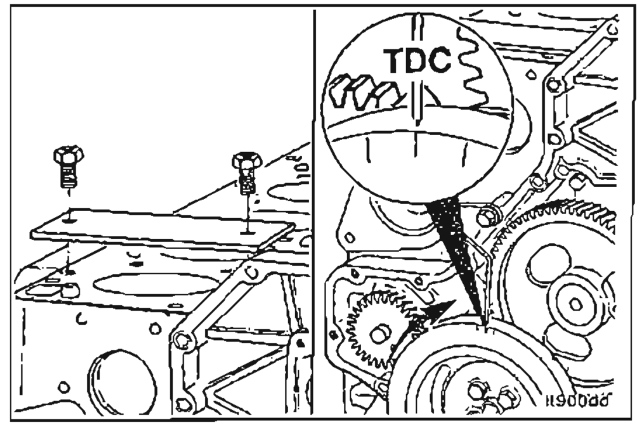
Mark the pulley.



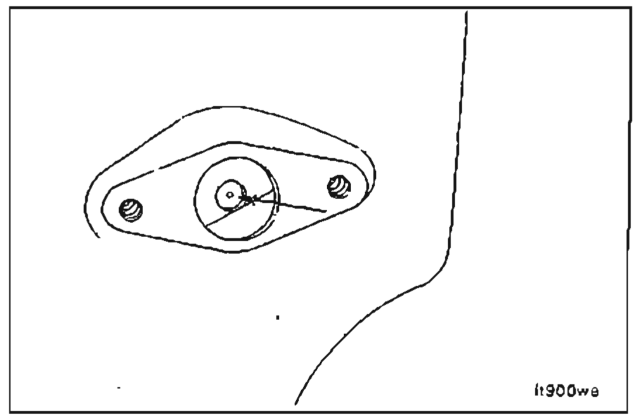
Mark the pulley for TDC which is one-half the distance between the first two marks.

15 mm

Remove the plate and rotate the engine until the pointer aligns with the TDC mark.

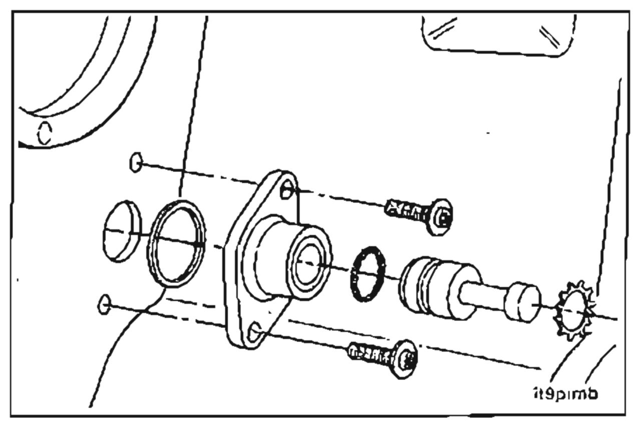


Look for the timing pin hole in the camshaft gear. If it is not visible, rotate the crankshaft one complete turn and align the pointer with the TDC mark.



T-25 Torx

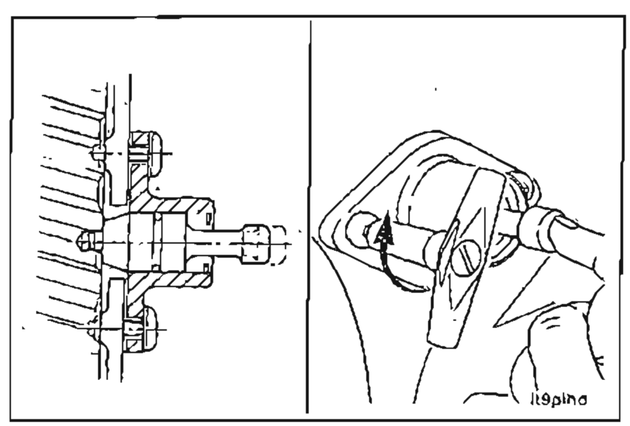
Install the timing pin assembly.

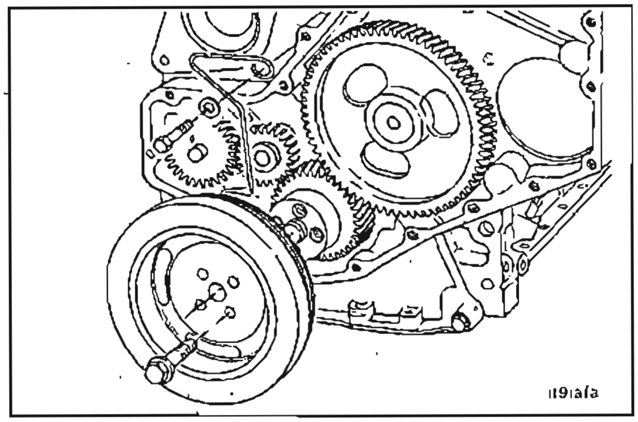


Push the pin into hole in the cam gear to align the housing.

Hold the pin in while tightening the torkscrews.

Torque Value: 5 N•m [48 in-lb]

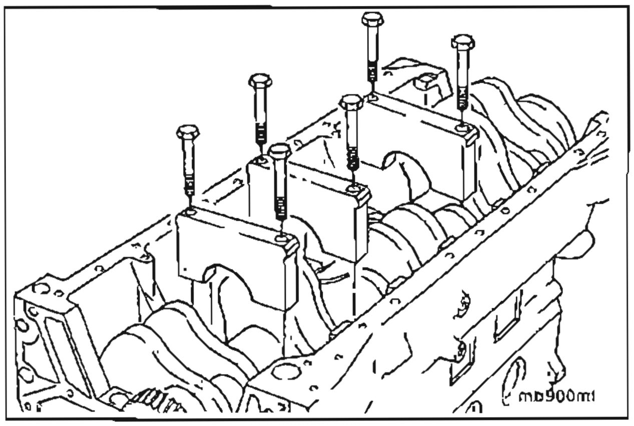




10 mm, 15 mm

Caution: Be sure timing pin is disengaged before rotating the engine.

Remove the crankshaft pulley and wire pointer.

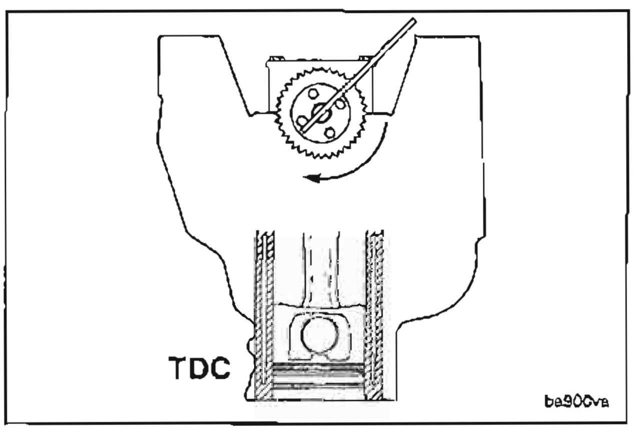


Balancer - Installation (0-79)

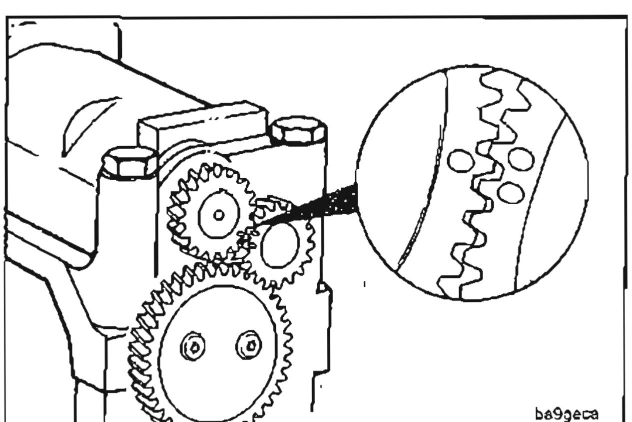
23 mm

Rotate the cylinder block on the relaxed stand until the crankshaft is positioned at the top and parallel to the floor.

The number 1 and number 4 main bearing capscrews **must** be removed to install the balancer.



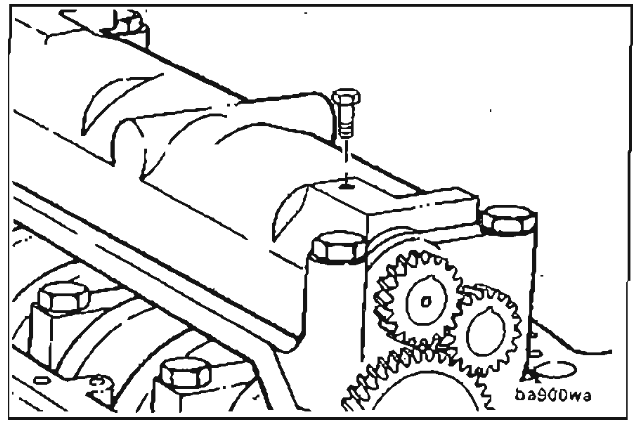
Rotate the crankshaft until No. 1 piston is at Top Dead Center. The engine **must** have a cylinder at TDC for correct gear teeth alignment when the balancer is installed.



Rotate the balancer gears until the timing marks are aligned. The balancer **must** be kept in this position for correct installation on the engine.

13 mm

If the balancer shaft has a tapped hole, the shaft can be locked in position by temporarily installing a M8 capscrew through the housing and into the shaft.



4.5 mm Allen, 1 inch Wide Masking Tape

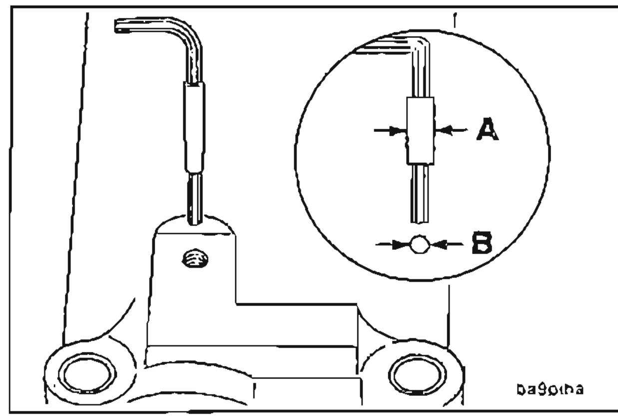
Caution: Make sure the idler gear retainer capscrews are loose.

Follow this procedure if the shaft does not have a tapped hole.

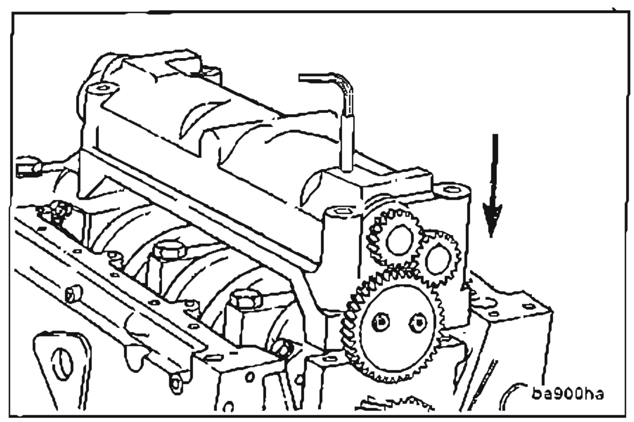
Wrap the 4.5mm allen wrench with masking tape until it has a snug fit in the hole in the balancer housing.

A = Approximately 10mm [0.4 inch]

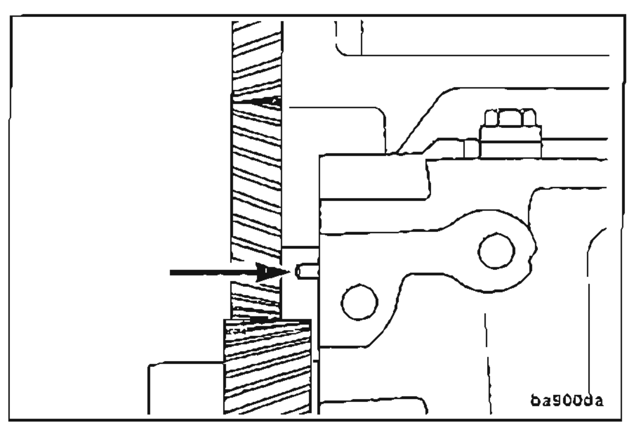
B = 10mm [0.4 inch]

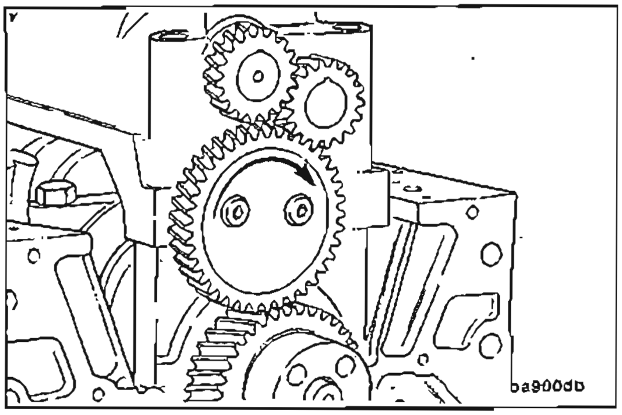


Position the locked balancer assembly onto the main bearing caps. The assembly must be located squarely with the alignment ears against the side of the caps.

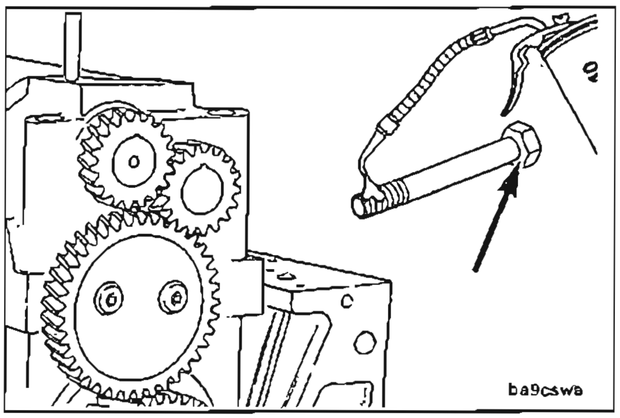


Align the slot in the idler gear retainer with the locating pin in the main bearing cap. Slide the balancer into position.

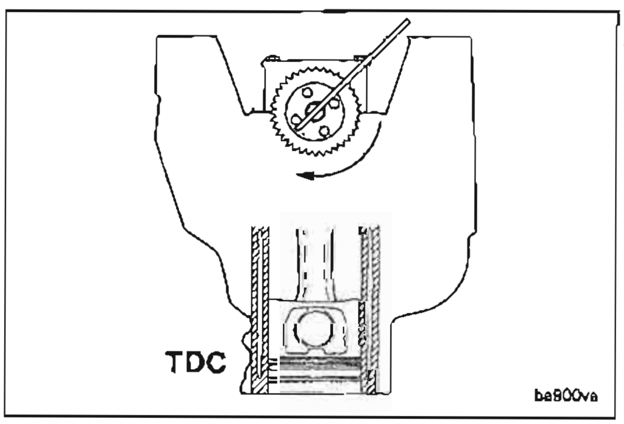




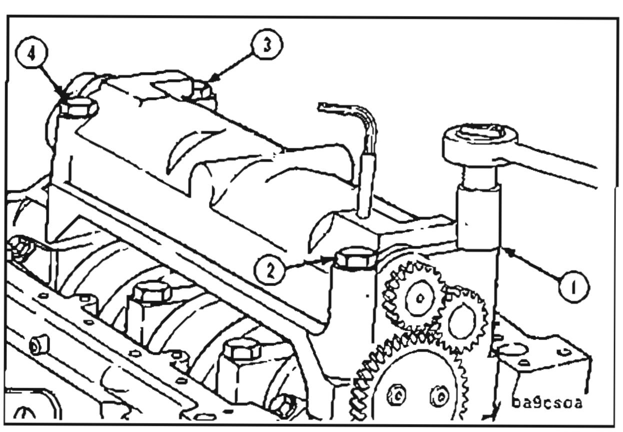
The idler gear can be slightly rotated to help in alignment.



Lubricate the main bearing capscrew threads and the underside of the capscrew heads with clean engine oil.



If the capscrews do not install freely, check to be sure the engine has a piston at TDC.

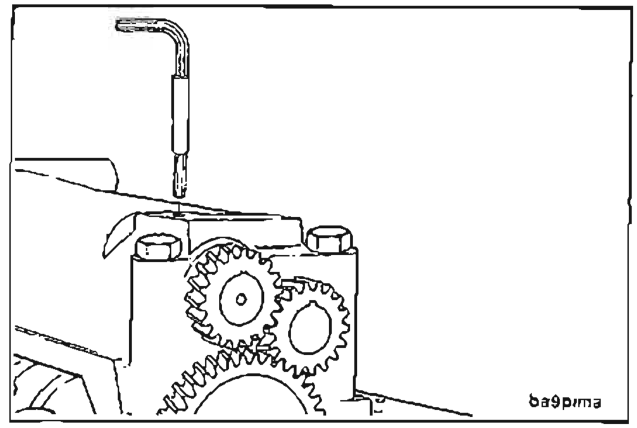


23 mm

Tighten the capscrews evenly and follow the illustrated sequence.

Step	Torque Value
1	60 N•m [44 ft-lb]
2	119 N•m [88 ft-lb]
3	176 N•m [130 ft-lb]

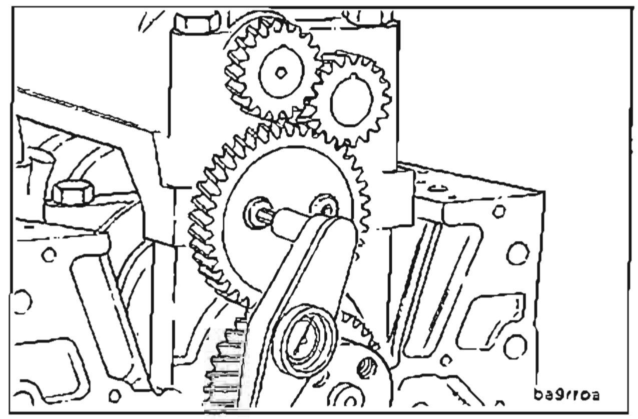
Remove the locking capscrew or allen wrench from the balancer.



8 mm Allen

Tighten the idler gear retainer capscrews.

Torque Value: 57 N•m [42 ft-lb]

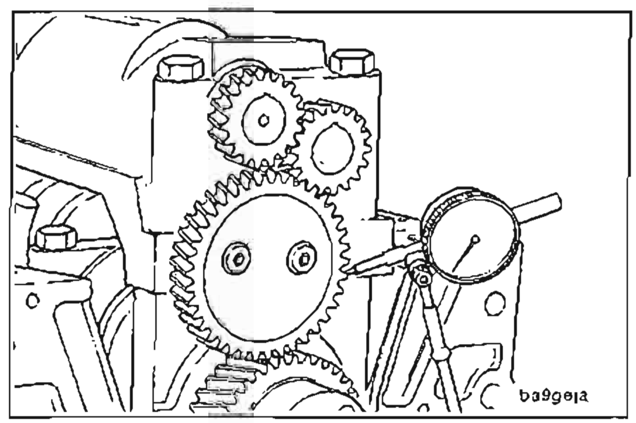


Measure the idler gear backlash.

Backlash		
mm		in
0.088	MIN	[0.003]
0.420	MAX	[0.017]

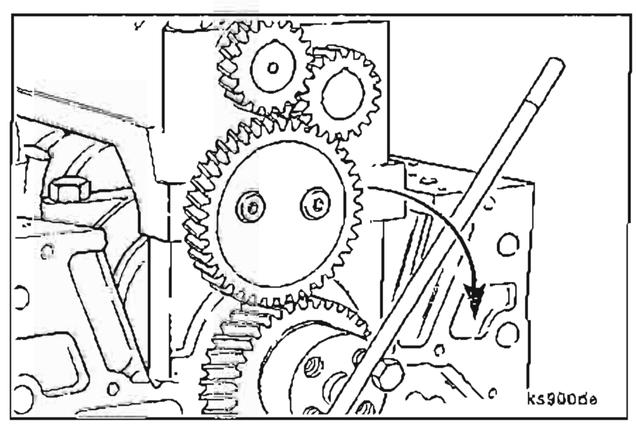
If the idler gear does not meet the specifications, loosen the idlar gear retainer capscrews. Reposition the idler gear and tighten the capscrews.

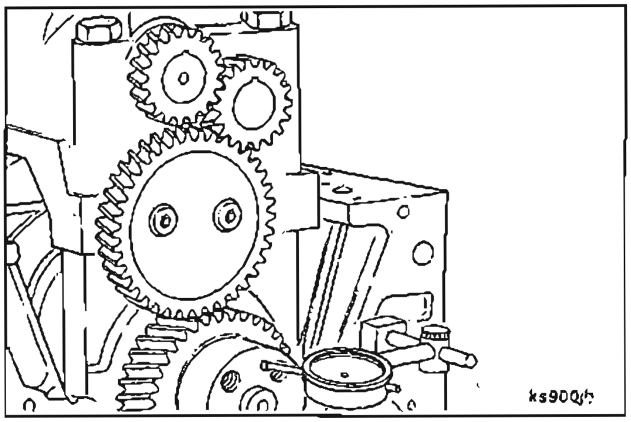
Torque Value: 57 N•m [42 ft-lb]



The Crankshaft Must Rotate Freely

If the crankshaft does not rotate freely, make sure the balancer does not have an interference.

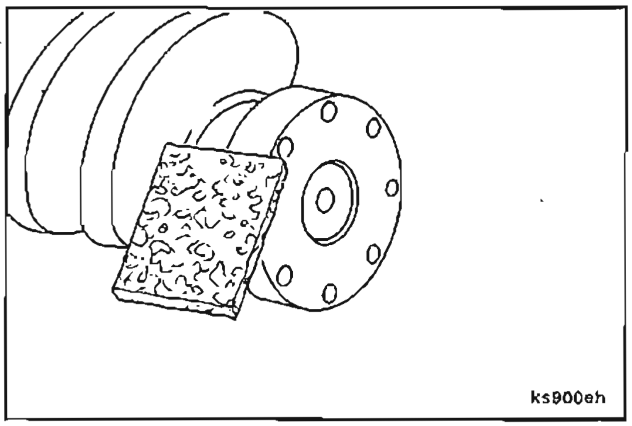




Crankshaft End Play - Measuring (0-80)

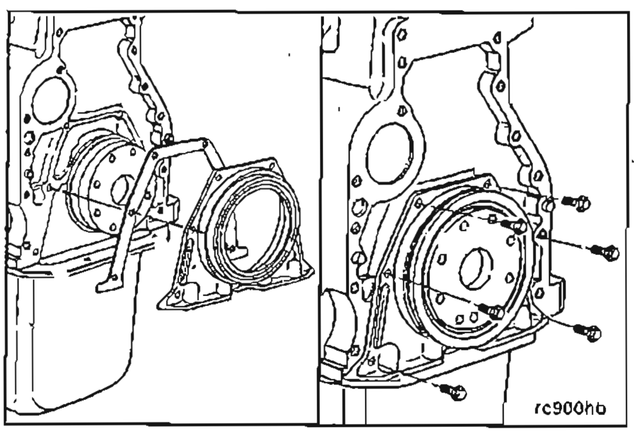
Use a dial indicator to measure the crankshaft end play.

Crankshaft End Play Limits		
mm		in
0.102	MIN	0.004
0.432	MAX	0.017

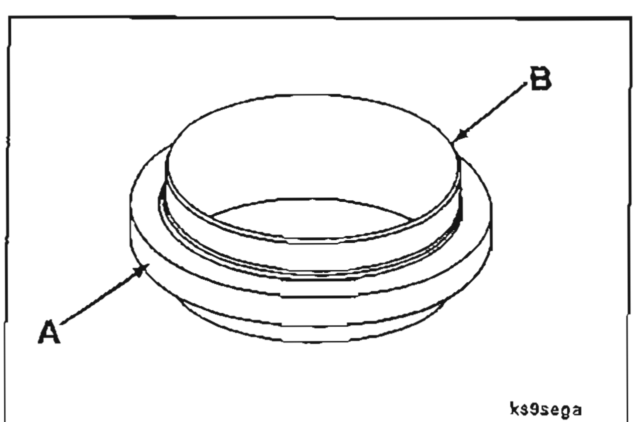


Rear Seal - Installation (0-81)

Inspect the crankshaft flange and rear cover for dirt and damage. Use a cleaning pad, Part No. 3823258, to remove dirt or rust deposits. Wipe the crankshaft flange dry.

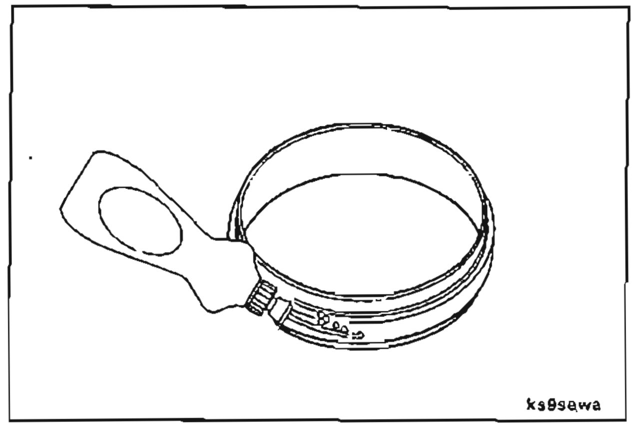


Install the rear cover and gasket. Do not tighten the capscrews to the correct torque value at this time.



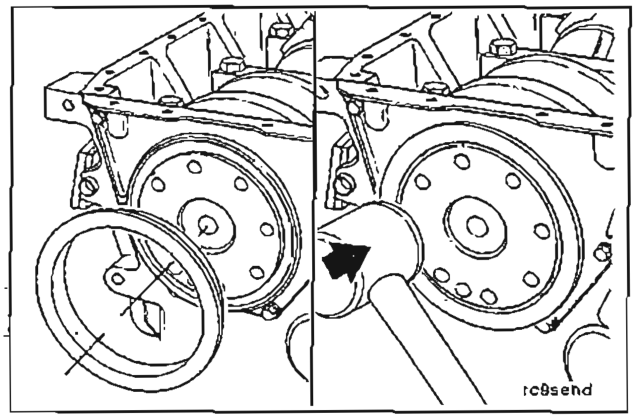
The replacement rear seal has a pilot tool installed. Do not remove the pilot tool at this time.

Apply a mild soap to the rubber outside diameter of the oil seal.



Use the alignment and installation tool packaged in the seal kit. Drive the seal into the housing until the driver bottoms.

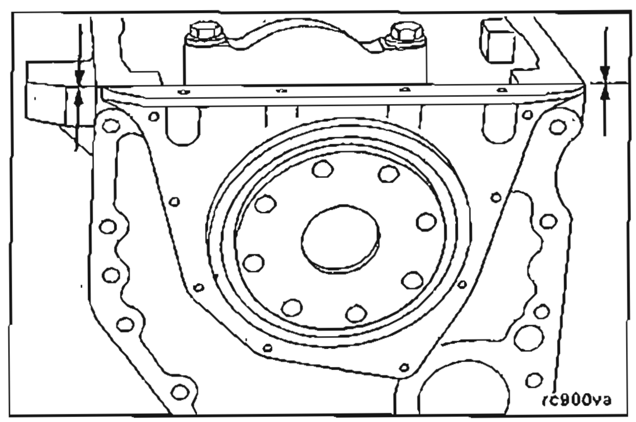
NOTE: Alternately, drive the seal at the 12, 3, 6 and 9 o'clock positions to install the seal square to the crankshaft flange.



Make sure the seal housing is level with both sides of the cylinder block oil pan rail. Tighten the rear cover capscrews.

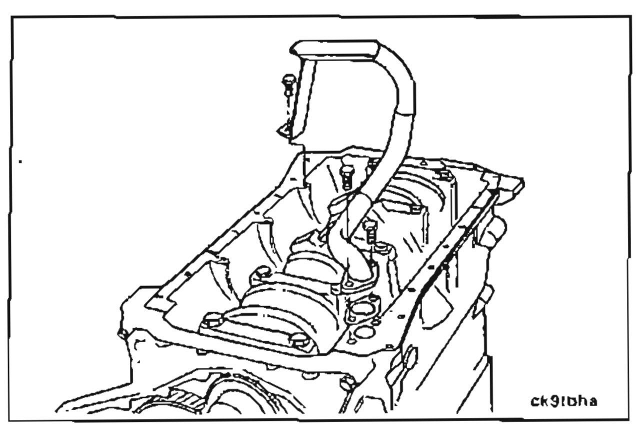
Torque Value: 7 N•m [80 in-lb]

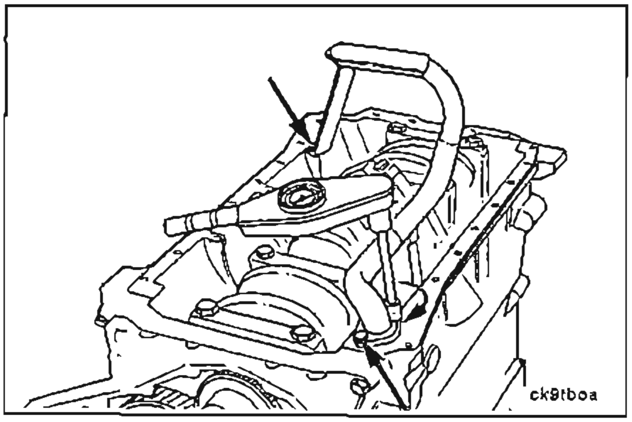
Remove the seal pilot tool. Trim the gaskets even with the oil pan mounting surface.



Suction Tube - Installation (0-82)

Position the suction tube and gasket on the cylinder block.

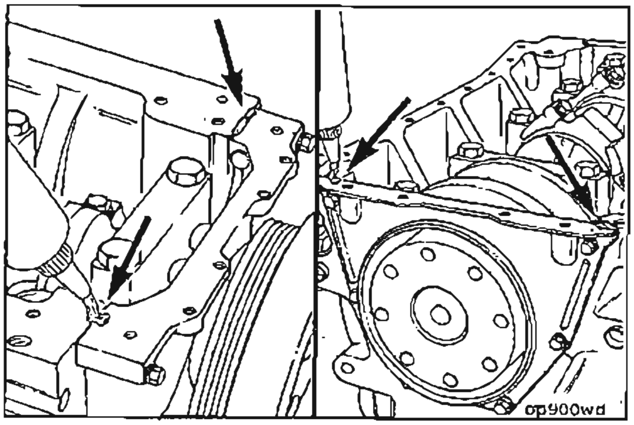




10 mm, 13 mm

Tighten the oil suction tube and brace capscrews.

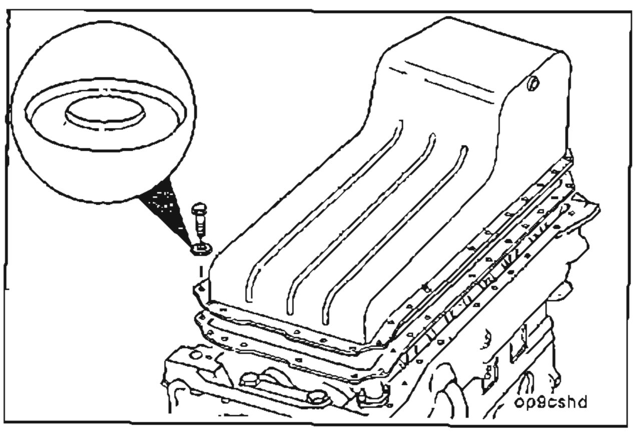
Torque Value: 24 N•m [18 ft-lb]



Oil Pan - Installation (0-83)

Oil Pan Sealing Surfaces - Sealants

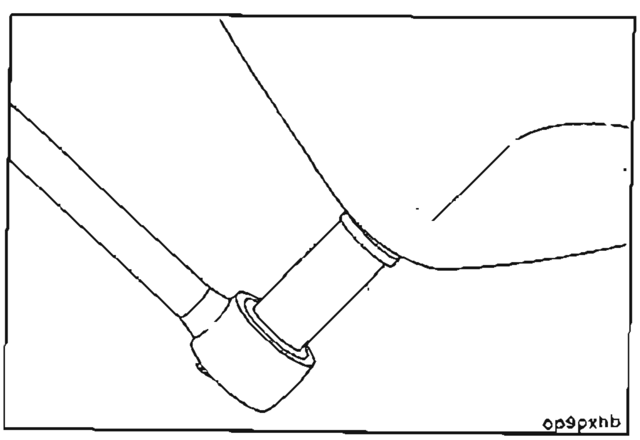
Use Three Bond 1207-C® to fill the joints between the pan rail, gear housing and rear cover.



10 mm

Assemble the oil pan and capscrews as illustrated.

Torque Value: 24 N•m [18 ft-lb]



17 mm

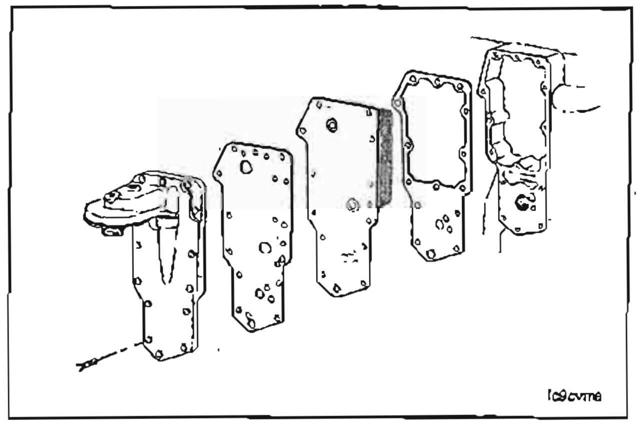
Install the drain plug and a new sealing washer.

Torque Value: 80 N•m [59 ft-lb]

Oil Cooler - Installation (0-84)

Caution: If a new element is to be installed, be sure to remove the shipping plugs.

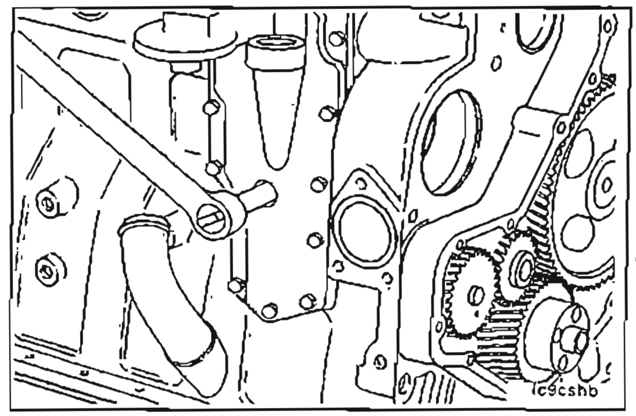
Insert two capscrews through the oil cooler cover. Package the cooler cover gasket, oil cooler, oil cooler gasket and oil cooler cover.



10 mm

Install the "package" on the cylinder block.

Torque Value: 24 N•m [18 ft-lb]

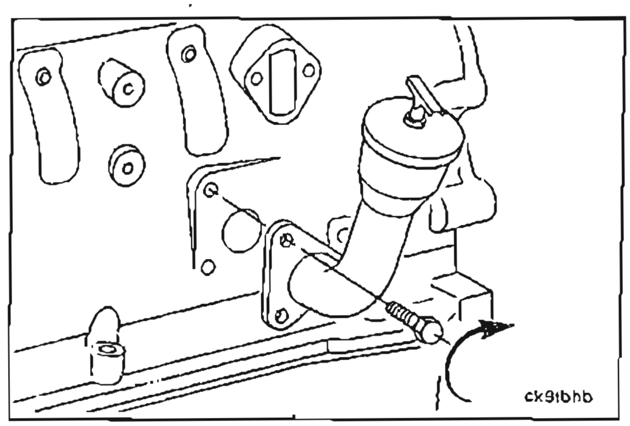


Side Oil Fill - Installation (0-85)

15 mm

If the engine is so equipped, install the side oil fill assembly and o-ring.

Torque Value: 43 N•m [32 ft-lb]

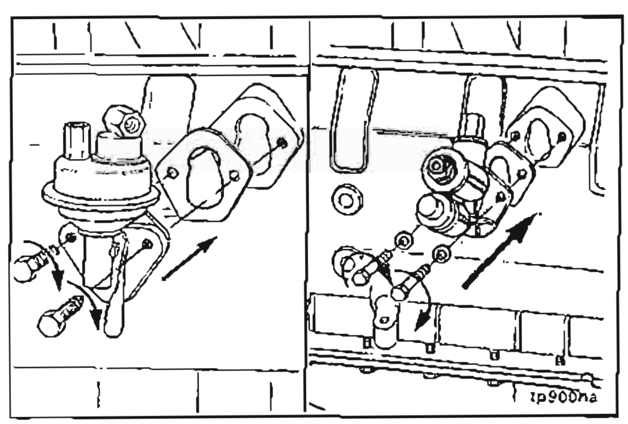


Fuel Transfer Pump - Installation (0-86)

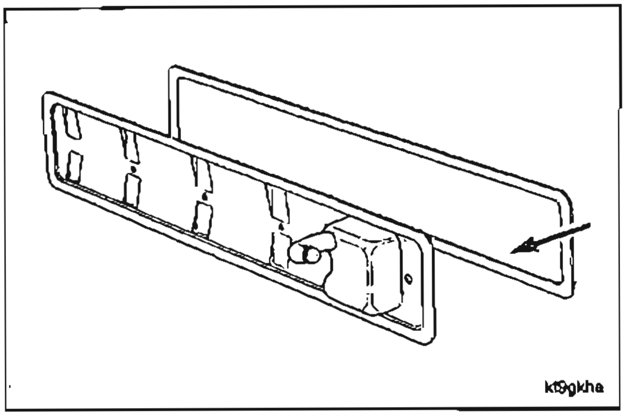
Caution: When installing piston style transfer pumps, alternately tighten the mounting capscrews. As the capscrews are tightened, the transfer pump plunger is pushed into the pump. Failure to tighten the capscrews in an even manner can result in the plunger being bent or broken.

Install the fuel transfer pump, gaskets and spacer if using a piston style pump.

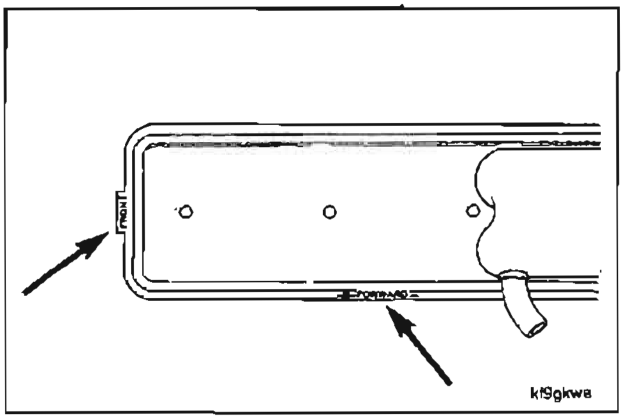
Torque Value: 24 N•m [18 ft-lb]



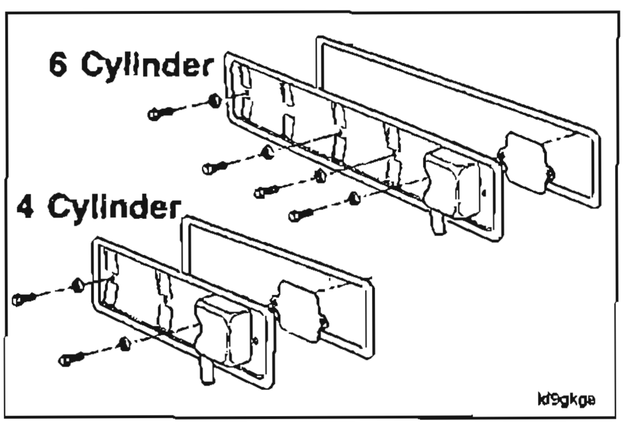
Tappet Cover - Installation (0-87)



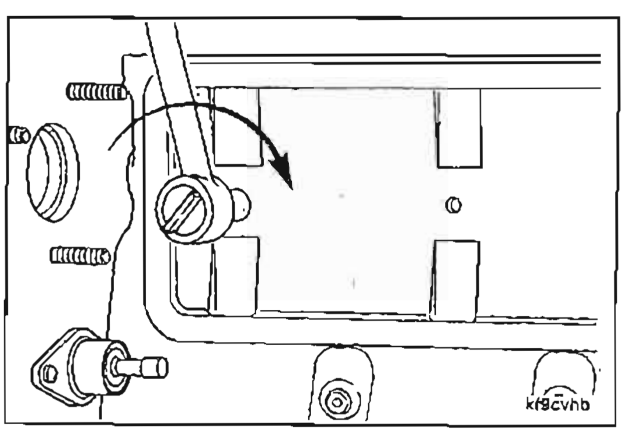
Install the tappet cover gasket.



The tappet cover gasket must be installed on the cover as shown in the illustration.



Install the tappet cover and baffle with the illustrated mounting capscrews and rubber seals. The remaining capscrews and rubber seals will be installed later with the fuel drain line.

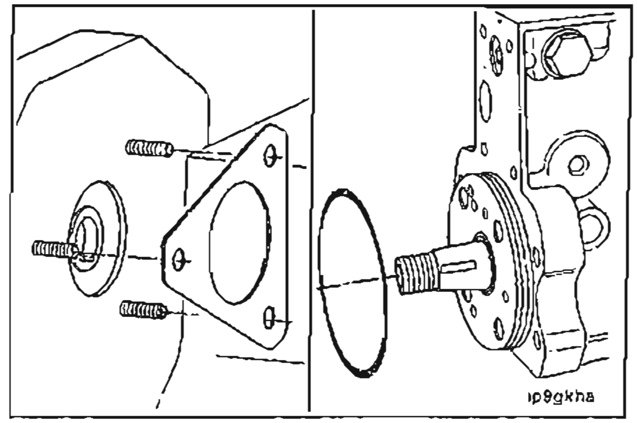


10 mm

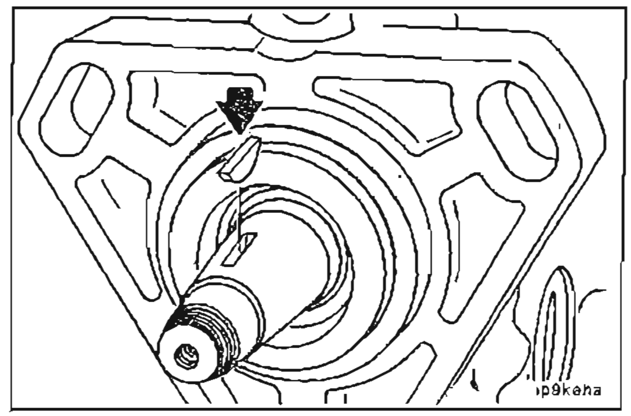
Torque Value: 24 N•m [18 ft-lb]

Injection Pump - Installation (0-88)

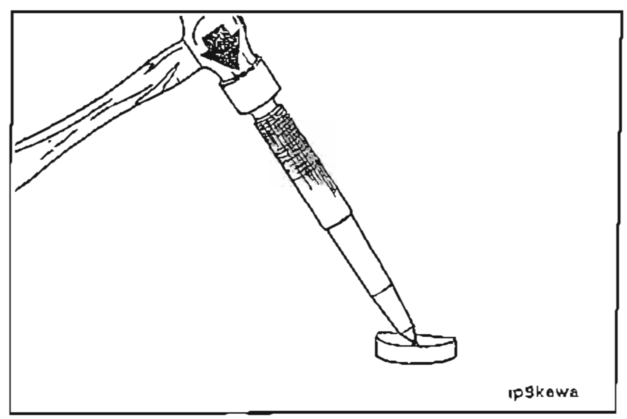
Install the injection pump gasket. The Nippondenso EP9 and the Bosch P7100 injection pump use a sealing o-ring instead of a sealing gasket. Make sure the o-ring is positioned properly and not damaged. Lubricate with clean engine oil.



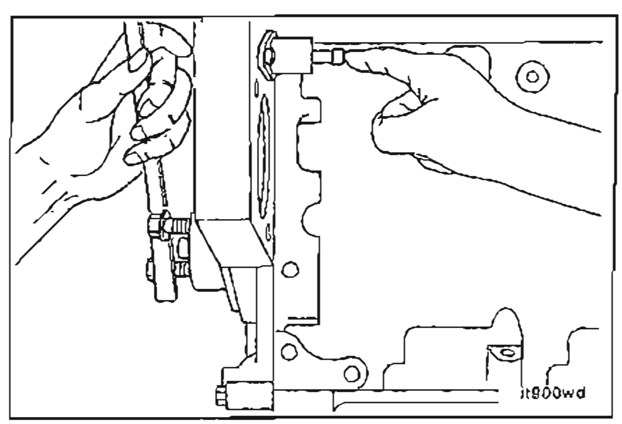
Install the key in the keyway of the Bosch and CAV injection pump shafts. The Nippondenso EP9 and the Bosch P7100 pumps do not require a key.

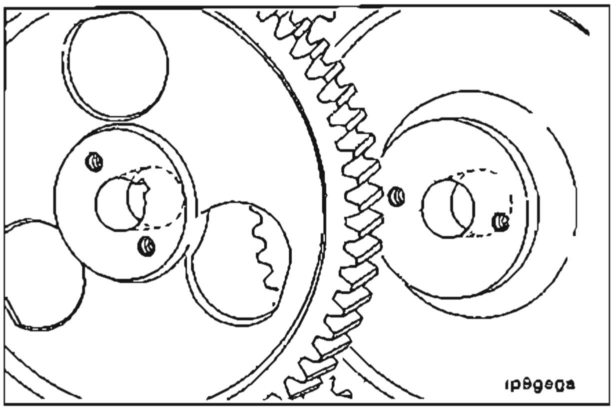


Service Tip: To prevent the key from falling out of the keyway in the shaft, use a small punch to swell one side of the key. When adequately expanded, it should require a hammer to lightly tap the key into positon in the keyway.



Locate top dead center (TDC) for Cylinder Number 1 by barring the engine while pushing in on the engine timing pin until it engages.





ip9gega

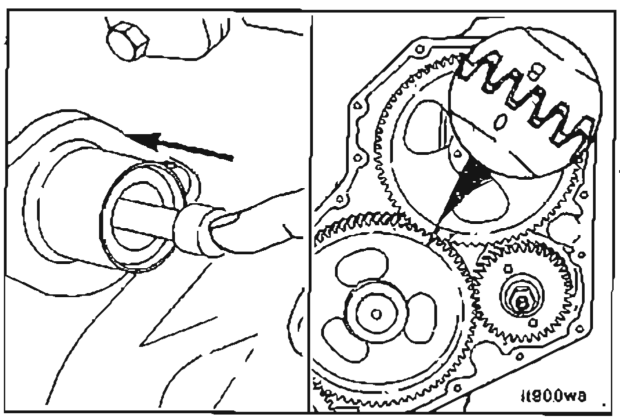
The injection pump drive gear has a tapered bore. Orient the wide end of the taper toward the engine (timing marks away). The drive gear for the Nippondenso EP9 and the Bosch P7100 pump does not have timing marks and must be positioned using the tapered bore as a reference.

Letter on Pump Gear	Engine Model	Injection Pump	Certification
A	4B3.9, 4BT3.9	Stanadyne	Non-Certified
A	4B3.9, 4BT3.9, 4BTA3.9	Lucas CAV DPA Pump	All Non-Certified
B	4B3.9, 4BTA3.9	Robert Bosch VE Pump	86,87 EPA All pre-86 All Non-Certified
C	6BT5.9, 6BTA5.9	Robert Bosch VE Pump	86,87 EPA All pre-86 All Non-Certified CPL 600
D	6B5.9, 6BT5.9	Stanadyne	Non-Certified
D	6B5.9, 6BT5.9, 6BTA5.9	Lucas CAV DPA Pump	All Non-Certified
E	6BT5.9, 6BTA5.9	Robert Bosch VE Pump	86,87,88,89,90,91,92 CARB 88,89,90,91,92 EPA
F	4BT3.9, 4BTA3.9	Robert Bosch VE Pump	86,87,88,89,90,91,92 CARB 88,89,90,91,92 EPA
G	6BTA5.9	Lucas CAV DPA	All Fuel Pump CPL 1165
H	Not Used at This Time		

it900ga

This table **must** be used to make sure of proper fuel injection pump-to-engine timing. The critical parts list (CPL) number from the engine data plate and the Control Parts List Manual (Bulletin No. 3379133-20) **must** be used to determine whether or not the engine is certified, and if so, what year and regulating agency (EPA or CARB).

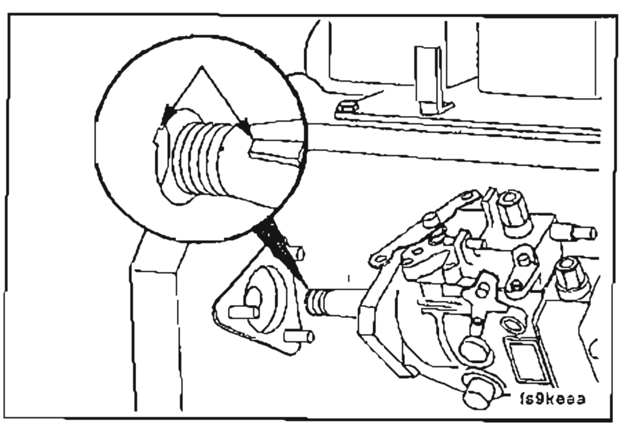
Given this information, use the table to determine which letter on the fuel injection pump drive gear is aligned with the camshaft gear.



it900wa

Align the timing marks and set the gear into the housing.

No timing mark alignment is required for the Nippondenso EP9, or Bosch Inline fuel pumps.



fs9keea

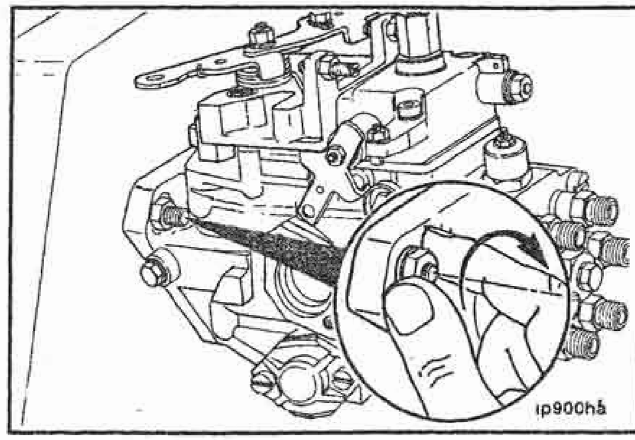
Locked Timed Injection Pump - Installation (0-89)

Install the pump. Make sure the key doesn't fall into the gear housing.

NOTE: The keyway in the shaft of new and reconditioned pumps will be locked in a position corresponding to the keyway in the drive gear when cylinder number 1 is at TDC.

If the Bosch, Stanadyne or CAV pump was not locked in this position before removal and a timing tool, Part No. 3377259, is not available for the Bosch pump, refer to installing an unlocked pump, procedures (0-91 and 0-92). Refer to Section 5 for the Nippondenso EP9 and Bosch inline timing procedure.

Attach the pump by finger tightening the mounting nuts. The pump must be free to move.

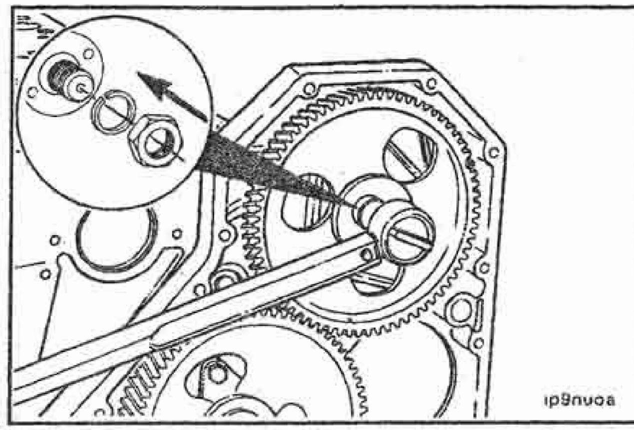


22 mm

Install the drive gear mounting nut and spring washer. The pump can rotate slightly due to gear helix and clearance. This is acceptable **providing** the pump is free to move on the flange slots and the crankshaft **does not** move.

Torque Value: 15 N•m [11 ft-lb]

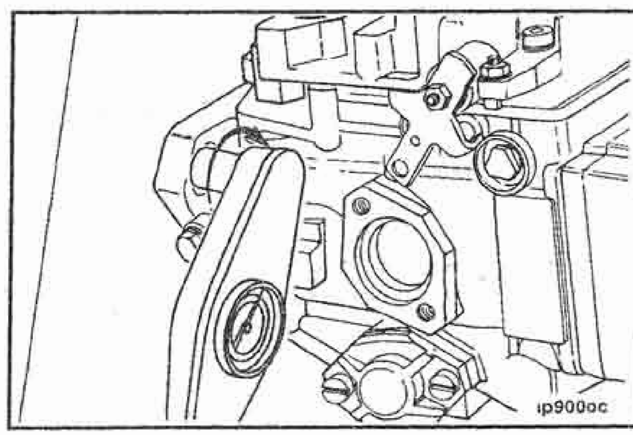
This is not the final torque. The drive shaft nut will be torqued to the final specification after the pump is unlocked.



13 mm or 15 mm

Rotate the pump to align the scribe marks and tighten the mounting nuts. The Nippondenso EP9 and Bosch inline do not have alignment marks.

Torque Value	
Nippondenso EP9	43 N•m [32 ft-lb]
Bosch P7100	43 N•m [32 ft-lb]
Lucas CAV, Stanadyne, Bosch VE	30 N•m [22 ft-lb]

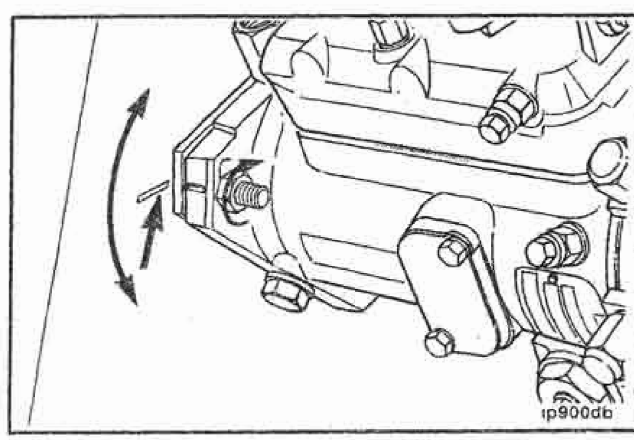


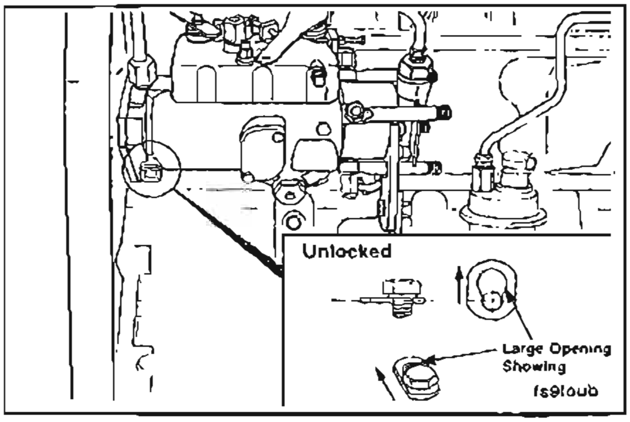
If a new or rebuilt Stanadyne, Bosch or CAV pump without scribe marks is being installed, take up the gear lash by rotating the pump against the direction of drive rotation.

Make sure the engine is at TDC.

Tighten the pump retaining nuts.

Torque Value: 24 N•m [18 ft-lb]



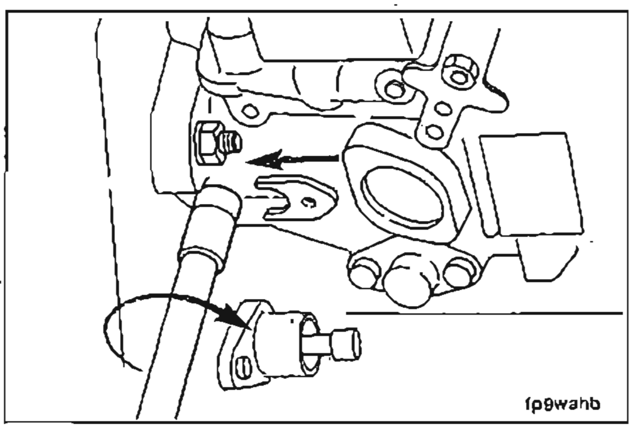


Injection Pumps - Unlocking (0-90)

14 mm

Loosen the Stanadyne and CAV pump lockscrew and position the special washer with the large opening showing behind the lockscrew head.

Torque Value: 20 N•m [15 ft-lb] (CAV)
12 N•m [9ft-lb] (Stanadyne)

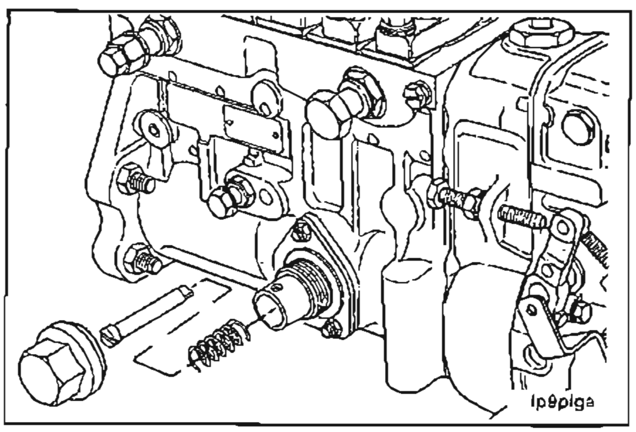


8 mm Allen or 10 mm Hex

The special washer for the Bosch pump is wired to the pump and must be installed under the lockscrew.

Tighten the pump lockscrew.

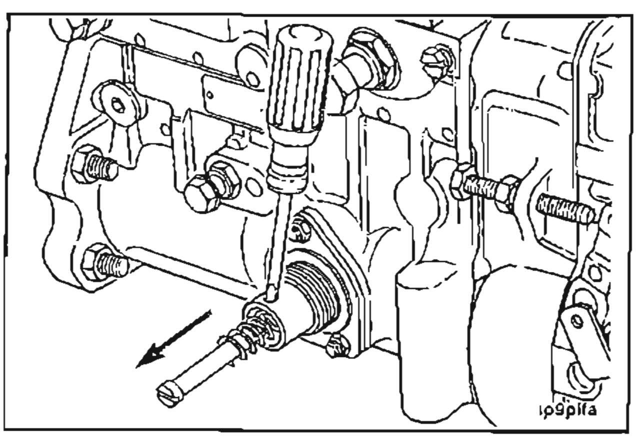
Torque Value: 13 N•m [10 ft-lb]



34 mm

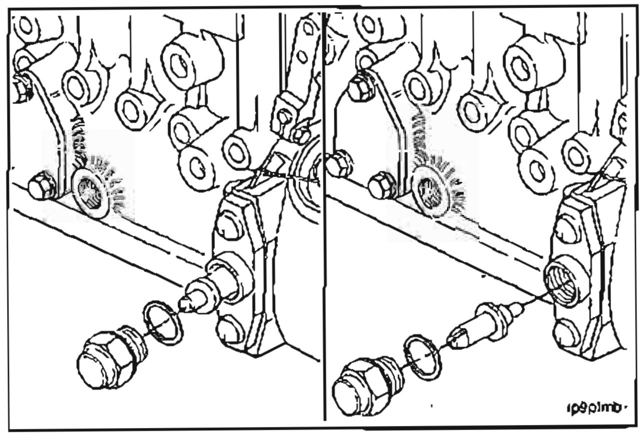
The Nippondenso EP9 has a plastic timing pin and spring which is located under the cap on the outboard side of the pump. This pin locates the pump shaft to correspond with TDC for number one cylinder. To unlock the pump, the spring is placed **under** the head of the timing pin and the cap installed.

Torque Value: 70 N•m [50 ft-lb]

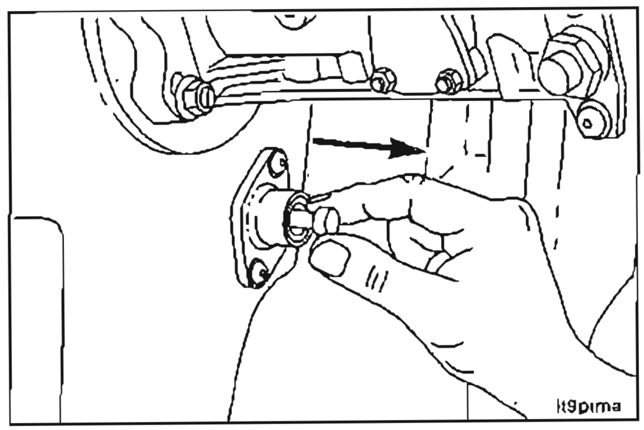


Service Tip: If difficulty is experienced with disengaging the plastic timing pin, use a small flat blade screwdriver to pry the pin free.

The Bosch P7100 has a timing pin located under a cap on the outboard side of the governor. To unlock the pump the position of the pin is reversed under the cap.



Disengage the timing pin.

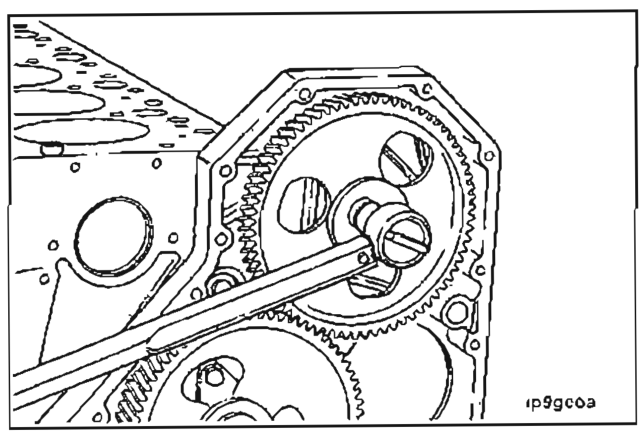


22 mm or 27 mm

Tighten the drive gear mounting nut.

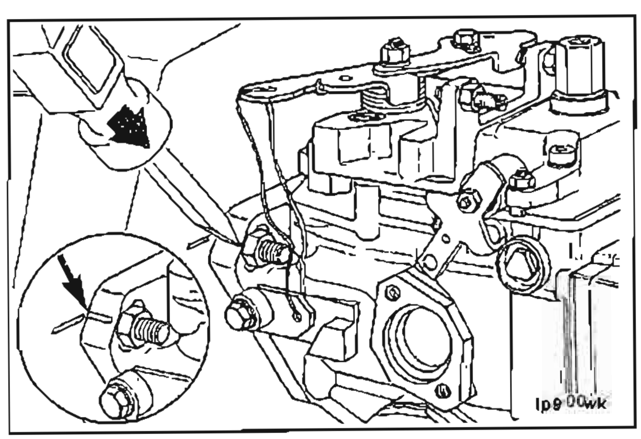
Torque Value

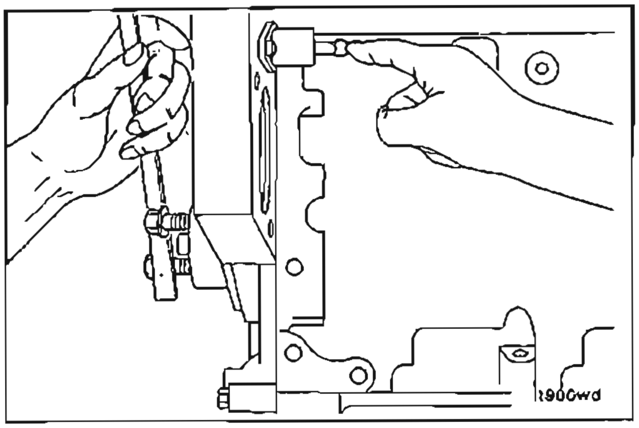
Stanadyne, Bosch and CAV (Rotary)	65 N•m [48 ft-lb]
Nippondenso EP9	123 N•m [91 ft-lb]
Bosch P7100	165 N•m [122 ft-lb]



Chisel, Hammer

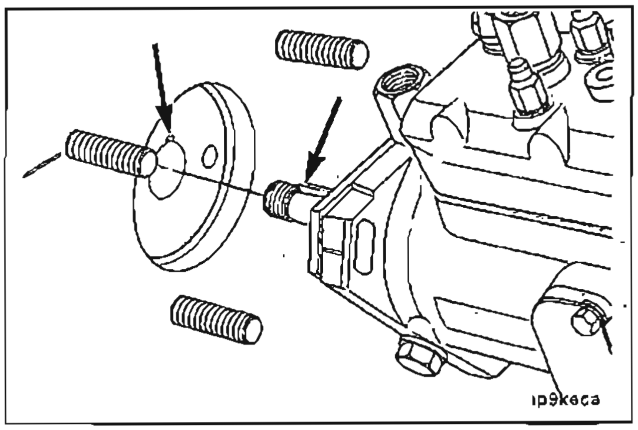
If a rebuilt pump is being installed, permanently mark the injection pump flange to match the mark on the gear housing. The Nippondenso EP9 and Bosch P7100 do not require timing marks.





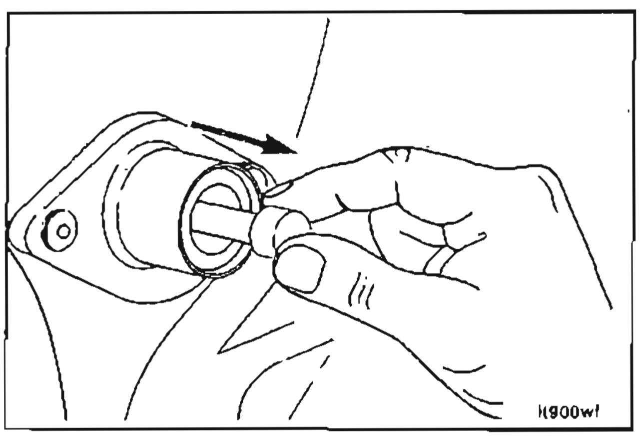
Unlocked CAV Injection Pump - Installation (0-91)

Locate Top Dead Center (TDC) for Cylinder Number 1 by barring the engine while pushing in on the timing pin until it engages.

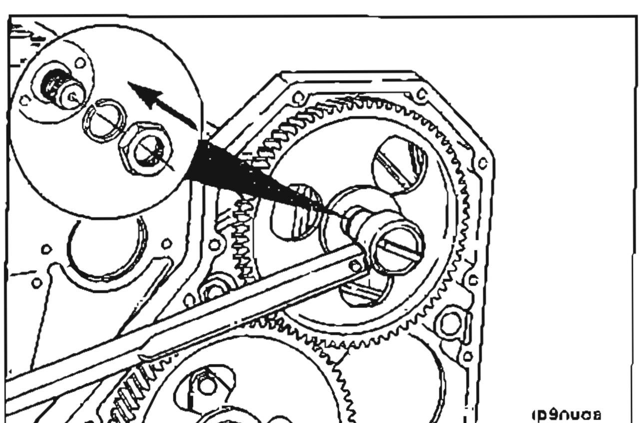


If the shaft of a Lucas CAV pump was not locked with the engine at TDC, rotate the pump shaft to align the key and the keyway in the gear.

Secure the pump by finger tightening the three mounting nuts.



Disengage the TDC pin.



22 mm

Secure the drive gear with the mounting nut and lock washer.

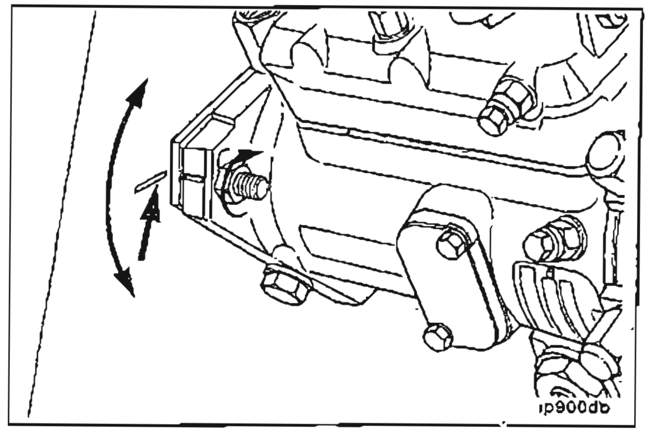
Torque Value: 65 N•m. [48 ft-lb]

13 mm

Rotate the pump to align the scribe marks on the pump and gear housing.

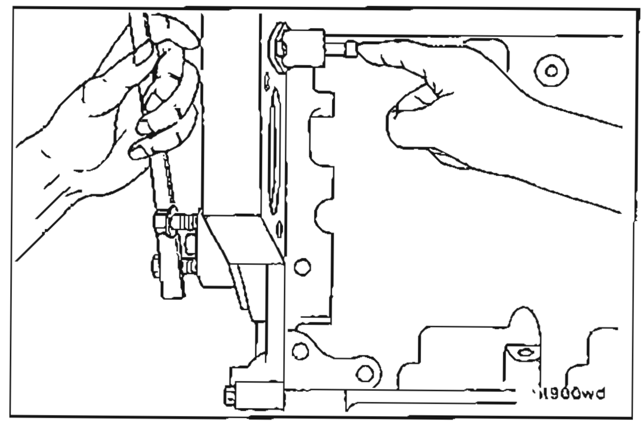
Torque Value: 30 N•m [22 ft-lb]

NOTE: If no timing marks exist, refer to Bulletin Nos. 3810348-01 or 3810486.

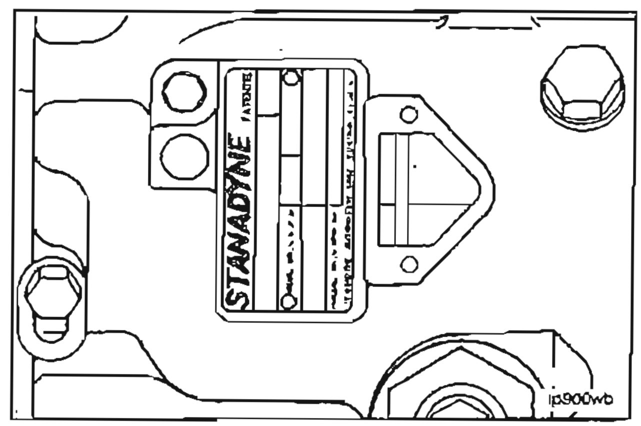


Unlocked Stanadyne DB4 Injection Pump - Installation (0-92)

Locate top dead center (TDC) for cylinder number 1 by rotating the crankshaft while pushing in on the timing pin until it engages.

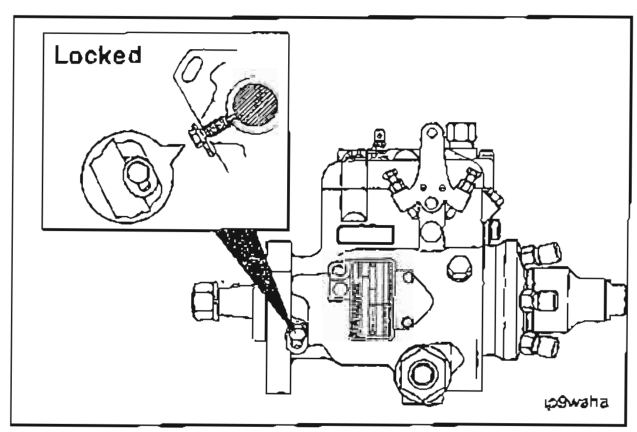


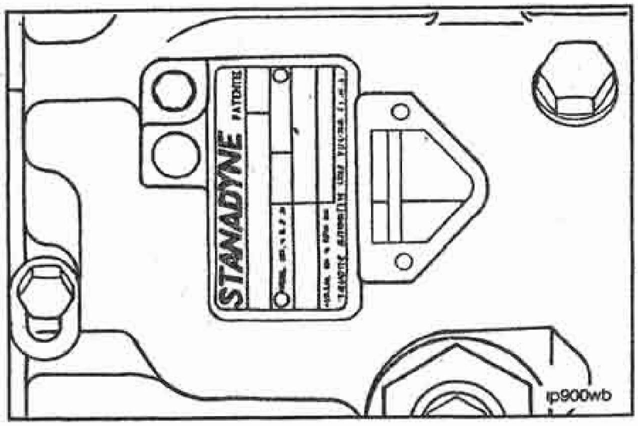
Rotate the fuel injection pump drive shaft in the direction of pump rotation to align the timing line on the weight retainer hub with the line on the cam ring.



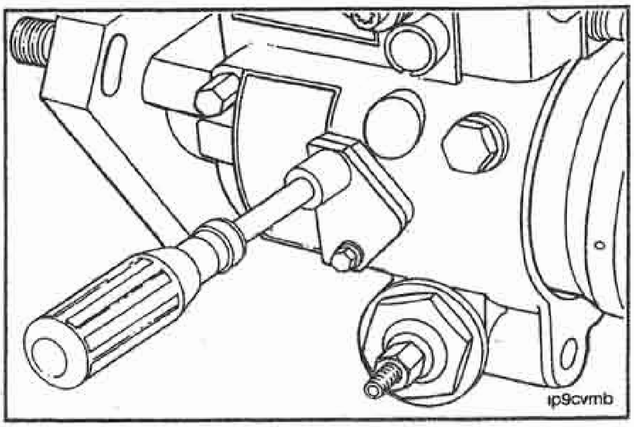
Position the fuel injection drive shaft locking key plate in the locked position. Turn the locking screw in until contact is made with the drive shaft.

Torque Value: 12 N•m [106 in-lb]

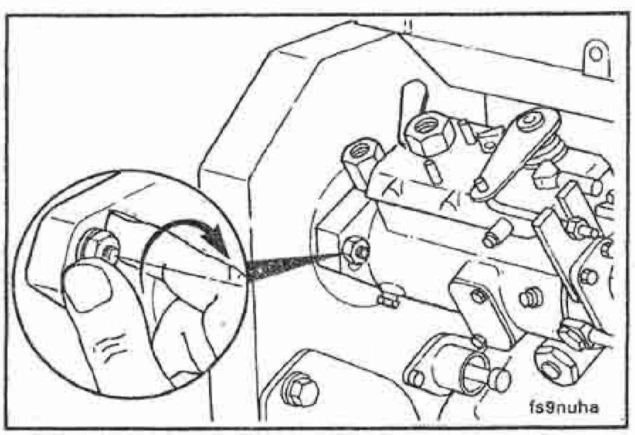




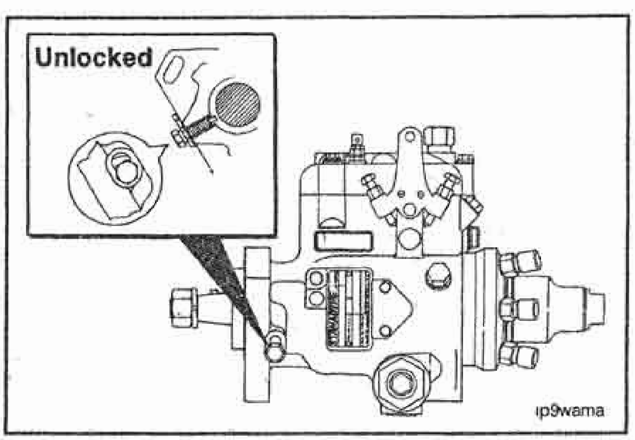
Verify the timing marks are aligned after lock timed.



Install the fuel injection pump timing cover.



Secure the pump by finger tightening the mounting nuts.



3/8 Inch

Loosen the Stanadyne DB4 fuel injection pump lock screw and position the special washer behind the lock screw head.

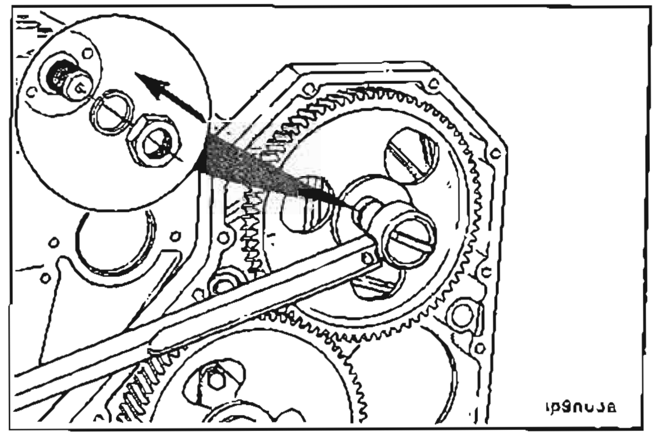
Tighten the lock screw.

22 mm

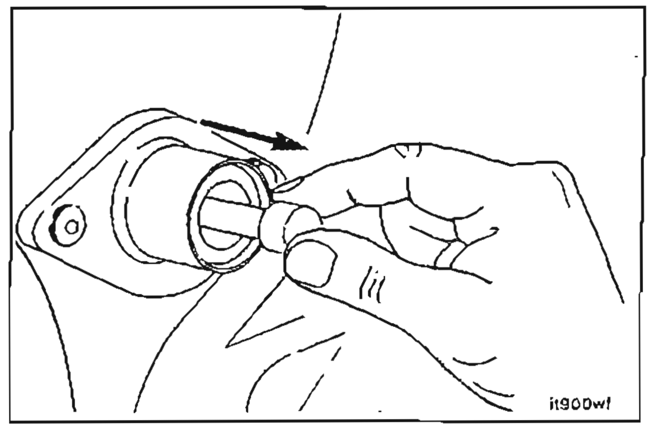
Secure the drive gear with the mounting nut and washer.

NOTE: This is not the final torque value.

Torque Value: 15 N•m [11 ft-lb]



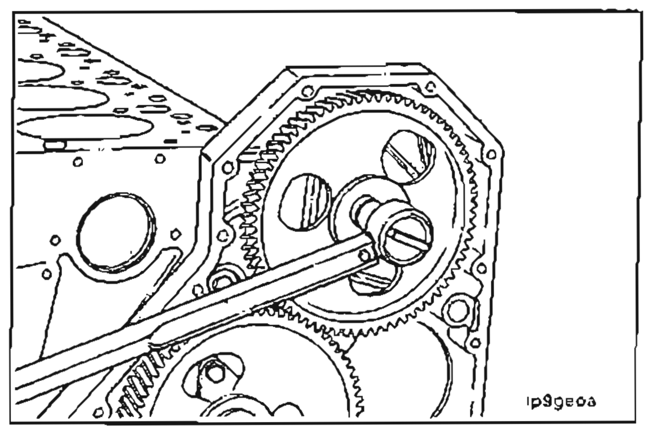
Disengage the timing pin.



22 mm

Tighten the drive gear mounting nut.

Torque Value: 65 N•m [48 ft-lb]

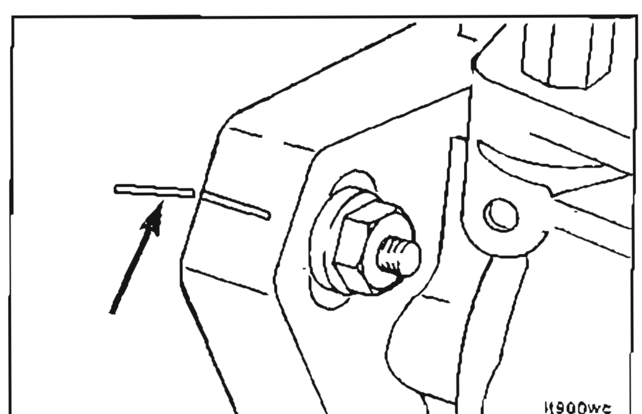


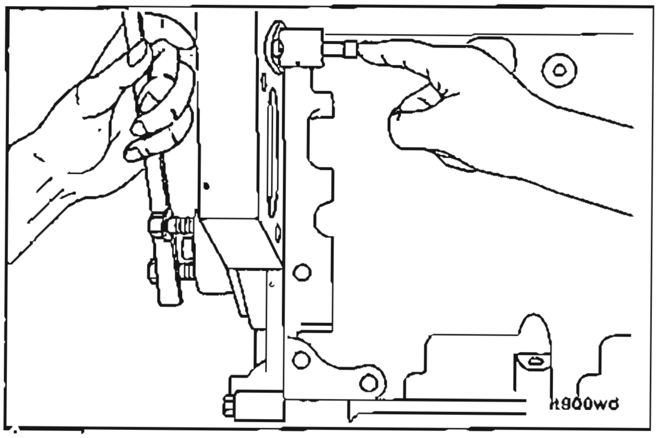
13 mm

Rotate the pump to align the scribe marks on the pump and housing.

Tighten the mounting nuts.

Torque Value: 30 N•m [22 ft-lb]



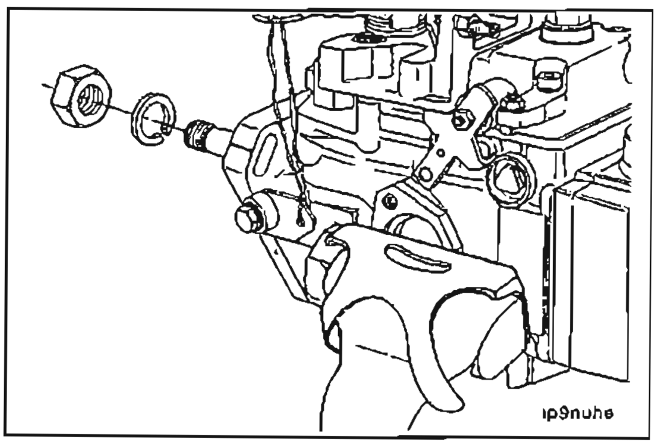


Unlocked Bosch VE and P7100 Injection Pump - Installation (0-93)

VE Installation

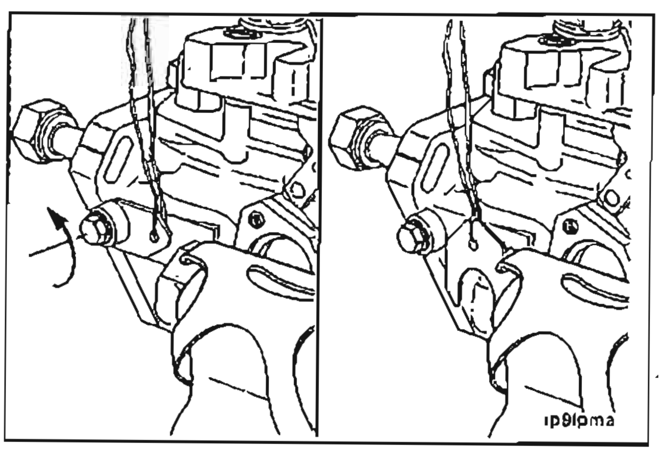
The following procedure was written for those without immediate access to a fuel pump timing tool, Part No. 3377259. The procedure for timing an unlocked Bosch VE fuel pump with the pump off of the engine is given in Section 5. **If the pump is installed using the following procedure, it should be adjusted to the exact timing using tool No. 3377259 before being put into service.** This procedure is available in Bulletin Nos. 3810348-01 and 3810486.

Locate top dead center (TDC) for Cylinder Number 1 by rotating the crankshaft while pushing in on the timing pin until it engages.



The Robert Bosch VE pump uses a spring loaded cam mechanism that makes positioning the keyway more difficult.

To align the Robert Bosch VE keyway, secure the pump in a vise and install the lock washer and nut on the drive shaft.



8 mm Allen or 10 mm Hex

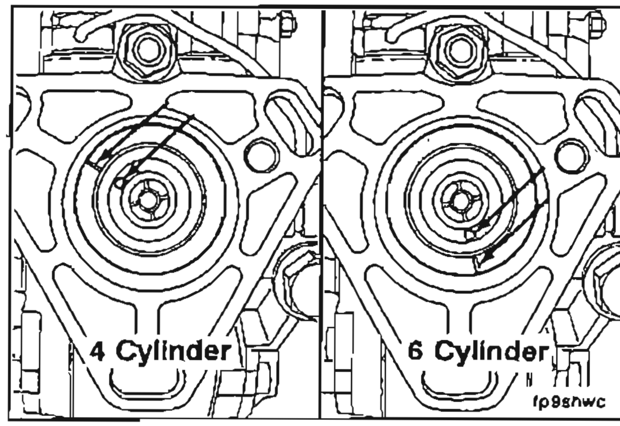
Remove the special washer by loosening the lockscrew.

22 mm; 8 mm Allen or 10 mm Hex

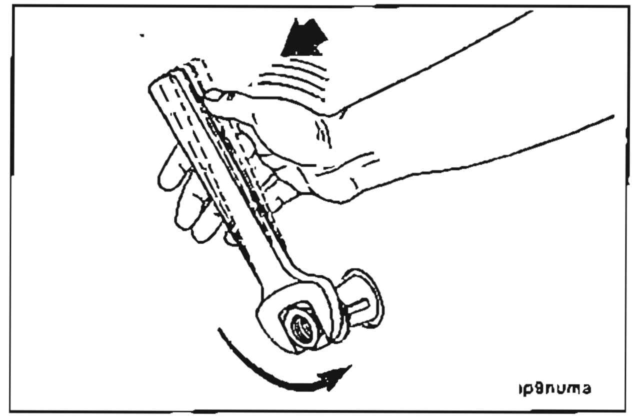
Turn the shaft so the key is aligned with the hash mark on the seal housing.

Lock the pump shaft by tightening the lockscrew.

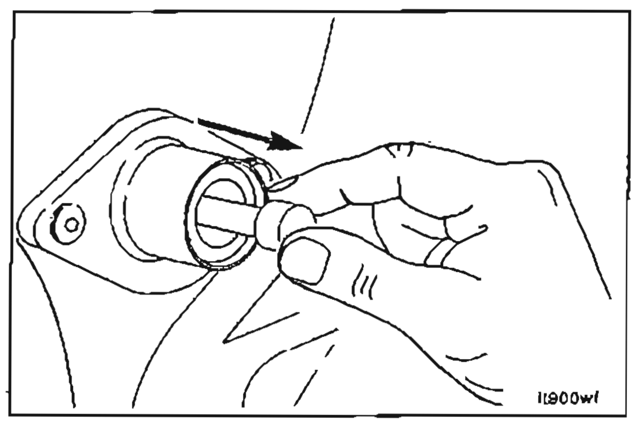
Torque Value: 30 N•m [22 ft-lb]



Remove the drive nut and washer from the drive shaft by striking the wrench with a sharp blow in a counterclockwise direction.

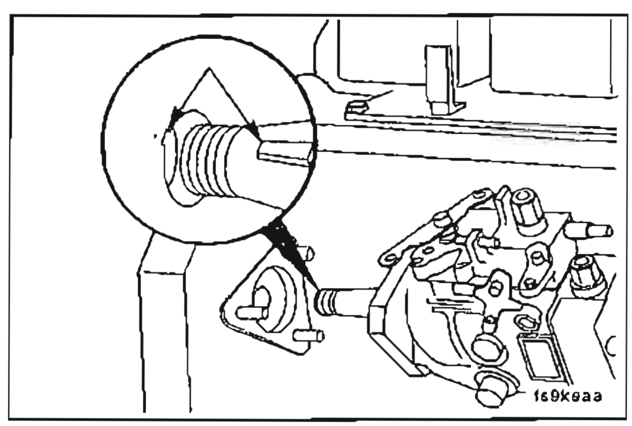


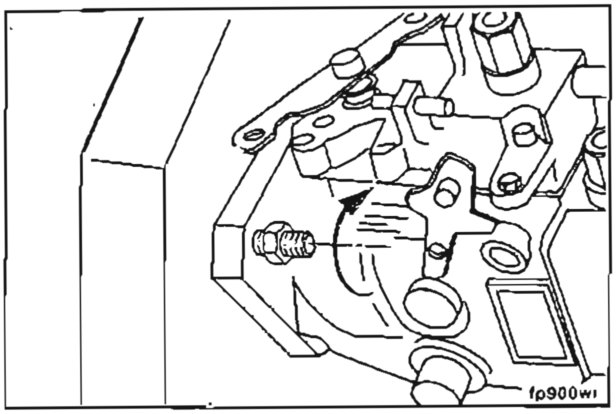
Be sure the timing pin is disengaged.



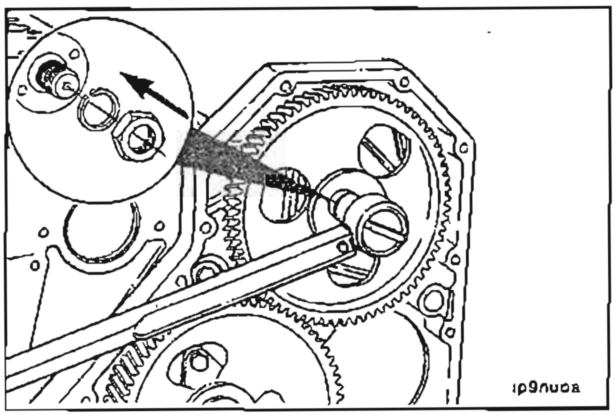
Caution: Make sure the key does not fall into the gear housing.

Install the pump.





Secure the pump by finger tightening the three mounting nuts. The pump must be free to move in the slots.

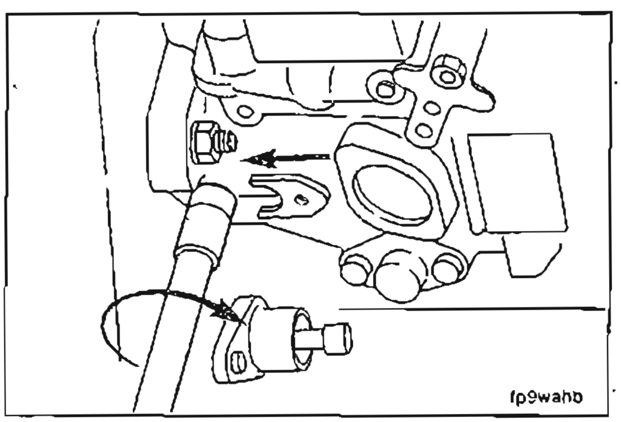


22 mm

Install the drive gear mounting nut and lock washer on the pump drive shaft.

Torque Value: 15 N•m   [11 ft-lb]

NOTE: This is not the final torque value. The drive shaft nut will be torqued to the final specification after the pump is unlocked.

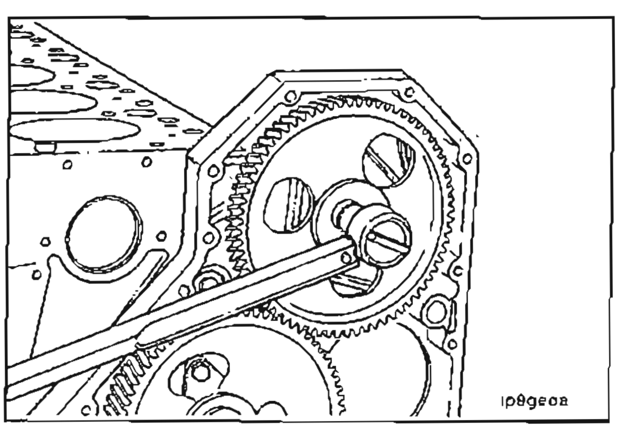


8 mm Allen or 10 mm Hex

Loosen the Bosch pump lockscrew and position the special washer behind the lockscrew head.

Tighten the lockscrew in the **unlocked** position.

Torque Value: 13 N•m   [10 ft-lb]



22 mm

Tighten the drive gear mounting nut.

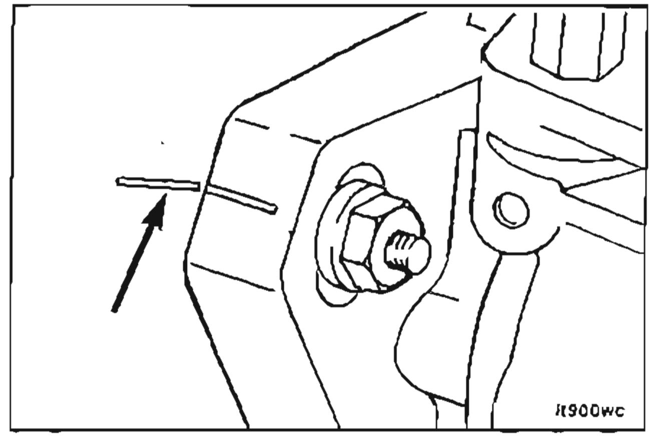
Torque Value: 65 N•m   [48 ft-lb]

13 mm

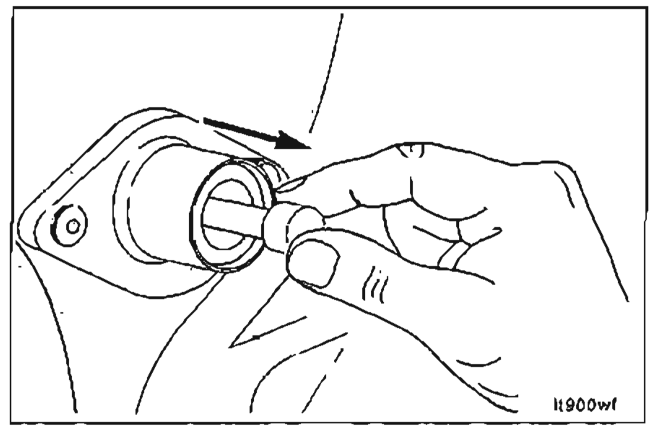
Rotate the pump to align the scribe marks on the pump and housing.

Tighten the three mounting nuts.

Torque Value: 24 N•m [18 ft-lb]

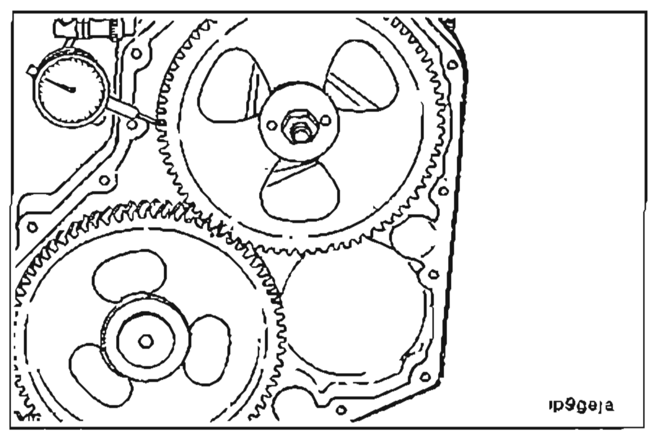


Disengage the TDC pin.



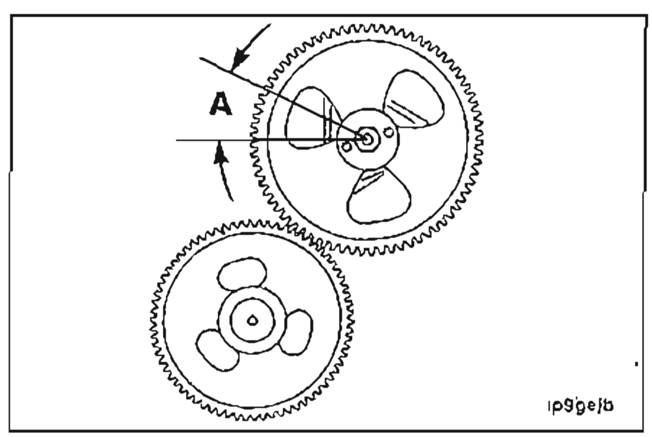
Be sure the backlash is correct for replaced gears.

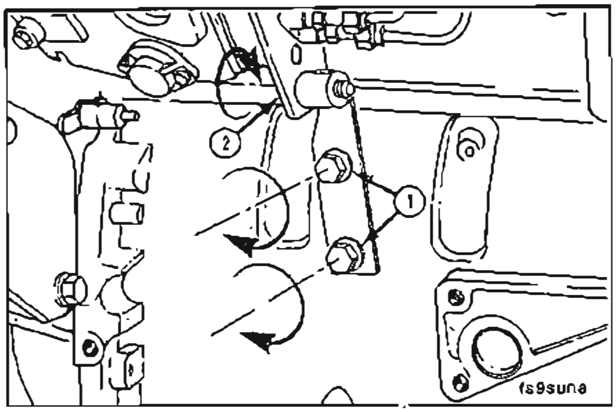
Use a dial indicator to measure backlash.



Pump Gear Backlash Limit

A = .076 to .330 mm [0.003 to 0.013 in]



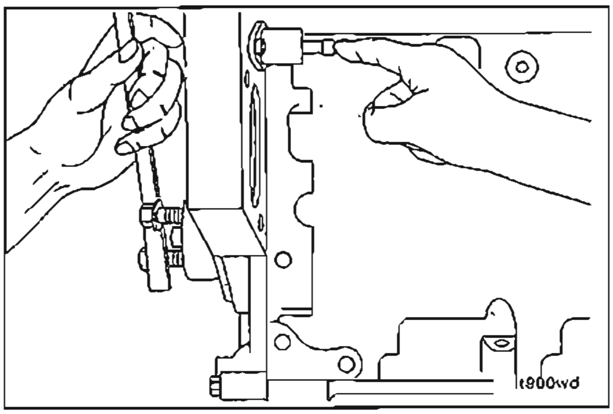


10 mm

Attach the injection pump support bracket. Finger tighten all capscrews before final tightening.

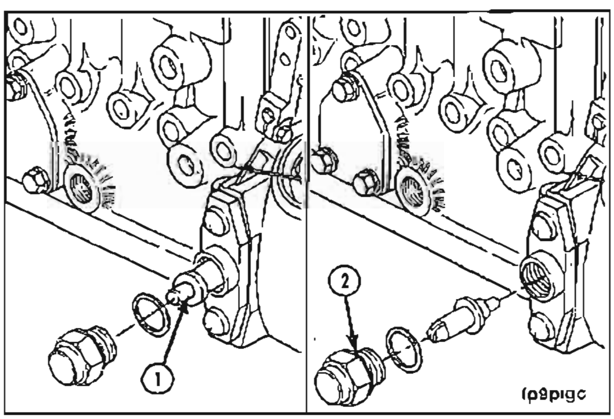
NOTE: Tighten the capscrews which attach the bracket to the block (1) before tightening the capscrew which secures the bracket to the pump (2).

Torque Value: 24 N•m [18 ft-lb]

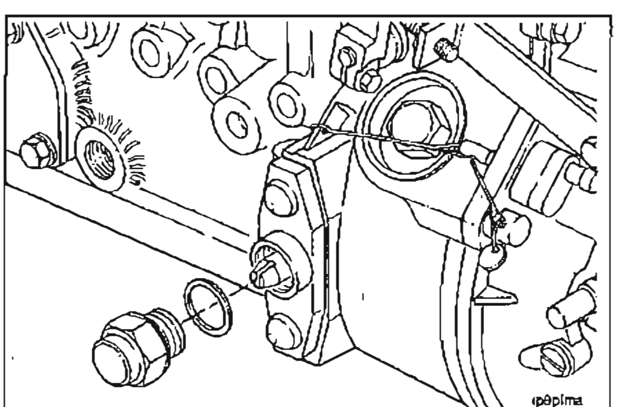


P7100 Injection Pump Installation

Make sure the engine has Cylinder No. 1 at TDC.



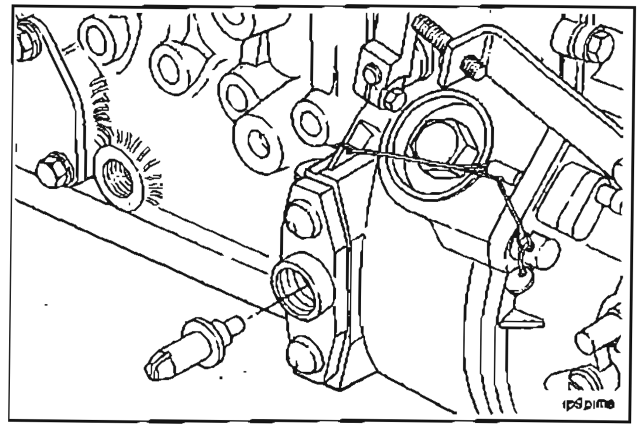
The injection pump also has a timing pin (1), located in the governor housing, to position the pump shaft to correspond with TDC for Cylinder No. 1 The pin is to be reversed and stored in the housing (2) after the pump is installed.



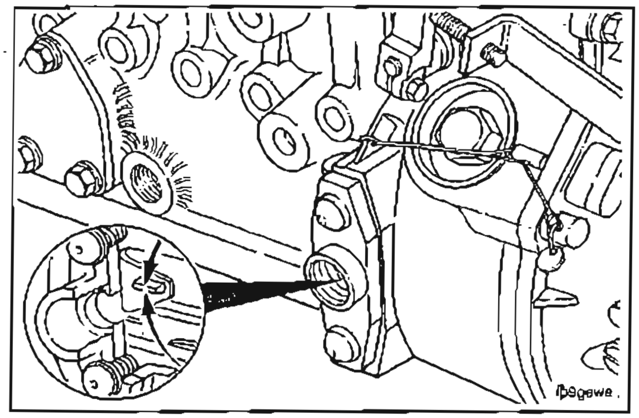
24 mm

Remove the access plug.

Remove the timing pin.

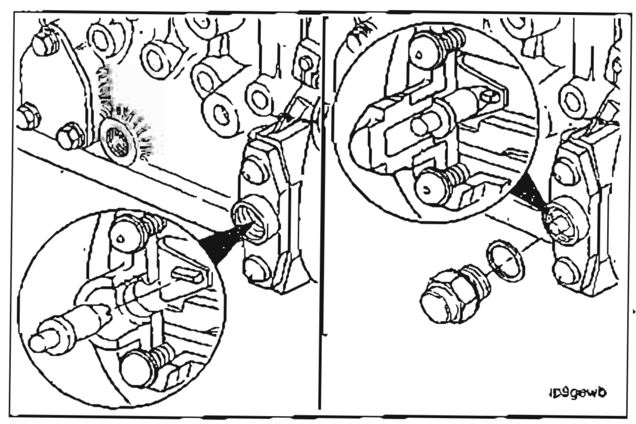


If the timing tooth is not aligned with the timing pin hole, rotate the pump shaft until the timing tooth aligns.

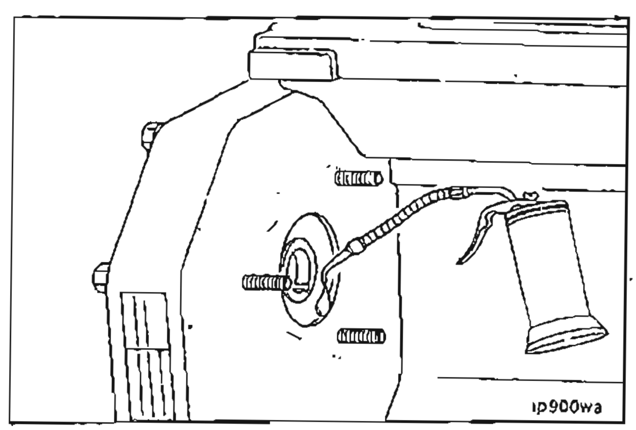


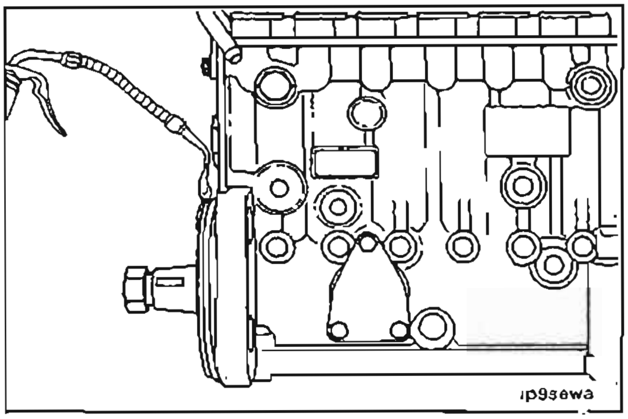
Reverse the position of the pin so the slot of the pin will fit over the timing tooth in the pump.

Install and secure the pin with the access plug.



Use a 50/50 mixture of clean engine oil and STP® or equivalent to lubricate the gear cover housing to ensure the injection pump will slide into the housing easily.

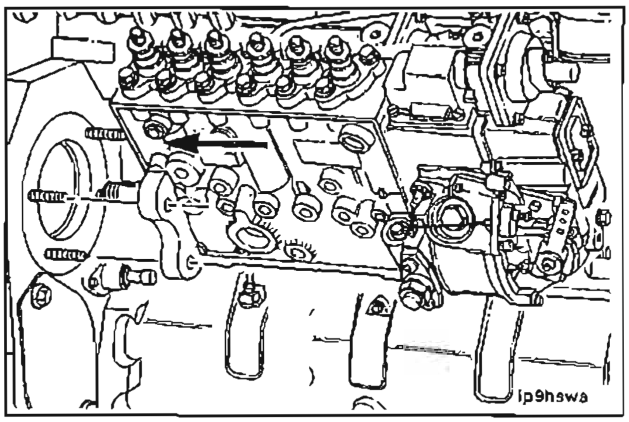




Also lubricate the mounting flange of the injection pump.

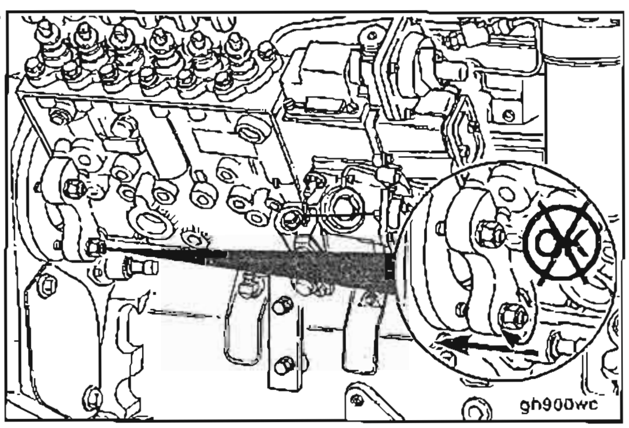
NOTE: The P7100 injection pump driveshaft has a provision for a Woodruff key, however, it is not required. Timing mark alignment is **not** required for the P7100 drive gear.

Make sure the fuel injection pump drive gear inside diameter and the shaft outside diameter are clean and dry before the gear is installed.

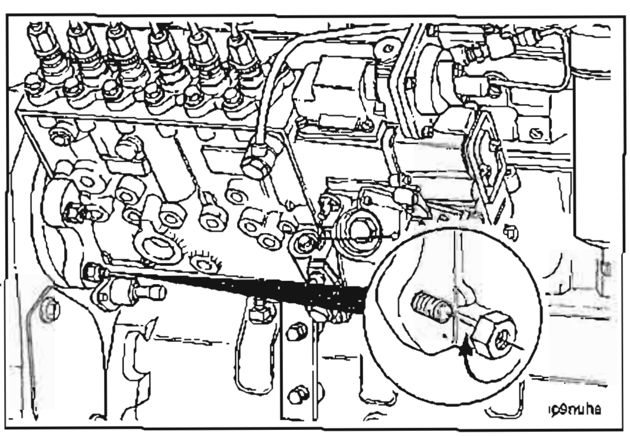


Slide the pump shaft through the drive gear and position the pump flange onto the mounting studs.

Push the pump forward until the mounting flange and o-ring are properly fitted into the gear housing bore.



Do not attempt to pull the pump flange into the gear housing with the mounting nuts as damage to housing will occur.



15 mm

Install the mounting nuts.

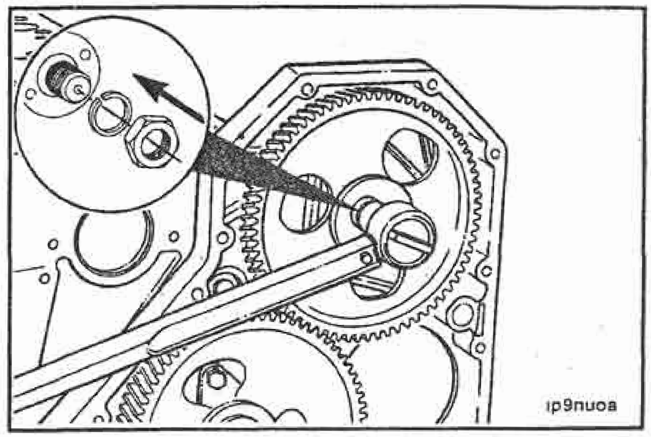
Torque Value: 43 N•m [32 ft-lb]

30 mm

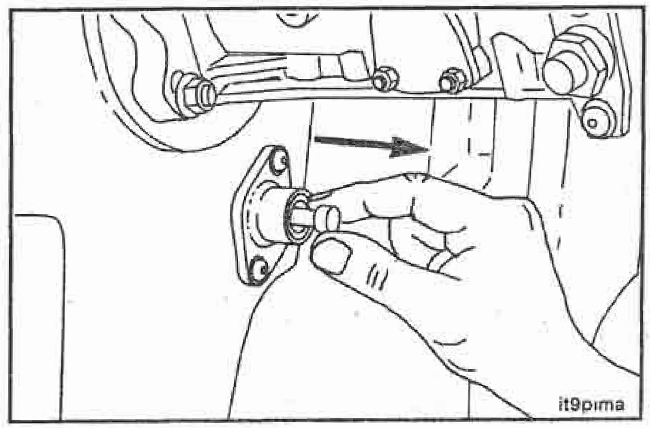
Install the retaining nut and washer.

Torque Value: 15 N•m [11 ft-lb]

To prevent damage to the timing pins, do not exceed the torque value given. This is not the final torque value for the retaining nut.



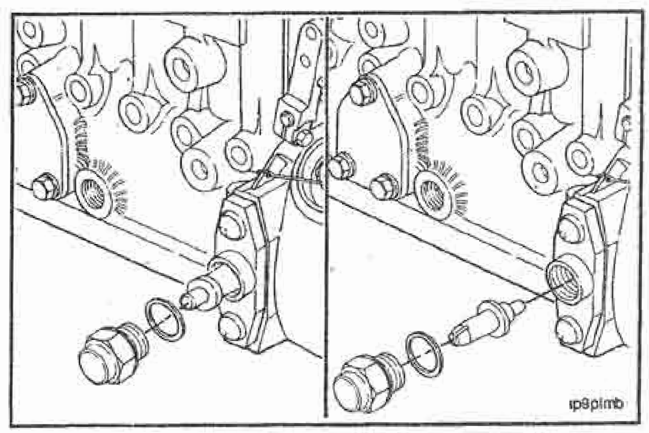
Disengage the engine timing pin.



24 mm

Remove the fuel pump timing pin plug, Reverse the position of the pin and install the pin, plug, and sealing washer.

Torque Value: 15 N•m [11 ft-lb]

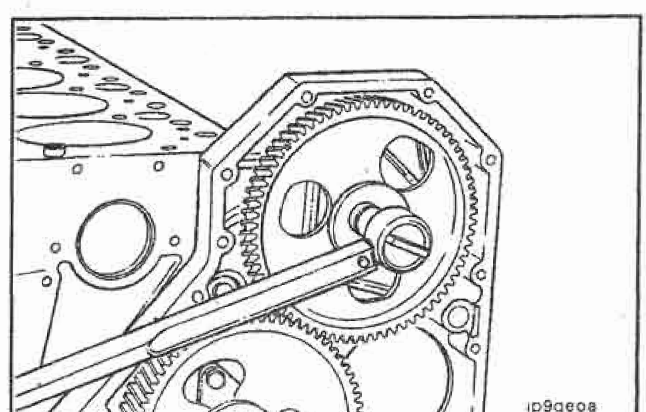


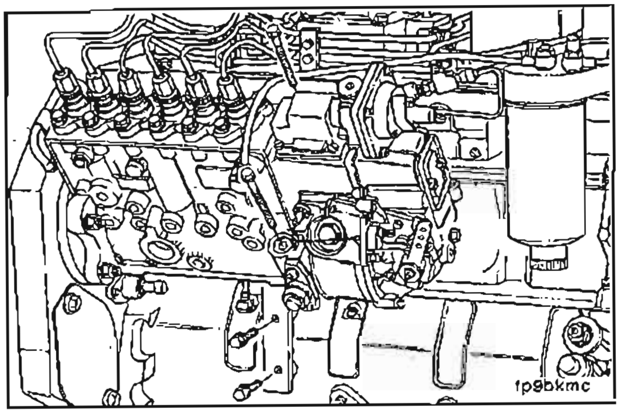
30 mm

Tighten the fuel pump drive nut.

Torque Value: 165 N•m [122 ft-lb]

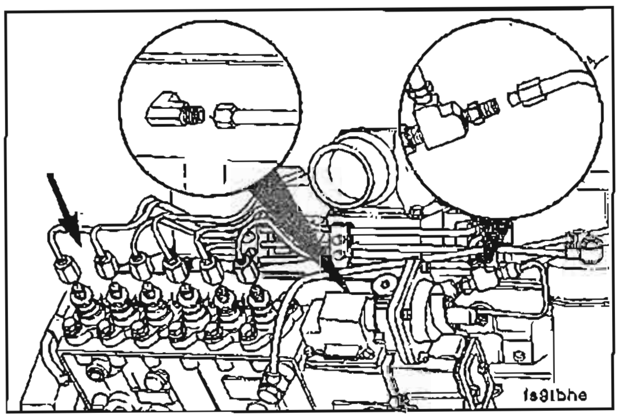
Install the gear cover access cap hand tight.





10 mm

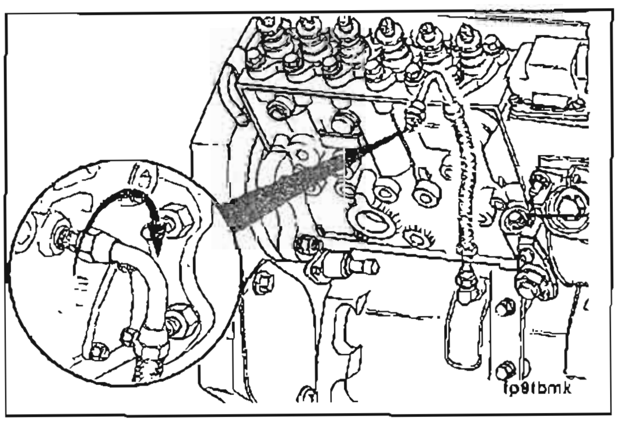
Install the fuel pump mounting bracket capscrews.



Install the fuel lines, control linkage and turbocharger wastegate line.

Torque Values:

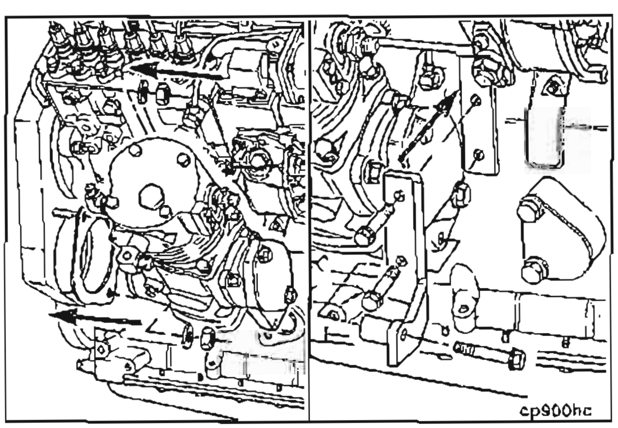
High Pressure Fuel Lines	24 N•m [18 ft-lb]
Low Pressure Fuel Supply Fitting	32 N•m [24 ft-lb]
AFC Fittings	9 N•m [80 in-lb]



9/16 in

Install the external oil feed line at the inboard side of the fuel pump and the main oil rifle.

Torque Value: 10 N•m [7 ft-lb]



Accessories - Installation (0-94)

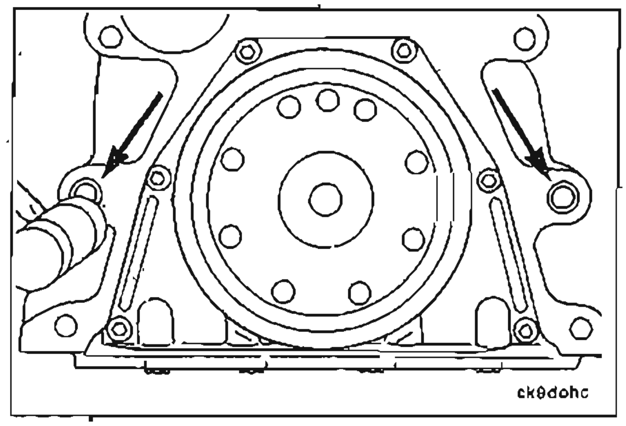
Install the cover plate or any additional gear driven accessories (hydraulic pump, air compressor, etc.) as needed.

NOTE: When gear driven accessories are installed, be sure to install the correct support bracket.

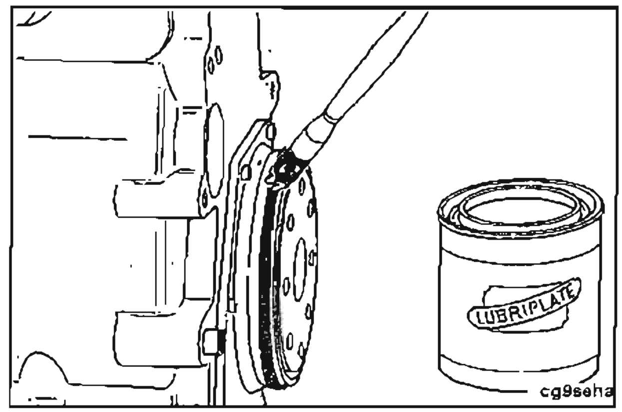
Flywheel Housing - Installation (0-95)

If removed, install the two ring dowels.

Drive the dowels in until they are against the bottom of the bore.



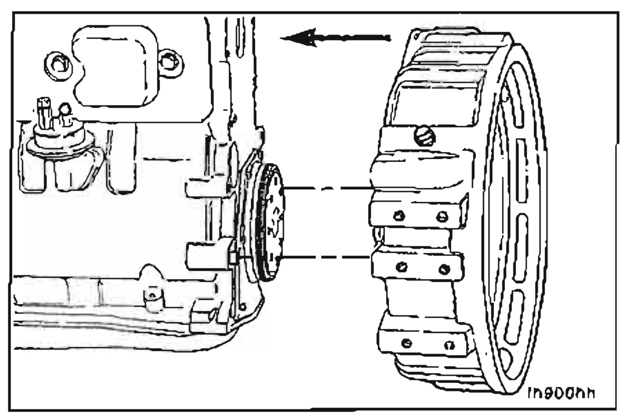
Install the rectangular seal and lubricate with Lubriplate® 105..



15 mm

Install the flywheel housing.

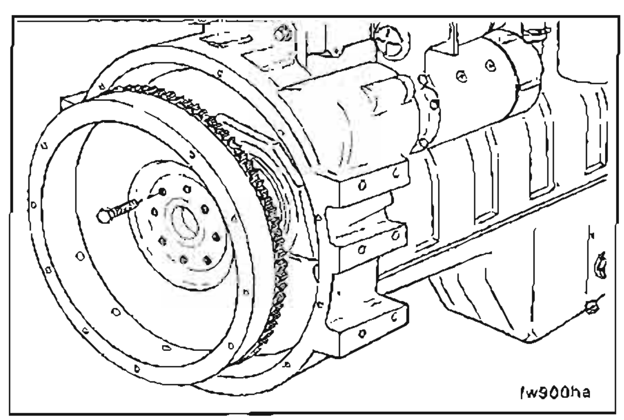
Torque Value: 77 N•m [57 ft-lb]

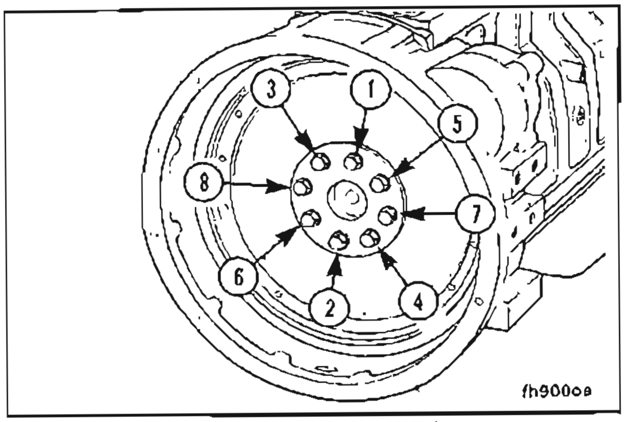


Flywheel - Installation (0-96)

Install the flywheel.

Caution: Install two capscrews in the front of the crankshaft or otherwise lock the crankshaft to tighten the flywheel capscrews. Do not use the timing pin to lock the engine.



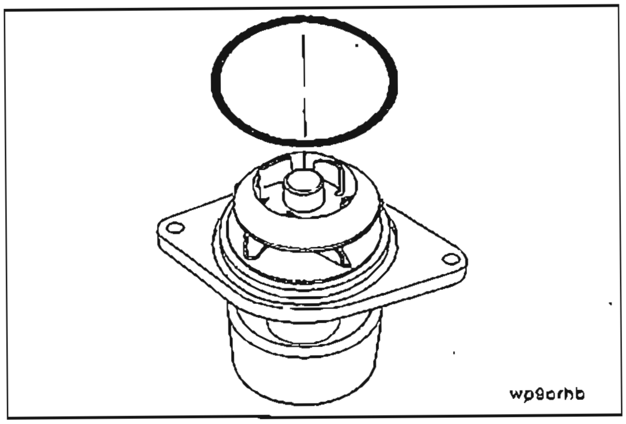


18 mm

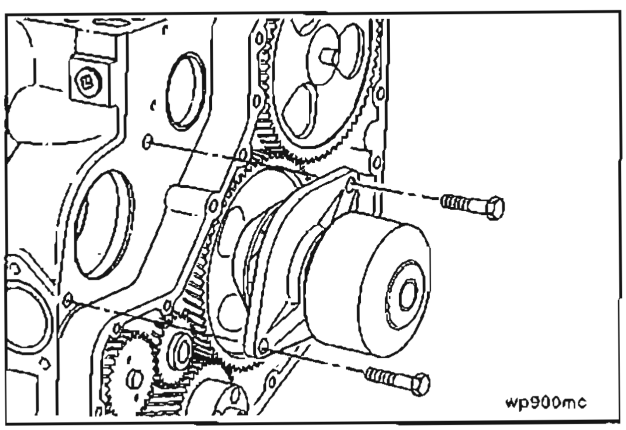
Follow the illustrated sequence to tighten the capscrews.

Torque Value: 137 N•m [101 ft-lb] sequence

Water Pump - Installation (0-97)



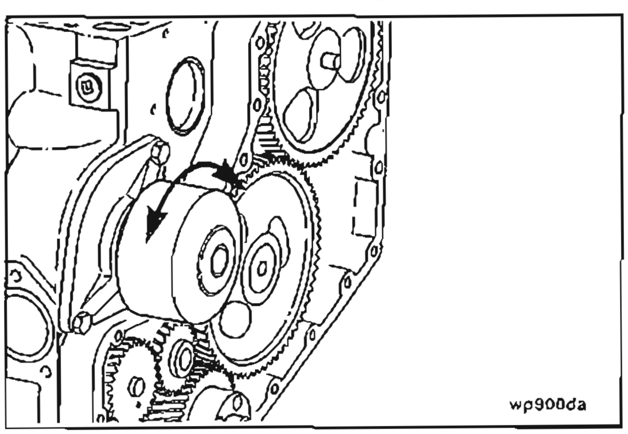
Install the o-ring in the groove in the water pump housing



13 mm

Install the water pump.

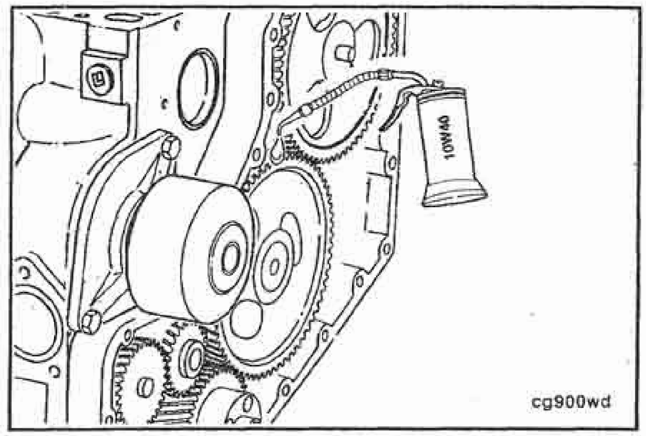
Torque Value: 24 N•m [18 ft-lb]



Rotate the water pump to make sure it turns freely.

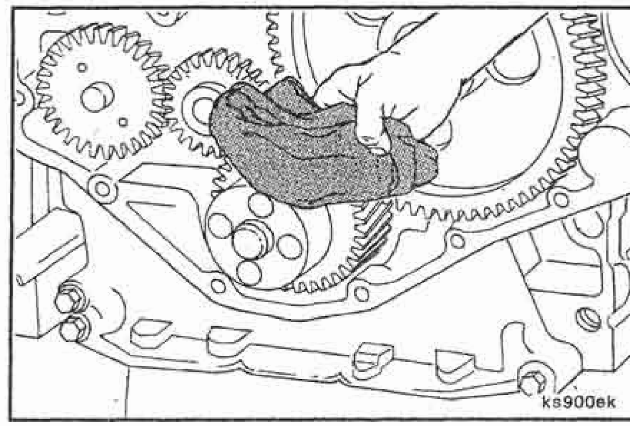
Front Cover - Installation (0-98)

Lubricate the front gear train with clean engine oil.



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

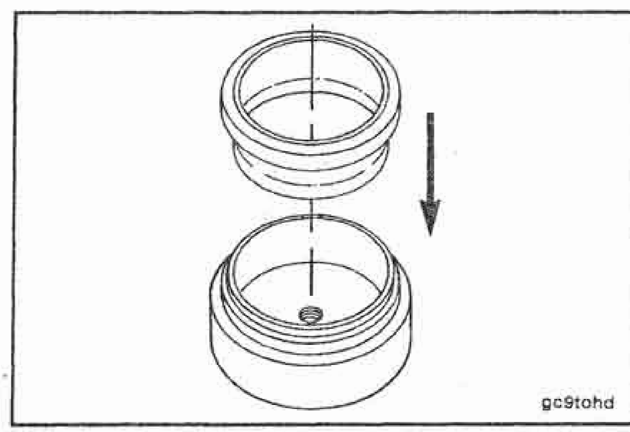
Thoroughly clean and dry the front seal area of the crankshaft.



3824498 Installation Tool

Leave the plastic pilot installation tool in the lubricating oil seal.

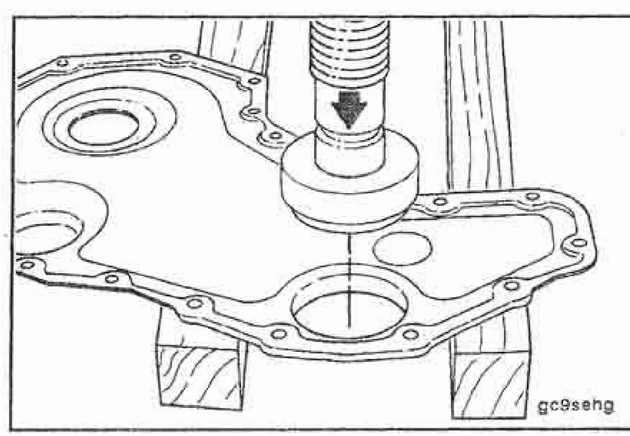
Position the seal on the service tool, Part No. 3824499, with the lubricating oil seal dust lip facing outward.

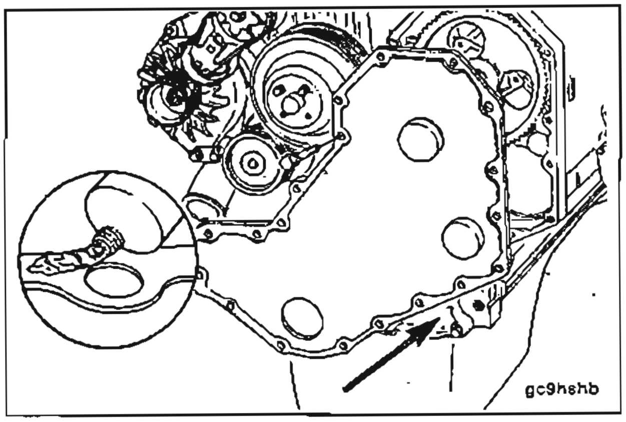


NOTE: Properly support the front cover lubricating oil seal flange to prevent damage to the lubricating oil seal and front cover.

Press the lubricating oil seal into the front cover from the back side of the cover toward the front side of the cover.

Press the lubricating oil seal until the service tool bottoms against the front cover.

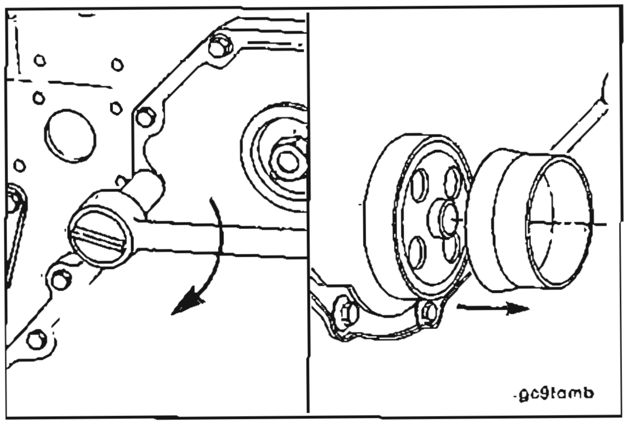




Apply a thin bead of Three Bond™ to the cover side of the front cover gasket only..

NOTE: Do not remove the plastic seal pilot tool from the lubricating oil seal at this time. Use the plastic seal pilot tool to guide the seal on the crankshaft.

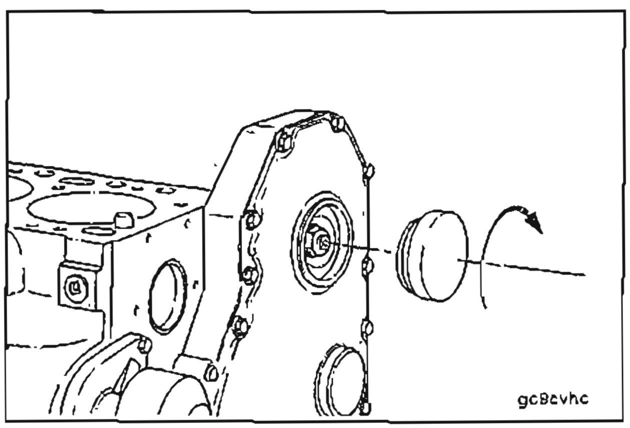
Install the gasket and front cover on the engine.



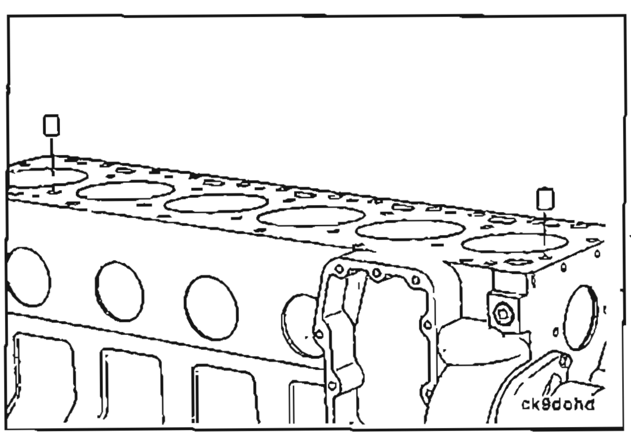
10 mm

Remove the alignment/installation tool after tightening the capscrews.

Torque Value: 24 N•m [18 ft-lb]



Install the front cover access cap and seal.



Cylinder Head - Installation (0-99)

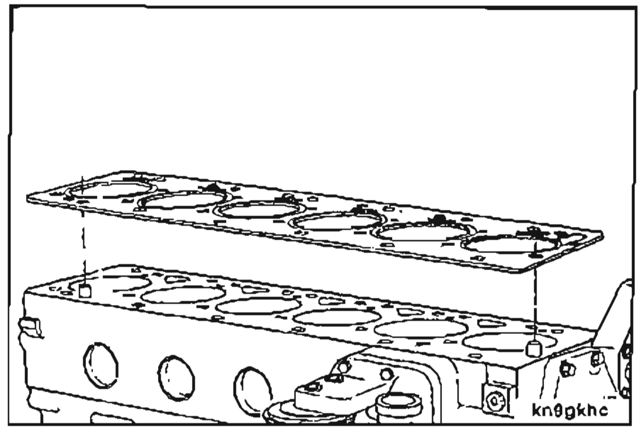
Caution: Make sure the cylinder head and block surface are clean and not nicked or gouged.

Mallet

If removed, install the two cylinder head dowels. Drive the dowels to the bottom of the dowel bore.

Caution: Be sure the gasket is correctly aligned with holes in the block.

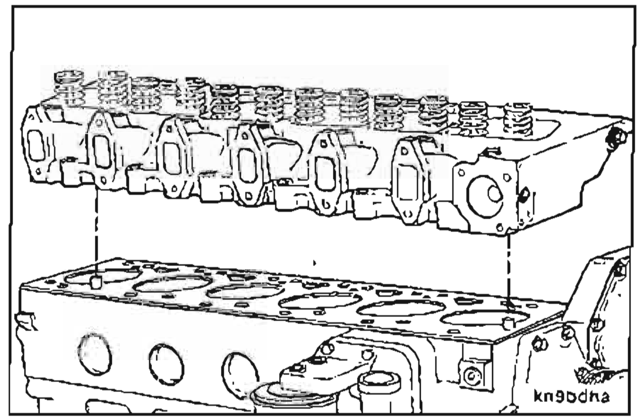
Position the head gasket over the dowels.



Carefully put the cylinder head on the block and seat it onto the dowels.

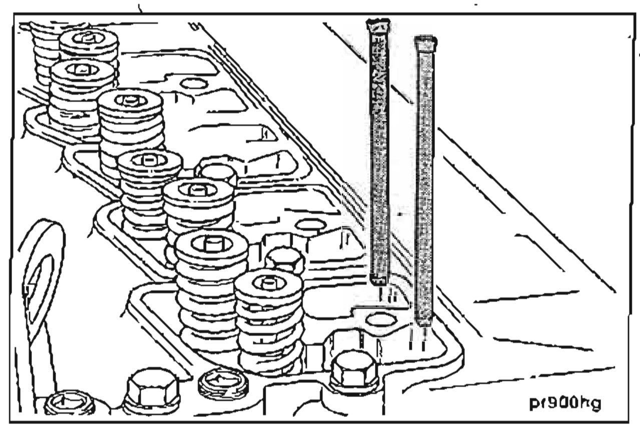
Cylinder Head Weight:

4 Cylinder 36 Kg [80 lb]
6 Cylinder 51.3 Kg [114 lb]

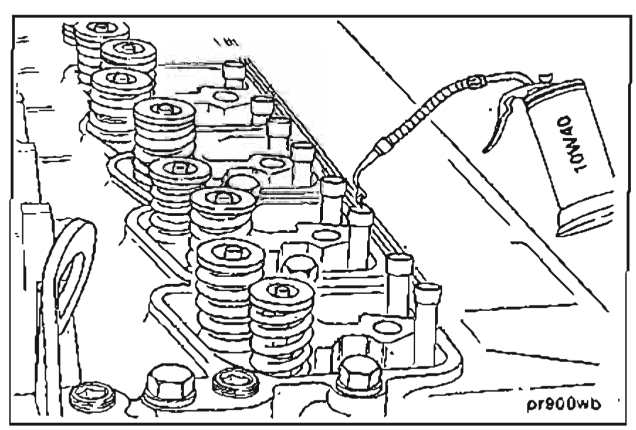


Push Rods - Installation (0-100)

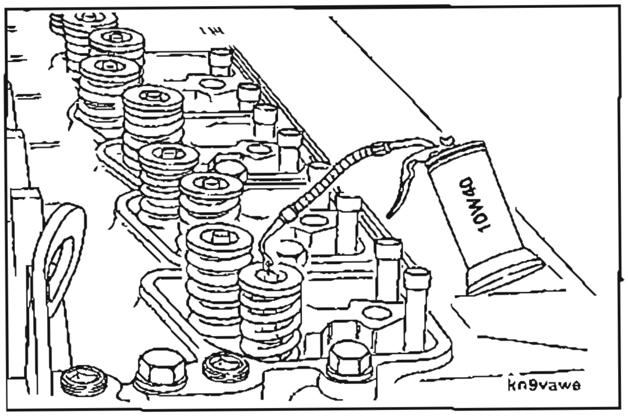
Position the push rods into the valve tappets.



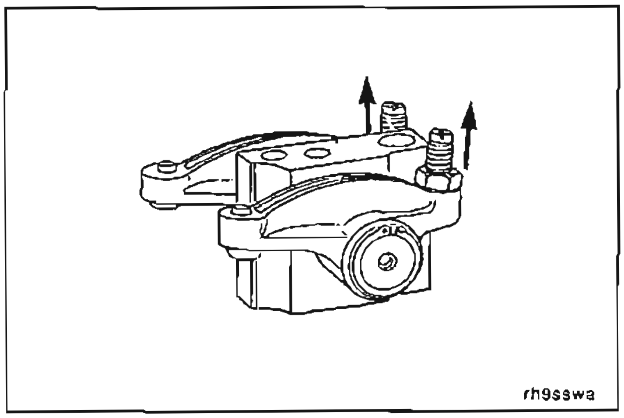
Lubricate the push rod sockets with engine oil.



Rocker Levers - Installation (0-101)

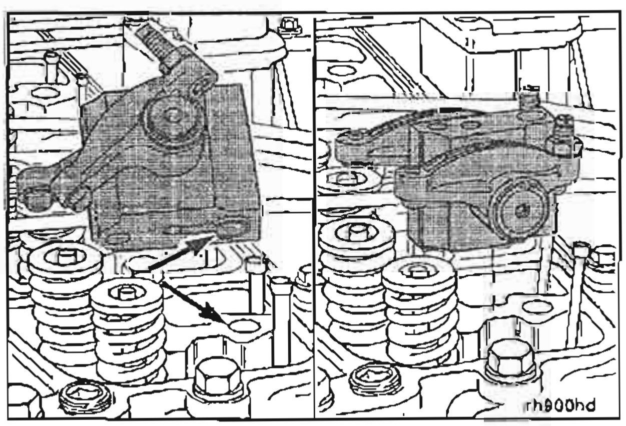


Lubricate the valve stems with engine oil.



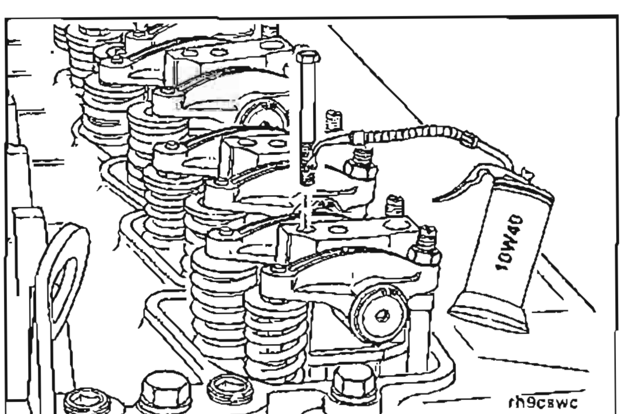
14 mm, Flat Blade Screwdriver

Completely loosen the rocker lever adjusting screws.



NOTE: The rocker lever pedestals are aligned with dowels.

Install the pedestals.

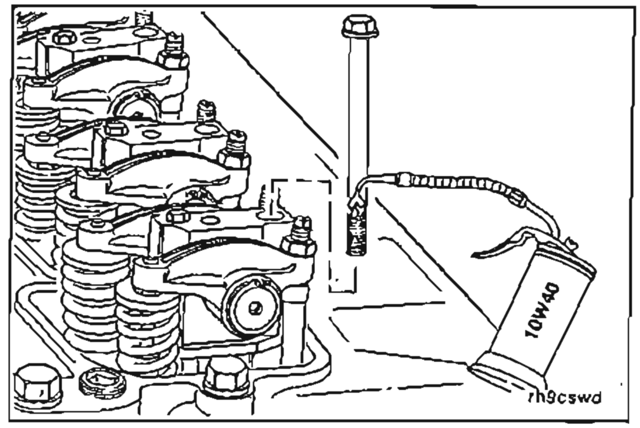


Lubricate the 8mm pedestal capscrew threads and under the capscrew heads with engine oil.

Install the capscrews finger tight.

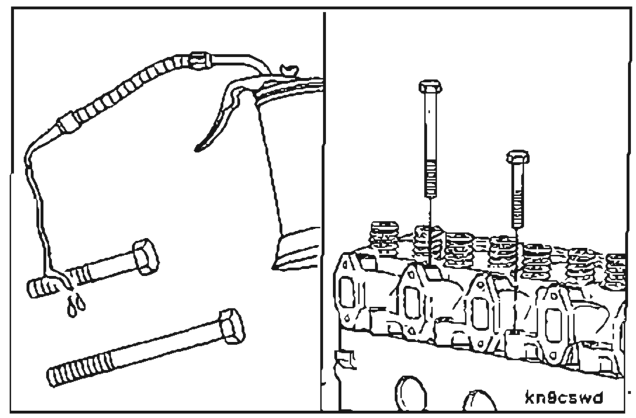
Lubricate the 12mm pedestal/head capscrew bolt threads and under the capscrew heads with engine oil.

Install the capscrews finger tight.



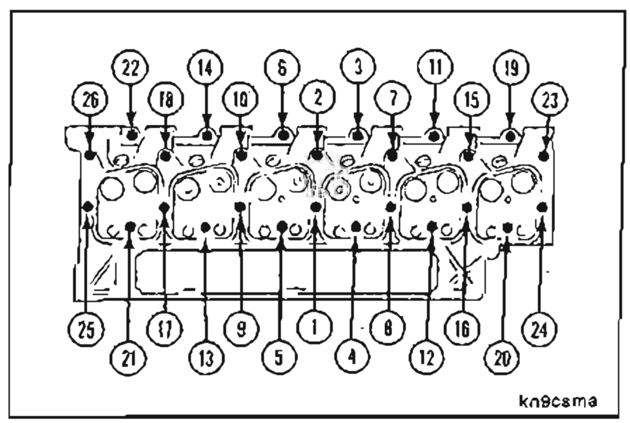
Lubricate the threads and under the heads on the remaining head capscrews with engine oil.

Install the capscrews finger tight.

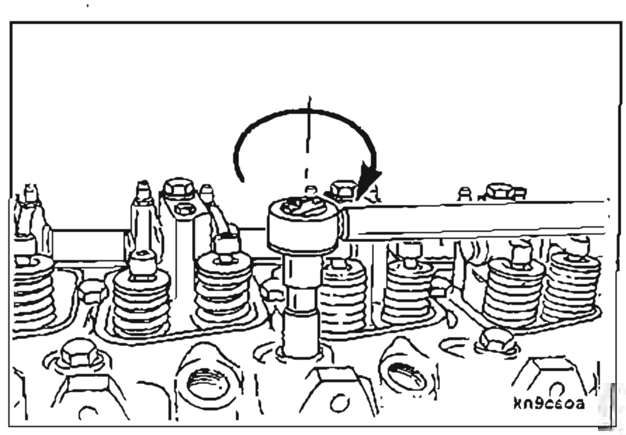


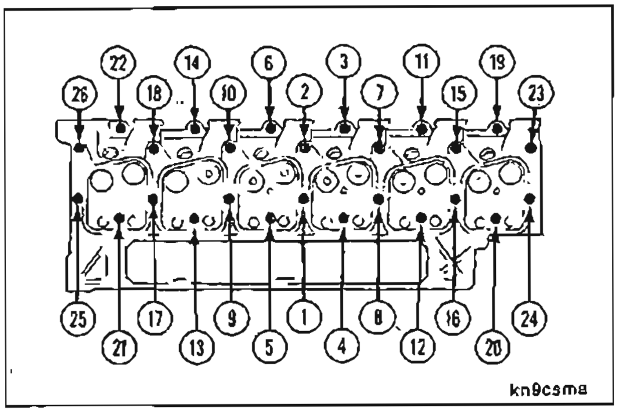
Cylinder Head - Tightening (0-102)

Use the illustrated sequence to tighten the cylinder head capscrews.

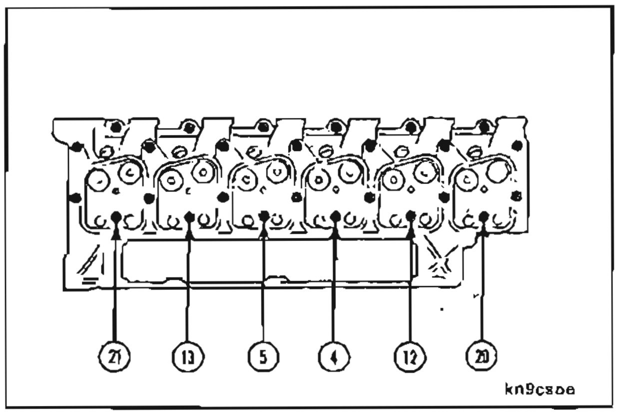


Follow the numbered sequence as shown above and tighten all capscrews to 90 Nm [66 ft-lb].

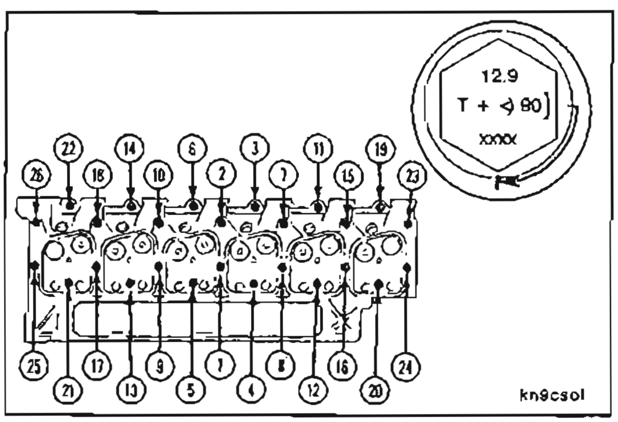




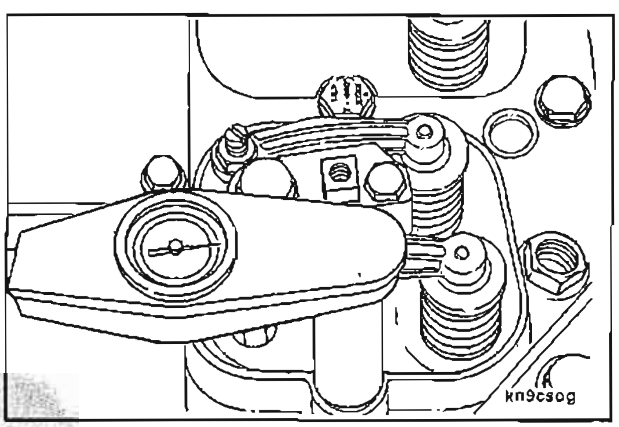
Follow the numbered sequence and recheck the torque on all capscrews to 90 Nm [66 ft-lb].



Follow the numbered sequence and tighten ONLY THE SIX LONG CAPSCREWS (No. 4, 5, 12, 13, 20 ,21) to 120 Nm [89 ft-lb].



Follow the numbered sequence and turn all capscrews an additional 90° of rotation.

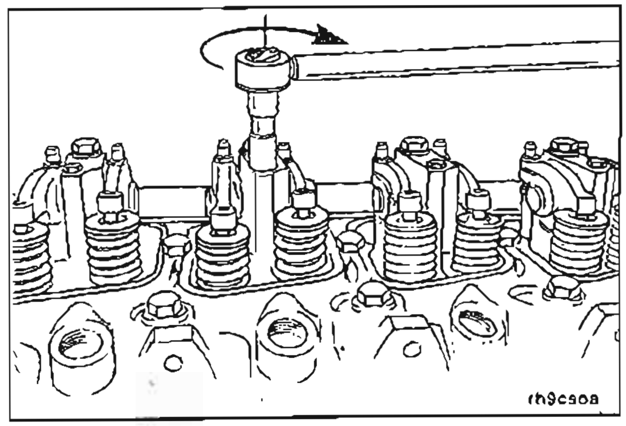


As an overcheck to make sure all capscrews have been rotated 90° check the torque on all capscrews to 136 Nm [102 ft-lb]. If any capscrews turn at 136 Nm [102 ft-lb] loosen only that capscrew and retighten using the above mentioned sequence.

13 mm

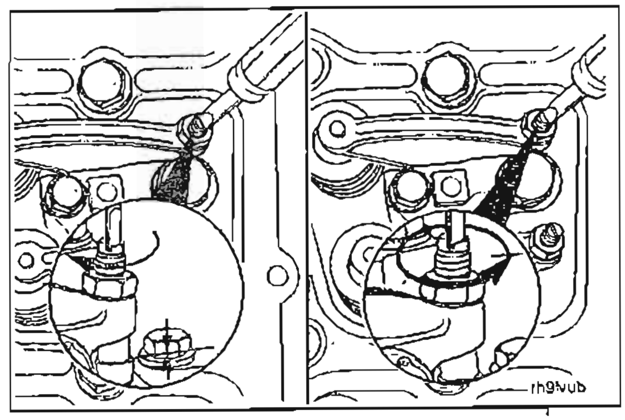
Tighten the 8mm pedestal capscrews.

Torque Value: 24 N•m [18 ft-lb]

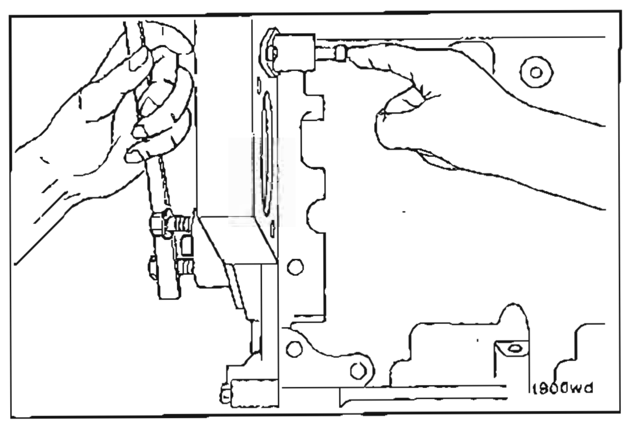


Valve Clearance - Adjustment (0-103)

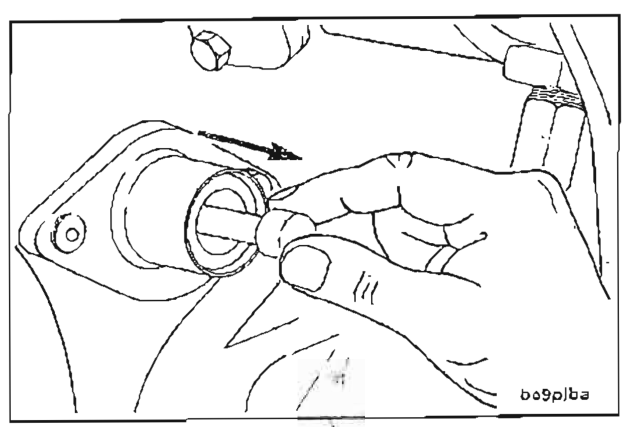
Turn the valve adjustment screws in until they touch the push rod sockets. Loosen them one full turn.

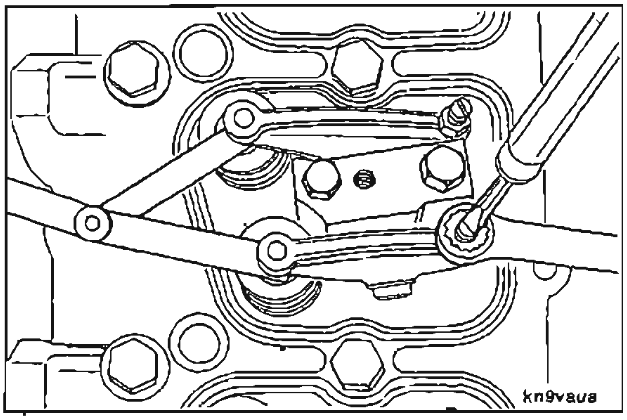


Locate TDC for Cylinder Number 1



Disengage the timing pin.





Feeler Gauge

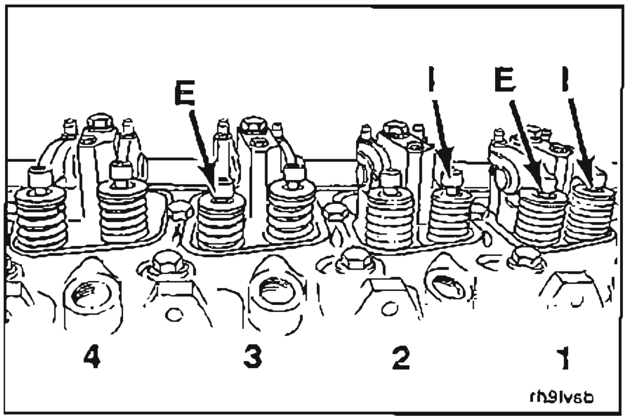
Valve Stem to Rocker Lever Clearance

Intake Valve	Exhaust Valve
0.254 mm [0.010 in]	0.508 [0.020 in]

The clearance is correct when some resistance can be "felt" when the feeler gauge is pulled through the space between the valve stem and rocker lever.

Adjust the valves as indicated in the following illustrations. Tighten the locknuts and check the clearance again.

Torque Value: 24 N•m [18 ft-lb]

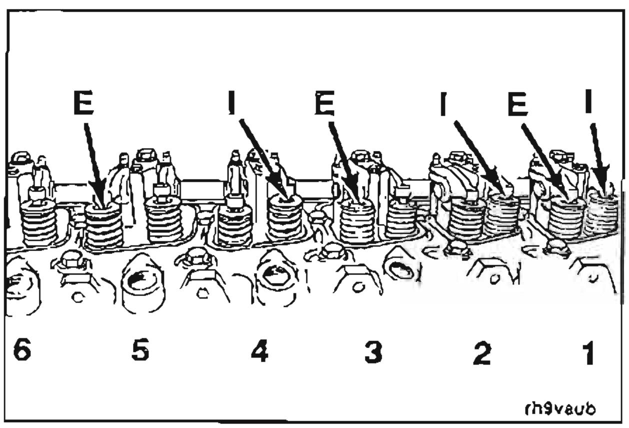


Caution: Perform step A of the valve set procedure with Cylinder Number 1 at TDC compression stroke (timing pin will engage).

Step A Four Cylinder

	Valve	
Cylinder	I = Intake	E = Exhaust
1		
2		
3		
4		

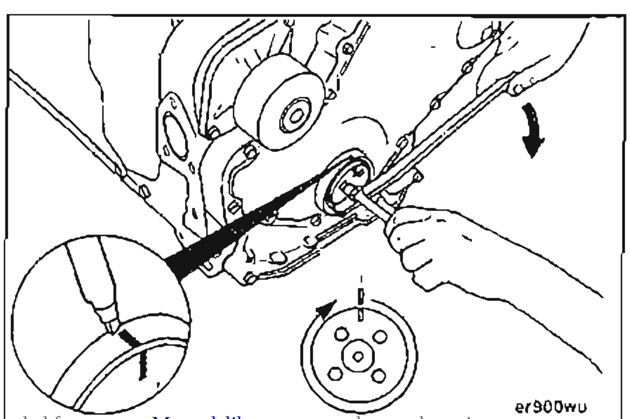
(* = Set)
(- = Do not Set)



Step A Six Cylinder

	Valve	
Cylinder	I = Intake	E = Exhaust
1		
2		
3		
4		
5		
6		

(* = Set)
(- = Do not Set)



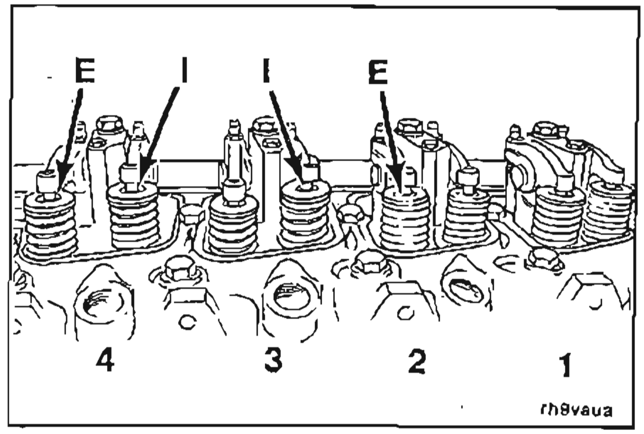
Perform Step B of the valve set procedure with Cylinder Number 1 at TDC plus 360 degrees (timing pin will not engage).

Mark the crankshaft and front cover. Rotate the crankshaft one full turn.

Step B Four Cylinder

Cylinder	Valve I = Intake	E = Exhaust
1		
2		
3		
4		

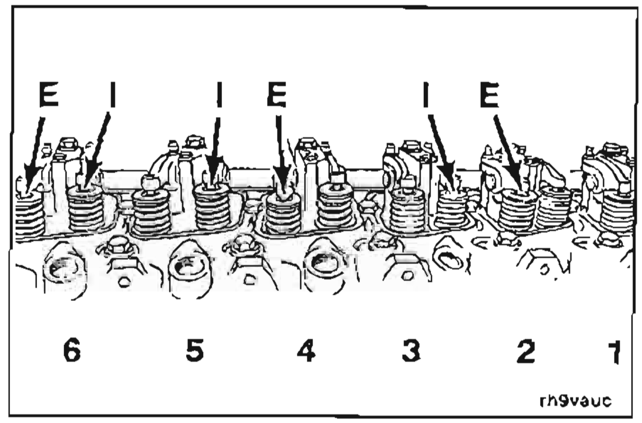
(* = Set)
(- = Do not Set)



Step B Six Cylinder

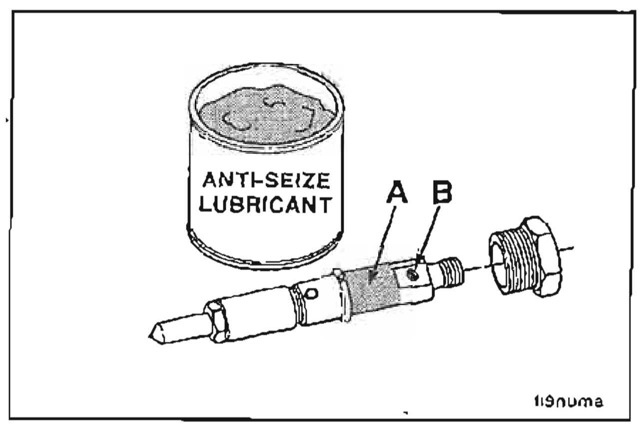
Cylinder	Valve I = Intake	E = Exhaust
1		
2		
3		
4		
5		
6		

(* = Set)
(- = Do not Set)



Injector Nozzles - Installation (0-104)

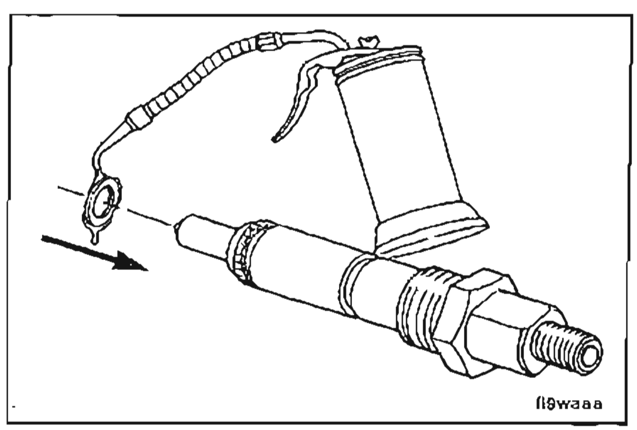
Apply a coat of anti-seize compound to the threads of the injector hold-down nut and between the top of the nut and injector body (A). Avoid getting anti-seize compound in the fuel drain hole (B).

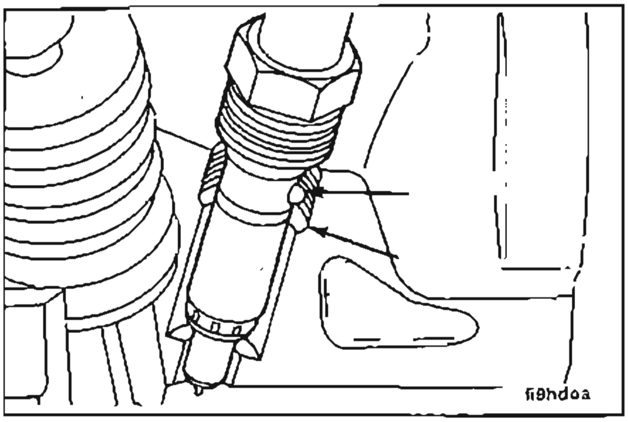


Assemble a sealing washer on each injector.

Use only one sealing washer.

NOTE: A light coat of clean 15W-40 engine oil between the washer and injector can help to keep the washer from falling during installation.





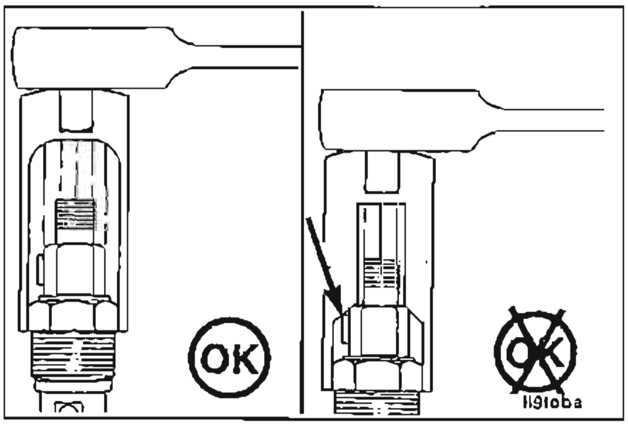
24 mm Deep Well Socket

Install the injectors.

Tighten the injector nozzle nuts.

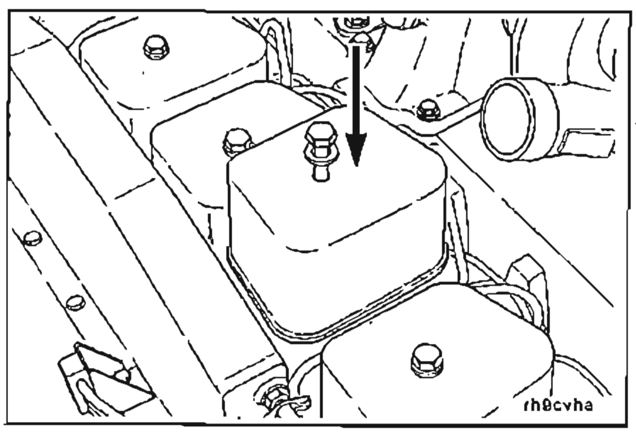
Torque Value: 60 N•m [44 ft-lb]

NOTE: The protrusion on the side of the nozzle fits into a notch in the cylinder head to orient the injector.



Caution: Some sockets can damage the sealing surface of the fuel drain outlet.

Valve Covers - Installation (0-105)

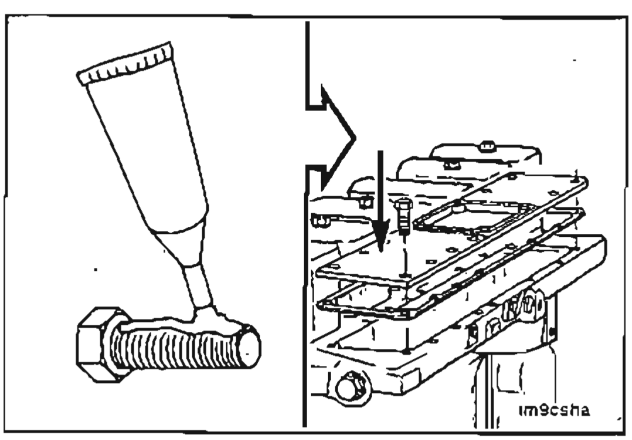


16 mm

Assemble the gaskets, valve covers, o-rings and special capscrews.

Torque Value: 24 N•m [18 ft-lb]

Manifold Cover - Installation (0-106)



3375066 Sealant

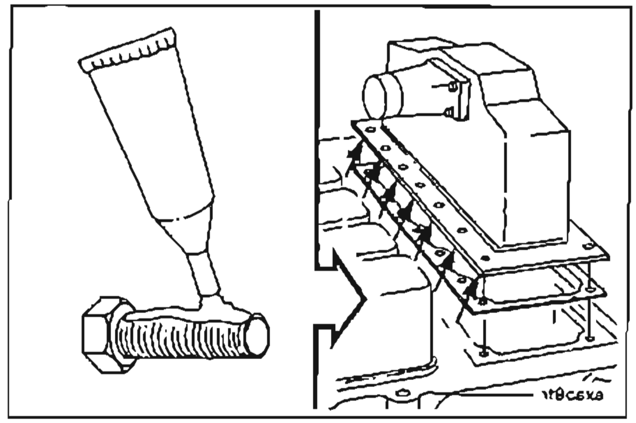
Apply sealant to the capscrews as shown in the illustration.

Install the manifold cover, gasket and capscrews.

Do not tighten the capscrews until the high pressure line brackets are assembled.

Aftercooler - Installation (0-107)

3375066, 3823494 Sealant



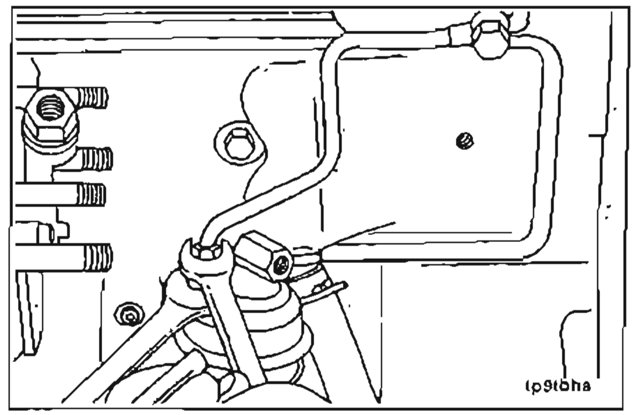
Apply sealant, Part No. 3375066, to the capscrews as shown in the illustration.

Apply a 4 mm bead of sealant, Part No. 3823494, around the sealing surface of the aftercooler as shown in the illustration.

Install the aftercooler. Do **not** tighten the capscrews until the high pressure fuel line brackets are installed.

Fuel Lines - Installation (0-108)

17 mm

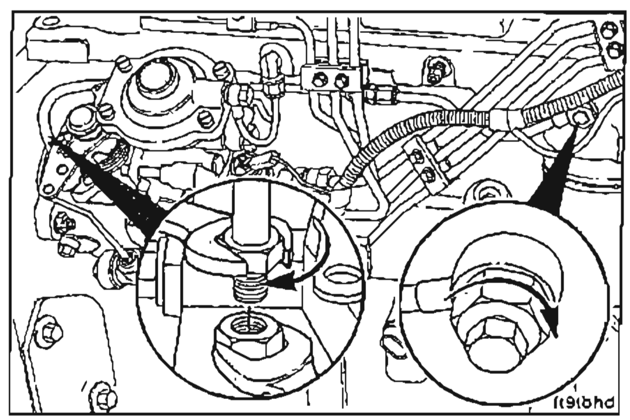


Install the fuel filter supply line.

The banjo fittings at the filter head require sealing washers on each side of the line. The banjo fitting with the vent screw is used to install the pump supply line.

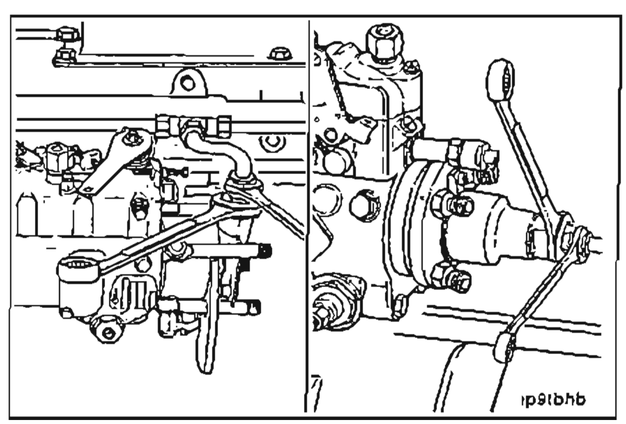
Injection Pump Supply Line - Installation (0-109)

17 and 14 mm

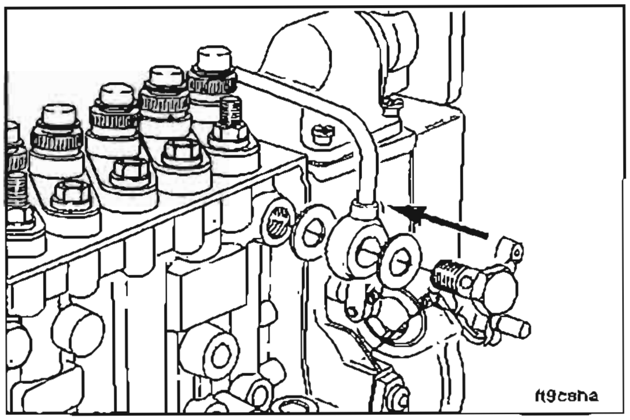


Install the Bosch injection pump supply line.

17 and 14 mm



Install the injection pump fuel supply line for the CAV or Stanadyne injection pump.

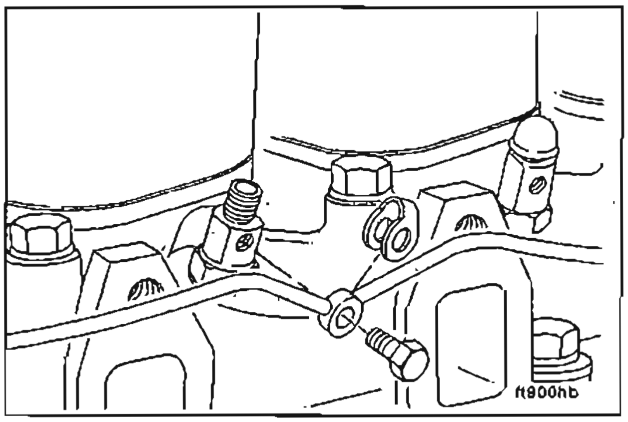


ft9caha

19 mm and 17 mm

Install the Bosch P7100 injection pump fuel supply line.

Torque Value: 32 N•m [24 ft-lb]



ft900hb

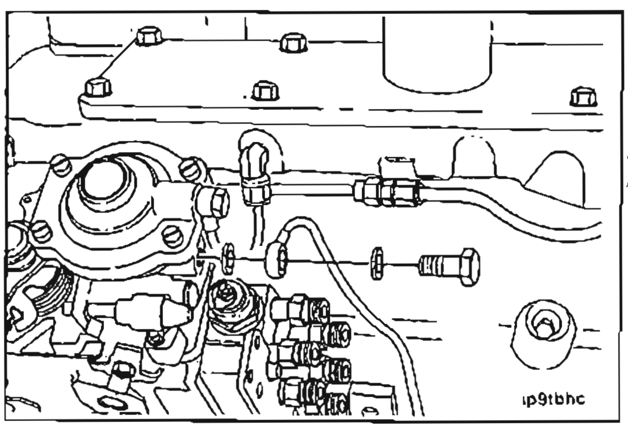
Fuel Drain Manifold - Installation (0-110)

10 mm

Use new sealing washers for the fuel drain manifold.

Install the fuel drain manifold.

Torque Value: 9 N•m [80 in-lb]

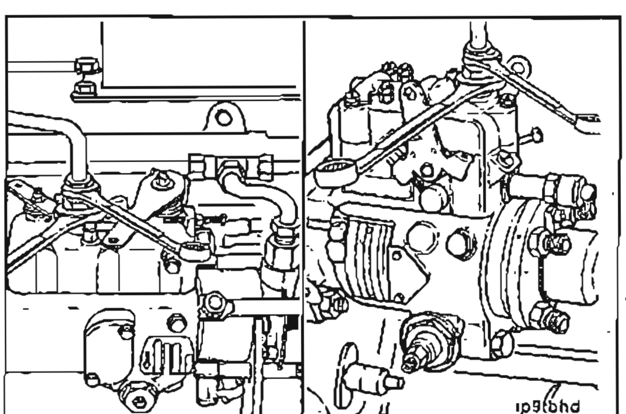


ip9tbhc

Injection Pump Vent Line - Installation (0-111)

10 and 19 mm

Connect the Bosch injection pump vent.



ip9tbhd

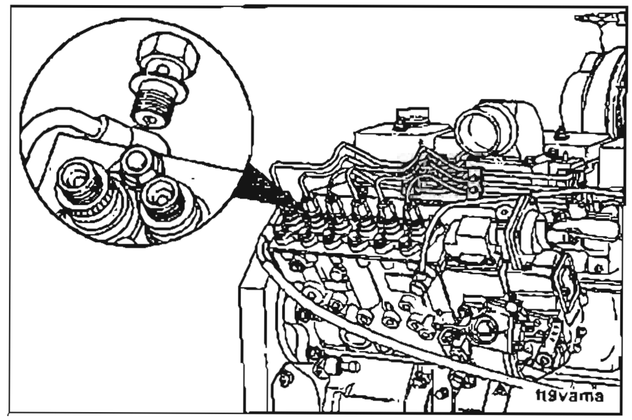
10 and 16 mm

Connect the injection pump vent for the CAV or Stanadyne injection pump.

19 mm

Connect the Bosch P7100 injection pump vent.

Torque Value: 32 N•m [24 ft-lb]



High Pressure Fuel Lines - Installation (0-110)

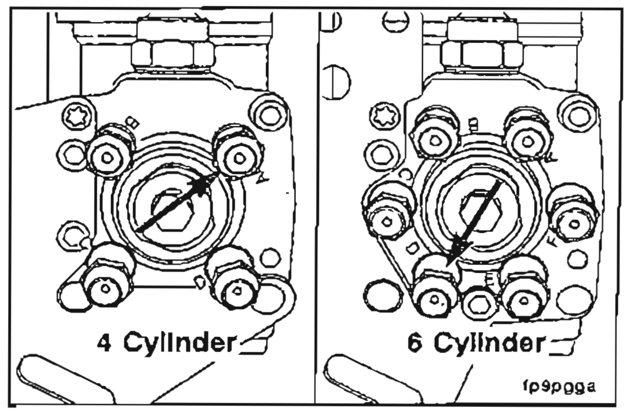
Assemble the high pressure fuel lines.

The number one cylinder delivery valve is marked on the pump as illustrated.

4 cylinder = A
6 cylinder = D

Firing Order

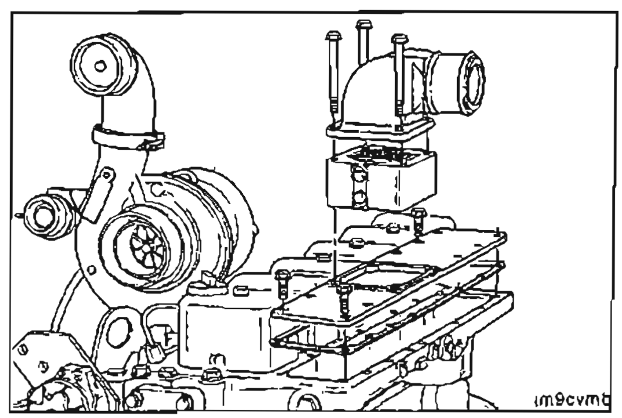
4 Cylinder	6 Cylinder
A = 1	D = 1
B = 3	E = 5
C = 4	F = 3
D = 2	A = 6
	B = 2
	C = 4



13 mm

Tighten all of the manifold cover capscrews.

Torque Value: 24 N•m [18 ft-lb]

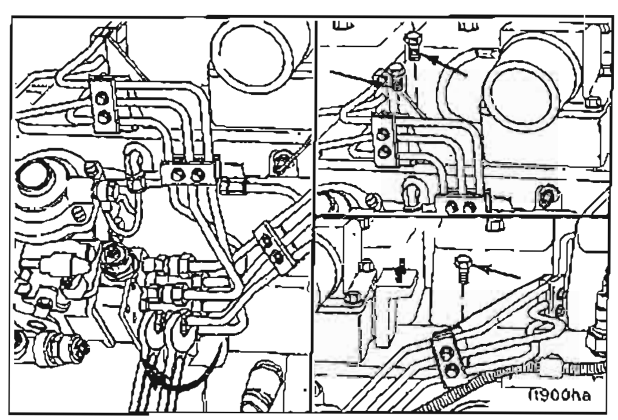


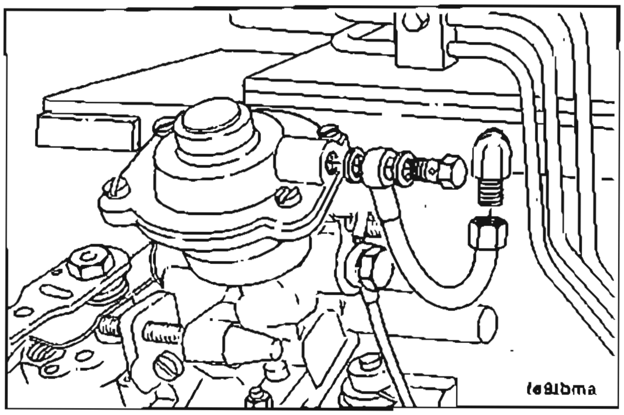
14 mm, 17 mm

Make sure that the high pressure lines will not rub against other engine components.

Tighten the high pressure lines at the injection pump and injectors securely.

Torque Value: 24 N•m [18 ft-lb]

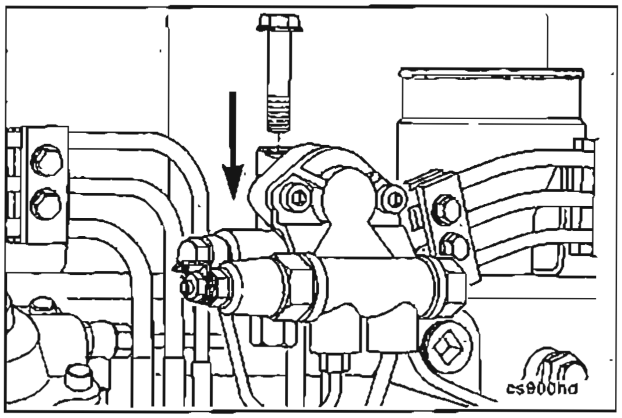




12 mm and 13 mm

Install the air fuel control tube.

Use new sealing washers when installing the tube.

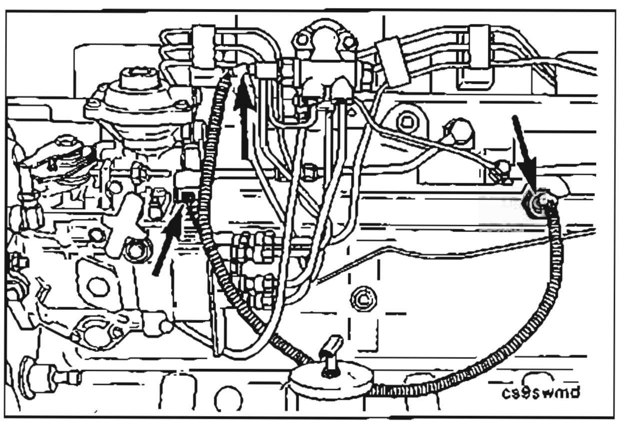


KSB (Remote Mounted) - Installation (0-113)

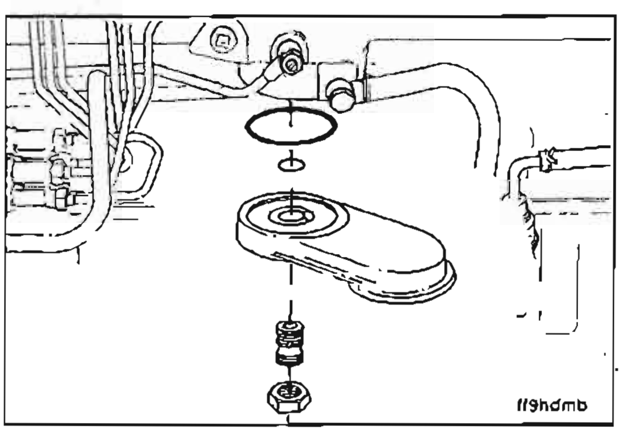
13 mm and 10 mm

Install the remote mounted KSB valve (if equipped) as illustrated.

Torque Values	
Mounting Capscrew	24 N•m [18 ft-lb]
Banjo Screw	8 N•m [6 ft-lb]



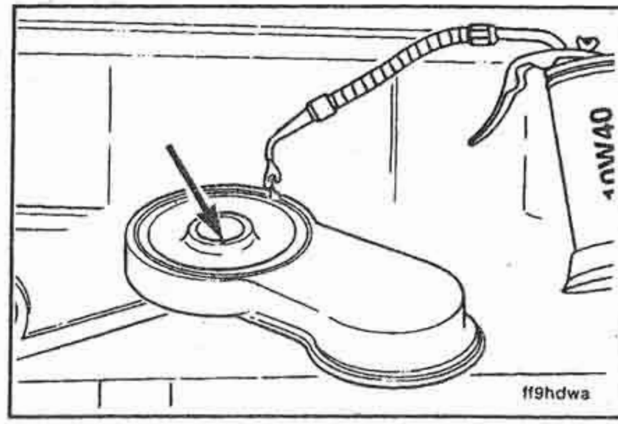
Connect the KSB wiring.



Fuel Filter Head - Installation (0-114)

If the optional dual filter is to be used, install the adapter and square cut sealing ring.

Lubricate the sealing ring and the center hole with engine oil.

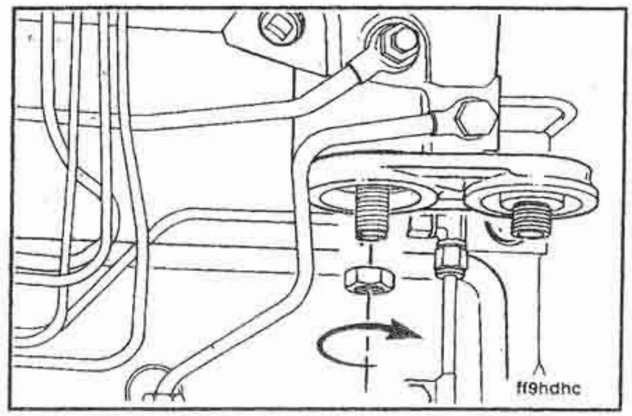


24 mm

Install the dual filter head.

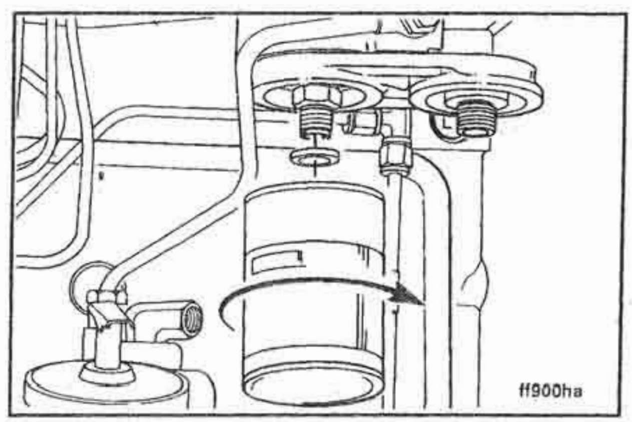
Tighten the nut.

Torque Value: 32 N•m [24 ft-lb]



Temporarily install fuel filter(s).

NOTE: When the engine is ready to be put into service, fill the filter(s) with clean #2 diesel fuel and tighten 1/2 turn after the lubricated gasket contacts the filter head.



Exhaust Manifold - Installation (0-113)

"Package" the exhaust manifold capscrews and gaskets on the manifold. Apply anti-seize compound to the capscrews.

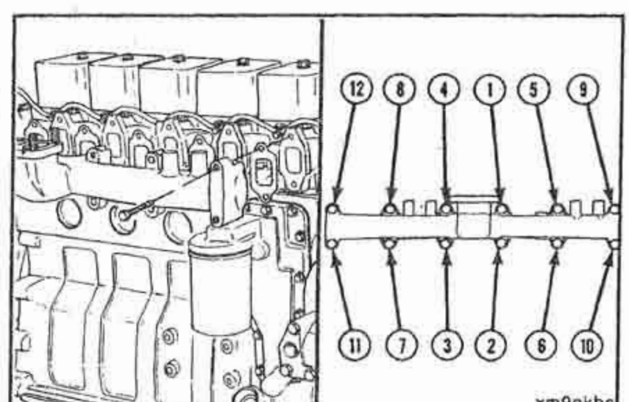
NOTE: The bead on the exhaust manifold gasket can be installed in either direction.

13 mm

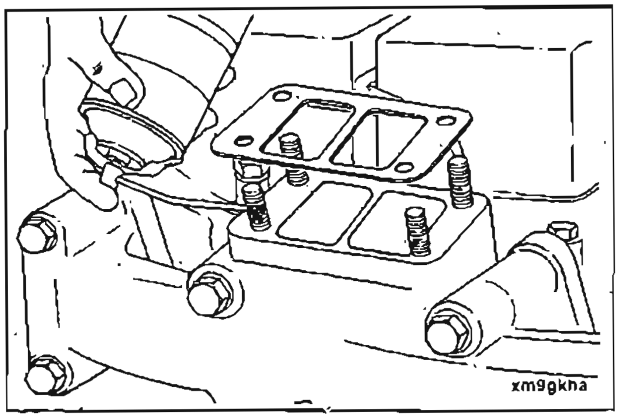
Install the exhaust manifold and gaskets.

Torque Value: 43 N•m [32 ft-lb]

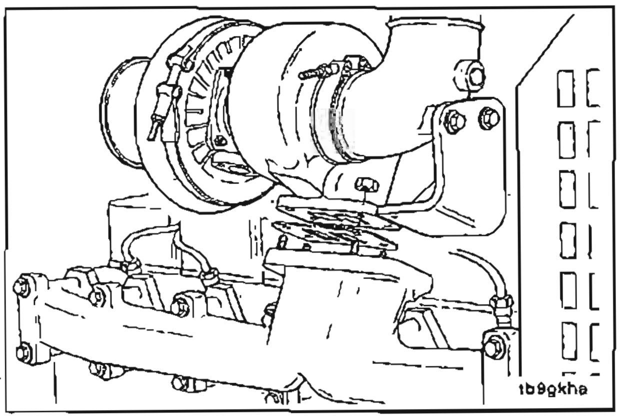
Follow the sequence shown.



Turbocharger - Installation (0-116)



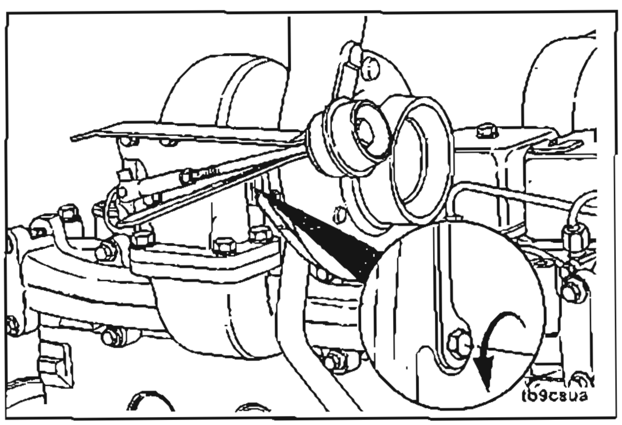
Install the turbocharger gasket and apply anti-seize compound to the mounting studs.



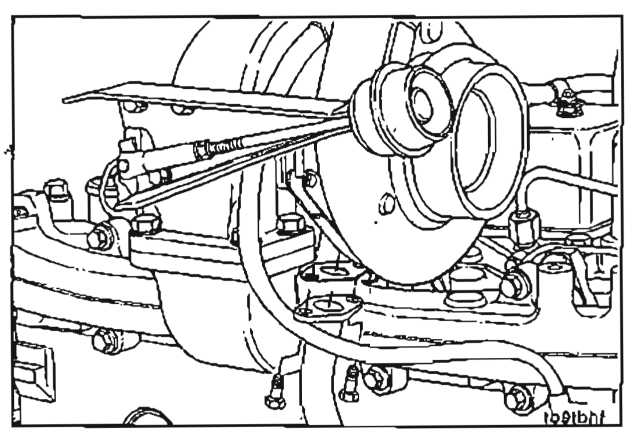
15 mm

Install the turbocharger.

Torque Value: 45 N•m [33 ft-lb]



If required, loosen the turbine housing capscrews and position the bearing housing to install the turbocharger drain tube.

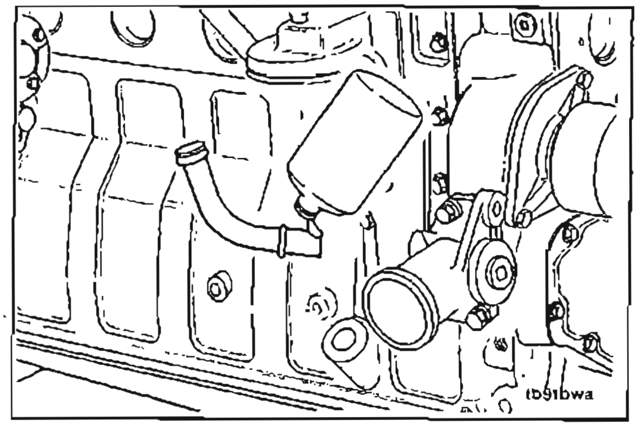


13 mm

Install the hose and clamps on the turbocharger drain tube loosely. Install the drain tube and gasket on the turbocharger.

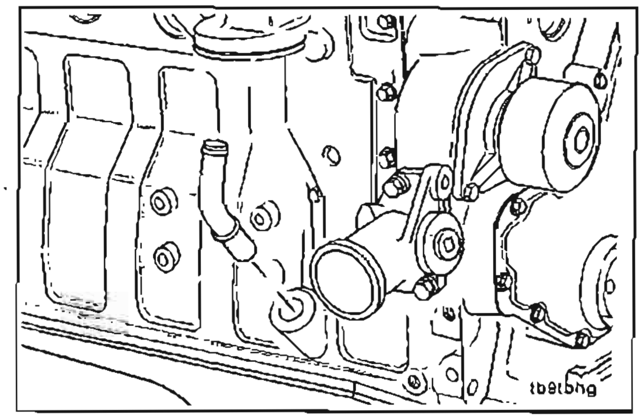
Torque Value: 24 N•m [18 ft-lb]

If the drain tube in the block was removed, apply sealant Part Number 3375068 to the sealing surfaces.



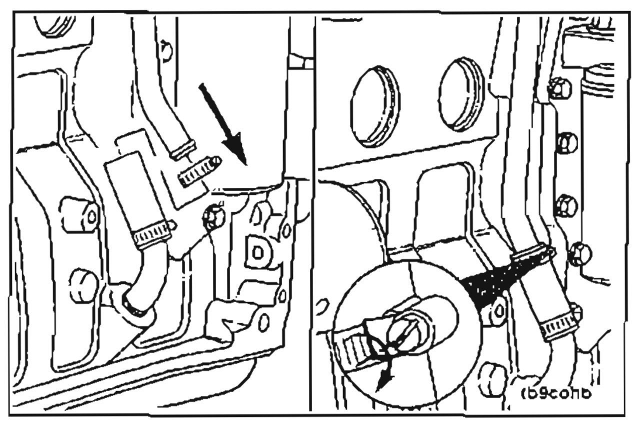
22 mm Open End Wrench, Hammer

Install the tube in the block so it is aligned with the turbocharger drain tube.



Screwdriver

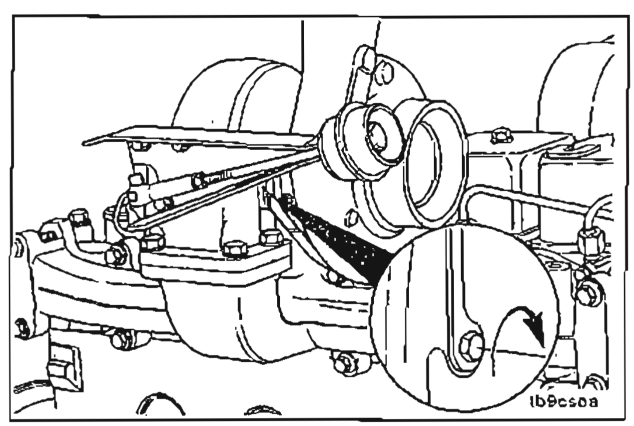
Position the turbocharger drain hose to connect the drain tubes; tighten the clamps.

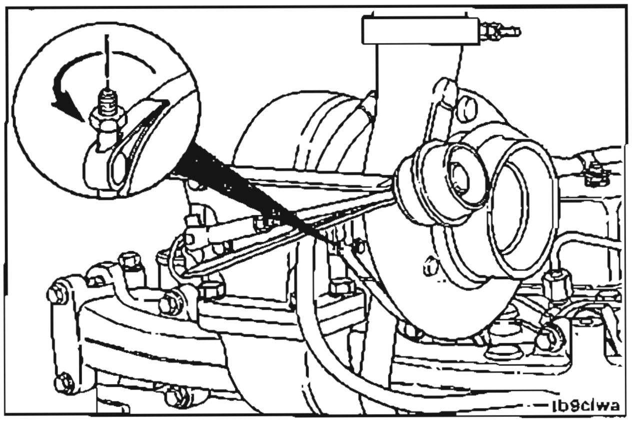


13 mm

If loosened, tighten the turbocharger turbine housing capscrews.

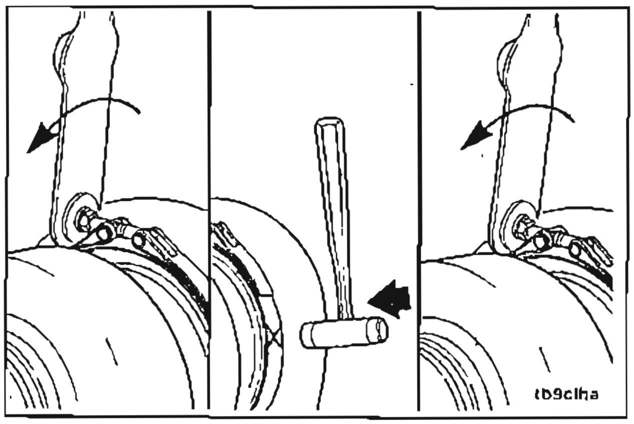
Torque Value: 20 N•m [15 ft-lb]





7/16 Inch

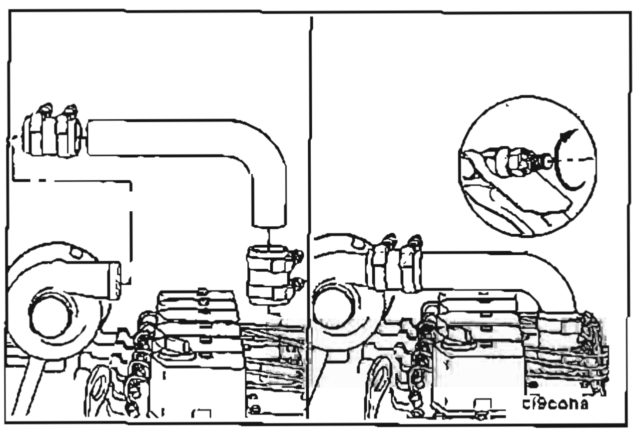
If required, loosen the compressor housing v-band clamp and position the housing to align with the air crossover tube.



7/16 Inch Plastic Hammer

Tighten the band clamp. Tap around the clamp with a plastic hammer and tighten again.

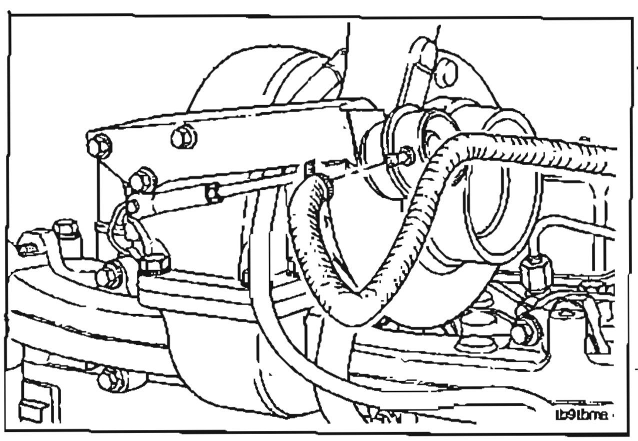
Torque Value: 8.5 N•m [75 in-lb]



Screwdriver or 5/16 inch

Install the air crossover tube and clamps and tighten.

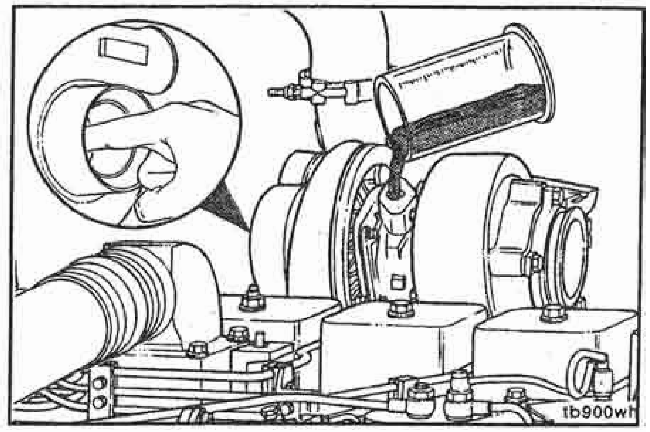
Torque Value: 8 N•m [71 in-lb]
5 N•m [44 in-lb]



Install the boost control capsule actuator hose.

Caution: The Turbocharger must be prelubricated.

Pour 50 to 60cc [2 to 3 oz.] of clean engine oil into the oil inlet fitting on top of the turbocharger while spinning the turbocharger impeller to distribute the oil in the bearing.

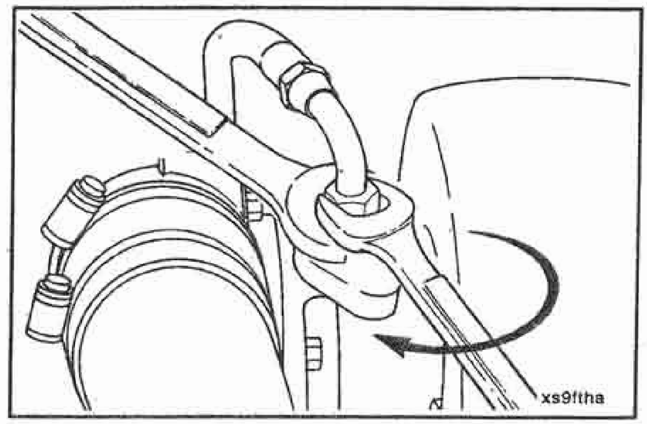


16 mm and 19 mm

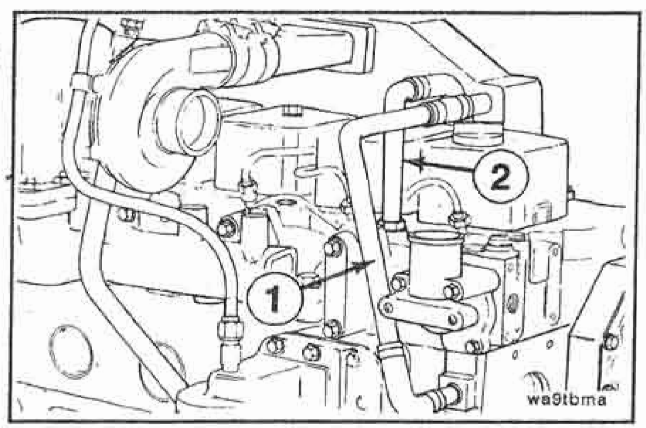
Install the oil supply line.

Tighten the fittings securely.

Torque Value: 15 N•m [11 ft-lb]
35 N•m [26 ft-lb] (on turbocharger)

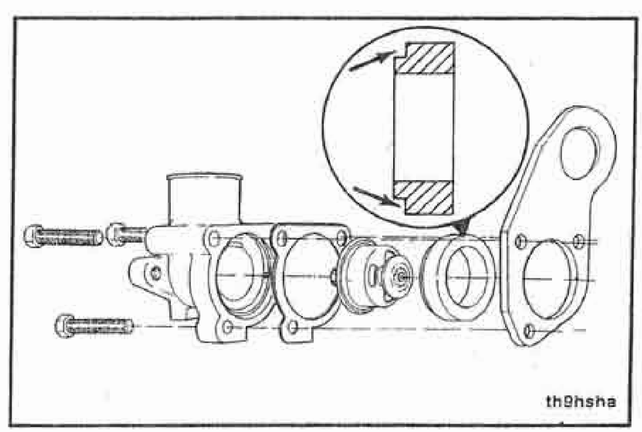


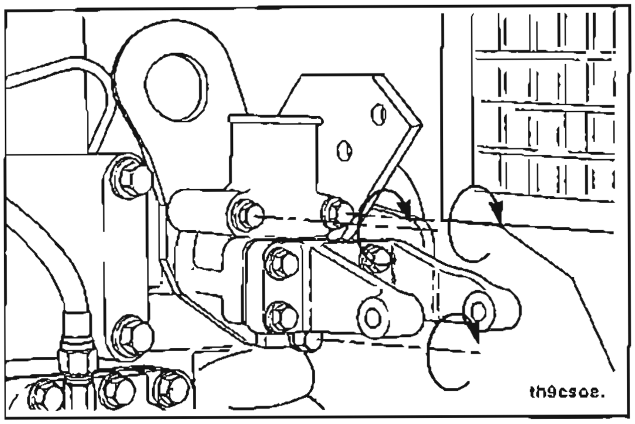
Connect the aftercooler coolant supply tube (1) and the coolant return tube (2).



Thermostat - Installation (0-117)

"Package" the lifting bracket and thermostat gasket to the thermostat and thermostat housing. Position the rubber seal as shown.

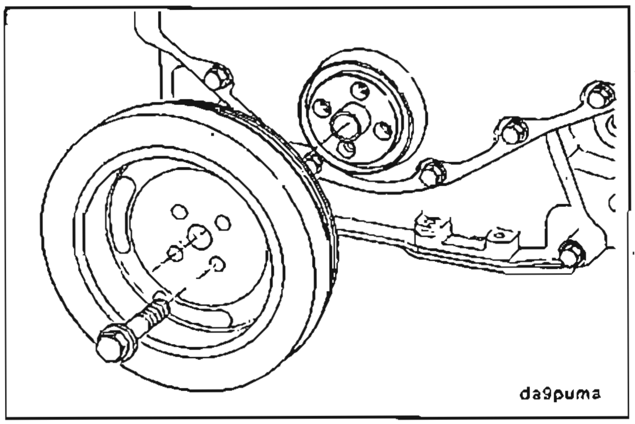




10 mm

Install the "package"

Torque Value: 24 N•m [18 ft-lb]

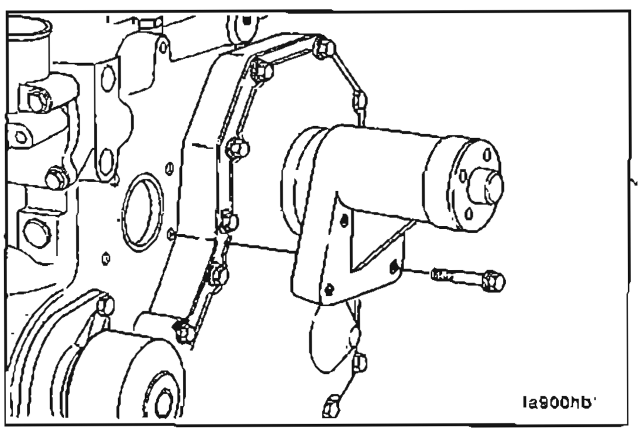


Vibration Damper - Installation (0-118)

15 mm

Install the crankshaft pulley/vibration damper.

Torque Value: 125 N•m [92 ft-lb]

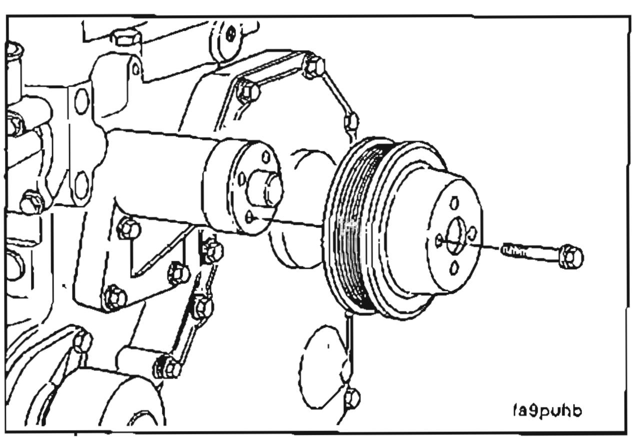


Fan Hub - Installation (0-119)

10 mm

Install the fan hub.

Torque Value: 24 N•m [18 ft-lb]



10 mm or 13 mm

Install the fan hub pulley.

	Torque Value
8 mm Capscrew	24 N•m [18 ft-lb]
10 mm Capscrew	43 N•m [32 ft-lb]

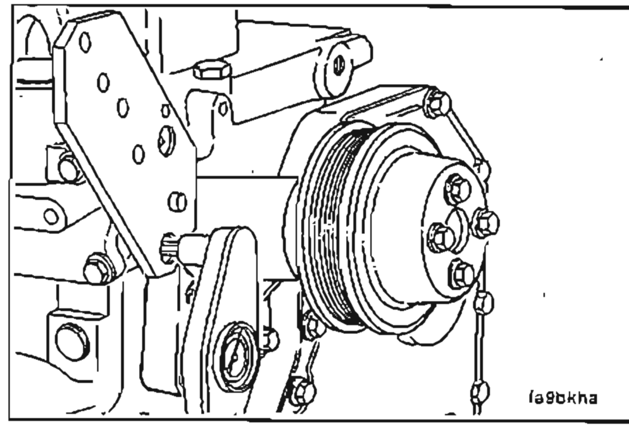
Belt Tensioner - Installation (0-120)

5 mm Allen

Install the tensioner bracket to the cylinder head.

Tighten the socket head screws.

Torque Value: 24 N•m [18 ft-lb]

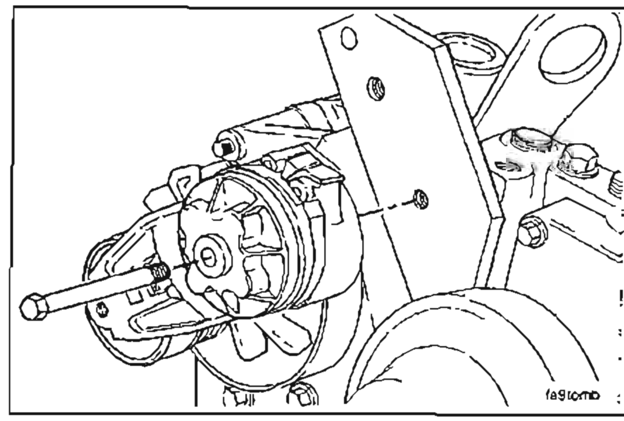


13 mm

Position the belt tensioner on the bracket and secure it with the capscrew.

Torque Value: 43 N•m [32 ft-lb]

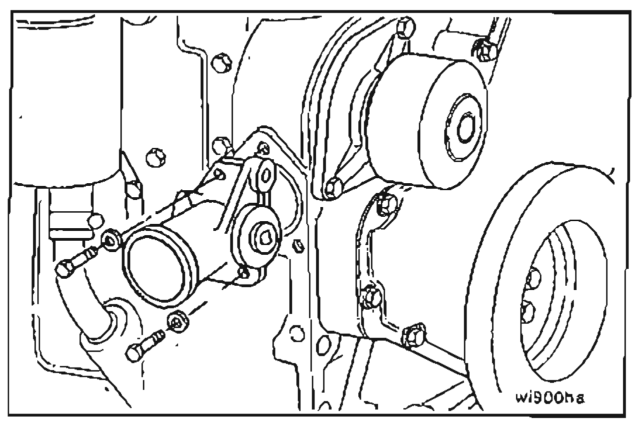
NOTE: Some tensioners can be bolted to two different locations on the bracket. Install into the location dictated by your requirement.



Water Inlet Connection - Installation (0-121)

Caution: Do not tighten at this time. To avoid misalignment and overstressing the lower support mounting ear on the alternator, leave the capscrews loose until all the alternator parts are installed.

Install the water inlet connection and sealing ring.

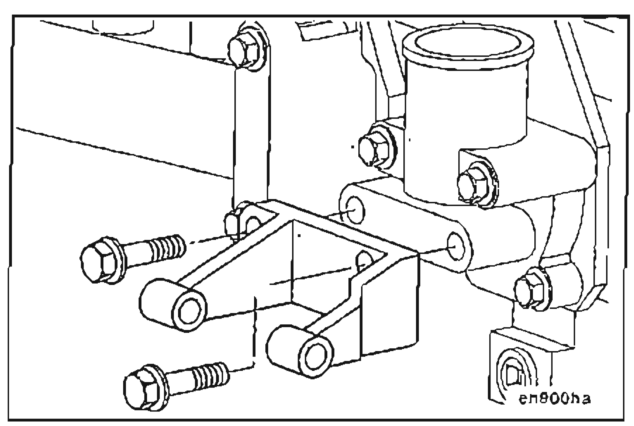


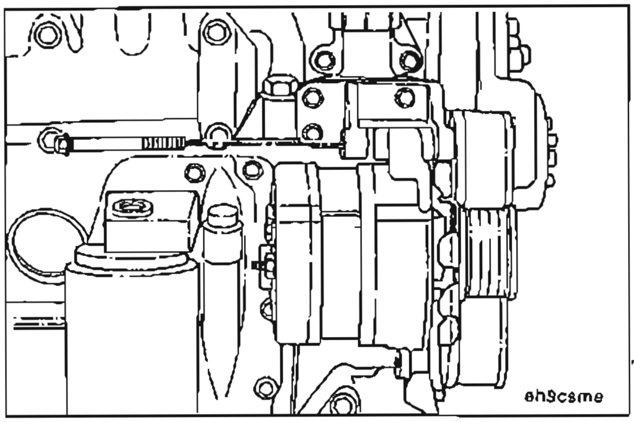
Alternator - Installation (0-122)

10 mm

Assemble the alternator bracket to the thermostat housing.

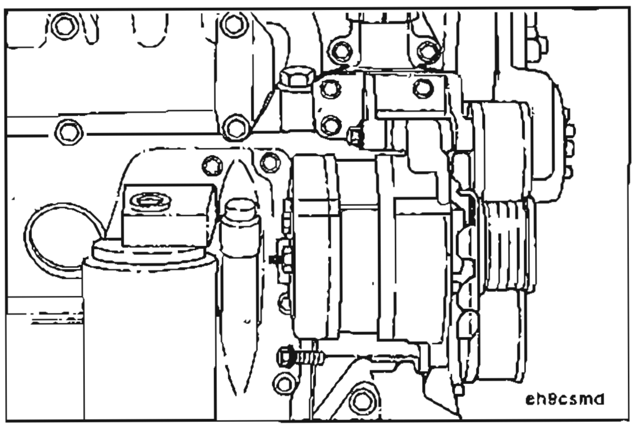
Torque Value: 24 N•m [18 ft-lb]





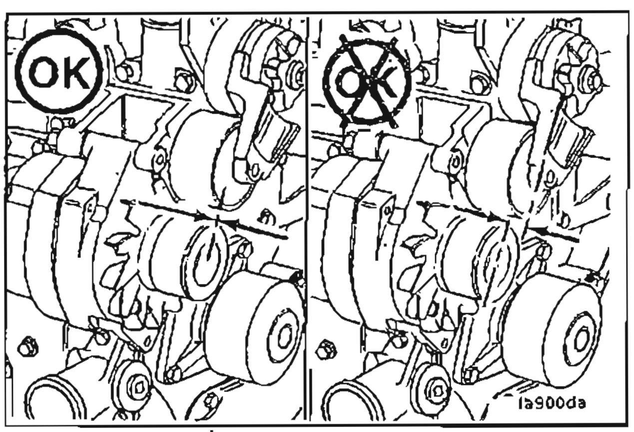
Position the alternator on the bracket and secure it with the mounting capscrew and spacer.

Do not tighten at this time.

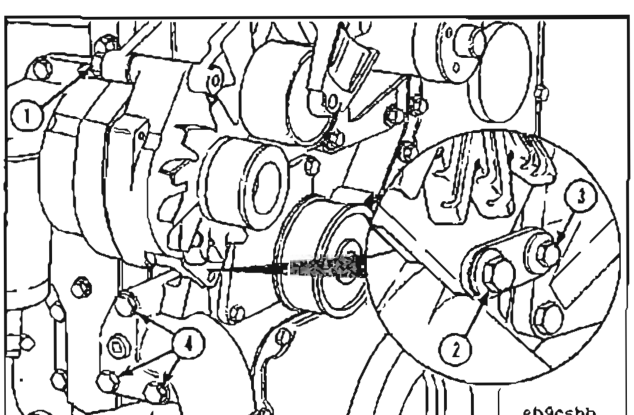


Caution: Do not tighten at this time. To avoid misalignment and overstressing the lower support mounting ear on the alternator, leave the capscrews loose until all the alternator parts are installed.

Install the alternator link.



Check the alternator pulley visually or with a straight edge to make sure it is aligned with the other pulleys and is parallel to the front face of the block.



After all parts are assembled, tighten all capscrews in the following sequence:

1. Alternator-to-alternator bracket capscrew.
2. Lower brace-to-alternator capscrew.
3. Alternator-to-water inlet capscrew.
4. Water inlet-to-block capscrews.

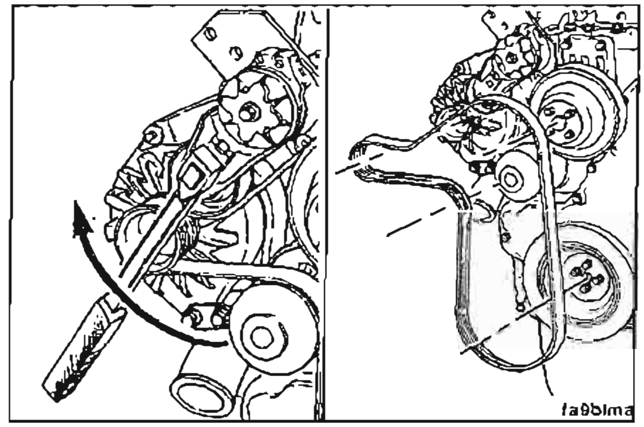
NOTE: Wrench size and torque value is determined by the make and model of alternator. Refer to the Engine Component Torque Values.

Drive Belt - Installation (0-123)

3/8 inch Square Drive

Lift the tensioner and install the belt.

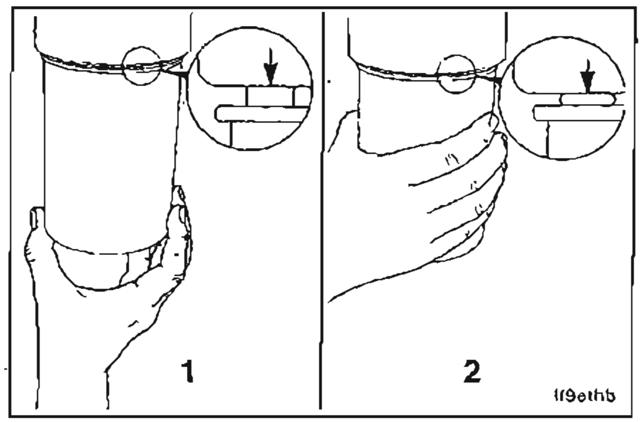
Service Tip: If difficulty is experienced installing the drive belt (the belt seems too short), position the belt over the grooved pulleys first and then while holding the tensioner up, slide the belt over the water pump pulley.



Oil Filter - Installation (0-124)

Lubricate the filter seal and tighten the filter according to the filter manufacturer's instructions.

Be sure to use the correct filter for your engine. Fleetguard LF3345 is used **only** for the 4B engine. Fleetguard LF3349 can be used for the 4B and 6B engine.

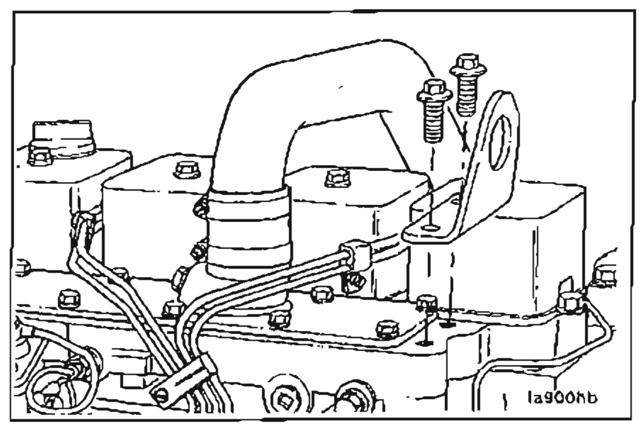


Rollover Stand - Engine Removal (0-125)

18 mm

Install the rear lifting bracket.

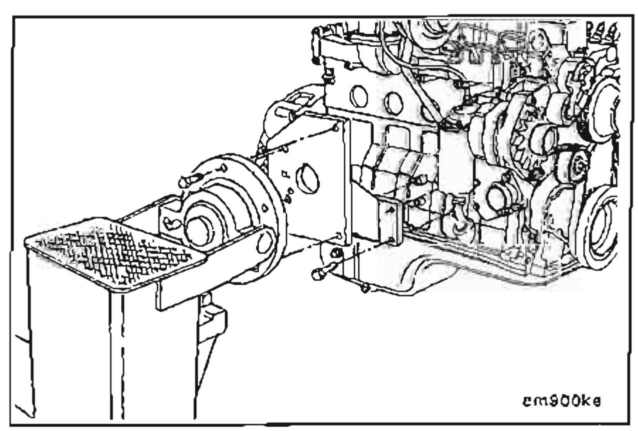
Torque Value: 77 N•m [57 ft-lb]

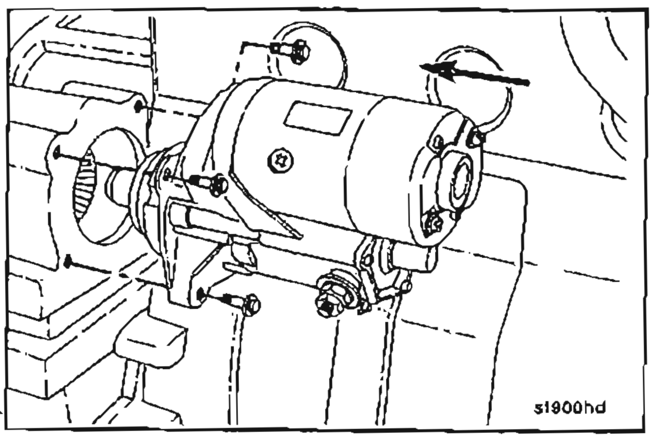


Remove the engine from the rollover stand.

Engine Weight

4B engine (wet) weight: 325-350 Kg [715-770 lb]
6B engine (wet) weight: 410-440 Kg [910-970 lb]





Starter - Installation (0-126)

10 mm

Install the starting motor.

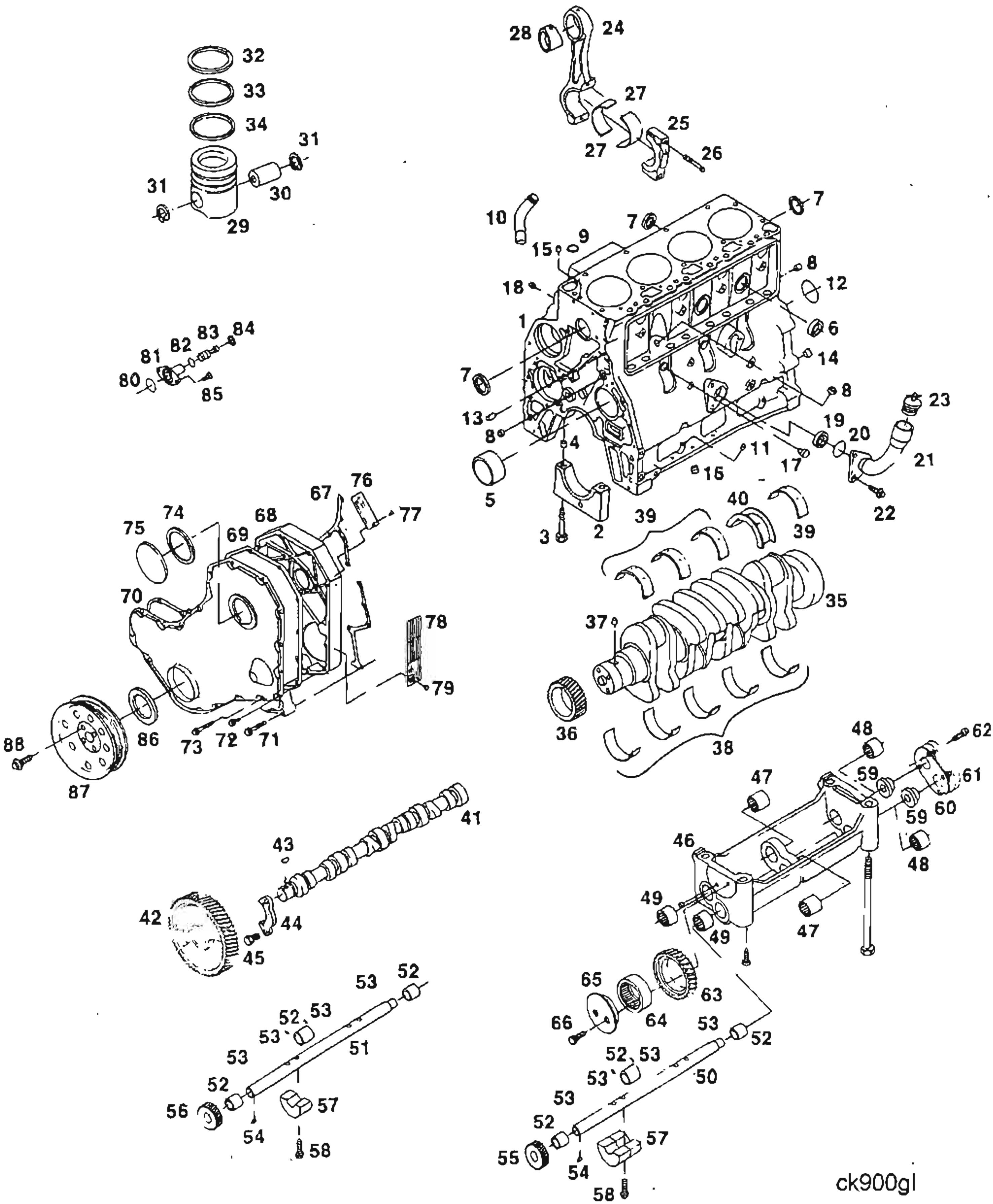
Torque Value: 43 N•m [32 ft-lb]

Section 1 - Cylinder Block - Group 1

Section Contents

Page

Cylinder Block - Exploded View



Item	Part Name	Qty.	Remarks
1	Block, Cylinder	1	
2	Cap, Main Bearing	5	7 for 6B
3	Screw, Hex Hd Cap (Flg)	10	M14-2.0 x 119
4	Ring Dowel	10	
5	Bushing, Cam	1	
6	Plug, Expansion	2	1.0 in.
7	Plug, Expansion	4	
8	Plug, Expansion	3	.70 in.
9	Plug, Expansion	1	Not used with Turbocharger
10	Tube, Turbo Oil Drain	1	
11	Plug, Expansion	1	3/8 in.
12	Plug, Expansion (Welch)	1	2.37 in.
13	Pin, Dowel	2	
14	Ring, Dowel	2	
15	Ring, Dowel	2	
16	Nozzle, Piston Cooling	4	
17	Plug, Pipe	2	1/8 NPTF
18	Plug, Pipe	1	1/2 NPTF (N/A Only)
19	Plug, Expansion	1	Use w/o side oil fill
20	Seal, Rectangular Ring	1	
21	Tube, Oil Filler	1	
22	Screw, Hex Head Cap	2	M12-1.75x25
23	Cap, Filler	1	
24	Rod, Connecting	4	6 for 6B
25	Cap, Connecting Rod	4	6 for 6B
26	Bolt, Connecting Rod	8	12 for 6B
27	Bearing, Connecting Rod	8	12 for 6B
28	Bushing	4	6 for 6B
29	Piston	4	6 for 6B
30	Pin, Piston	4	6 for 6B
31	Ring, Retaining	8	12 for 6B
32	Ring, Piston (Top)	4	6 for 6B
33	Ring, Piston (Mid)	4	6 for 6B
34	Ring, Piston (Oil)	4	6 for 6B
35	Crankshaft	1	
36	Gear, Crankshaft	1	
37	Pin, Dowel	1	
38	Bearing, Main (Lower)	5	7 for 6B
39	Bearing, Main (Upper)	4	6 for 6B
40	Bearing, Main (Thrust)	1	
41	Camshaft	1	
42	Gear, Camshaft	1	
43	Key	1	
44	Support, Cam Thrust	1	

Item	Part Name	Qty.	Remarks
45	Screw, Hex Hd Cap	2	M8-1.25x20
46	Housing, Balancer	1	
47	Bearing, Needle	2	
48	Bearing,Needle	2	
49	Bearing, Needle	2	
50	Shaft, Balancer	1	
51	Shaft, Balancer	1	
52	Race, Inner Bearing	6	
53	Pin	8	
54	Key	2	
55	Gear, Balancer Shaft	1	
56	Gear, Balancer Shaft	1	
57	Weight, Balancer Counter	3	
58	Screw, Hex Head	10	
59	Collar, Thrust	2	
60	Plate, Thrust Bearing	1	
61	Plate, Thrust Bearing	1	
62	Screw, Hex Head	2	
63	Gear, Idler	1	
64	Bearing, Needle	1	
65	Retainer, Gear	1	
66	Screw, Socket Head	2	
67	Gasket, Gear Cover	1	
68	Housing, Gear	1	
69	Gasket, Gear Housing Cover	1	
70	Gear Cover	1	
71	Screw, Hex Head (Flange)	4	M8-1.25x50
72	Screw, Hex Head (Flange)	16	M8-1.25x16
73	Screw, Hex Head (Flange)	7	M8-1.25x50
74	Seal, Rectangular Ring	1	
75	Cover, Access Hole	1	
76	Plate, Data	1	
77	Screw, Drive	2	
78	Plate, Data	1	
79	Screw, Drive	2	
80	Seal, Rectangular Ring	1	
81	Housing, Timing Pin	1	
82	O-Ring	1	
83	Pin, Timing	1	
84	Ring, Retaining	1	
85	Screw, Round Hex (Torx)	2	M5-0.8x17
86	Seal, Front Crank	1	
87	Pulley, Crankshaft	1	
88	Screw, Hex Head (Flange)	4	M12-1.25x36

Cylinder Block - General Information

The B-Series engine is available in 4 cylinder or 6 cylinder versions.

Most parts are common between the 4 and 6 cylinder versions (e.g. pistons, rings, connecting rods, water pump).

In general, the only parts that differ between the 4 and 6 cylinder versions are those that must change due to the difference in number of cylinders (e.g. crankshaft, block casting, cylinder head, etc).

Camshaft:

The camshaft end clearance is determined by the clearance between the camshaft and the thrust plate.

Camshafts that are damaged or worn on the fuel transfer pump lobe or valve lobes must be replaced. Cummins Engine Company, Inc. does not recommend the grinding of camshaft lobes.

Crankshaft:

The crankshaft is a balanced, forged steel, full fillet hardened unit. The 4 cylinder crankshaft has 5 main bearing journals and the 6 cylinder crankshaft has 7 main bearing journals. All of the upper main bearing shells are the same except for the next to last journal which uses a flanged upper bearing shell. The flanges on the upper bearing shell control the end thrust of the crankshaft.

Oversize main bearings, thrust bearings, and connecting rod bearings are available for service. Cummins Engine Company, Inc. recommends regrinding ALL of the main bearing or the connecting rod journals when ONE requires regrinding.

Cylinder Block

The cylinder block has provisions for the oil cooler housing, thermostat seats, coolant bypass line, water pump volute, oil pump housing, water pump inlet, and bored piston cylinders with spacing between cylinders to provide room for dry liners, if needed for service.

Oil Seals

All crankshaft seals on the B Series are Teflon lay-down lip (scroll) type. The Teflon lay-down lip type seal does not contain a spring on the back of the sealing lip. The sealing lip is a thin, stiff piece of Teflon.

Teflon seals must be dry before installation. Do not lubricate the seal lip or the shaft.

After the first few turns of the shaft, a thin film of Teflon is transferred from the seal lip to the shaft. If the shaft or seal is not clean and dry, this transfer will not occur and the seal will leak.

Pistons

The pistons have a cast aluminum body and 3 ring grooves. The top ring groove on turbocharged engines has a ni-resist insert with a Keystone profile. The pistons for different engine configurations are similar in appearance, but are not interchangeable. Always check the part number to be sure the correct piston is used during piston replacement.

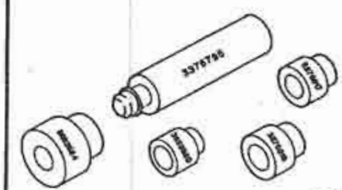
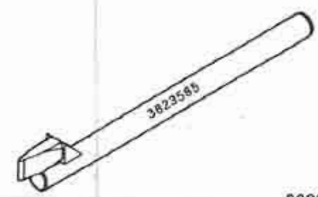
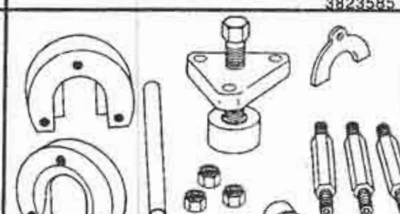
Vibration Damper

Six cylinder engines are equipped with a vibration damper to control the torsional vibration of the crankshaft. A vibration damper is engineered for use on a specific engine model.

It is not economical to repair a vibration damper in the field. Install a new or a rebuilt damper if inspection indicates the damper is defective.

Cylinder Block - Service Tools

The following special tools are recommended to perform procedures in Group 01 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
3823524 3823520	**Cup Plug Driver**	 3376796
3823585	**Gear Splitter (for use on pre-1991 engines).**	 3823585
3823589	**Camshaft Gear Installation Kit**	 3823589
3823137	**Piston Ring Expander**	 3823137

Cylinder Block Group Inspection Checklist

Head Deck Flatness .... ☐

Main Bearing Bore Diameter .... ☐

Camshaft Bore Diameter .... ☐

Tappet Bore Diameter .... ☐

Build Up of Deposits in the Coolant Passages .... ☐

Crankshaft Seal Wear Surfaces .... ☐

Rod and Main Journal Scoring .... ☐

Vibration Damper Index Line and Rubber Member .... ☐

Visually Inspect Piston Assemblies for Damage .... ☐

Measure the Piston Skirt Diameter .... ☐

Piston Ring Clearance .... ☐

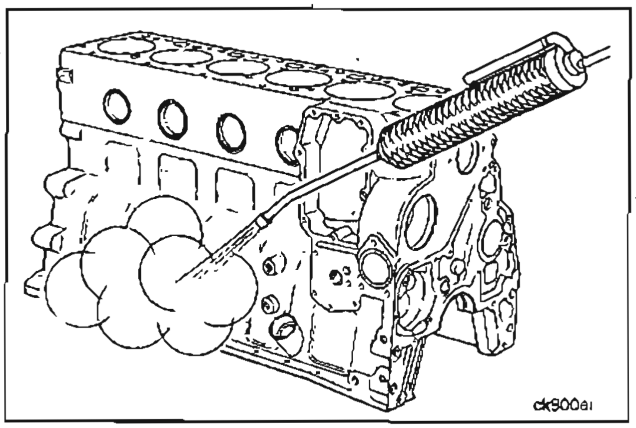
Measure the Piston Pin Bore .... ☐

Visually Inspect the Connecting Rod Assembly .... ☐

Connecting Rod Pin Bore Diameter .... ☐

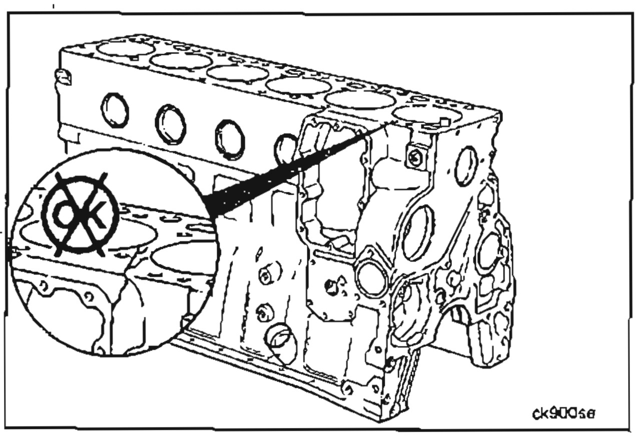
Main Bearing Clearance .... ☐

Connecting Rod Bearing Clearance .... ☐

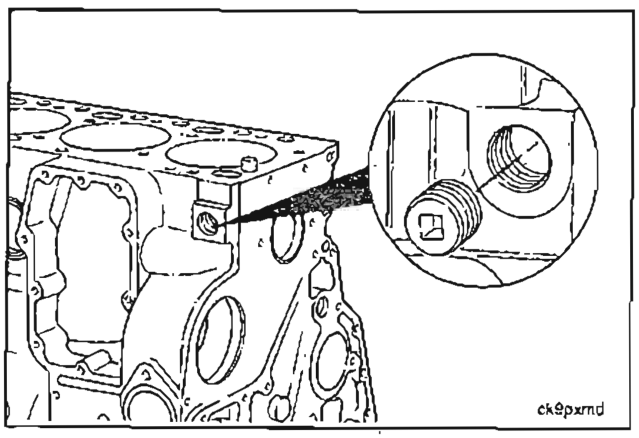


Cylinder Block - Precheck Before Disassembly (1-01)

Thoroughly clean the cylinder block with steam.



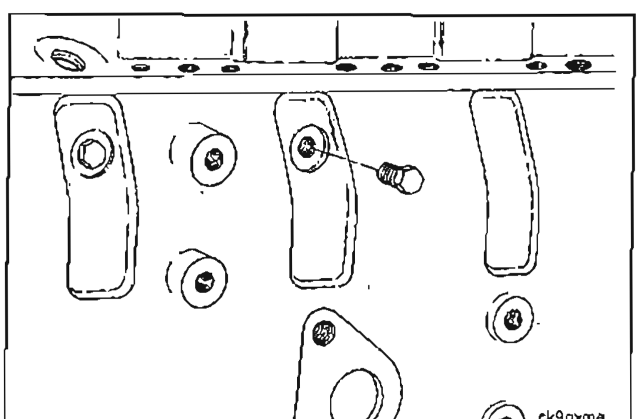
Visually inspect the cylinder block for damage that would prohibit reuse.



Cylinder Block - Disassembly (1-02)

3/8 Inch Square Drive

Remove the pipe plug from the water passage.



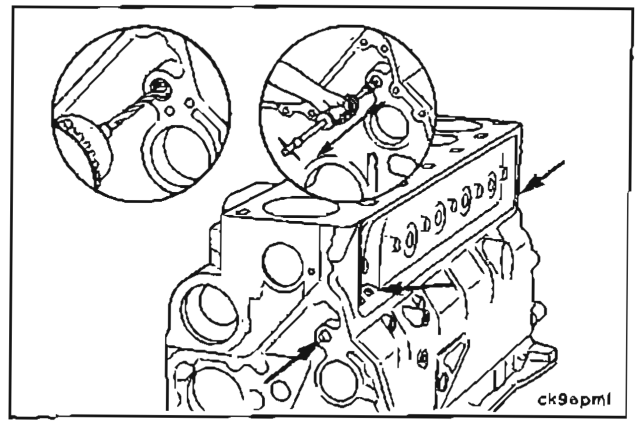
11 mm

Remove the pipe plugs from the oil passages.

Drill Motor, 3mm [1/8 inch] drill bit, Slide Hammer, No. 10 Sheet Metal screw.

Drill a 3mm [1/8 inch] hole and use a slide hammer equipped with a No. 10 sheet metal screw to remove expansion plugs.

Remove the expansion plugs from the oil passages.

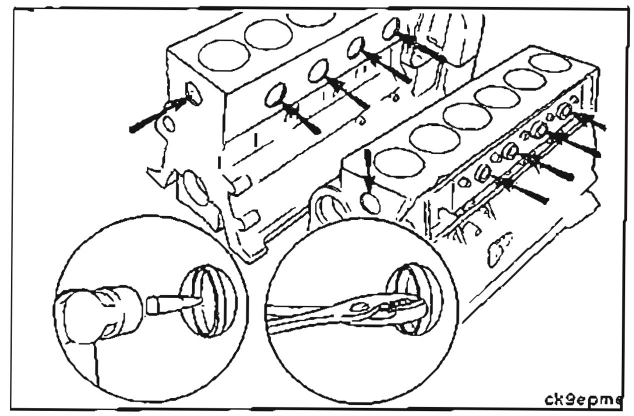


Punch, Visegrips®, Hammer

Remove the large expansion plugs (58.06 mm [2.29 in.]) from the coolant passages.

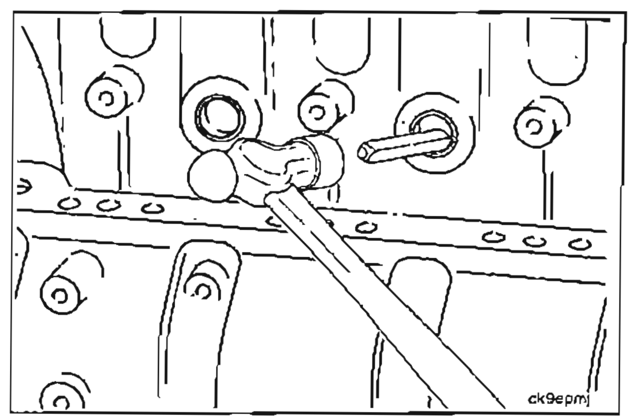
Care should be taken not to drive the expansion plug into the water jacket, especially the plug on the end of the block.

Service Tip: If it becomes apparent the cup plug is not going to pivot in the bore, use a center punch to catch the edge of the cup plug and pry against the block to pivot the plug out.



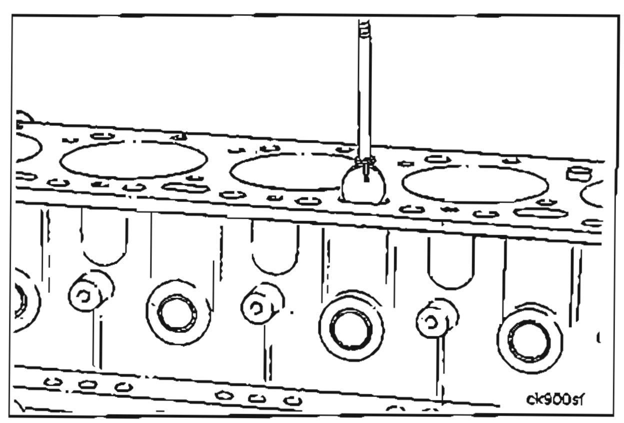
Hammer, Punch

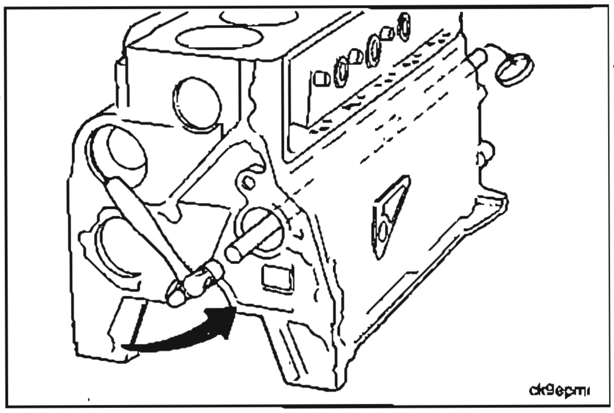
Remove the small expansion plugs (25.07 mm [1 in.]) by driving the plugs into the water jacket.



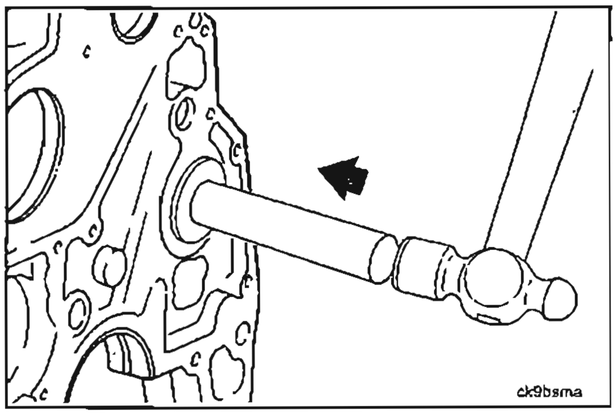
Mechanical Fingers

Retrieve the plugs through the water passages in the top of the block.



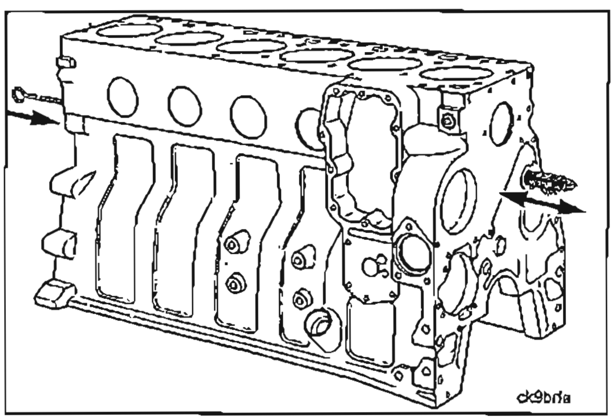


Remove the expansion plug from the camshaft bore.



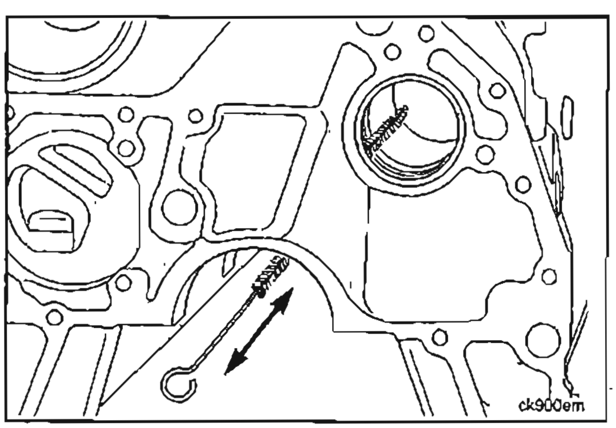
Universal Bushing Installation Tool

Remove the camshaft bushing.



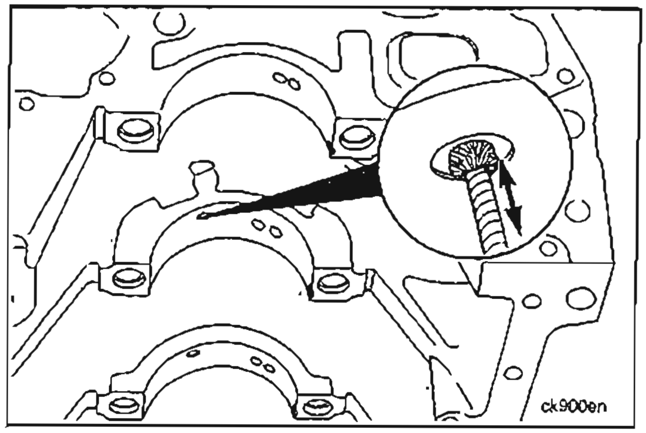
Cylinder Block - Cleaning (1-03)

Use clean solvent and a brush to clean the main oil drilling.

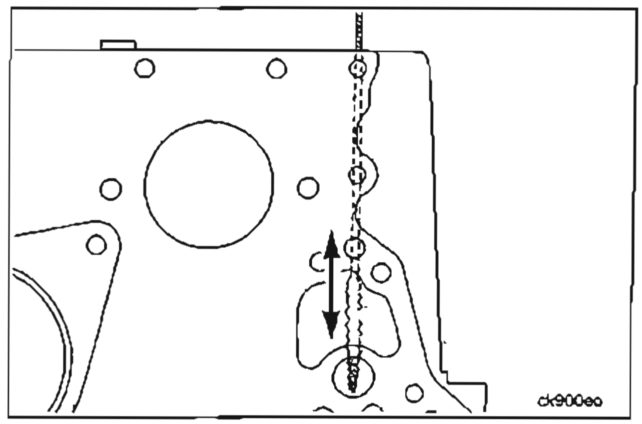


Use clean solvent and a brush to clean the main bearing to cam bore oil drilling.

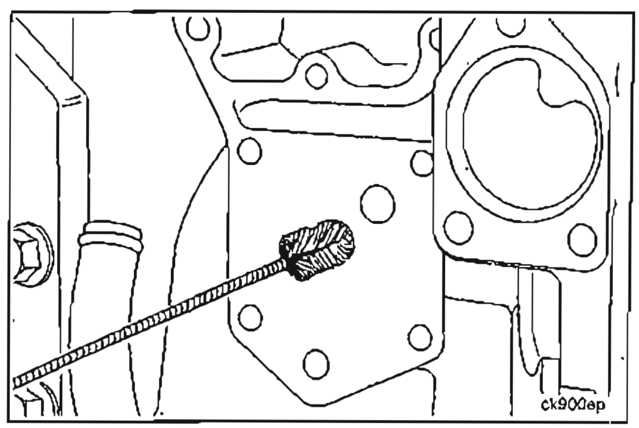
Use clean solvent and a brush to clean the piston cooling nozzle bores.



Use clean solvent and a brush to clean the main oil rifle to overhead oil drilling.

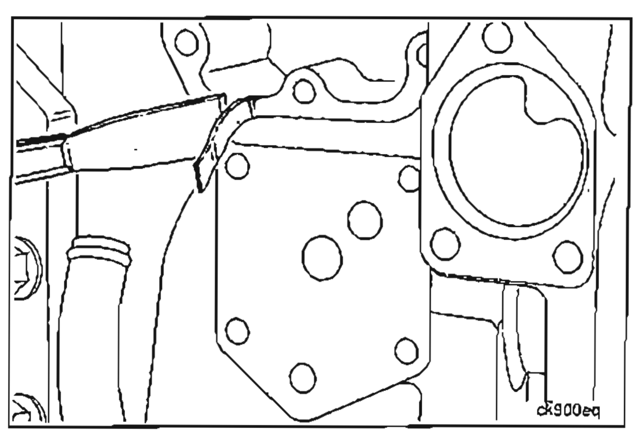


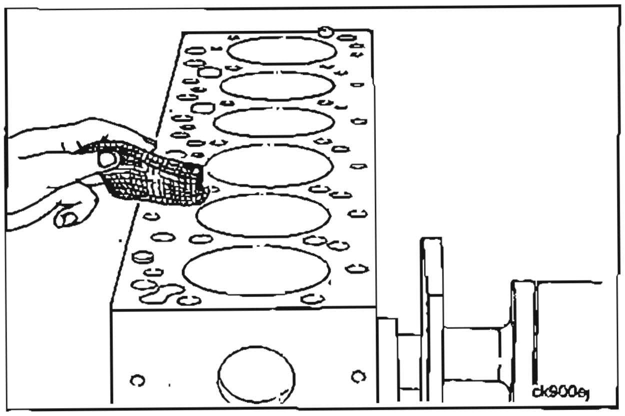
Use clean solvent and a brush to clean the oil cooler oil passages.



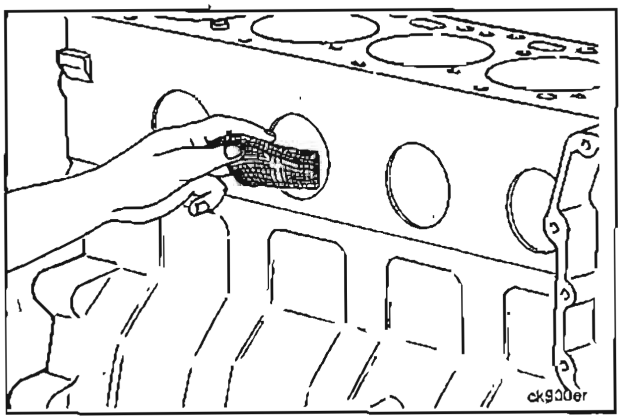
Gasket Scraper

Thoroughly clean all gasket sealing surfaces.



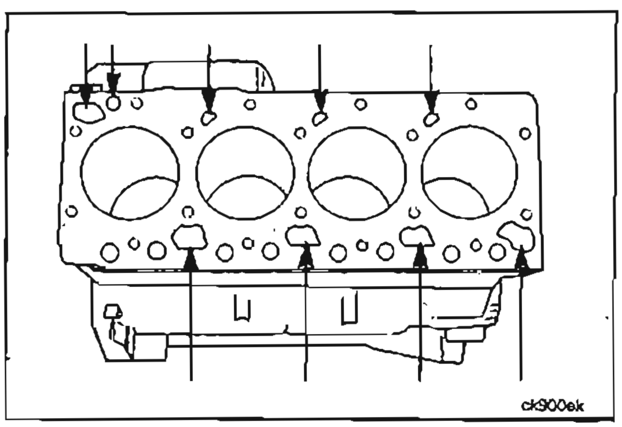


Clean the combustion deck with a Scotch-Brite® cleaning pad or equivalent and diesel fuel or solvent.



Brush, 400 Grit Sandpaper, Diesel Fuel

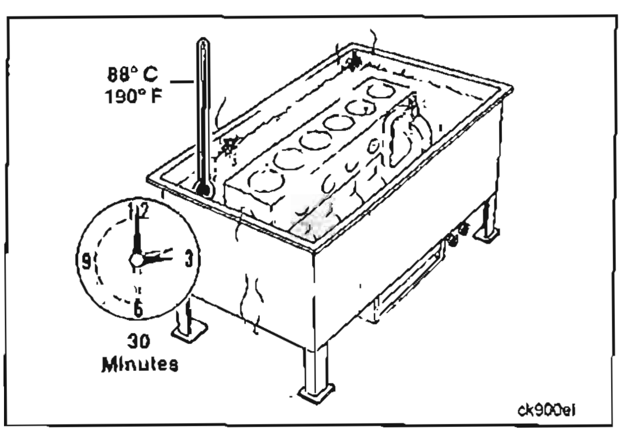
Thoroughly clean all cup plug holes.



Caution: Excessive deposits may be cleaned in an acid tank, but the cam bushing must first be removed.

Build-up of deposits in the coolant passages can cause engine overheating.

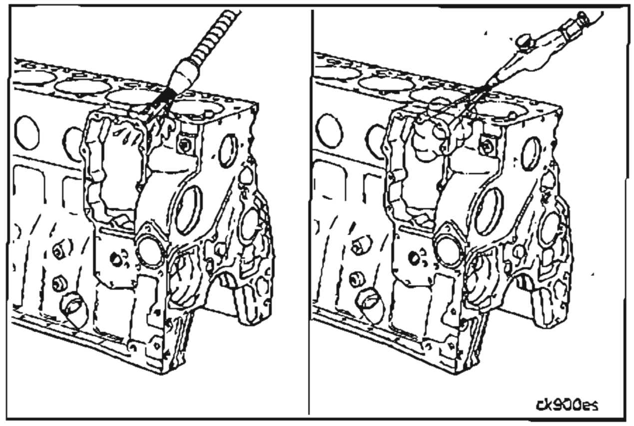
Be sure the coolant passages are clean.



Warning: Use protective measures to prevent personal injury.

The block may be cleaned in a hot tank using a soap and water solution without removing the cam bushing.

After rinsing with clean solvent, use compressed air to dry the block.

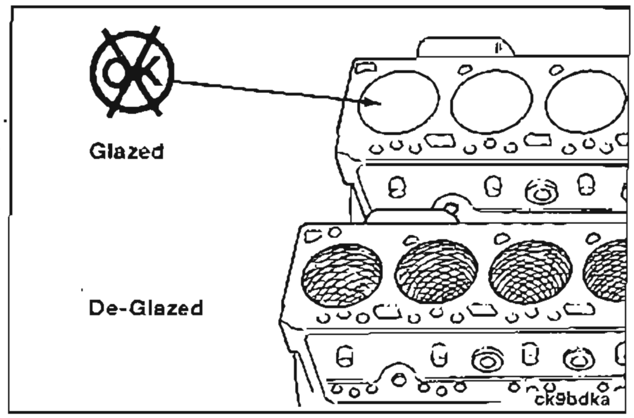


Cylinder Block - Inspection (1-01)

Inspect the cylinder bores for glazing.

A surface without glaze will have a crosshatched appearance with the lines at 25 to 30 degree angles with the top of the cylinder block.

If de-glazing is required, refer to procedure number (1-05).



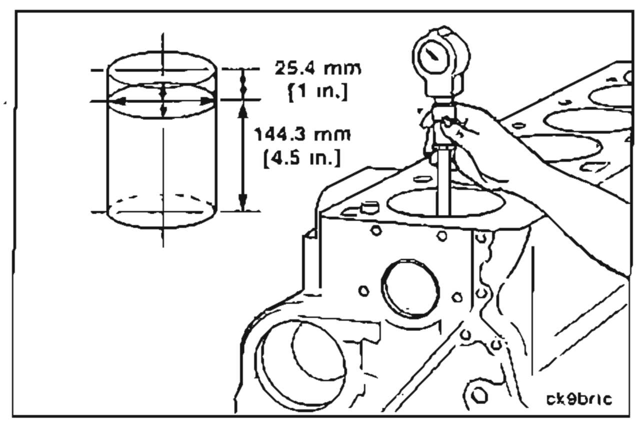
Inspect the cylinder bores for damage or excessive wear.

Measure the cylinder bores.

mm	Diameter	in
102.000	MIN	[4.0161]
102.116	MAX	[4.0203]

Out-of-Roundness: .038 mm [.0015 in]
Taper: 0.076 mm [.003 in]

Oversize pistons and rings (0.5 mm and 1.0 mm oversize) are available for re-bored cylinder blocks.

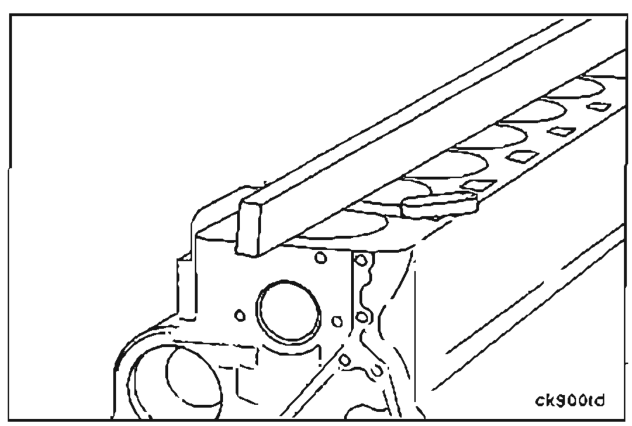


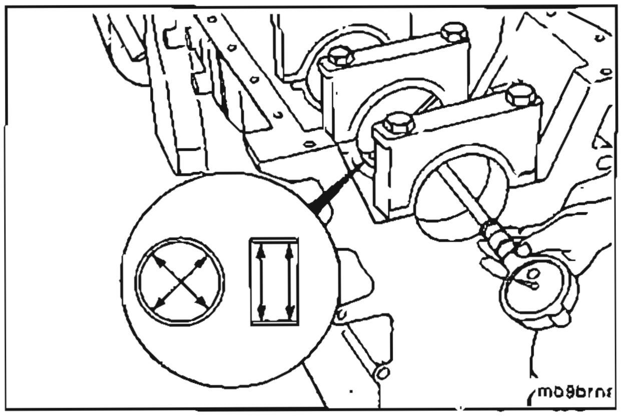
Measure the cylinder block overall flatness:

End-to-End 0.076 mm [0.003 in.]

Side-to-Side 0.051 mm [0.002 in.]

Visually inspect for any localized dips or imperfections. If present, the cylinder head deck must be reground.



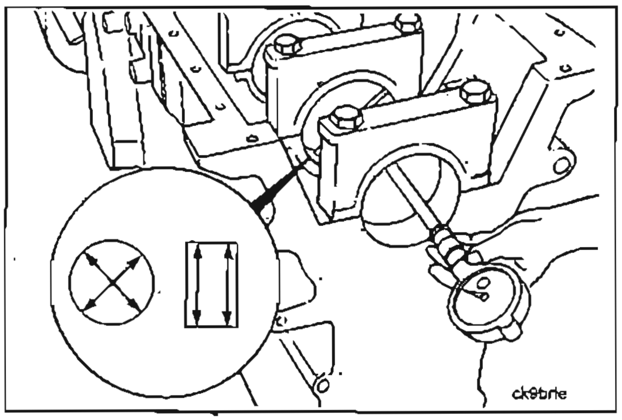


Inspect the main bearing bores for damage or abnormal wear.

Install the main bearings and measure main bearing bore diameter with main bolts tightened to 176 N•m [130 ft-lb].

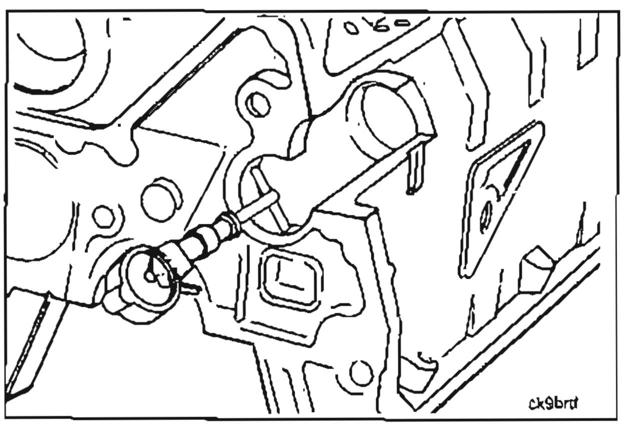
NOTE: Record this measurement for use in determining main bearing clearance as described in procedure (1-12).

Diameter		
mm		in
83.106	MAX	3.2720



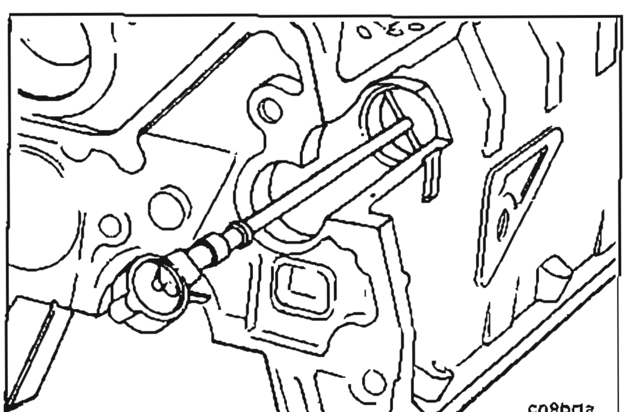
Remove the bearing and install the main bearing cap. Torque the main bearing capscrews to 176 N•m [130 ft-lb]. Measure the main bearing bore with the bearing removed.

Diameter		
mm		in
87.983	MIN	3.4639
88.019	MAX	3.4653



Inspect the camshaft bore without the bushing for scoring or excessive wear.

Diameter No. 1		
mm		in
57.222	MIN	2.2528
57.258	MAX	2.2543



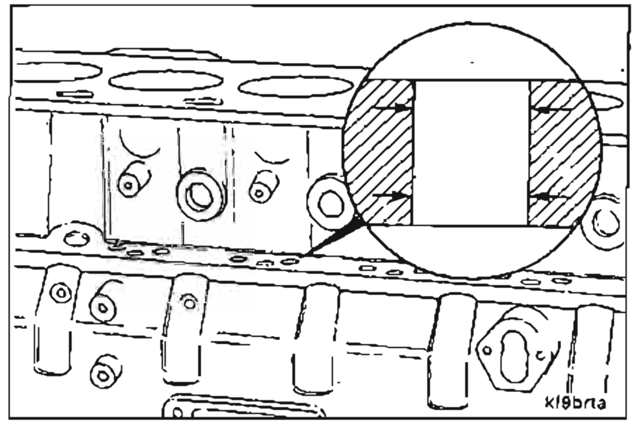
Measure the diameter of camshaft bores No. 2 through No. 5.

Diameter No. 2-5		
mm		in
54.089	MIN	[2.1295]
54.164	MAX	[2.1324]

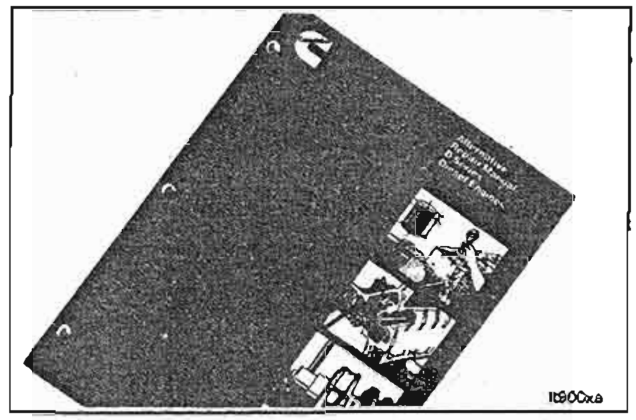
Service bushings are available and must be used if wear exceeds above dimensions.

Inspect the tappet bores for scoring or excessive wear.

Diameter		
mm		in
16.000	MIN	[0.630]
16.055	MAX	[0.632]



NOTE: If the cylinder head or cylinder block is out of specification, the out of specification surface must be machined. Refer to the Alternative Repair Manual, Bulletin No. 3666109, for re-surfacing information.

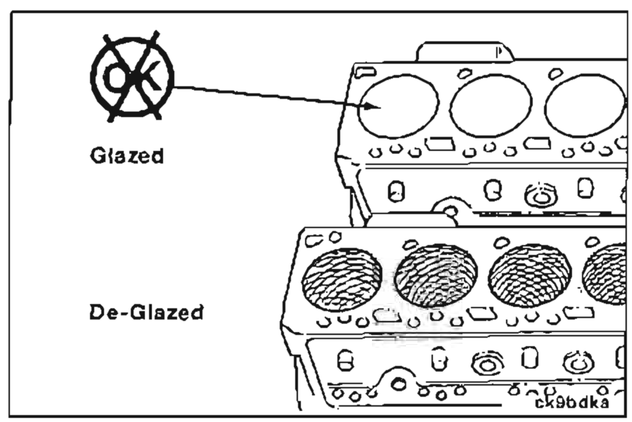


Cylinder Block - De-Glazing (1-05)

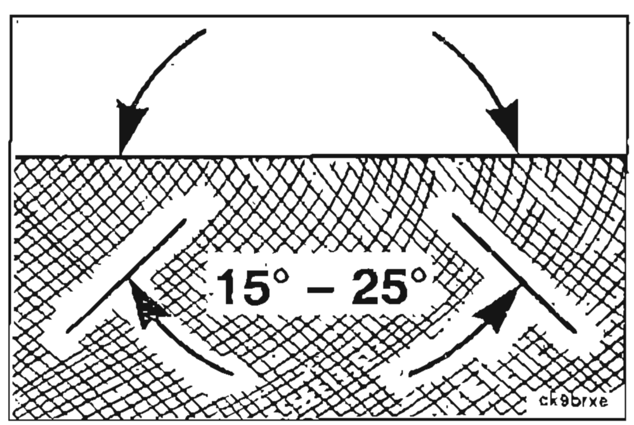
New piston rings may not seat in glazed cylinder bores.

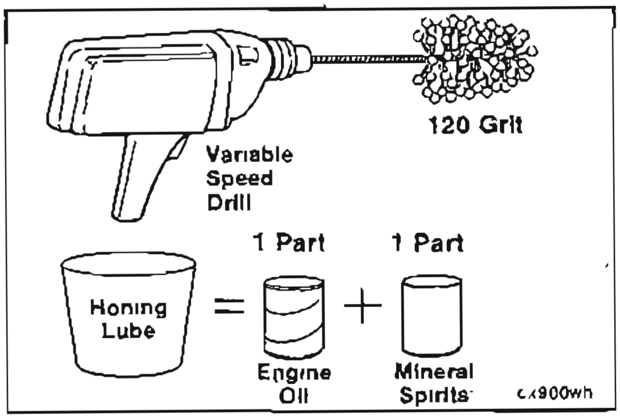
De-glazing makes the bore "rough" to help seat the rings. The size of the bore is not changed by proper de-glazing.

Improper de-glazing will change the size of the bore.

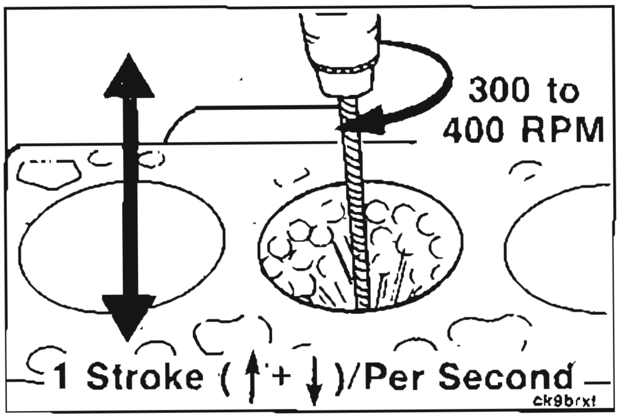


A correctly de-glazed surface will have a crosshatched appearance with the lines at 15 to 25 degree angles with the top of the cylinder block.

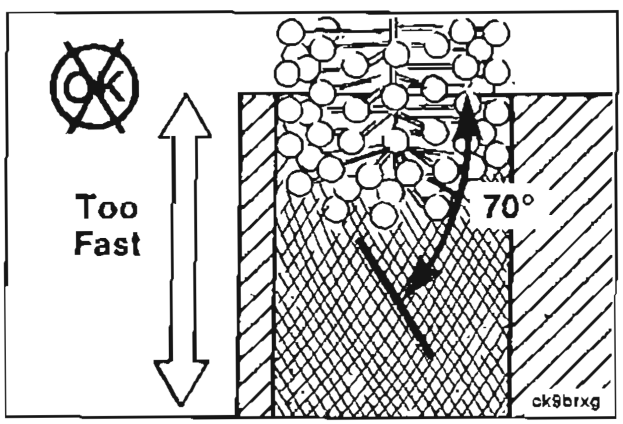




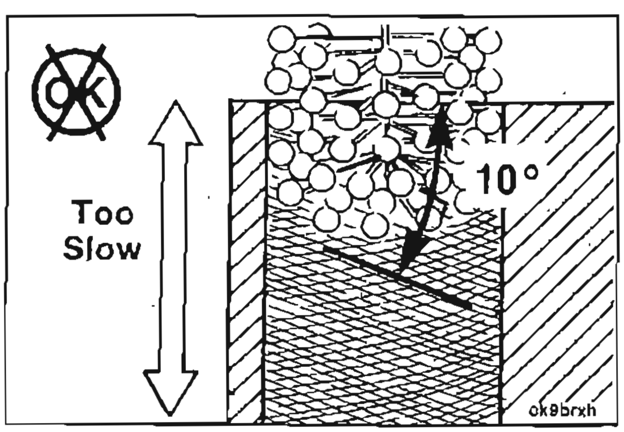
Use a drill, a medium grit Flexi-Hone and a mixture of equal parts of diesel fuel and SAE 30W engine oil to de-glaze the bores.



The crosshatch angle is a function of drill speed and how fast the hone is moved vertically.



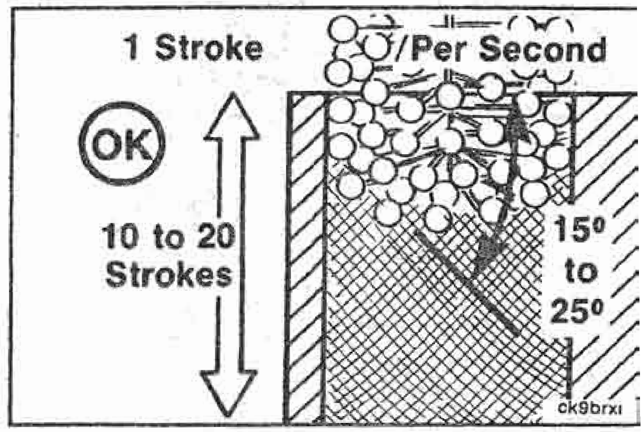
This illustration shows the result of the drill speed is too slow or the vertical stroke is **too fast**.



This illustration shows the result of the drill speed is too fast or the vertical stroke is **too slow**

NOTE: Vertical strokes must be smooth continuous passes along the full length of the bore.

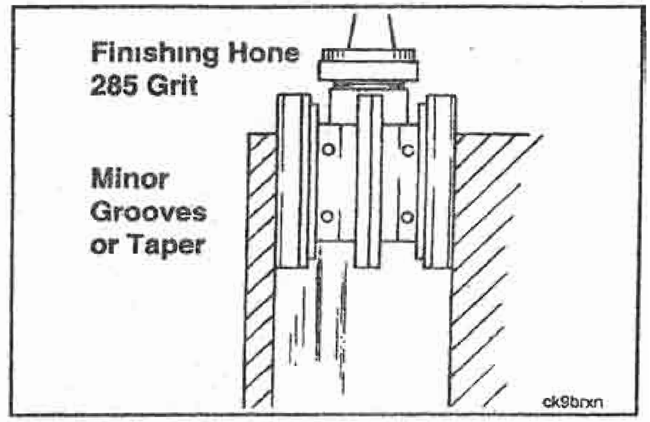
Inspect the bore after 10 strokes.



Caution: Be extremely careful not to hone the bore out of specification.

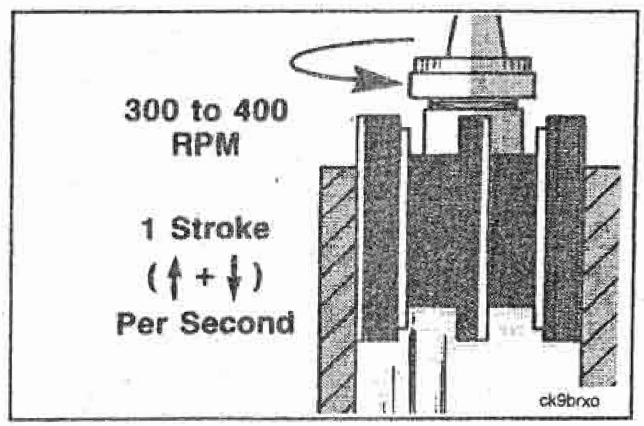
A sizing hone can be used to remove minor grooves or to correct minor out of taper.

Taper: 0.076 mm [0.003 in]



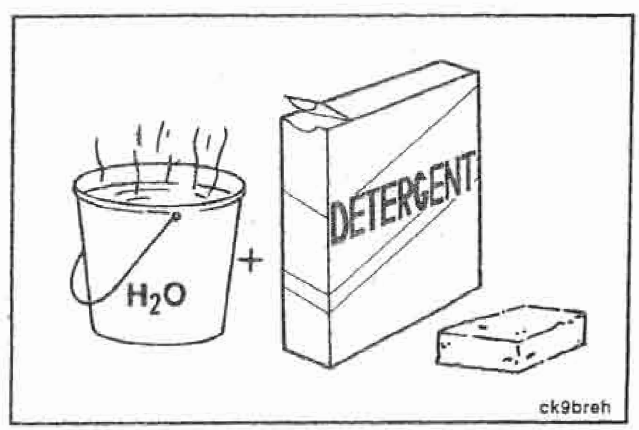
Operate the sizing hone similarly to the Flexi-Hone.

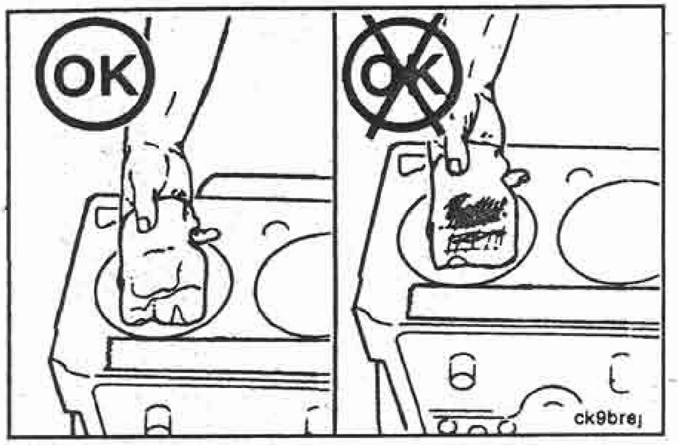
Inspect the bore after 10 strokes.



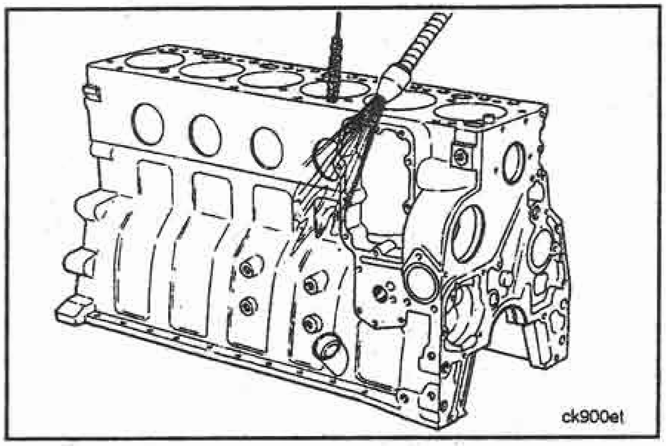
Immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, use compressed air to dry the block.



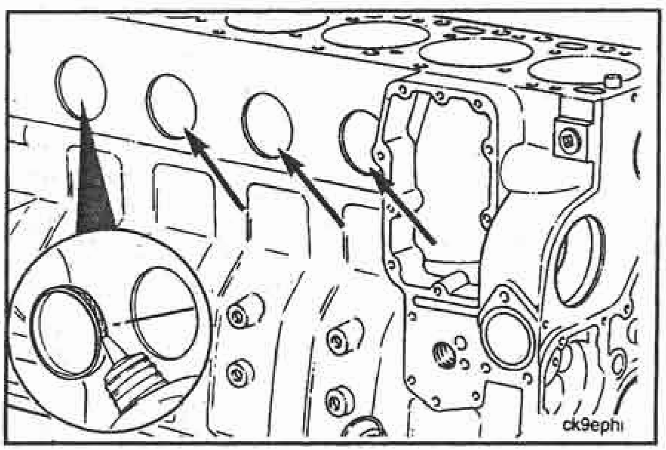


Check the bore cleanliness by wiping with a white, lint free, lightly oiled cloth. If grit residue is still present, re-clean.



Wash the block in solvent.

Use a brush to clean all oil passages.



Expansion and Pipe Plug - Installation (1-06)

All expansion plug bores in the block are machined to a standard english dimension (i.e., 11/16 in, 1-1/4 in, etc.).

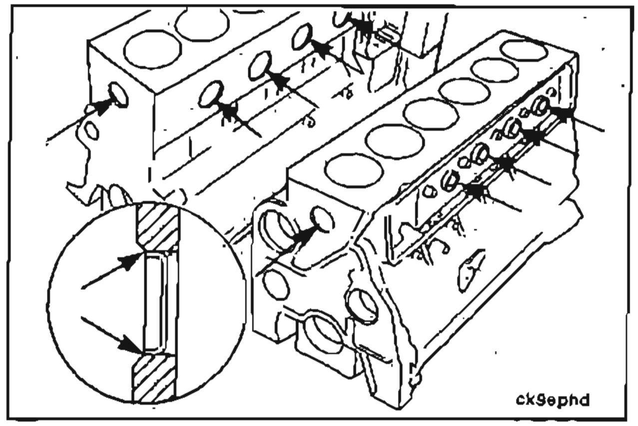
To achieve the correct press fit of the expansion plug in the bore, the expansion plug must be larger than the bore diameter and the expansion plug driver must be smaller than the bore diameter. Therefore, expansion plugs and their drivers are not made to a standard english dimension.

The plug drivers are called out by the dimension of the bore they are to be used on (i.e., a 1 in driver for 1" bore). The expansion plugs are called out by Cummins part number (a dimension is also listed for reference).

Apply a bead of Three Bond, Part No. 3823494, around the outside diameter of all expansion plugs before installing.

Drive all expansion plugs in until the outer edge is flush with the counter sink in the block.

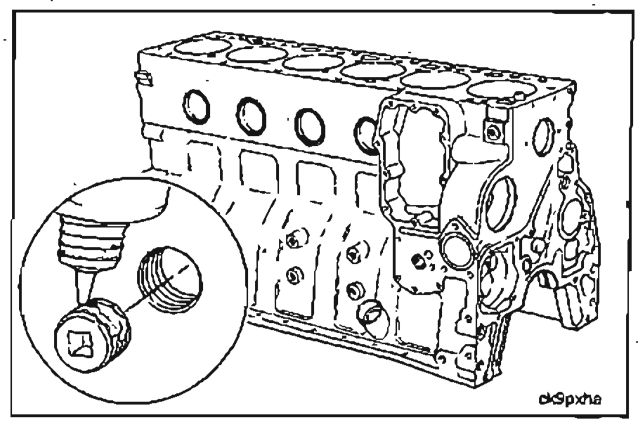
Refer to procedure (1-07) for camshaft expansion plug installation.



Apply a film of pipe plug sealant, Part No. 3375066, or equivalent, to the threads.

Install and tighten the pipe plugs.

Refer to the following chart for torque values.



Tighten pipe plugs to the appropriate torque values.

Pipe Plug Torque Values

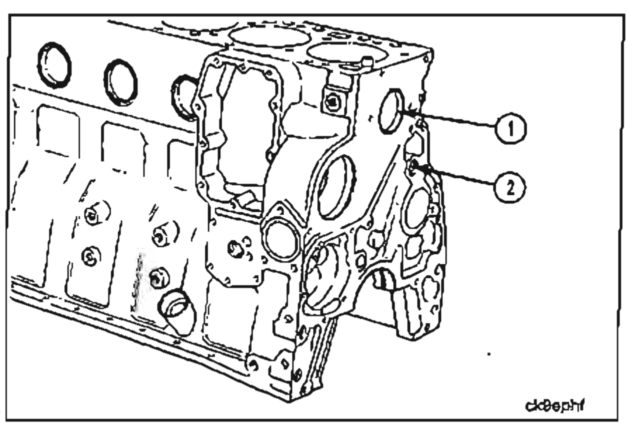
Size			Torque		Torque	
Thread	Actual Thread O.D.		In Aluminum Components		In Cast Iron or Steel Components	
in.	mm	[in]	N•m	[ft-lbs]	N•m	[ft-lbs]
1/16	8.1	[0.32]	5	[45 in-lb]	15	[10]
1/8	10.4	[0.41]	15	[10]	20	[15]
1/4	13.7	[0.54]	20	[15]	25	[20]
3/8	17.3	[0.68]	25	[20]	35	[25]
1/2	21.6	[0.85]	35	[25]	55	[40]
3/4	26.7	[1.05]	45	[35]	75	[55]
1	33.5	[1.32]	60	[45]	95	[70]
1¼	42.2	[1.66]	75	[55]	115	[85]
1½	48.3	[1.90]	85	[65]	135	[100]

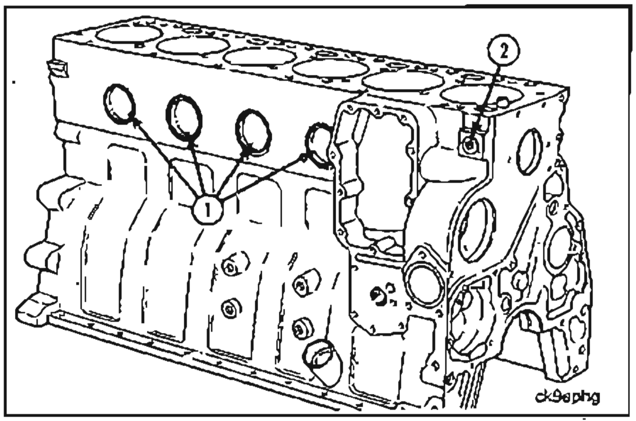
ck8ppos

Driver Part No. 3823524 (Coolant Passages), Part No. 3823520 (Oil Rifle)

Expansion plug locations. Front of block.

1. Expansion Plug Part No. 3900965 (58.06 mm)
2. Expansion Plug Part No. 3900956 (17.73 mm)

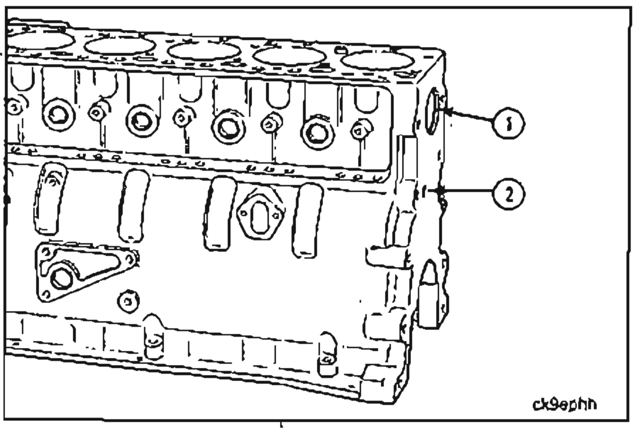




Driver Part No. 3823524 (Coolant Passages)

Pipe plug and cup plug locations. Right side of block.

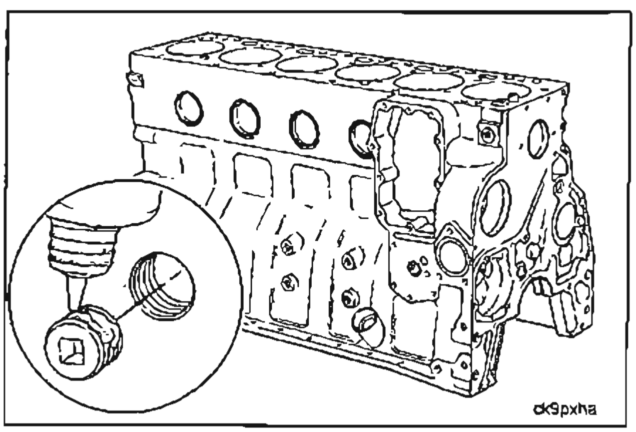
1. Expansion Plug Part No. 3812090 (58.06 mm)
2. Pipe Plug, 0.50 in (1/2 in)



Driver Part No. 3823524 (Coolant Passages), Part No. 3823520 (Oil Rifle)

Expansion plug locations. Rear of block.

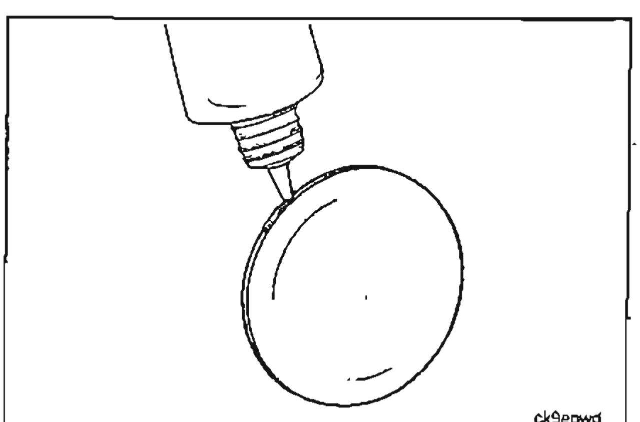
1. Expansion Plug Part No. 3812090 (58.06 mm)
2. Expansion Plug Part No. 3900956 (17.73 mm)



Driver Part No. 3823520 (Oil Rifle), Part No. 3376816 (Crankcase), Part No. 3376817 (Alternate Oil Fill), Part No. 3822372 (Alternate Dipstick Holes)

Pipe plug and expansion plug locations. Left side of block.

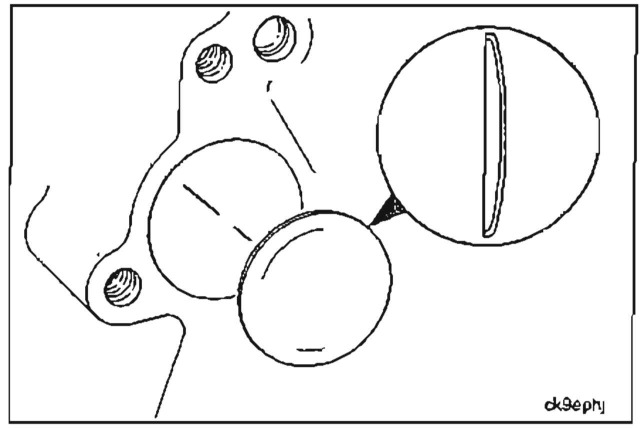
1. Expansion Plug Part No. 3900956 (17.73 mm)
2. Expansion Plug Part No. 3914035 (25.75 mm)
3. Expansion Plug Part No. 3900955 (9.80 mm)
4. Expansion Plug Part No. 3900958 (32.03 mm)
5. Pipe Plug, 0.125 in (1/8) NPTF Hex Head



Camshaft Expansion Plug - Installation (1-07)

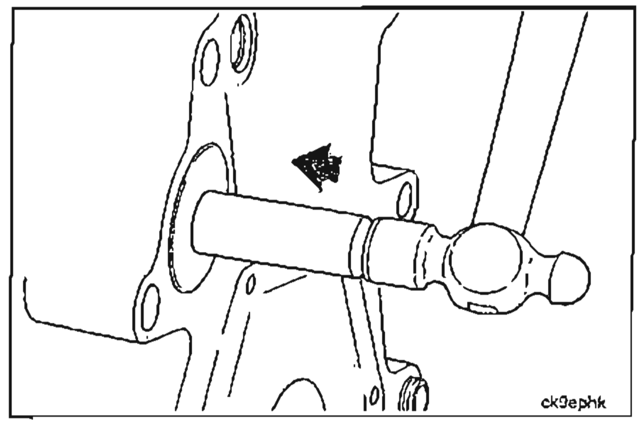
Apply a bead of Three-Bond, Part No. 3823494, around the outside diameter of the camshaft expansion plug.

Position the plug with the convex side out.

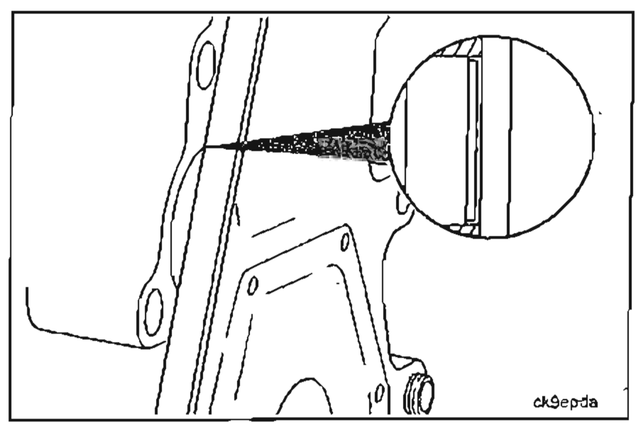


Large Drift, Hammer

Expand the plug with a large drift and a hammer.

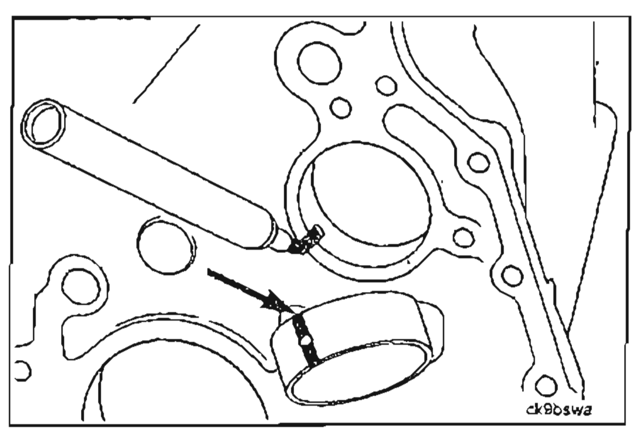


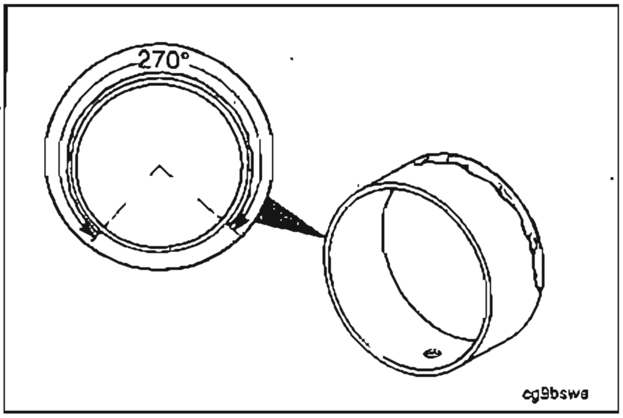
Expand the plug until the convex side is flush with the block.



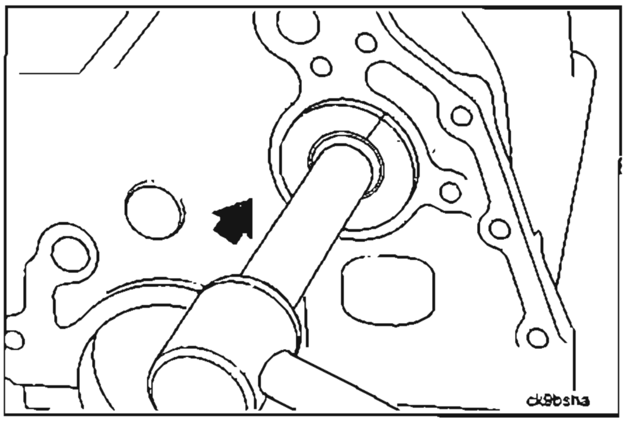
Camshaft Bushing - Installation (1-08)

Mark the camshaft bushing and block to align the oil hole.



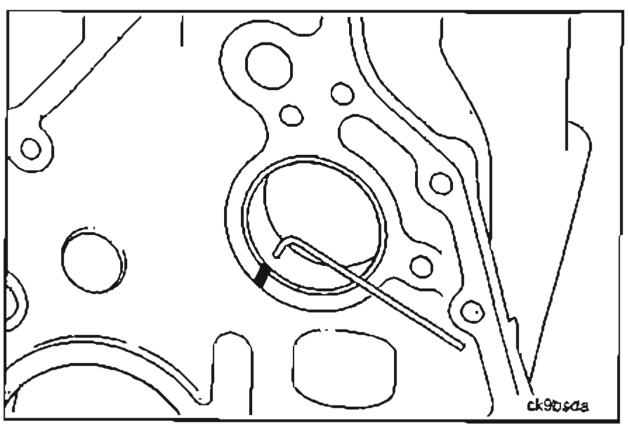


Apply a bead of Loctite™ 609 to the edge of the bushing that will be installed to the rear of the bore. Apply the Loctite™ to 270 degrees of the diameter of the bushing, see the illustration. Use care to not apply Loctite™ near to or in line with the oil hole.



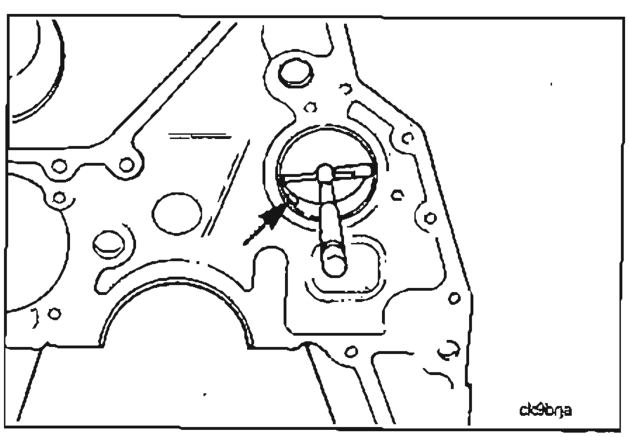
Universal Bushing Installation Tool

Install the camshaft bushing flush with the block.



Be sure the oil hole is aligned.

A 3.2mm [0.126 in] diameter rod must be able to pass through the hole.



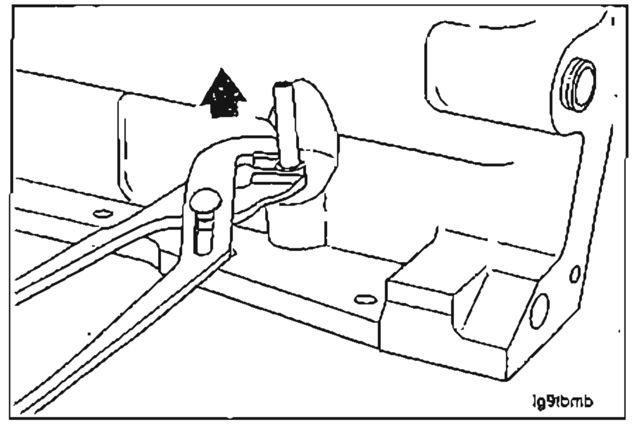
Measure the installed camshaft bushing.

Camshaft Bushing Bore		
mm		in
54.107	MIN	2.1302
54.146	MAX	2.1317

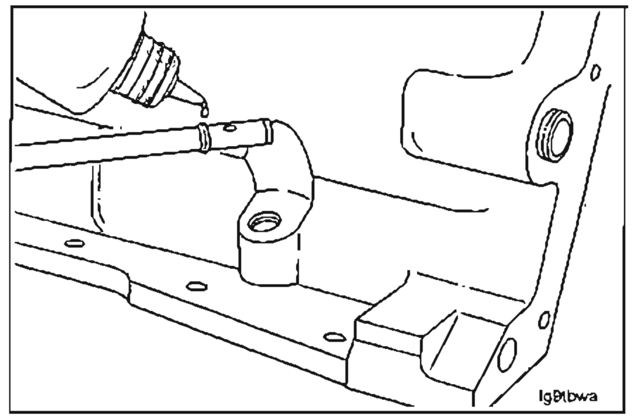
Dipstick Tube - Replacement (1-09)

Pliers

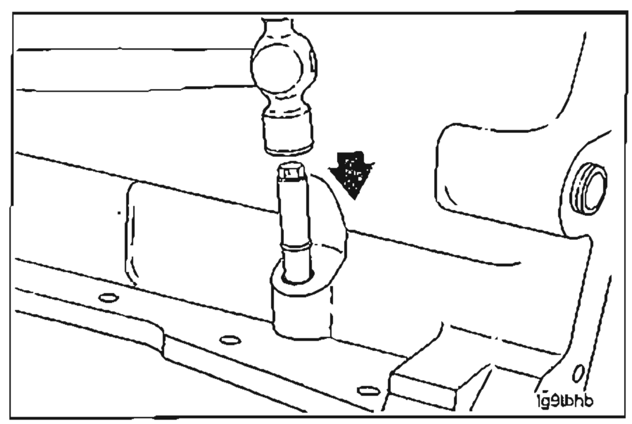
If the dipstick tube is loose or damaged, remove it from the cylinder block.



Apply sealant, Part No. 3375068, to the new dipstick tube.

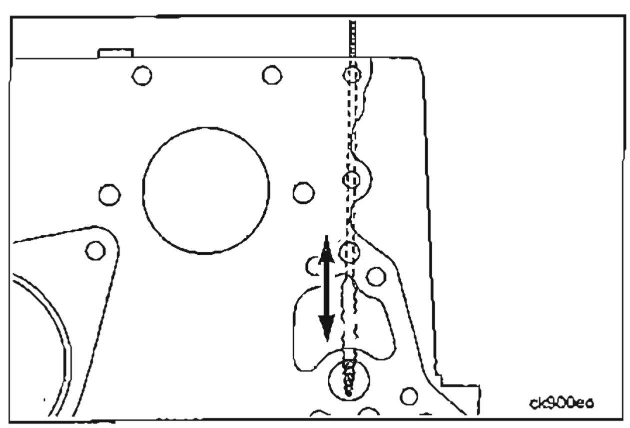


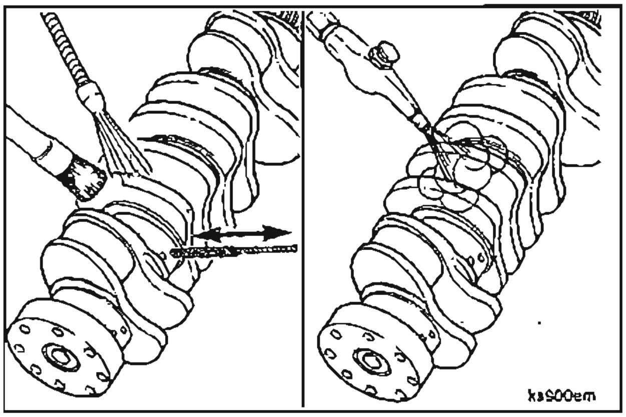
Use a hex head capscrew to drive the tube into the block.



Cylinder Block - Storing (1-10)

If the block is not to be used immediately, lubricate all surfaces to prevent rusting.

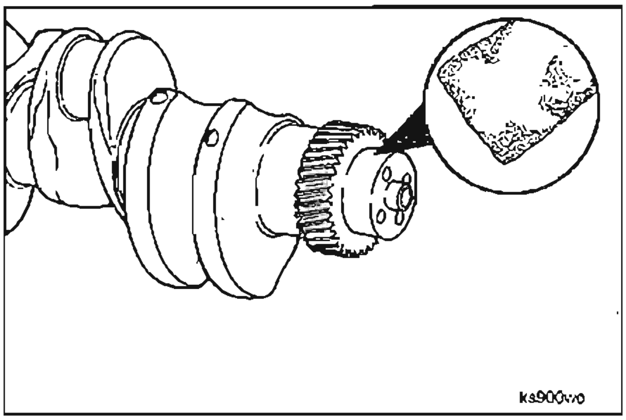




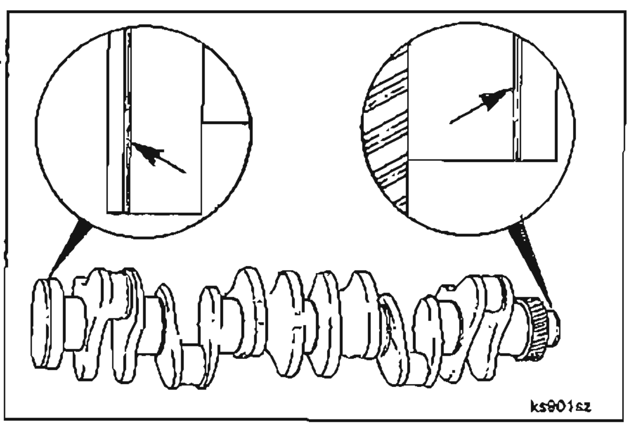
Crankshaft - Cleaning (1-11)

Clean the crankshaft oil drillings with a brush.

Rinse in clean solvent and use compressed air to dry.



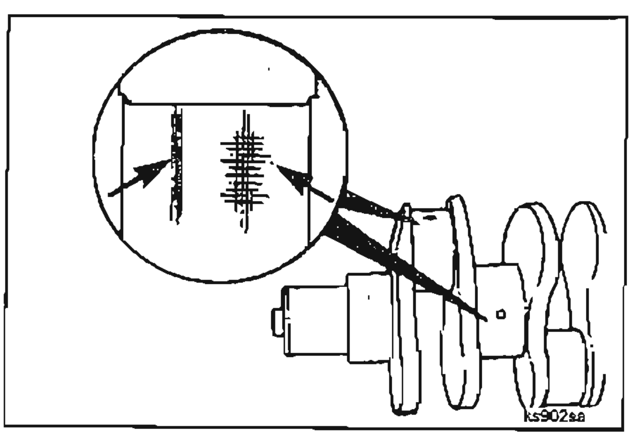
Clean the oil seal wear surfaces with diesel fuel and crocus cloth.



Crankshaft - Inspection (1-12)

Inspect the crankshaft seals wear surfaces for scratches or grooving.

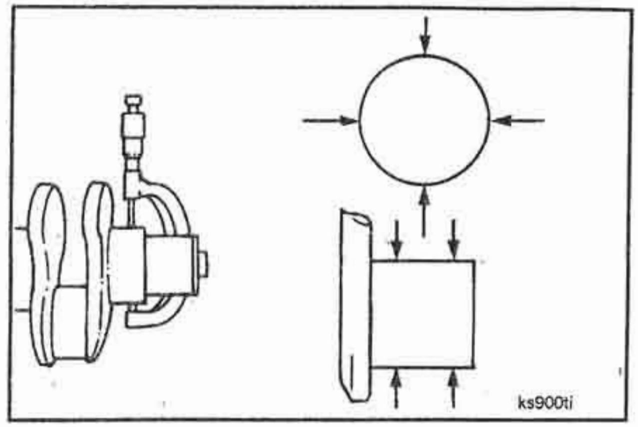
If shaft is grooved, install a wear sleeve.



Inspect the rod and main journals for deep scoring, overheating, etc.

Determining Main Bearing Clearance

Measure the main journal diameters and determine main bearing clearance.



Main Bearing Journal Diameter		
mm		in
82.962	MIN	3.2662
83.013	MAX	3.2682

Out-of-Roundness: 0.050mm [0.002 in]
Taper: 0.013mm [0.0005 in]

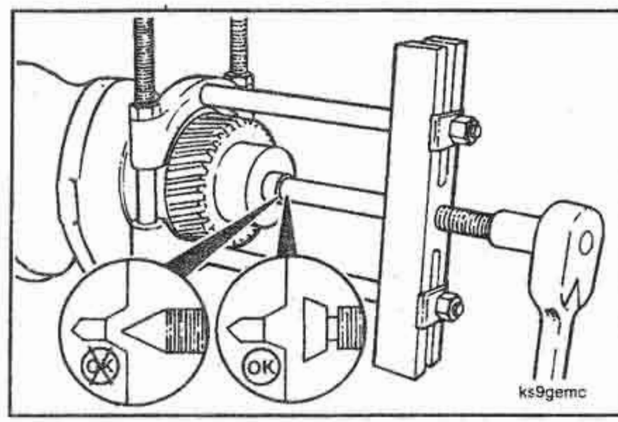
Bearing Clearance = Main Bore Diameter with bearing installed minus (–) Crankshaft Main Journal Diameter.

Maximum Bearing Clearance: 0.119mm [0.0047 in]

Crankshaft Gear - Replacement (1-13)

Remove the crankshaft gear.

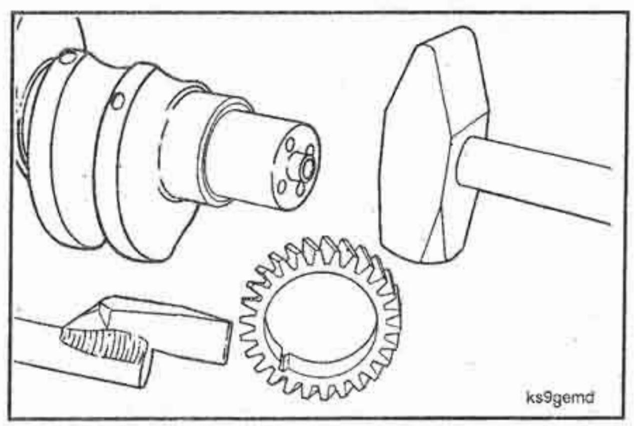
Use a heavy duty puller.



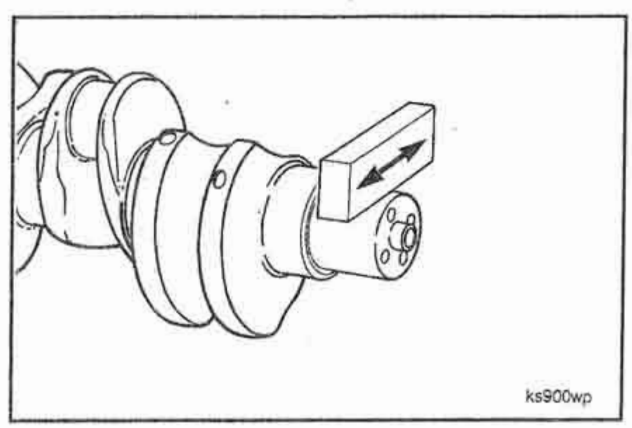
2 lb Steel Hammer, Gear Splitter Part No. 3823585

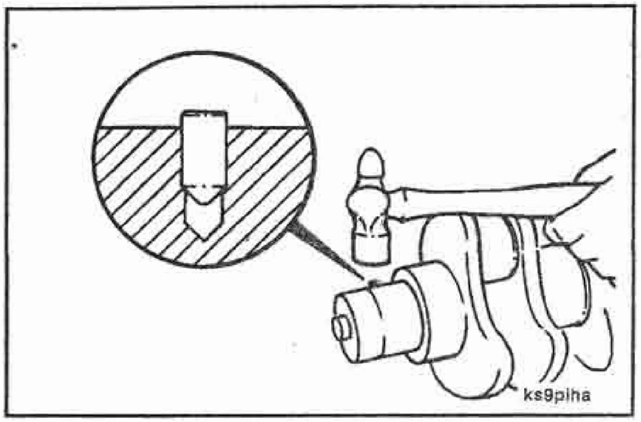
An optional tool is available to split the crankgear off of Pre-1991 crankshafts.

Service Tip: Always use a large steel hammer when splitting the crankshaft gear. Lead hammers absorb the shock required to break the gear.



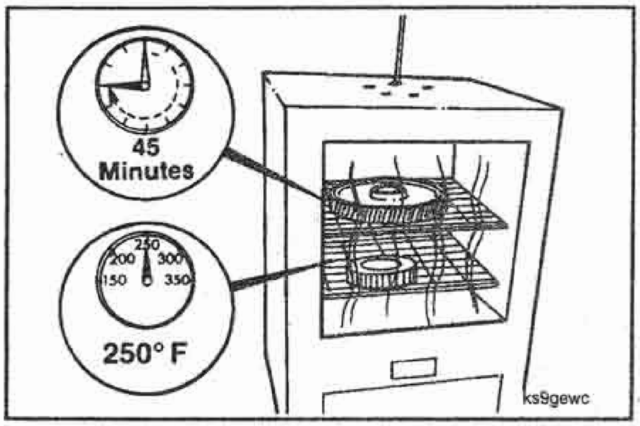
Remove all burrs and make sure the gear surface on the end of the crankshaft is smooth.





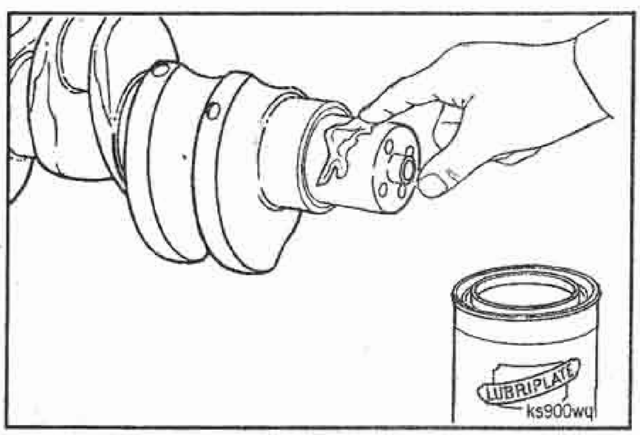
Hammer

If previously removed, install the alignment pin until it bottoms.

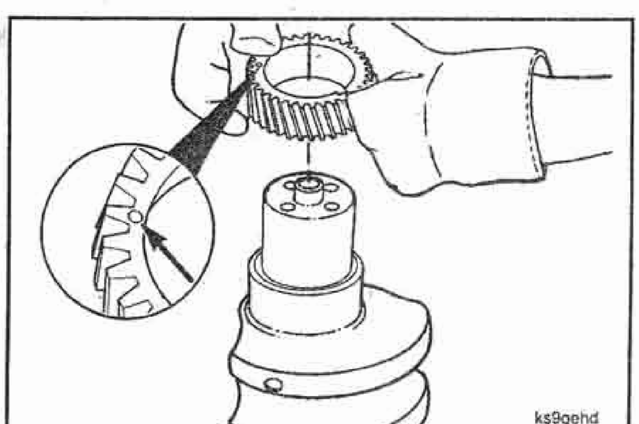


Caution: The gear will be permanently distorted if overheated. The oven temperature should never exceed 177°C [350°F].

Heat the crankshaft gear in a preheated oven for 45 minutes at 149° C [300° F].



Apply a thin coating of lubricant to the nose of the crankshaft.

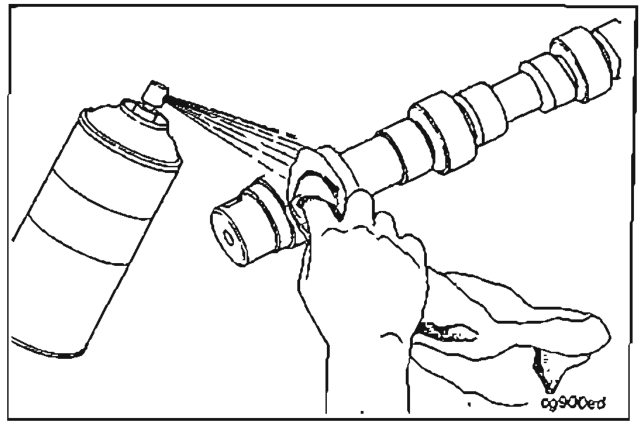


Warning: Wear protective gloves to prevent personal injury.

Install the hot gear up to the crankshaft shoulder with the timing mark out.

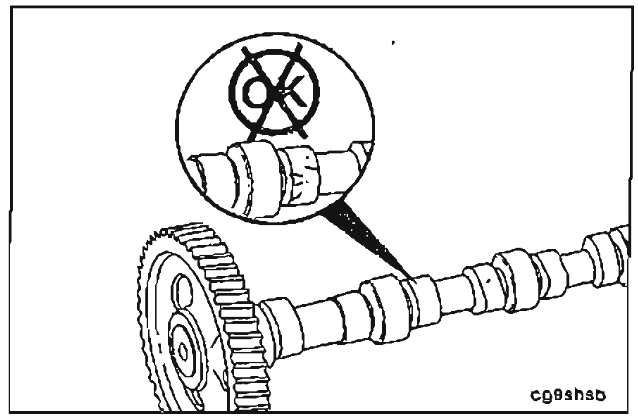
Camshaft - Cleaning (1-14)

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

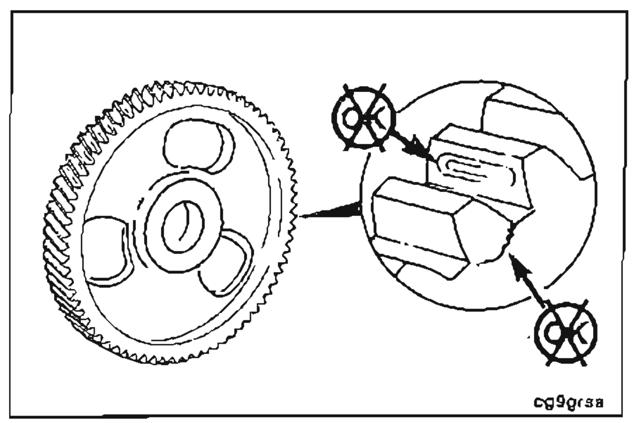


Camshaft and Gear - Inspection (1-15)

Inspect the lift pump lobe, valve lobes and bearing journals for cracking, pitting or scoring.

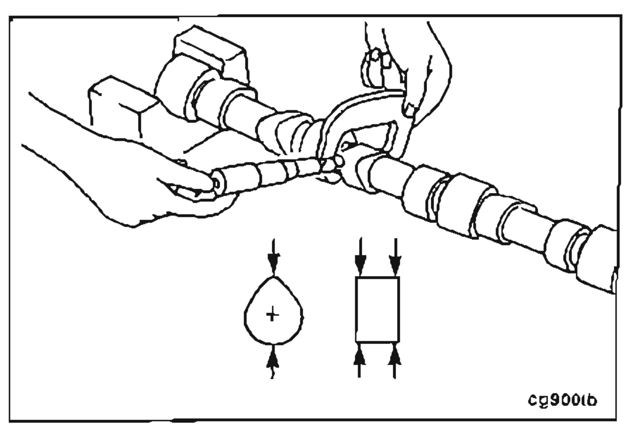


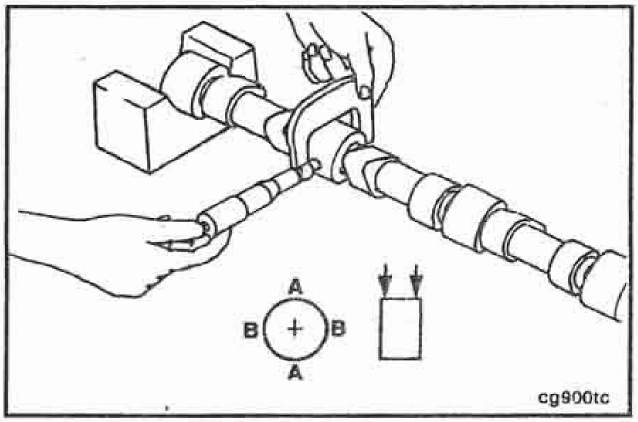
Inspect the gear teeth for pitting; look for cracks at the root of the teeth.



Measure the fuel transfer pump lobe and valve lobes.

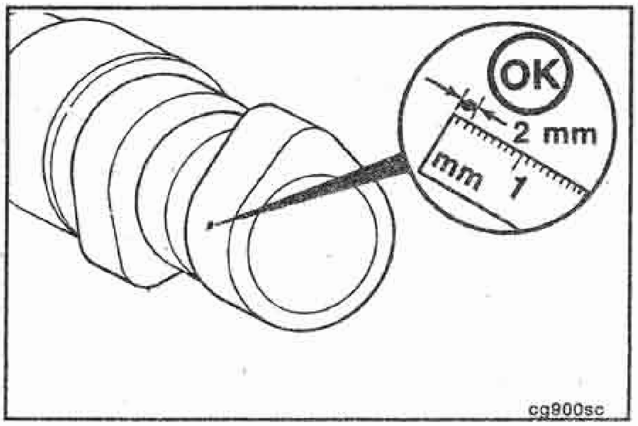
Diameter at Peak of Lobe	mm		in
Intake	47.040	MIN	1.852
	47 492	MAX	1.870
Exhaust	46.770	MIN	1.841
	47.222	MAX	1.859
Lift Pump	35.500	MIN	1.398
	36.260	MAX	1 428





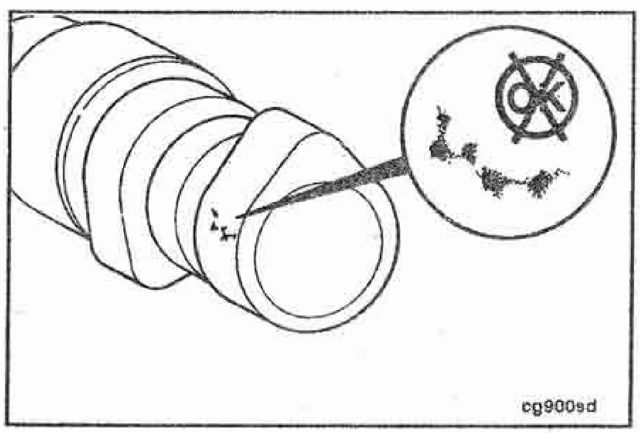
Measure the bearing journals.

Journal Diameter		
mm		in
53.962	MIN	2.1245
54.013	MAX	2.1265

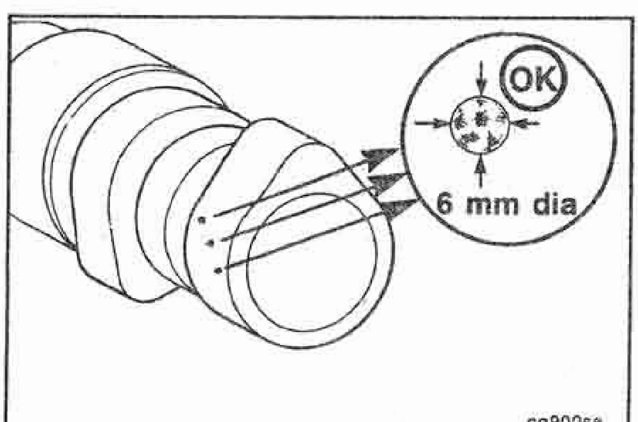


Camshaft Lobe Pitting Reuse Criteria (1-16)

A single pit should not be greater than the area of a 2 mm [.079 in] diameter circle.

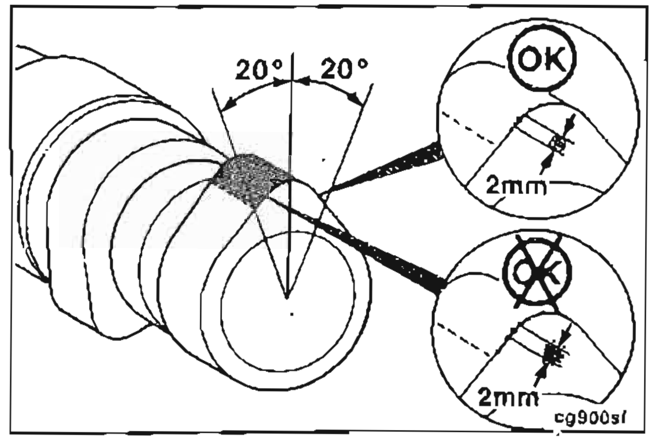


Interconnection of pits is not allowable and is treated as one pit.



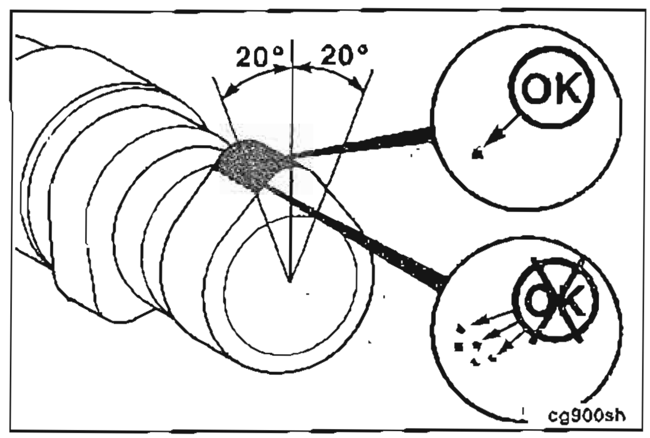
The total pits, when added together, should not exceed a circle of 6 mm [0.236 in].

Only one pit is allowed within + or - 20 degrees of the nose of the cam lobe.

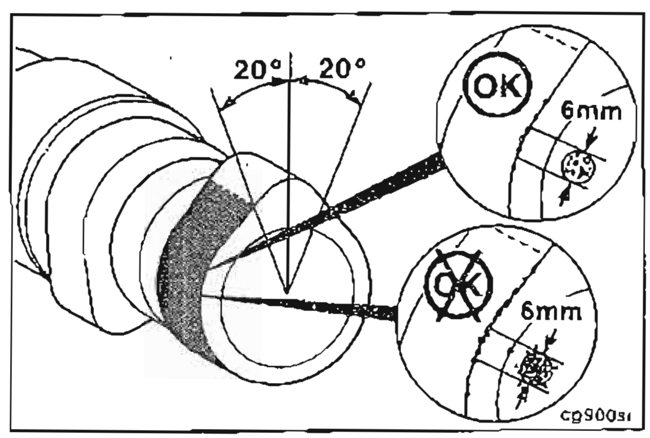


Camshaft Lobe Edge Deterioration (Breakdown) Criteria (1-17)

The area of edge deterioration should not be greater than the equivalent area of a 2 mm [0.079 in] circle within + or - 20 degrees of the nose of the cam lobe.

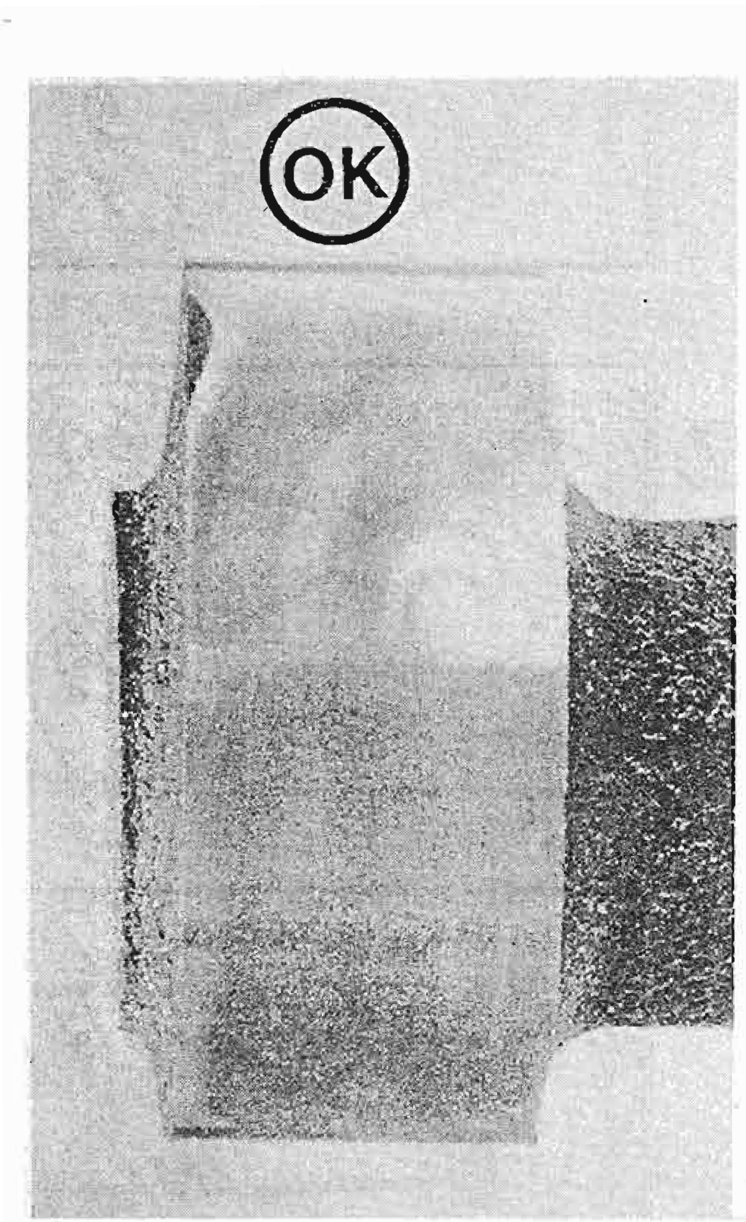


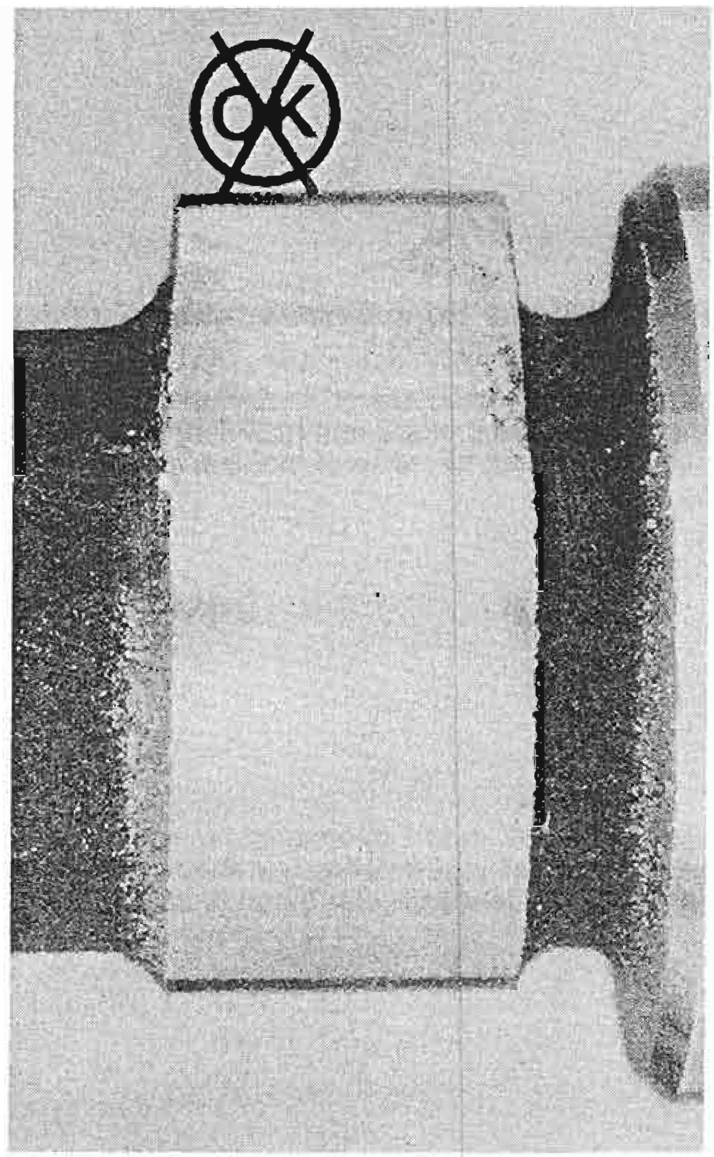
Outside of the + or - 20 degrees of the nose of the cam lobe, the areas of edge deterioration should not be greater than the equivalent area of a 6 mm [0.236 in] circle.

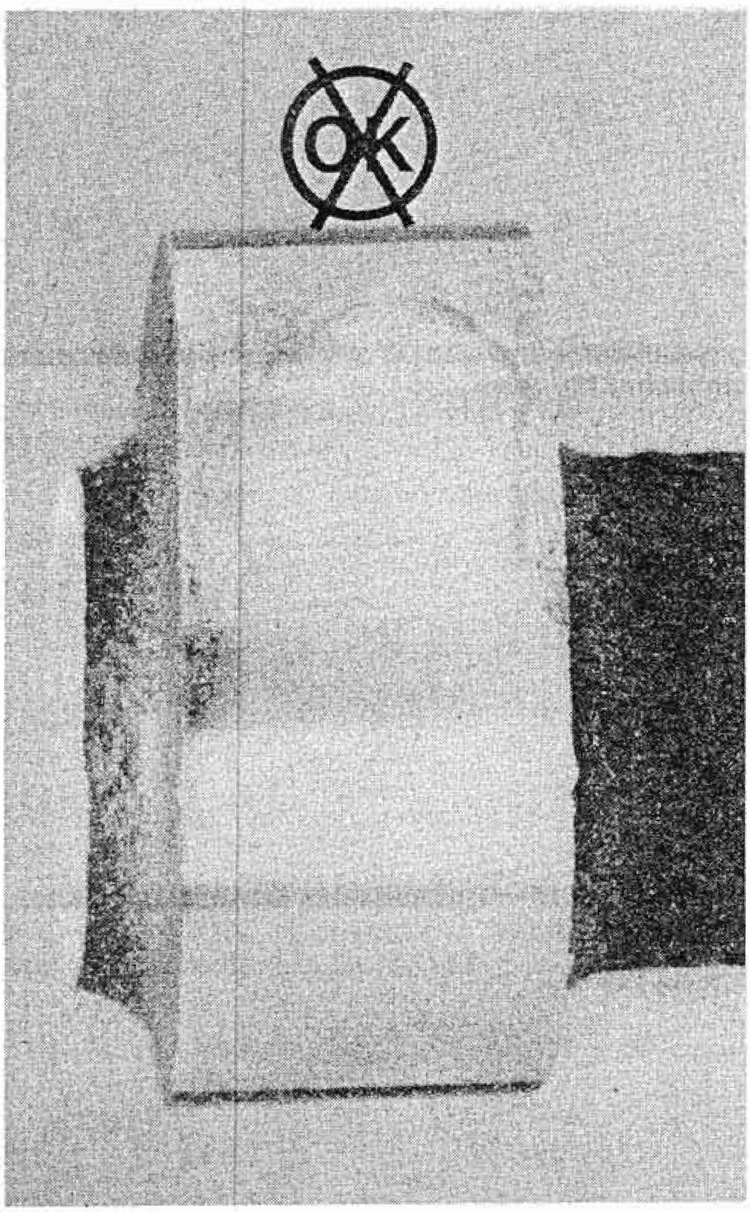


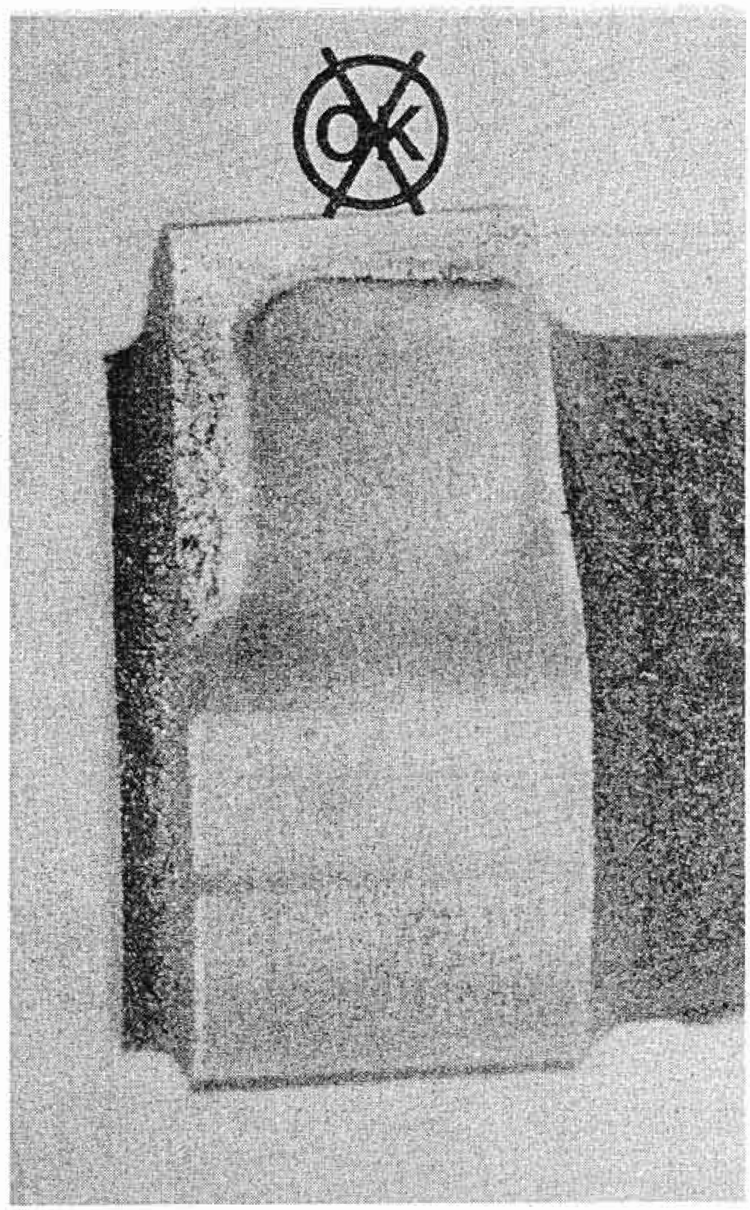
The first of the following illustration shows normal polish and a casting flaw within the nose area. Both of these conditions are acceptable for reuse.

The following three illustrations show wear patterns that are not acceptable for reuse.

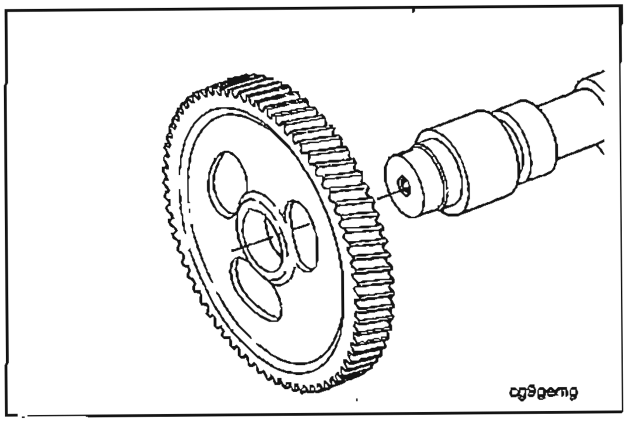






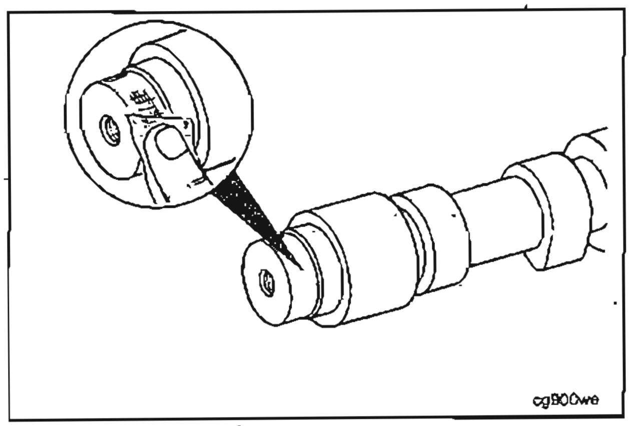


Camshaft Gear - Replacement (1-18)

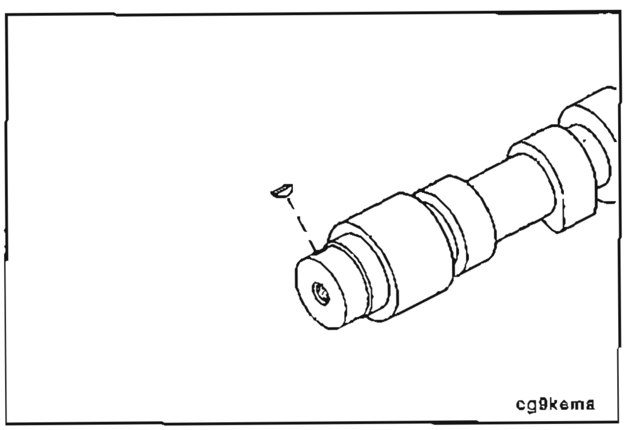


Camshaft Gear - Removal (1-19)

Remove the gear.

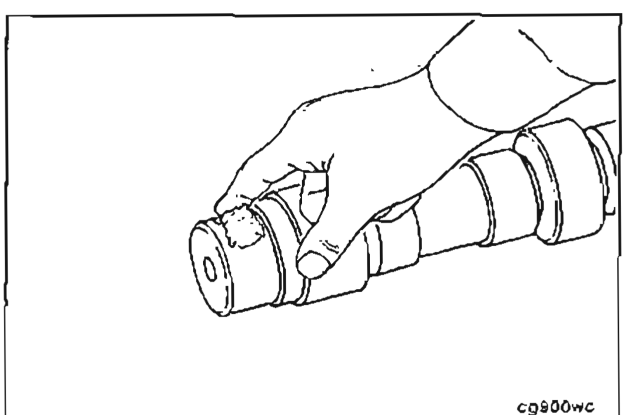


Remove all burrs and smooth any rough surfaces caused by removing the gear.



Camshaft Gear - Installation (Heated Gear Method) (1-20)

Install the key.

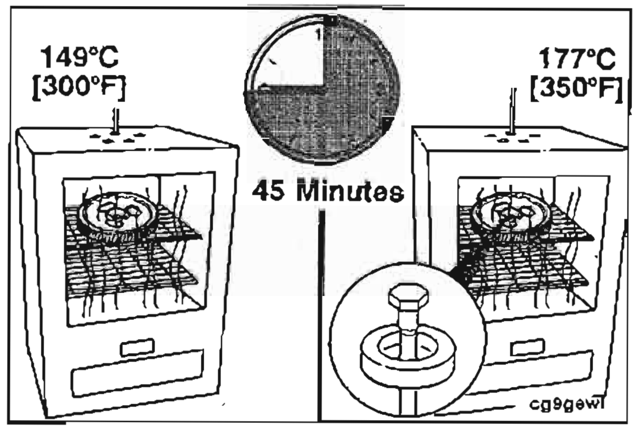


Lubricate the camshaft surface with Lubriplate 105.

Caution: The gear will be permanently distorted if overheated. The oven temperature should never exceed 177°C [350°F].

Heat the camshaft gear in a preheated oven at 149°C [300°F] for 45 minutes.

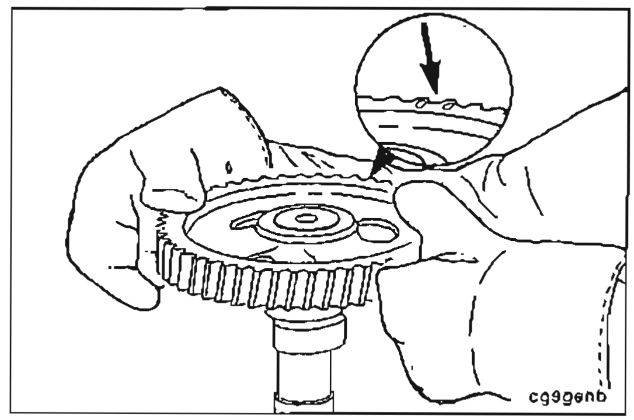
Heat the gear for bolted camshafts (steel gear) to 177°C [350°F].



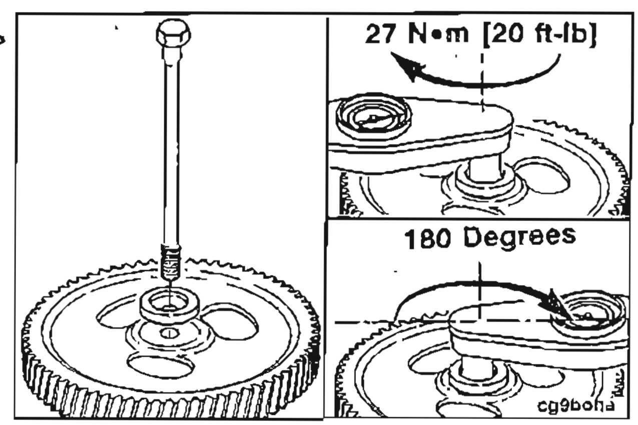
Wear protective gloves to prevent personal injury.

Install the gear with the timing marks away from the camshaft.

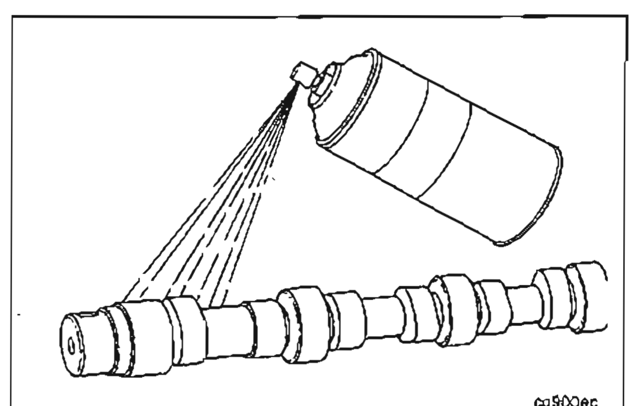
Be sure the gear is seated against the camshaft shoulder.

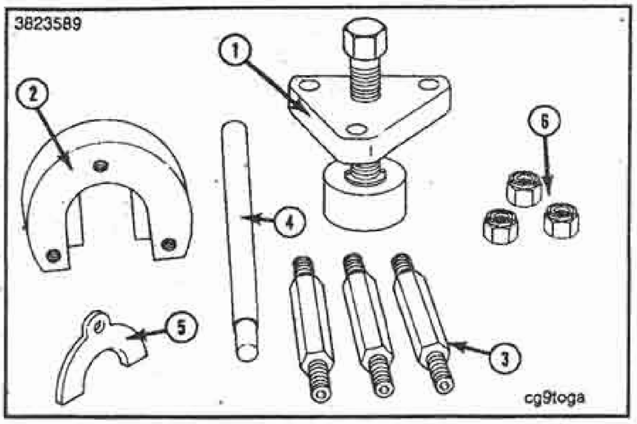


Automotive engines, manufactured before 1994, that use Bosch P7100 fuel pumps require a camshaft capscrew be installed. Refer to procedure (1-21)



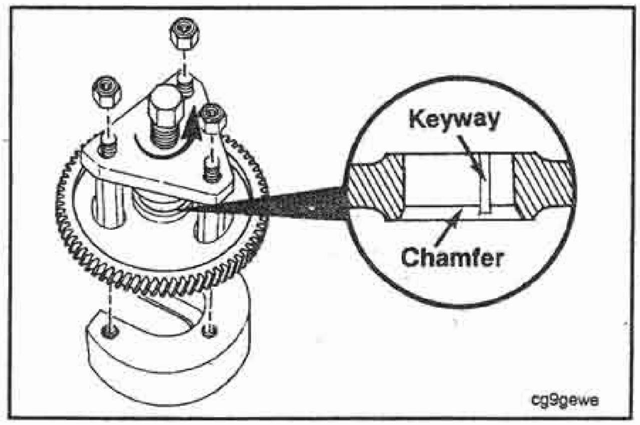
If the camshaft is not to be used immediately, lubricate the lobes and journals to prevent rusting.



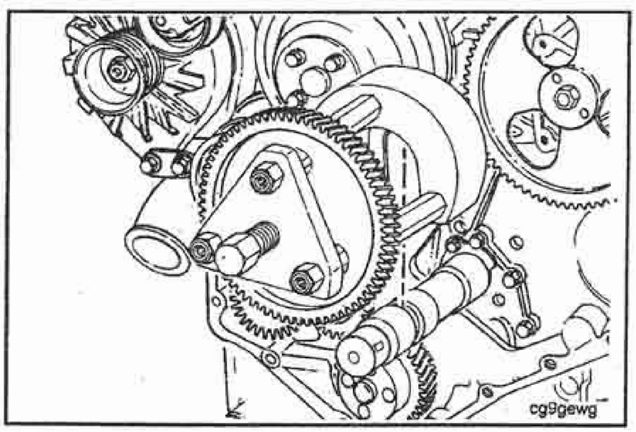


Camshaft Gear - Installation (With Special Tool 3823589) (1-21)

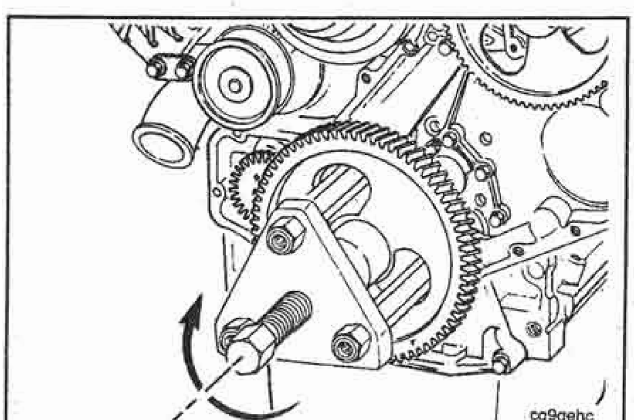
No.	Description	Qty.
1	Screw Press	1
2	Yoke	1
3	Rods	3
4	Torque Arm	1
5	Retainer	1
6	Nuts	3



Assemble the screw press, yoke, rods, nuts, and camshaft gear with the chamfered side of the gear facing the camshaft.



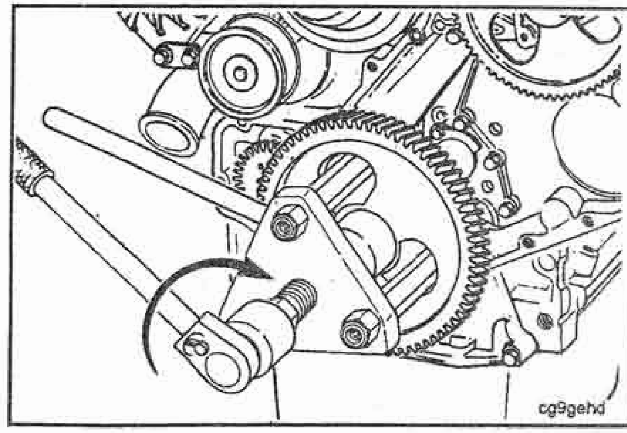
Clean all oil and lubricant from the camshaft and camshaft gear. Position the gear and tool assembly on the camshaft with the yoke placed over the end camshaft bearing journal.



Hand-tighten the screw press and engage the gear to the camshaft and keyway.

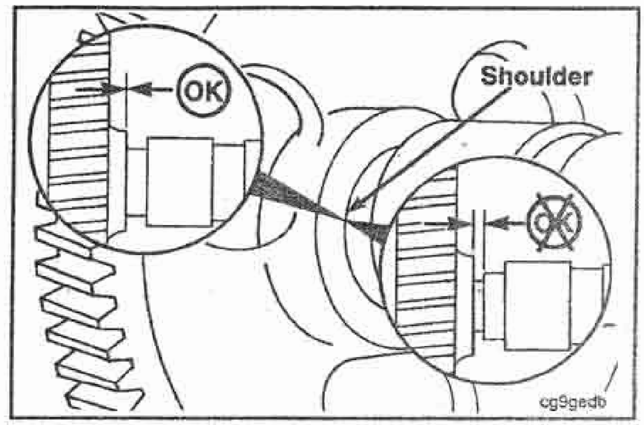
Once the gear is properly started on the camshaft, insert the torque arm into the screw press and, using a wrench with the screw press, install the camshaft gear.

NOTE: Do not exceed 100 ft-lb of torque while installing the gear. Do not use an impact wrench with this or any other Cummins special tool. It can damage the engine parts or the tool.

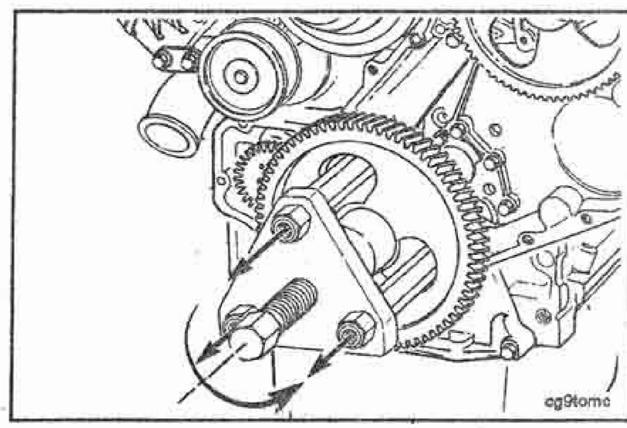


While turning the screw, the effort required should increase steadily until the gear seats against the camshaft shoulder.

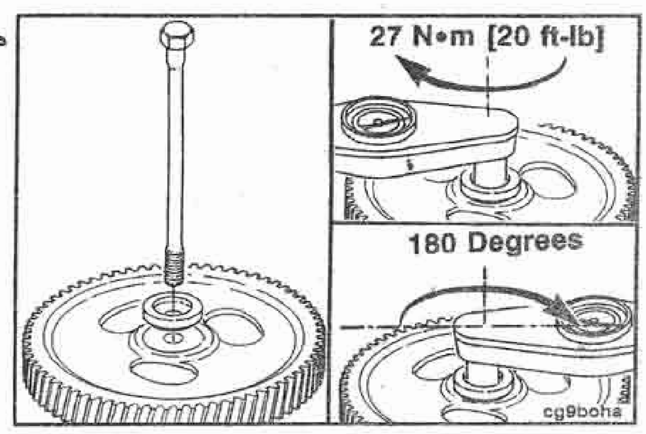
When the gear is properly installed, the gear is in contact with the shoulder on the camshaft.



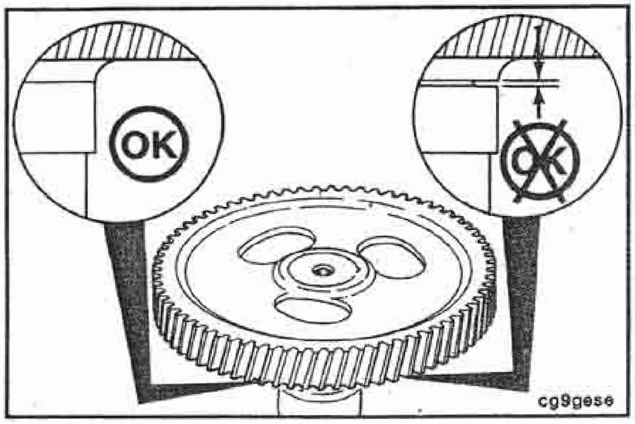
Disassemble the camshaft gear installation tool and remove the camshaft retainer.



Automotive 1991 engines with Bosch P7100 inline injection require a camshaft capscrew be installed. Refer to procedure (1-22).

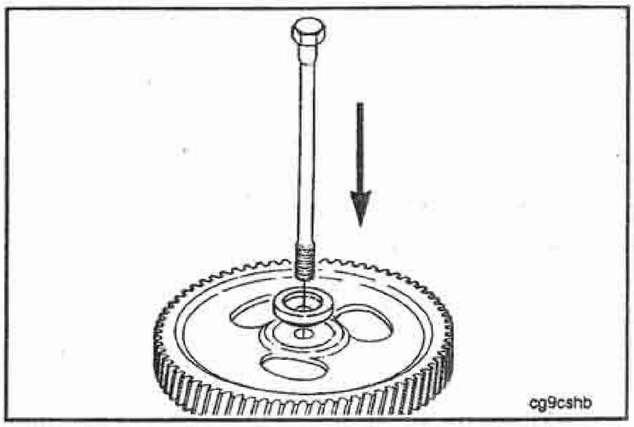


Camshaft Capscrew - Installation (1-22)

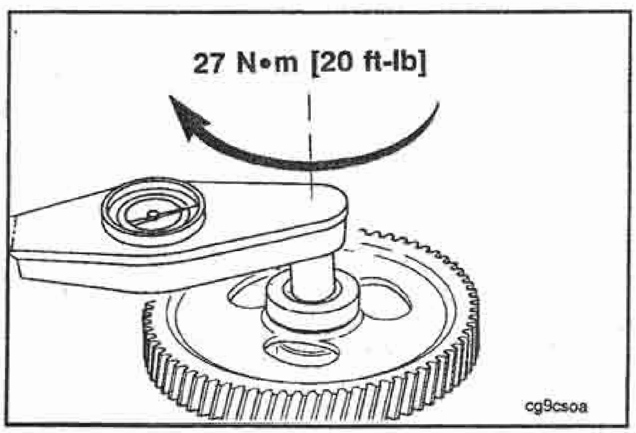


Be sure the gear is seated against camshaft shoulder.

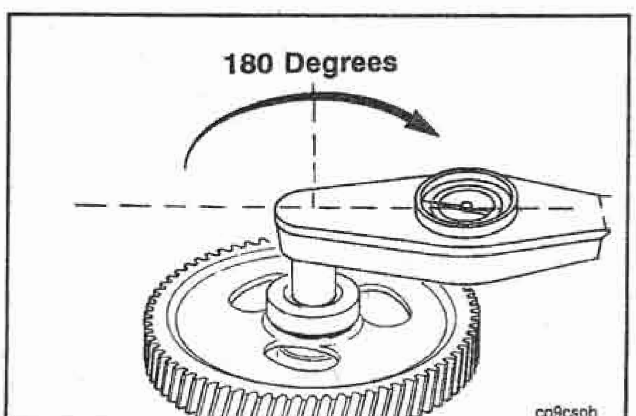
Using a .001 inch feeler gauge, check to see if the feeler gauge can be inserted between the gear and the shoulder on the camshaft. If the feeler gauge can be inserted, the gear is not properly seated.



Insert the camshaft capscrew into the gear retainer and install the capscrew/retainer assembly into the camshaft.



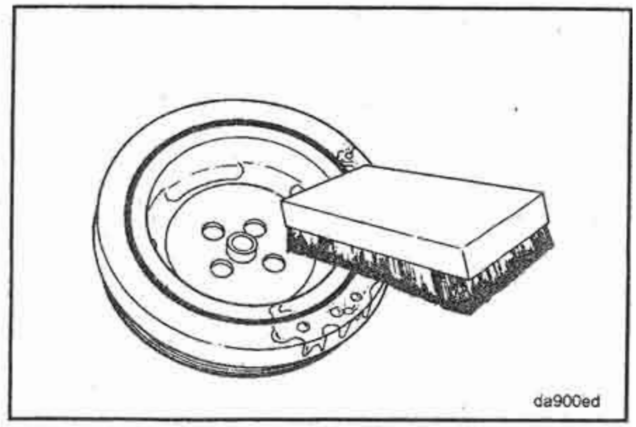
Torque the camshaft capscrew to 27 N•m [20 ft-lb].



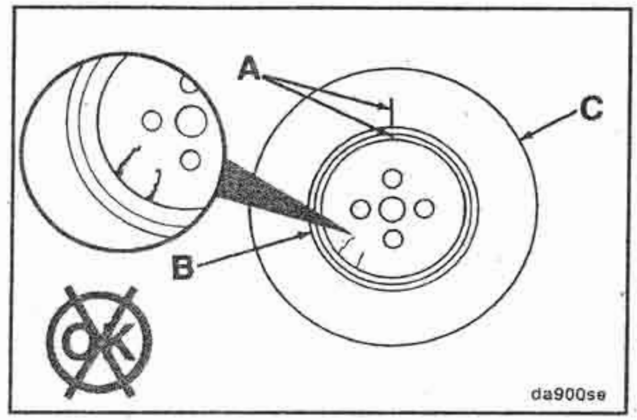
After torquing the camshaft capscrew to 27 N•m [20 ft-lb], then rotate the capscrew an additional 180° of rotation.

Rubber Element Vibration Damper - Cleaning and Inspection (1-23)

Clean the damper with hot soapy water and a brush. After rinsing with clean water, use compressed air to dry.

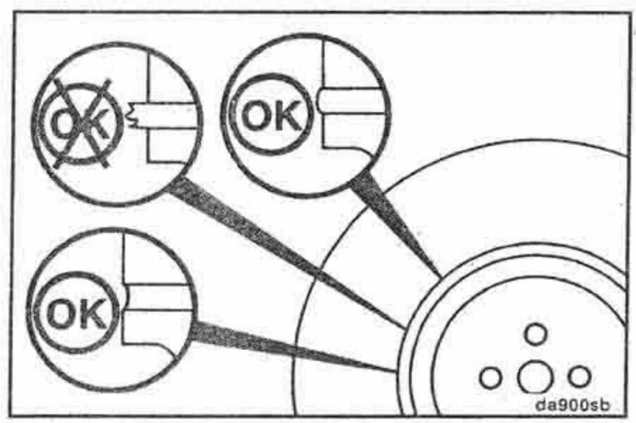


Check the index lines (A) on the damper hub (B) and inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the damper.



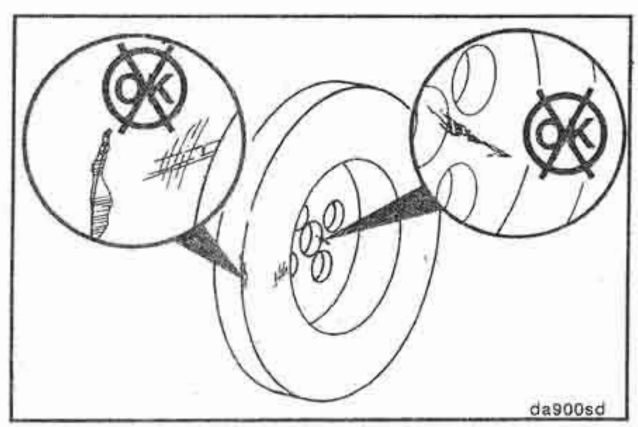
Inspect the rubber member for deterioration and missing pieces. If pieces of rubber are missing or the member is more than 3.18 mm [1/8 in] below the metal surface, replace the damper.

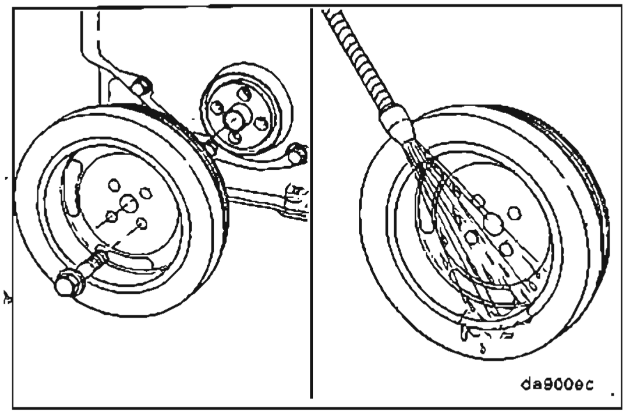
NOTE: Also look for forward movement of the damper ring on the hub. Replace the damper if any movement has occured.



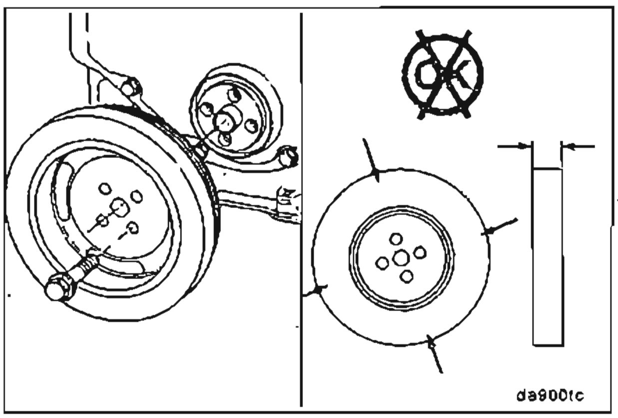
Viscous Vibration Damper Cleaning and Inspection

Check the mounting web for cracks. Check the housing for dents or raised surfaces. Replace the damper if any of these defects are identified. Refer to replacement procedure in this section.

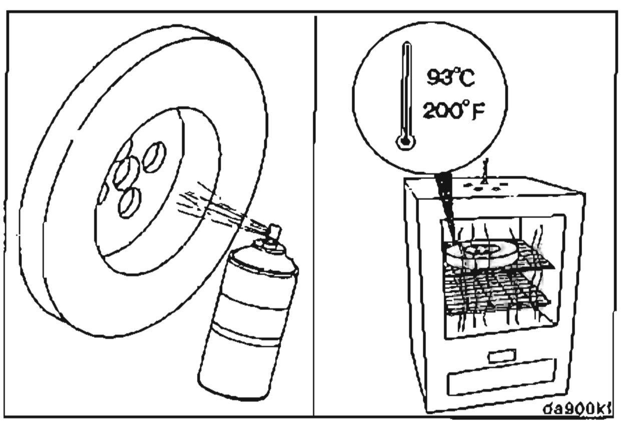




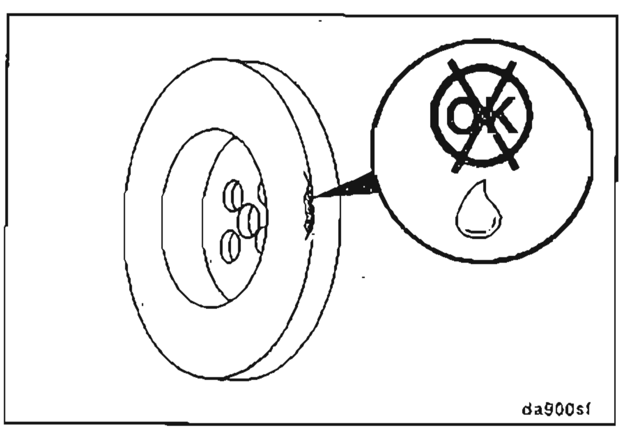
Clean the damper with a solvent cleaner.



The viscous damper is filled with a silicone fluid. After many hours or use, the silicone fluid may become thicker and expand. To determine if the damper thickness is correct, remove the paint from the damper in four locations on either side of the damper. Measure and record the thickness of the damper in four places. Measure the thickness 3.175 mm [0.125 inch] from the out side of the damper. Replace the damper if its thickness varies by more than 0.25 mm [0.010 inch].



Spray the damper with spot check developer, Type SKD-NF or its equivalent. Heat the damper in an oven (rolled lip side down) at 93°C [200°F] for 2 hours.

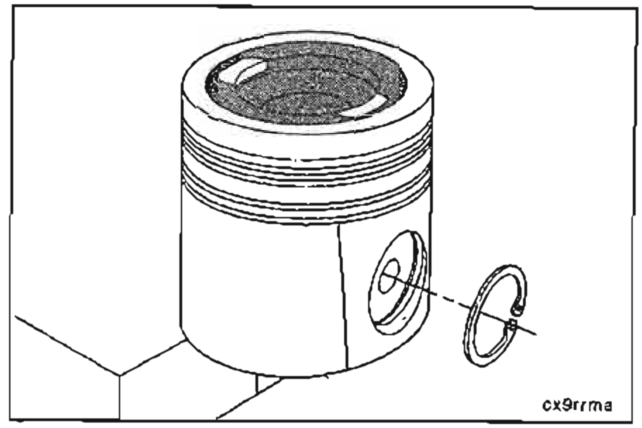


Caution: Wear protective gloves to prevent personal injury when handling parts that have been heated.

Remove the damper from the oven and check for fluid leakage. If there is leakage, replace the damper.

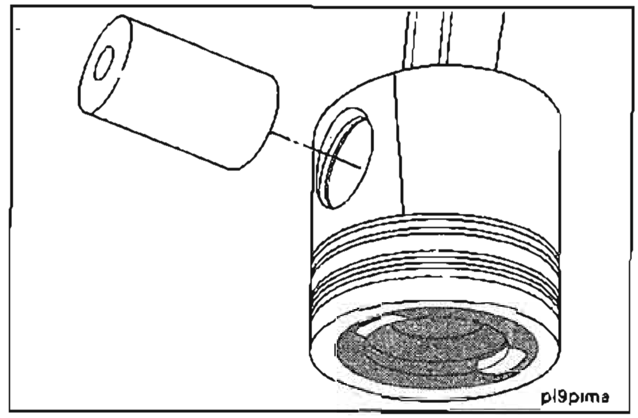
Piston and Connecting Rod - Disassembly (1-24)

Remove the retaining rings.



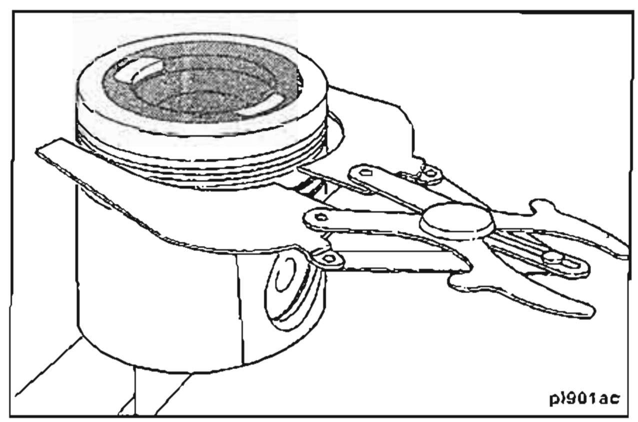
Remove the piston pin.

Heating the piston is not required.



Piston Ring Expander Part No. 3823137

Remove the piston rings.

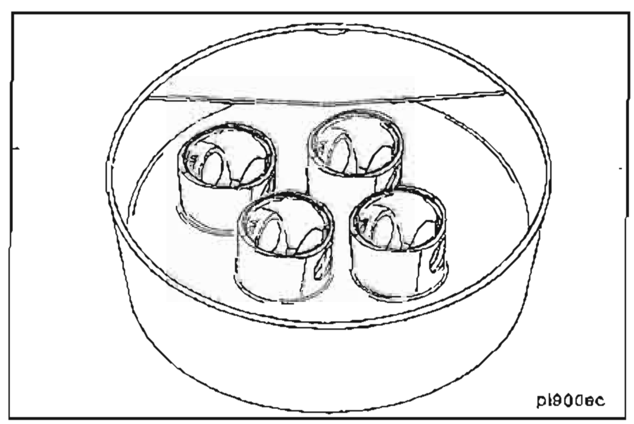


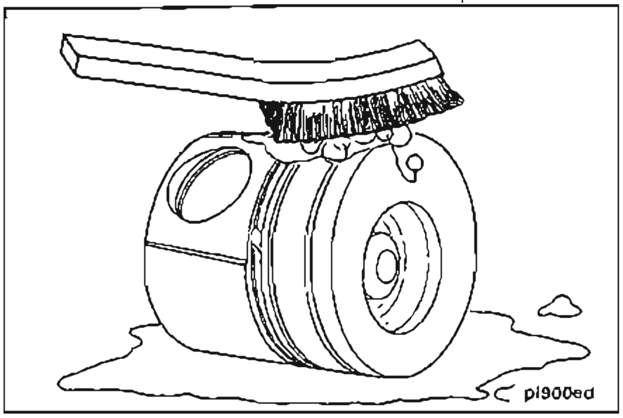
Piston, Pin and Connecting Rod - Cleaning (1-25)

Caution: Do not use the bead blast method to clean the piston. The piston will be damaged by blast material embedded in the aluminum.

Soak the pistons in cold parts cleaner.

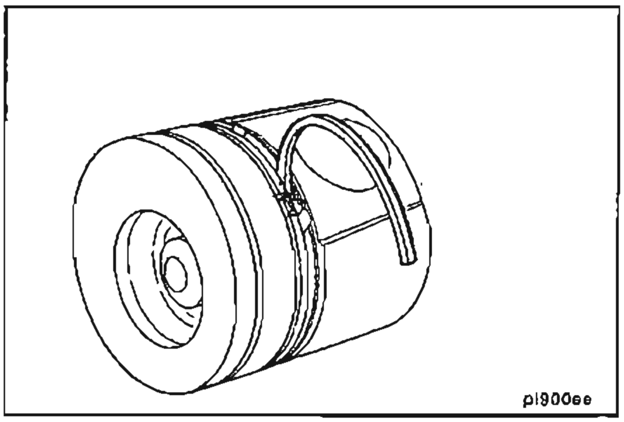
Soaking the pistons overnight will usually loosen the carbon deposits.





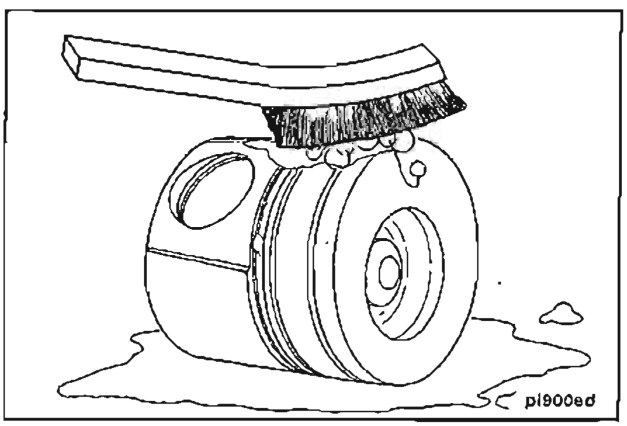
Caution: Do not clean the pistons and rods in an acid tank.

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



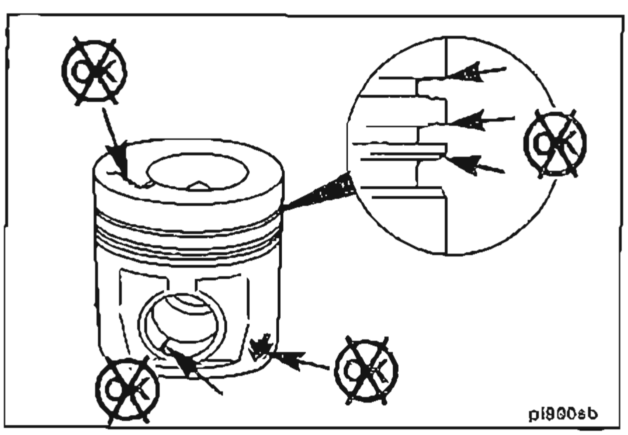
Caution: Do not use a ring groove cleaner and be sure not to scratch the ring sealing surface in the piston groove.

Clean the remaining deposits from the ring grooves with the square end of a broken ring.



Wash the pistons again in a detergent solution or solvent.

After rinsing, use compressed air to dry.

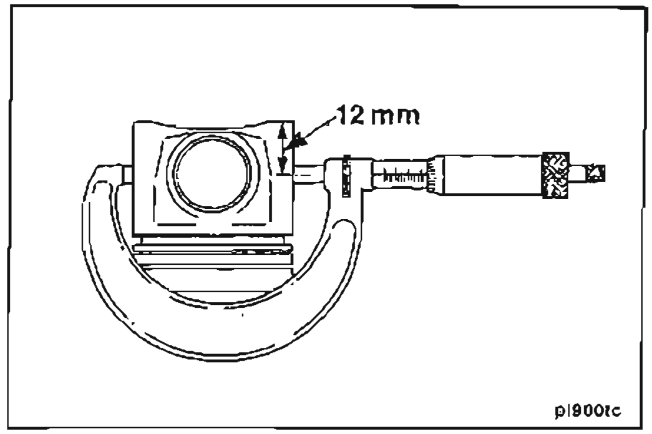


Piston Inspection (1-26)

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

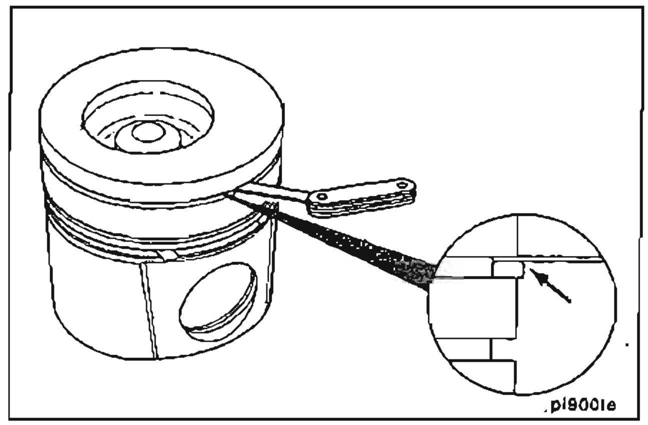
Measure the piston skirt diameter as illustrated.

Diameter		
mm		in
101.823	MIN	[4.0088]
101.887	MAX	[4.0113]



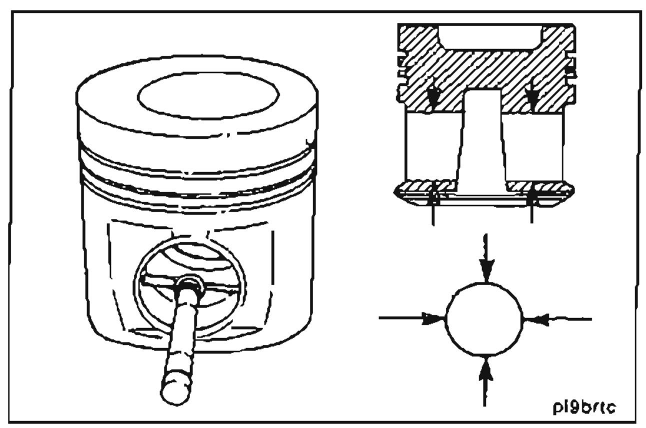
Use a new piston ring to measure the clearance in the ring groove.

	Ring Clearance		
	mm		in
Top (Turbocharged)	No Check Needed		
(Naturally Aspirated)	0.075	MIN	[0.003]
	0.150	MAX	[0.006]
Intermediate	0.075	MIN	[0.003]
	0.150	MAX	[0.006]
Oil Control	0.040	MIN	[0.002]
	0.130	MAX	[0.005]



Measure the pin bore.

Diameter		
mm		in
40.006	MIN	[1.5750]
40.025	MAX	[1.5758]

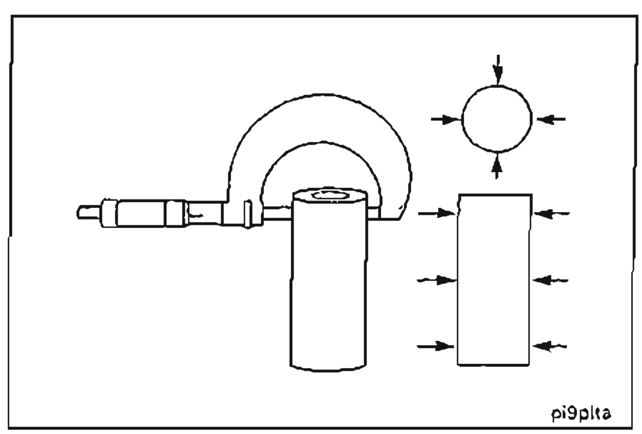


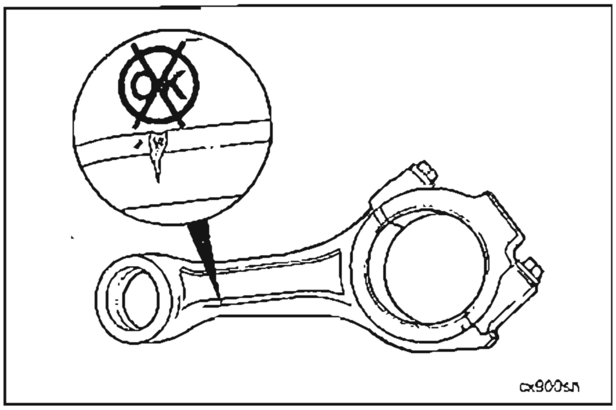
Piston Pin - Inspection (1-27)

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

Measure the pin diameter.

Diameter		
mm		in
39.990	MIN	[1.5744]
40.003	MAX	[1.5749]

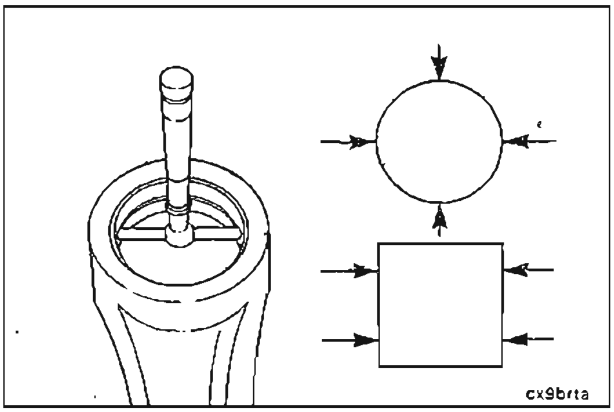




Connecting Rod - Inspection (1-28)

Caution: The I-Beam section cannot have dents or other damage. Damage to this part can cause stress risers which will progress to breakage.

Inspect the rod for damage and wear.



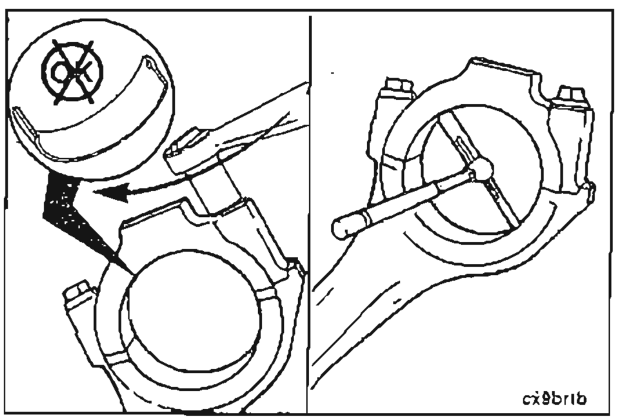
Measure the pin bore (with bushing installed).

1991 Specifications

Diameter		
mm		**in**
40.053	MIN	[1.5769]
40.076	MAX	[1.5778]

1994 Specifications

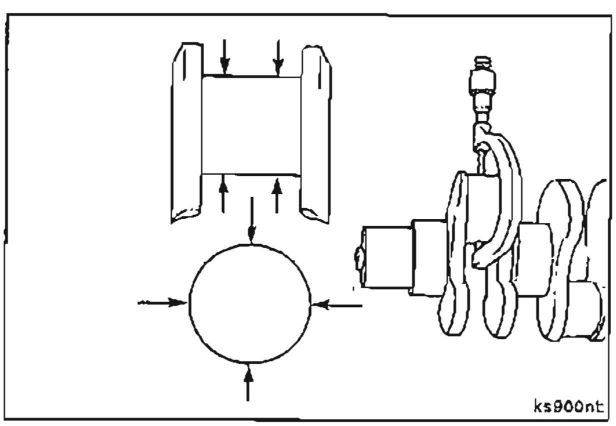
Diameter		
mm		**in**
40.019	MIN	1.5756
40.042	MAX	1.5765



Rod Bearing Clearance - Checking (1-29)

Measure the crankshaft bore with the bearings installed and the capscrews tightened to 99 N•m [73 ft-lb].

Record the smallest diameter.



Measure and record the mean diameter of rod journal on the crankshaft.

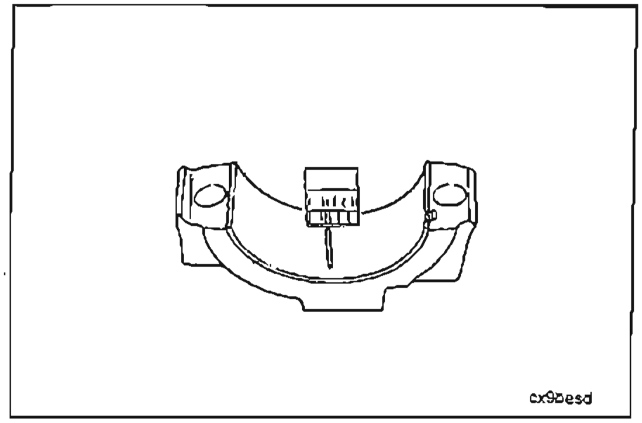
Diameter		
mm		**in**
68.962	MIN	[2.7150]
69.013	MAX	[2.7170]

Out-of-Roundness: 0.050mm [0.002 in]
Taper: 0.013mm [0.0005 in]

Bearing clearance = Rod Inside Diameter Minus Crankshaft Journal Diameter.

Clearance: 0.114mm [0.0045 in] maximum

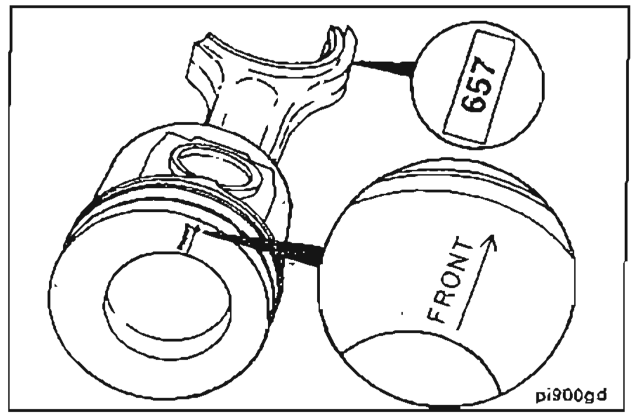
Bearing clearance can also be determined with plastigage during engine assembly.



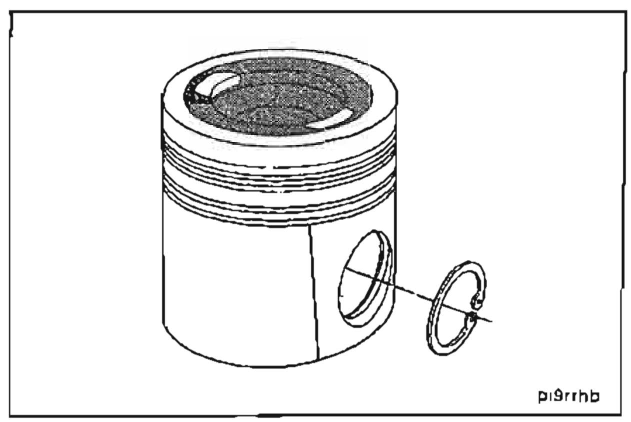
Piston and Connecting Rod - Assembly (1-30)

Be sure "**front**" marking on piston and the numbers on the rod and cap are oriented as illustrated.

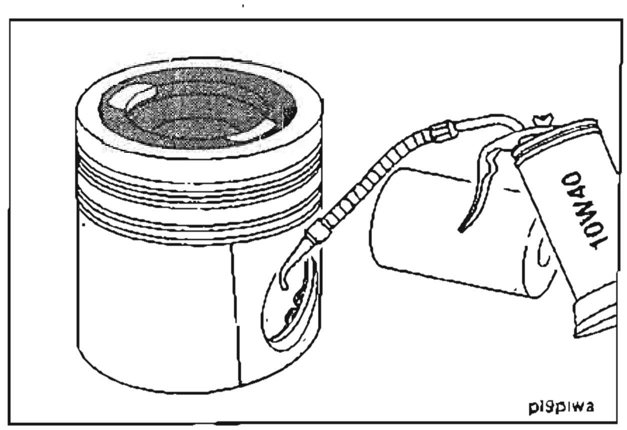
NOTE: The numbers shown in the illustration are for example purposes only.

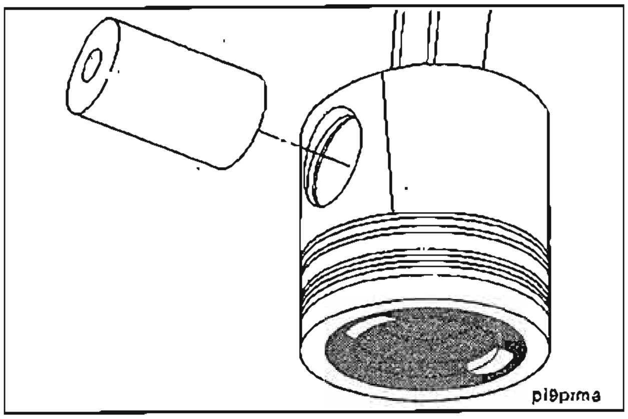


Install the retaining ring in the pin groove on the "front" side of the piston.



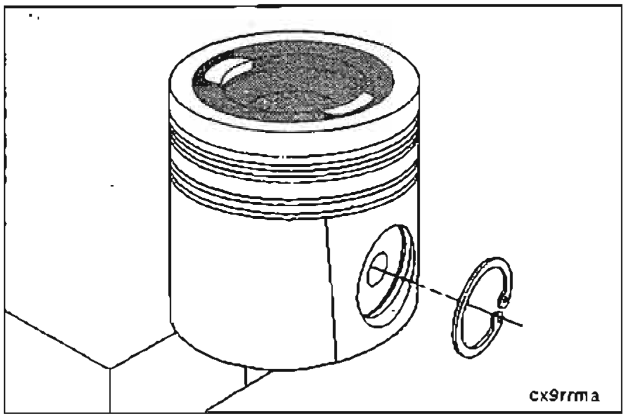
Lubricate the pin and pin bores with engine oil.





Install the pin.

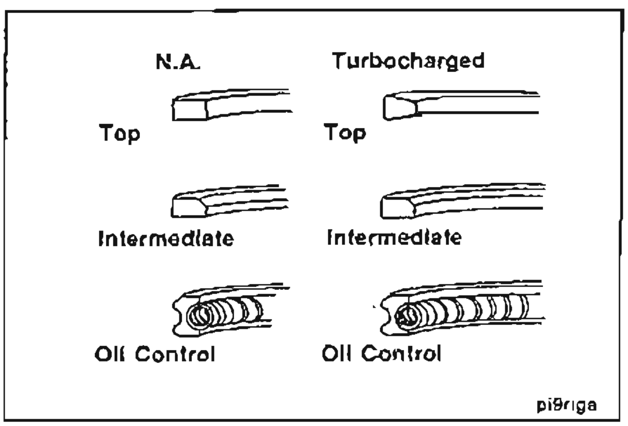
Pistons do not require heating to install the pin, however, the pistons do need to be at room temperature or above.



Install the second retaining ring.

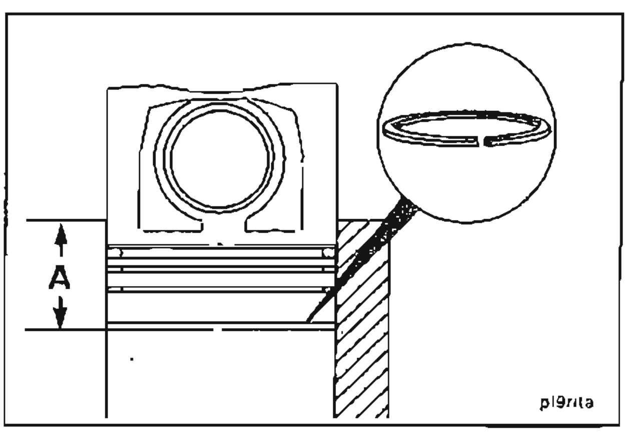
Piston Ring Gap - Checking (1-31)

The top ring for a turbocharged engine is not the same as the top ring for a naturally aspirated engine.



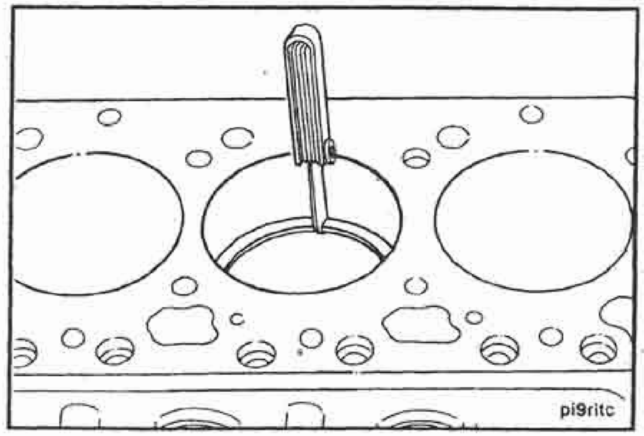
Position each ring in the cylinder and use a piston to square it with the bore.

A = 89mm [3.5 in]



Use a feeler gauge to measure the gap.

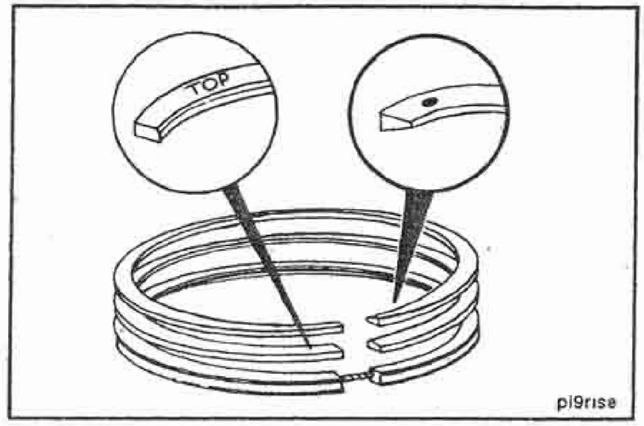
Ring Gap	mm		in
Top (Turbocharged)	0.40	MIN	[0.016]
	0.70	MAX	[0.028]
Top (N. Aspirated)	0.25	MIN	[0.010]
	0.55	MAX	[0.022]
Intermediate	0.25	MIN	[0.010]
	0.55	MAX	[0.022]
Oil Control	0.25	MIN	[0.010]
	0.55	MAX	[0.022]



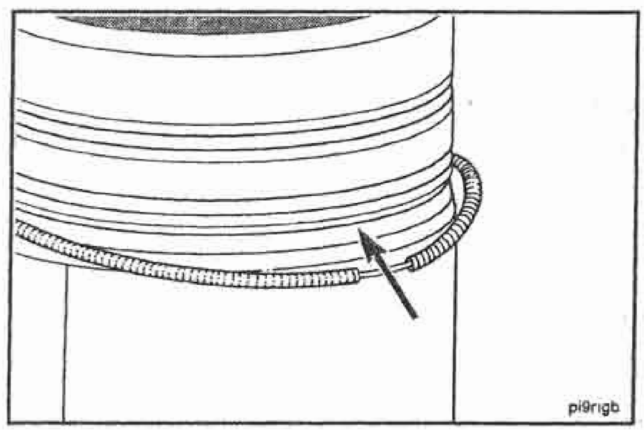
Piston Rings - Installation (1-32)

Caution: If a ring expander tool is being used, be careful not to over expand the ring.

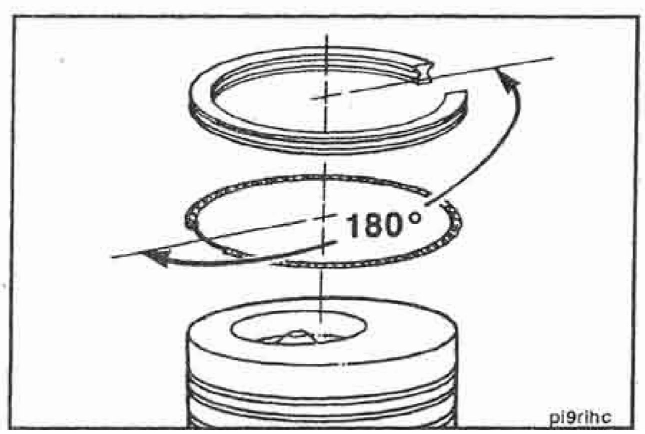
The top surface of all of the rings are identified: Assemble the word "top" up.

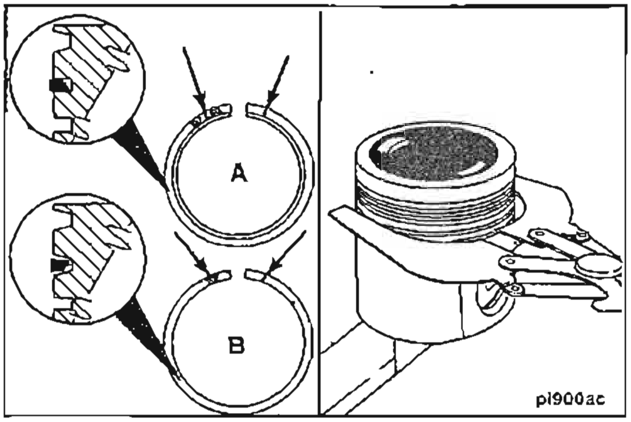


Position the oil ring expander in the control ring groove.



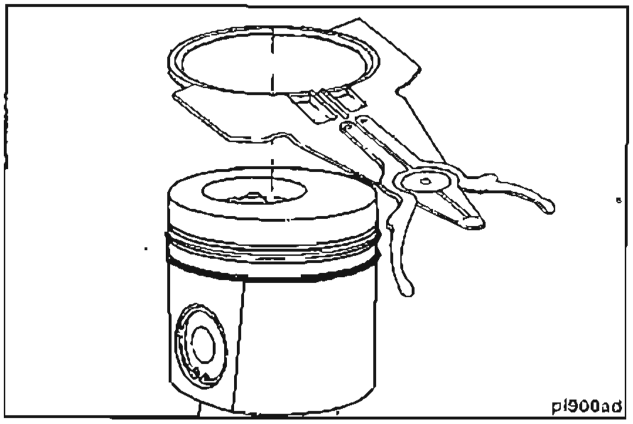
Install the oil control ring with the end gap 180° from the ends of the expander.





Piston Ring Expander, Part No. 3823137

Install the intermediate ring.



Piston Ring Expander, Part No. 3823137

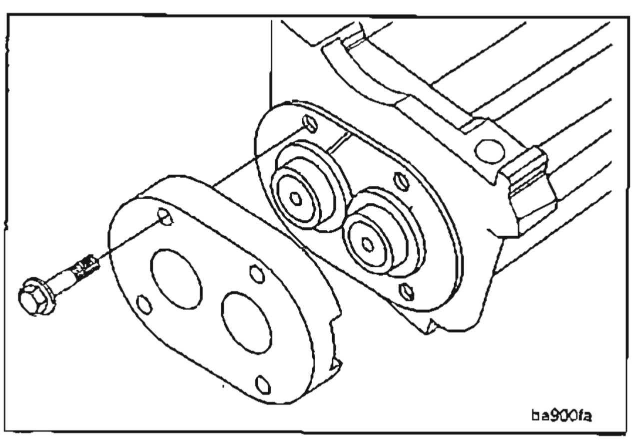
The top ring for a turbocharged engine is not the same as the top ring for a naturally aspirated engine.

Install the top ring.

Balancer - Disassembly (1-33)

Refer to the procedures and specifications given in the engine disassembly section, procedure (0-59), (0-60) and (0-61).

- The idler gear must be replaced if the backlash end play exceed the specifications.
- The shaft gears must be replaced if the backlash exceeds the specifications.
- The thrust bearing must be replaced if the shaft end play exceeds the specifications.

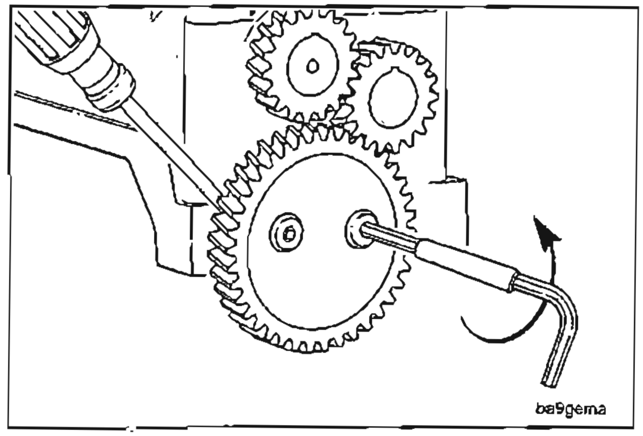


13 mm

Remove the thrust housing.

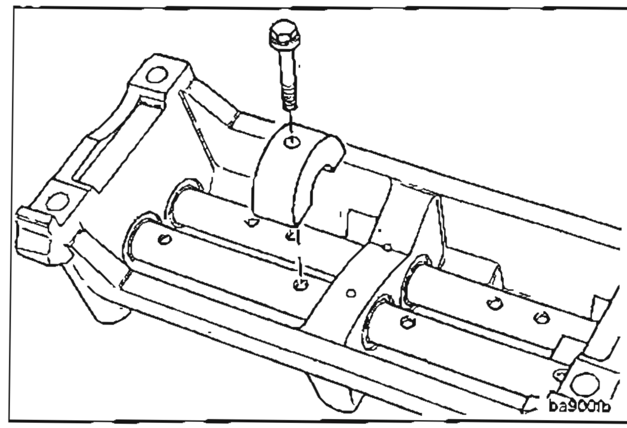
8 mm Allen

Remove the idler gear assembly.

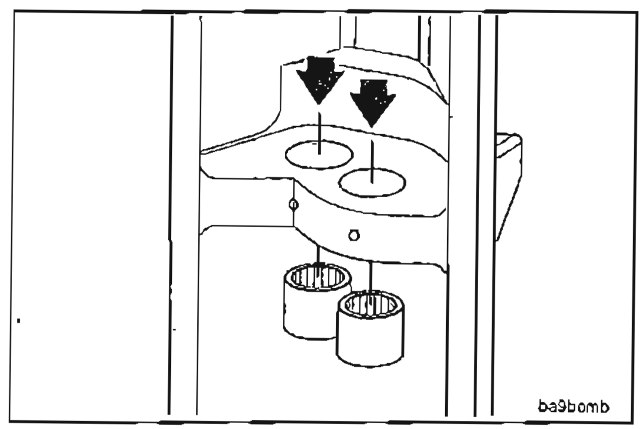


13 mm

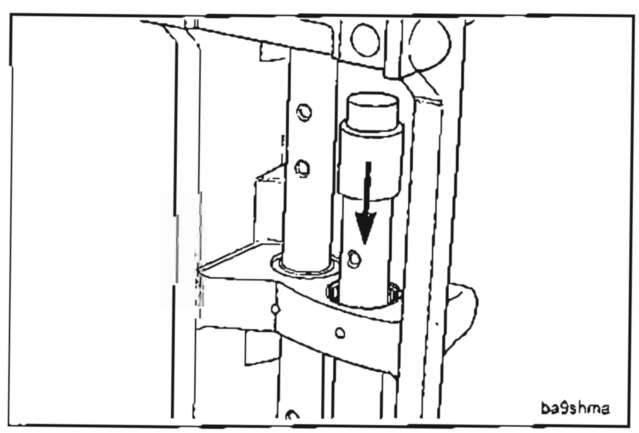
Remove the balancer weights.

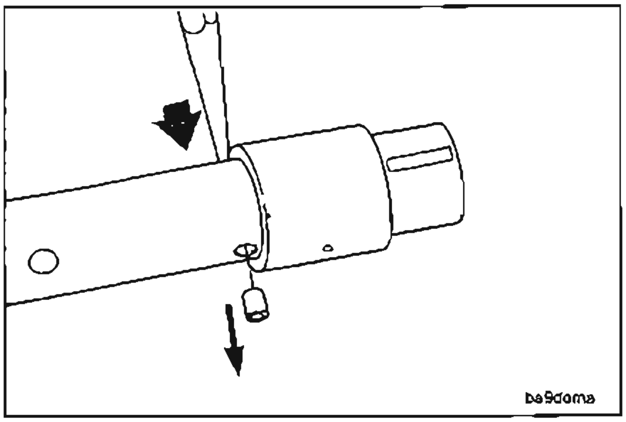


Press the shafts from the gears.



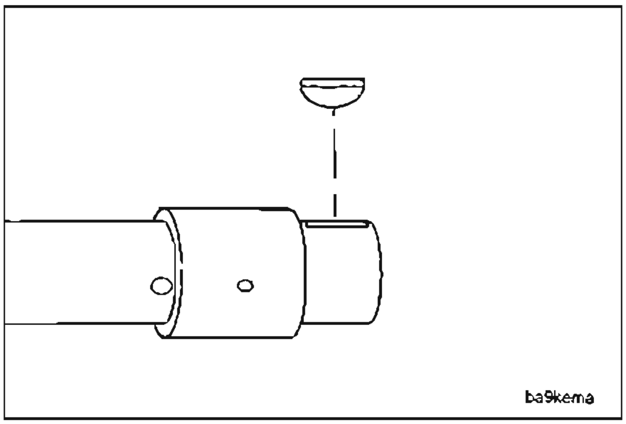
Remove the shafts from the balancer housing.



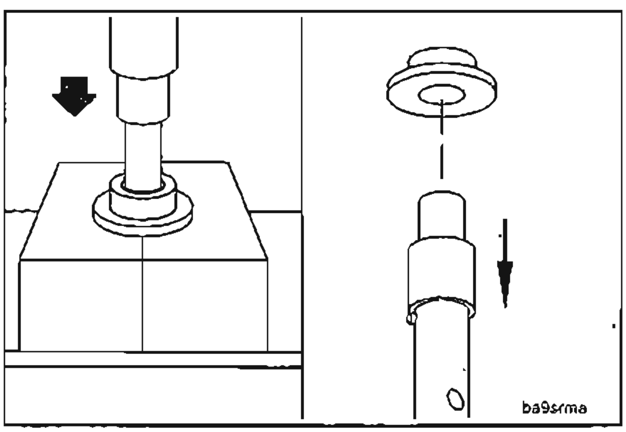


3/16 Inch Punch, Hammer

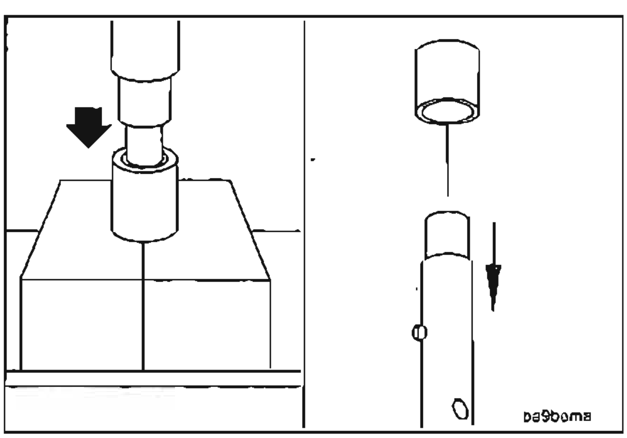
Use the punch to drive the roll pins from the shafts.



Remove the Woodruff keys from the shafts.

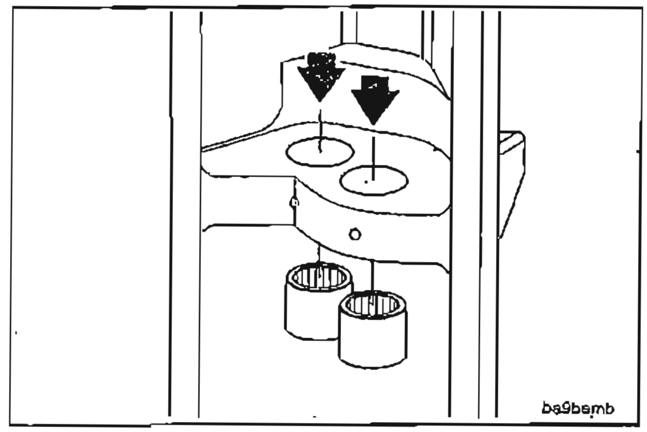


Press the shafts out of the thrust collars.



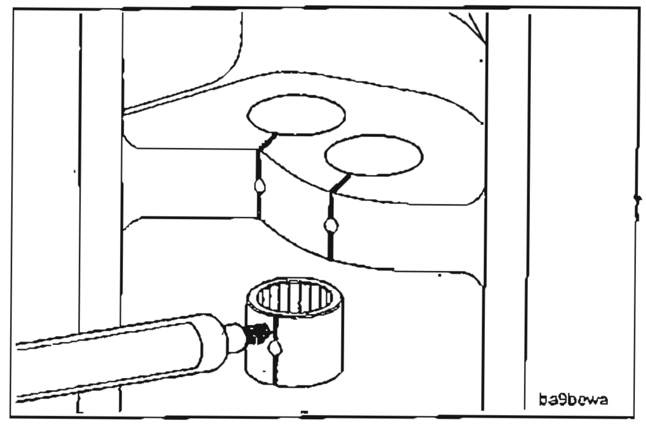
Press the shafts out of the bearing inner races.

Press the bearings out of the balancer housing.



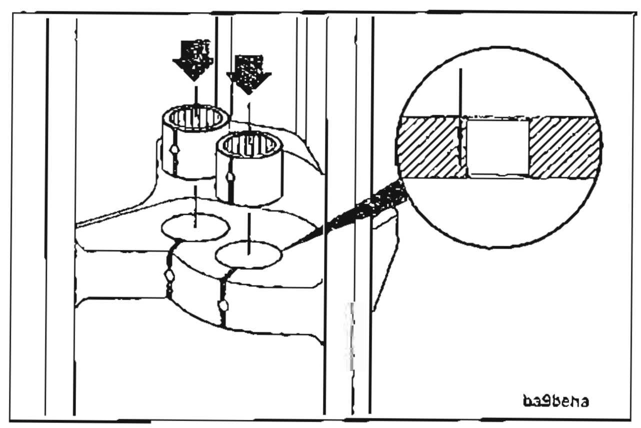
Balancer - Assembly (1-34)

The oil hole in the center bearings must align with the oil hole in the housing. Mark the housing and bearings so you can align the holes.

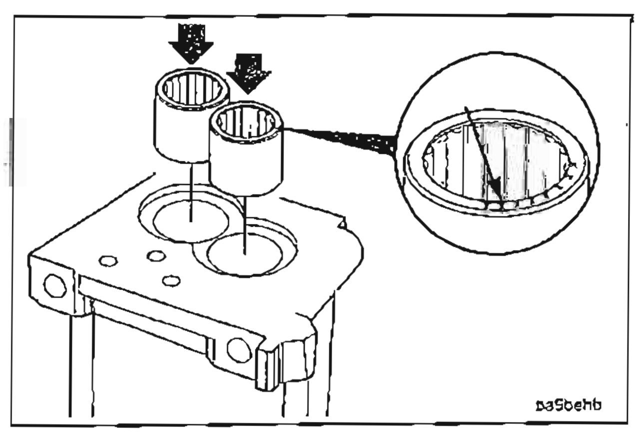


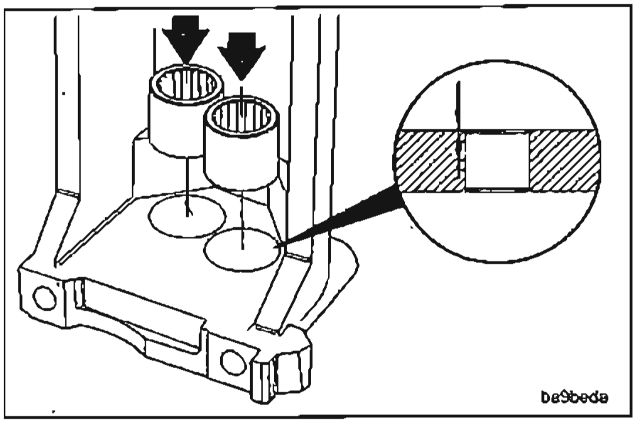
Caution: Press against the end of the bearing that has the identification mark. Failure to do so will result in damage to the bearing.

Press in the new center bearings until flush with the housing.



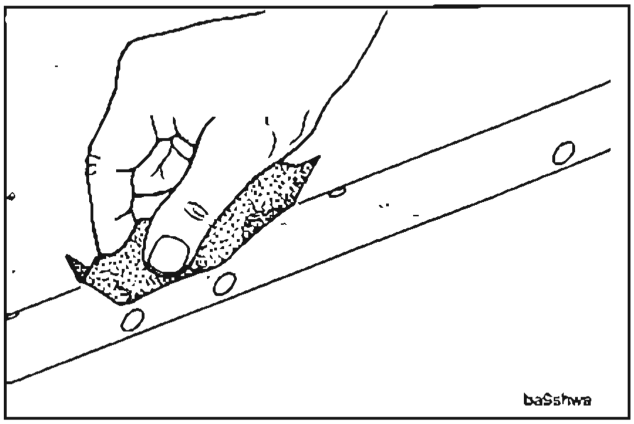
Install the bearings in the housing so the identification marks are toward the outside of the housing.





Caution: Press against the end of the bearing that has the identification mark. Failure to do so will result in damage to the bearing.

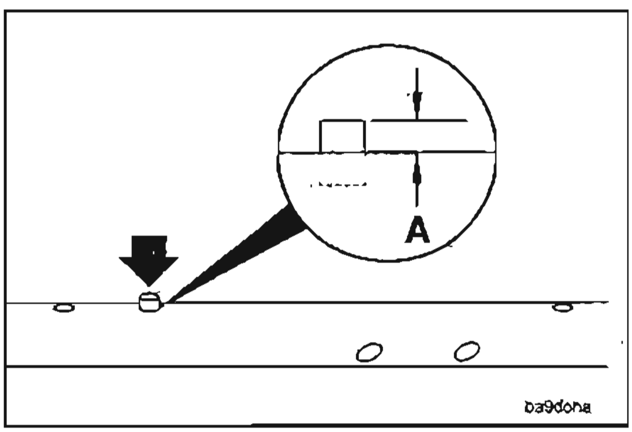
Press in the new bearings until flush with the inside of the housing.



The balancer shafts must be sub-assembled before being installed into the housing. The assembly procedure is the same for both shafts.

Use 500 grit sandpaper to polish the bearing surfaces and to remove burrs and Loctite material.

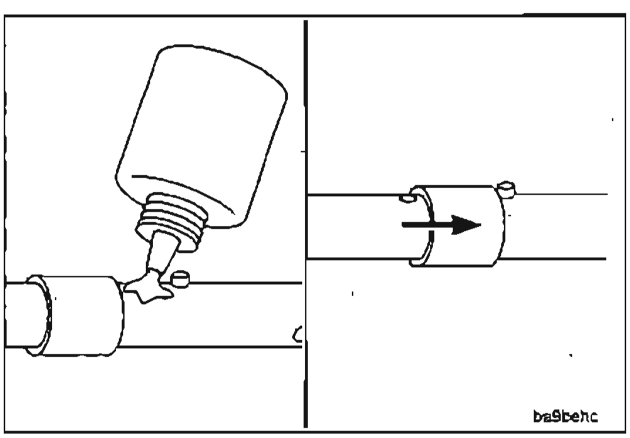
Use cleaning solvent to clean the shafts and bearing surfaces.



Hammer or Mallet

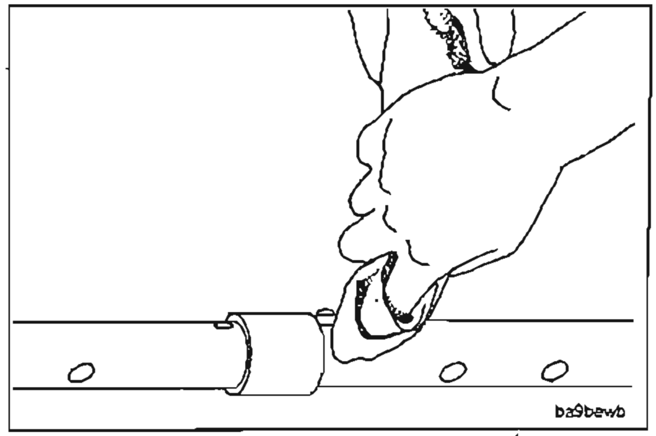
Install a new roll pin into one of the center holes in the shafts.

A = 2.5 mm [0.09 (3/32) in]



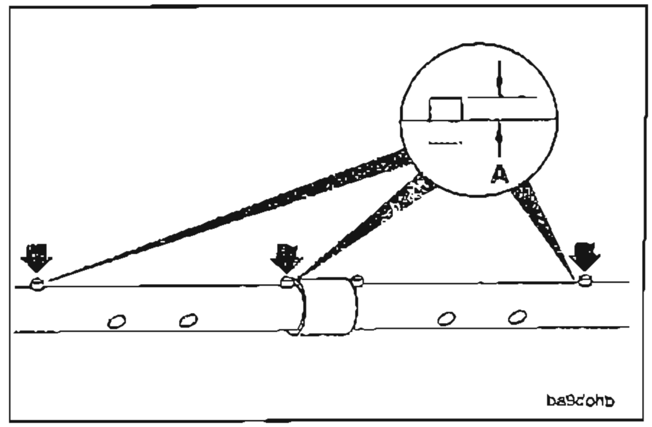
Apply a coat of Loctite 609 to the bearing surface of the shaft. Slide a new inner race into position on the shaft.

Remove the excessive Loctite from the shaft.

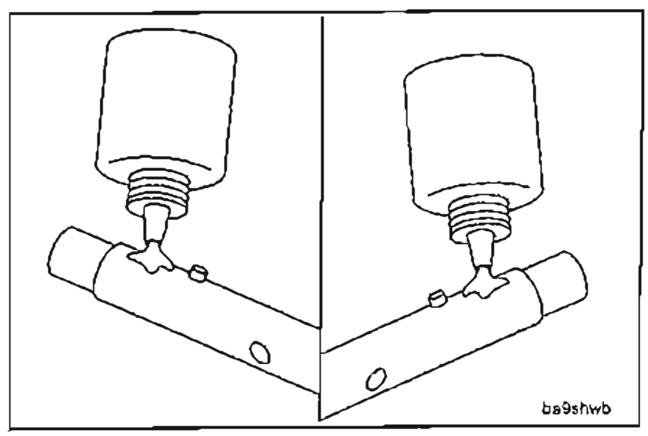


Install the three remaining roll pins.

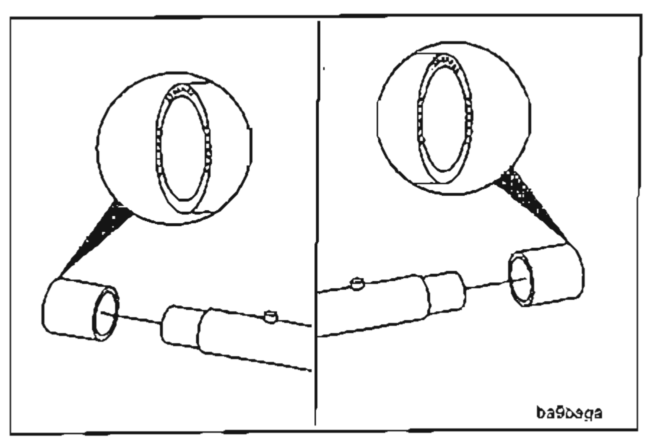
A = 2.5 mm [0.09 (3/32) in]

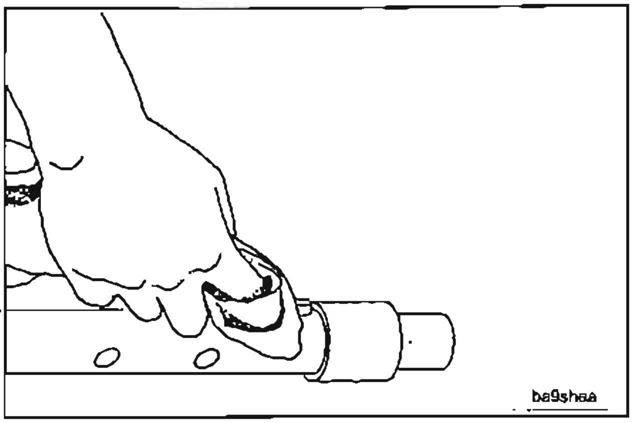


Apply a coat of Loctite 609 to the bearing surfaces.

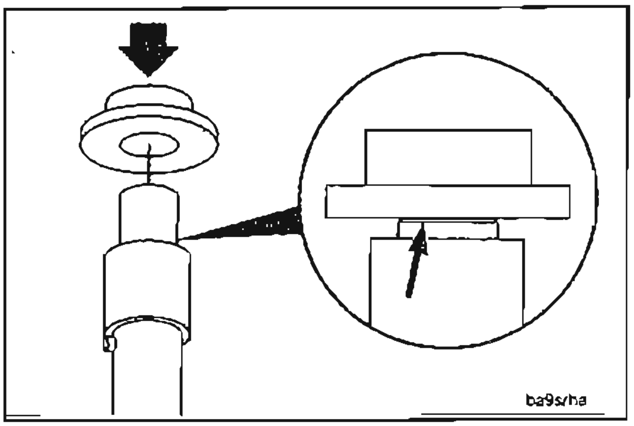


Slide two new inner races onto the ends of the shafts. The identification marks must be toward the end of the shaft.

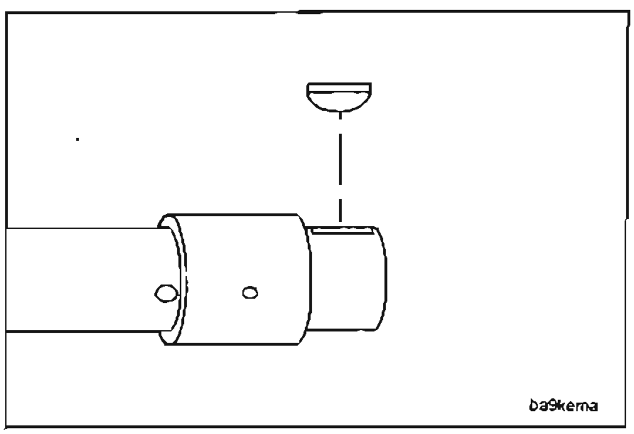




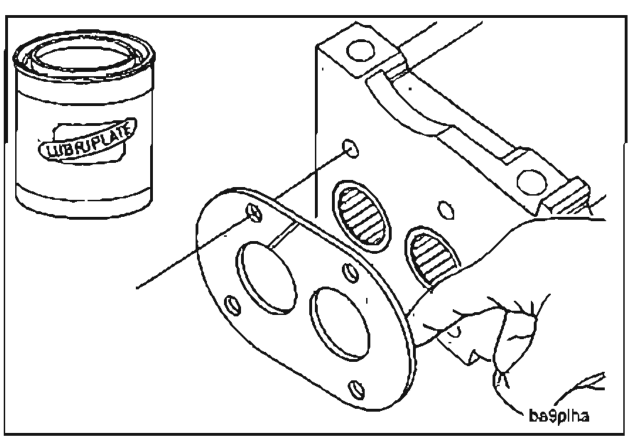
Remove the excessive Loctite.



Press on the thrust collars to the step on the shafts.



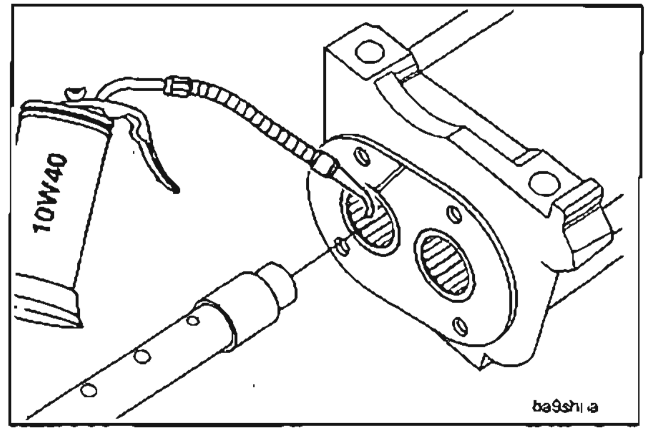
Install the Woodruff keys into the shafts.



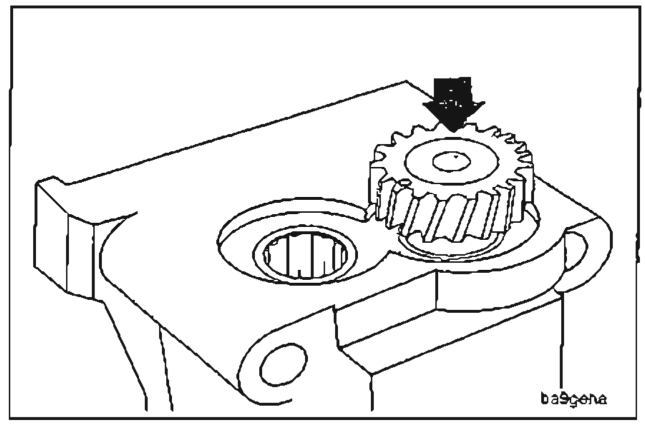
Apply a coat of lubriplate to the thrust plate. Position the thrust plate onto the housing.

Use clean engine oil to lubricate the bearings. Install the bottom shaft into the housing. The bottom shaft has the hole for the timing pin.

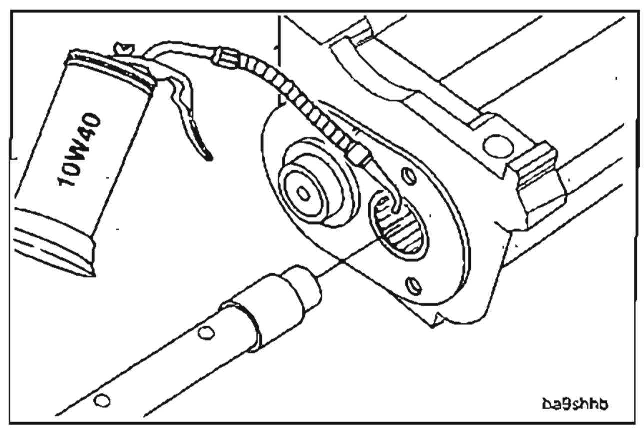
NOTE: Late model shafts have a tapped hole for the timing pin. Earlier shafts have the timing pin hole drilled completely through the shaft.



Press the gear that has one timing mark onto the bottom shaft until the gear is flush with the end of the shaft.

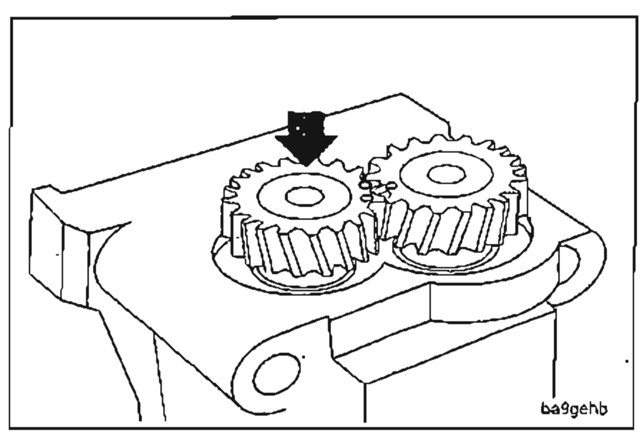


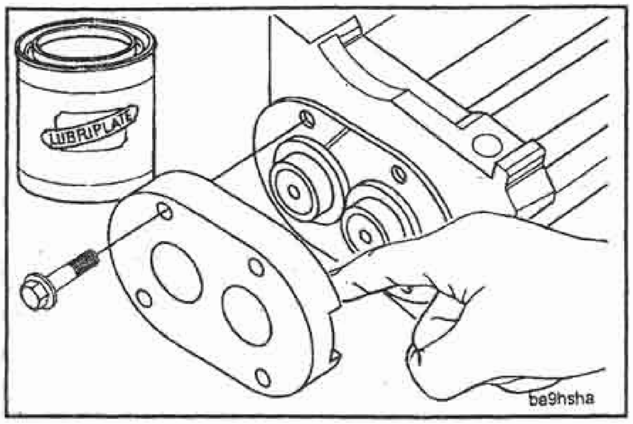
Use clean engine oil to lubricate the bearings and install the top shaft.



Caution: The timing marks must be aligned when you press the gear onto the shaft.

Press on the gear that has two timing marks until the gear is flush with the end of the shaft.

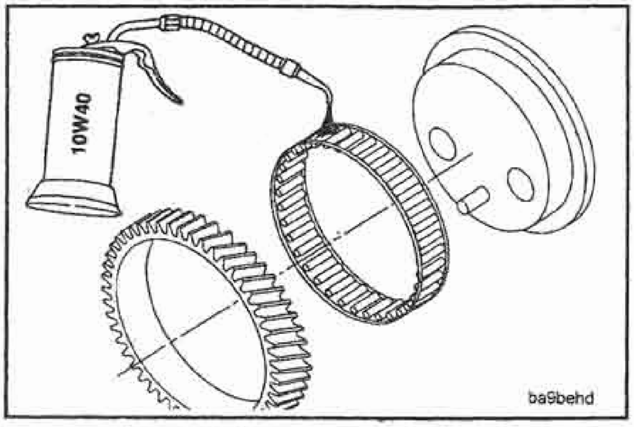




13 mm

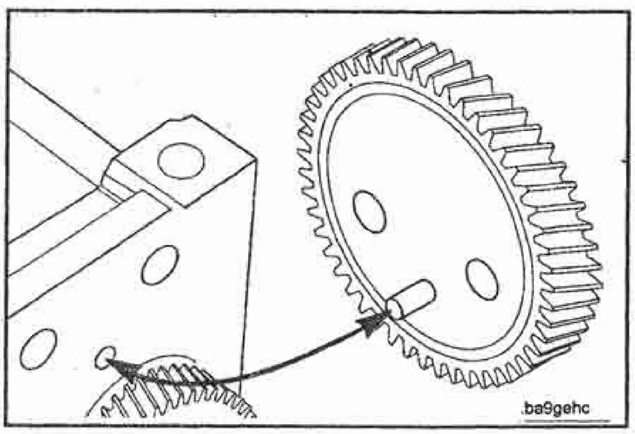
Apply a coat of lubriplate to the thrust housing. Install the thrust housing. **The mounting holes align in only one position.**

Torque Value: 24 N•m [18 ft-lb]

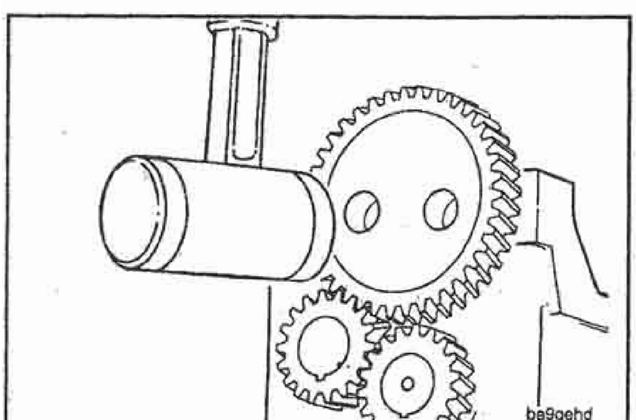


Use clean engine oil.

Lubricate and install a new bearing into the idler gear assembly.



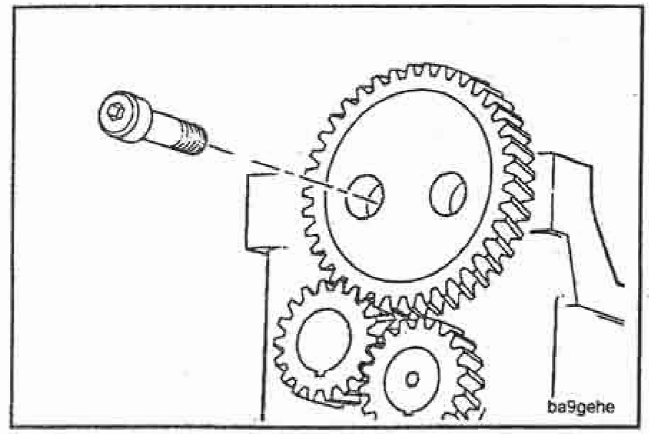
Align the idler gear assembly alignment pin with the hole in the housing.



Plastic Mallet

Tap the idler assembly gently into position.

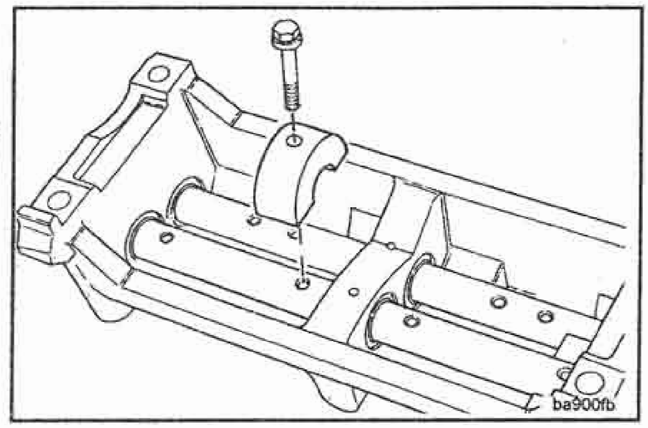
Install the two Allen head capscrews into the idler assembly. Use your fingers to tighten the capscrews.



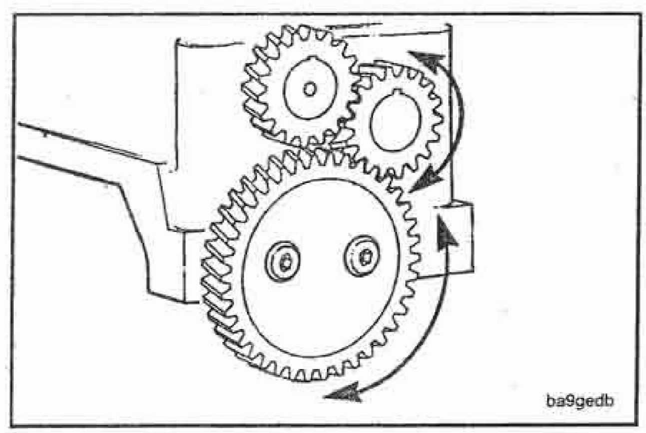
8 mm Allen

Install the balancer weights onto the shafts. The weights must be installed on the counterbore side of the holes.

Torque Value: 24 N•m [18 ft-lb]

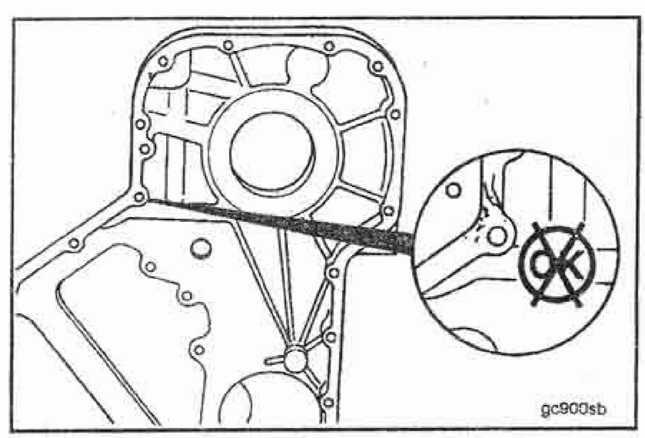


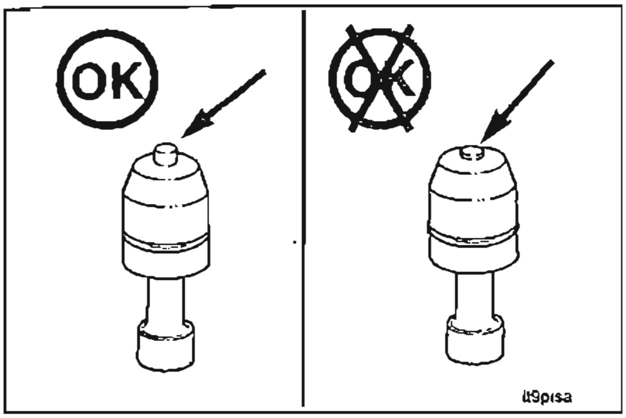
Check the balancer assembly for free rotation. If it does not rotate freely, check the thrust housing and bearings for correct installation.



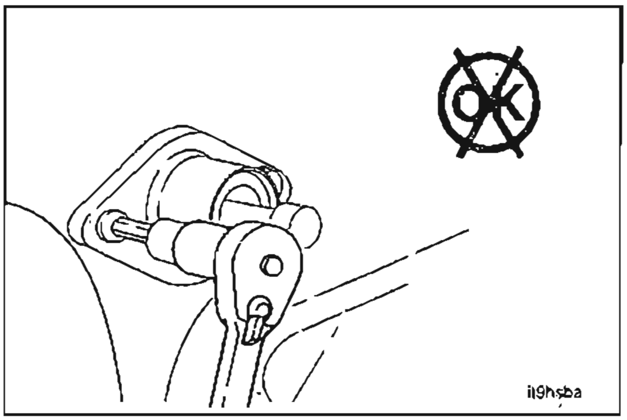
Gear Housing and Timing Pin Assembly - Inspection (1-35)

Visually inspect the gear housing for cracks or damaged sealing surfaces.



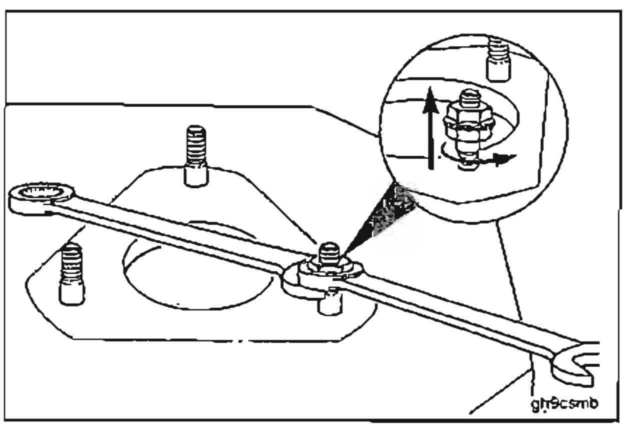


Inspect the timing pin housing and pin for damage.



Gear Housing - Disassembly (1-36)

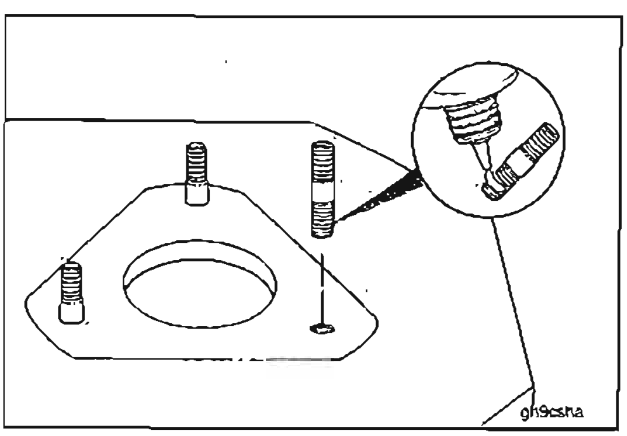
Do not remove the timing pin housing unless it is damaged or leaking, or the gear housing is being replaced. Refer to Page 0-57 for replacement procedures.



Fuel Pump Stud - Replacement (1-37)

13 mm

To install or remove fuel pump studs, use two nuts jam locked onto the stud.



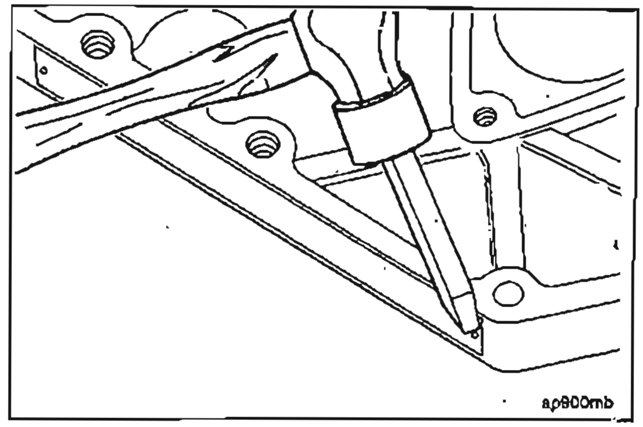
13 mm

Coat the threads with Loctite™ 601 prior to installation.

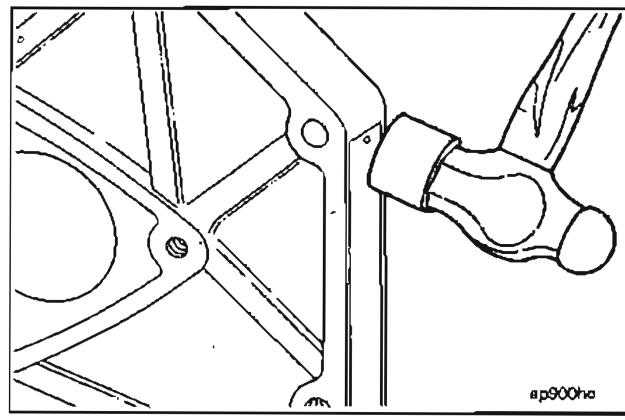
Data Plate - Replacement (1-38)

Small Chisel and Hammer

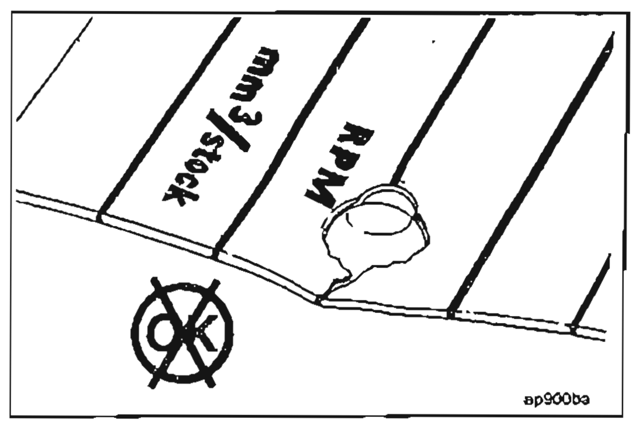
If the gear housing is being replaced, remove the engine data tags and install on the new housing.



Drive the rivets in until they contact the data tag.

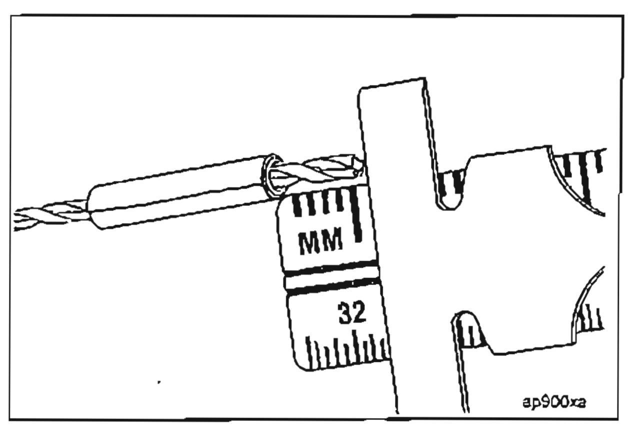


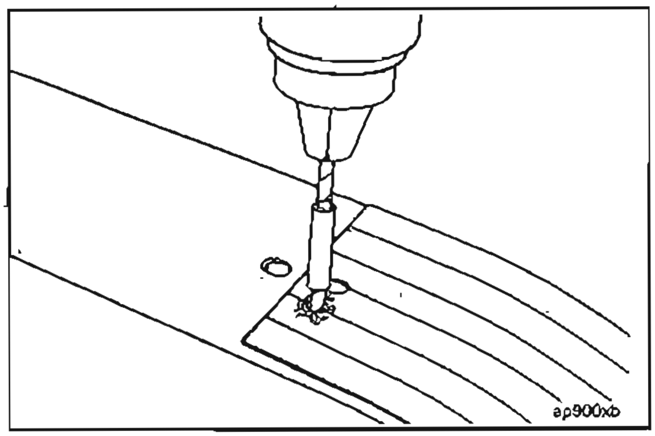
Caution: If the rivets are driven in too far, they will cut through the data tag.



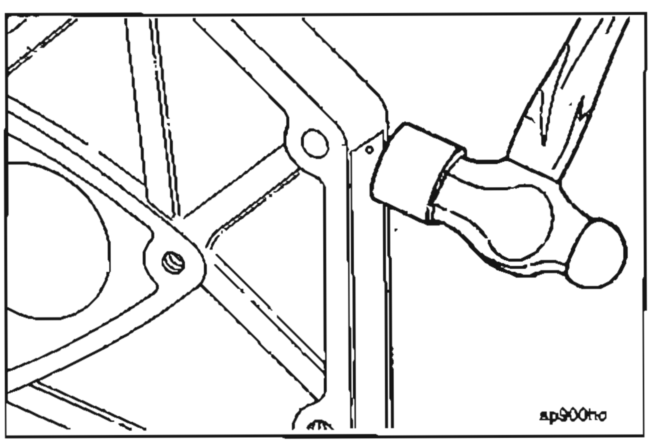
2.0 mm Drill Bit

If the data tag is loose or has been damaged, drill new holes and attach with new rivets. Mark the drill bit at 6.0 mm [0.236 in (15/64)]to avoid drilling too deep.





Drill the data tag taking care not to interfere with the printed data on the tag.



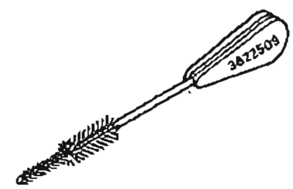
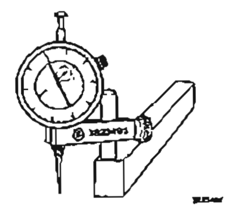
Drive the rivets in until they contact the data tag.

Section 2 - Cylinder Head - Section 2

Section Contents

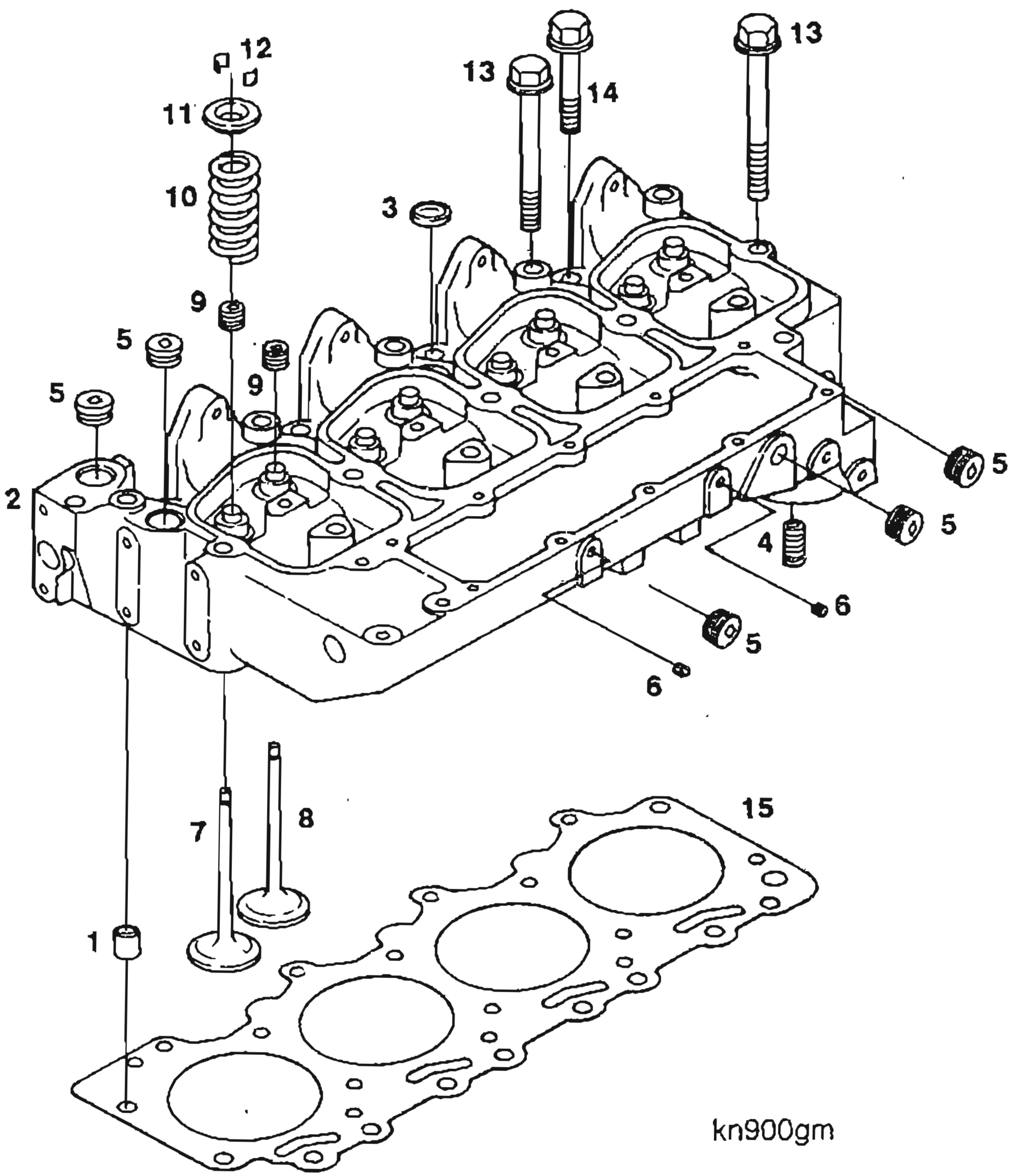
Cylinder Head - Service Tools

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
3822509	Injector Bore Brush	 3822509
3823495	Gauge Block	

Cylinder Head - Group 2

Exploded View



Ref. No	Part Name	Qty.	Remarks
1	Dowel, Ring	1	Reference Only.
2	Cylinder Head	1	
3	Plug, Expansion	3	13/16 in.
4	Insert, Fuel Filter	1	Reference Only
5	Plug, Pipe	4	1/2 in. NPTF
6	Plug, Pipe	2	1/8 in. NPTF
7	Valve, Intake	4	
8	Valve, Exhaust	4	
9	Seal, Valve	8	
10	Spring, Valve	8	
11	Retainer, Valve Spring	8	
12	Collet, Valve Half	16	
13	Screw, Hex Head Cap	10	M12-1.75x120
14	Screw, Hex Head Cap	4	M12-1.75x70
15	Gasket, Cylinder Head	1	

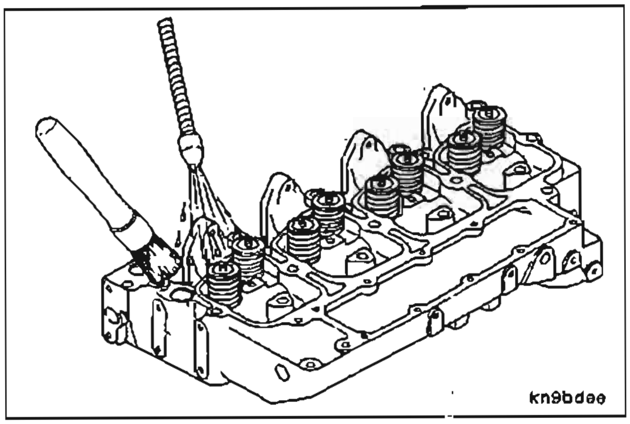
General Information

The cylinder head is a one piece, crossflow design with two valves per cylinder. The cylinder head features integrally cast valve guides, induction hardened seat surfaces, integral intake manifold, fuel filter head, and thermostat housing. On high horsepower automotive six cylinder engines equipped with in-line injection pumps, the fuel filter head is eliminated to allow for adequate injection pump clearance. The fuel filter head bracket is relocated to allow for adequate injection pump clearance. The injectors are mounted in the cylinder head for direct injection into the cylinders.

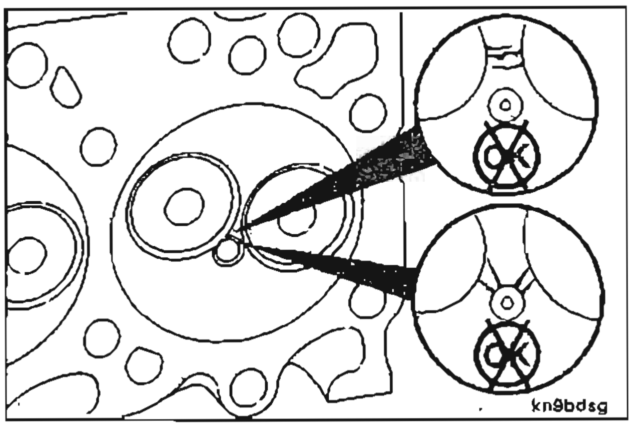
The cylinder head gasket is a composite design with a fire ring to seal the cylinder bores. Orifices in the gasket control coolant flow.

The valve seats can be re-ground once. Valve seats that have been previously re-ground can be replaced with service valve seats. Service valve guides are also available to replace worn guides. Refer to the Alternative Repair Manual, Bulletin No. 3810234, for seat and guide replacement procedures.

Cylinder Head - Precheck Before Disassembly (2-01)

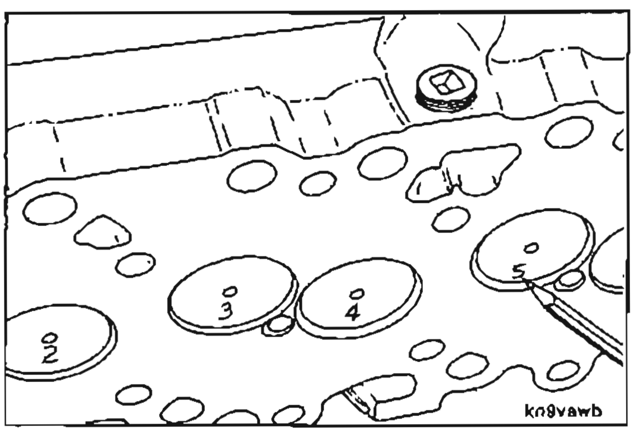


Clean the cylinder head with solvent.

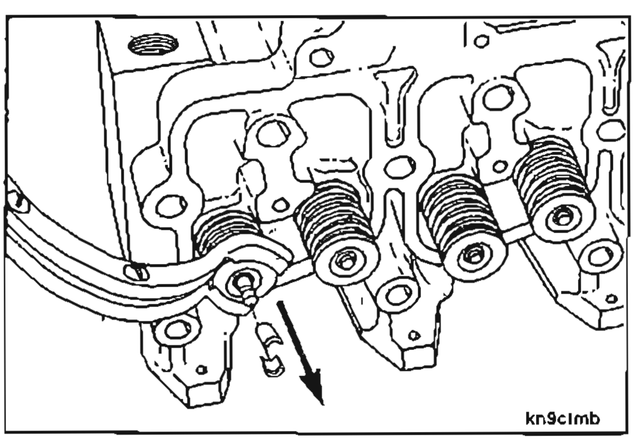


Visually inspect the cylinder head for obvious damage that would prohibit reuse. Check for cracks and damage to the combustion face that would result in loss of sealing.

Cylinder Head - Disassembly (2-02)

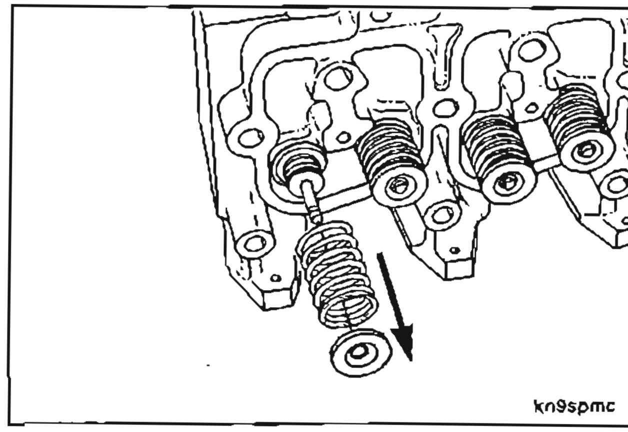


Mark the valves to identify their position.



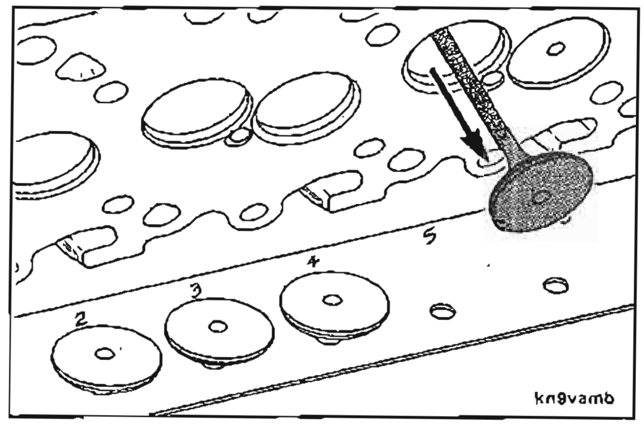
Compress the valve spring and remove the valve stem collets.

Release valve spring and remove the retainer and spring.

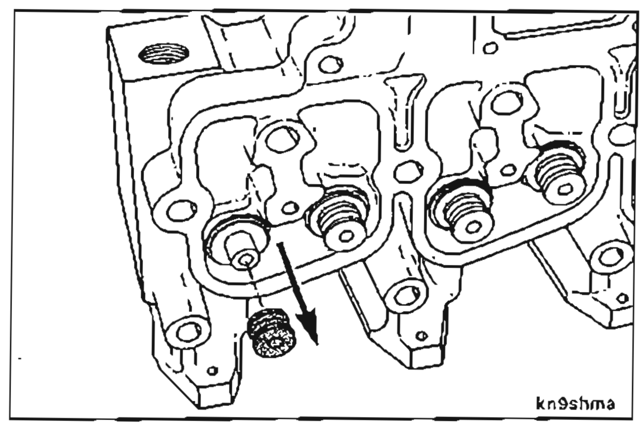


Remove the remaining collets, retainers, springs and valves.

Keep the valves in a labeled rack for a correct match with companion seats while making measurements.



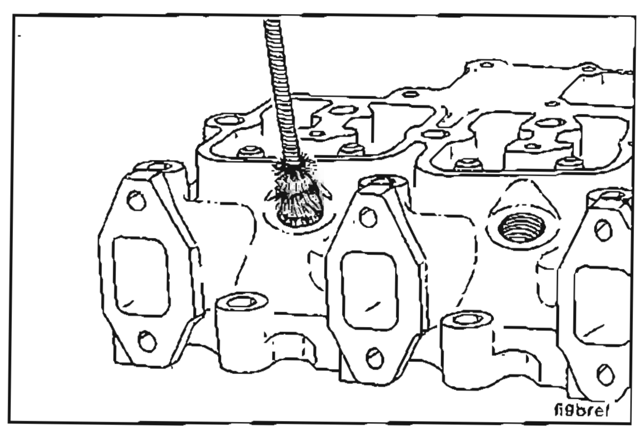
Remove the valve stem seals.

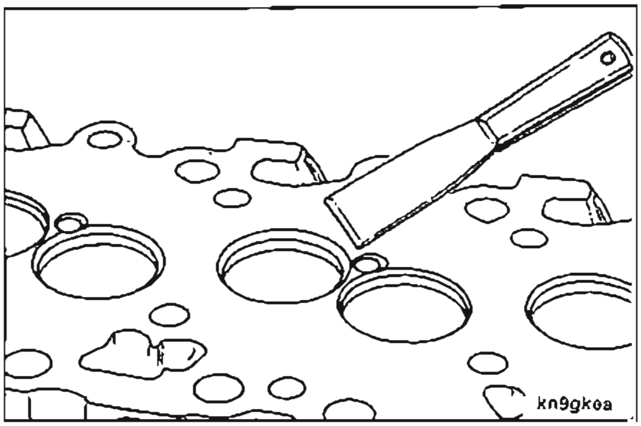


Cylinder Head - Cleaning (2-03)

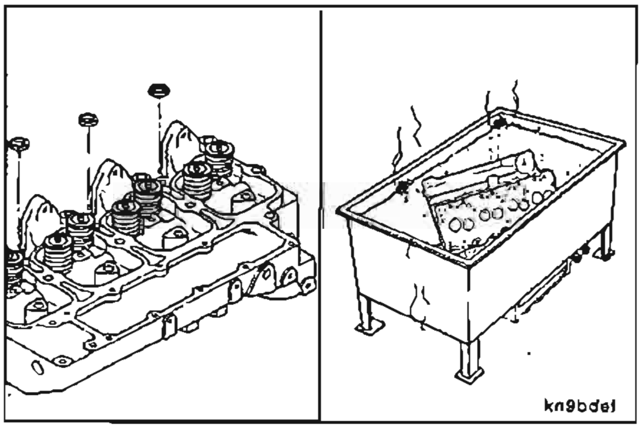
Injector Bore Brush 3822509

Clean the carbon from the injector nozzle seat.

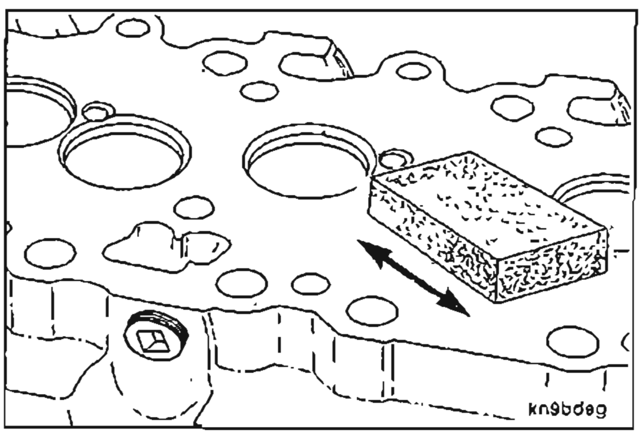




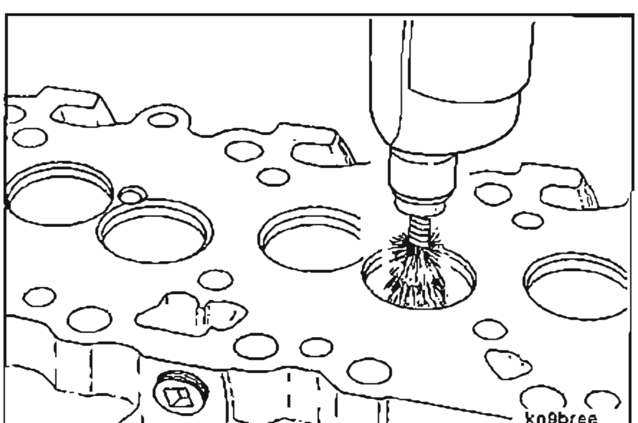
Scrape the gasket material from all gasket surfaces.



Clean the build-up of deposits from the coolant passages. Excessive deposits may be cleaned in an acid tank but the cup plugs must first be removed. Refer to Cup Plug Replacement procedure (2-10).



Clean the combustion face with a Scotch-Brite® pad or an equivalent cleaning pad and diesel fuel or solvent.



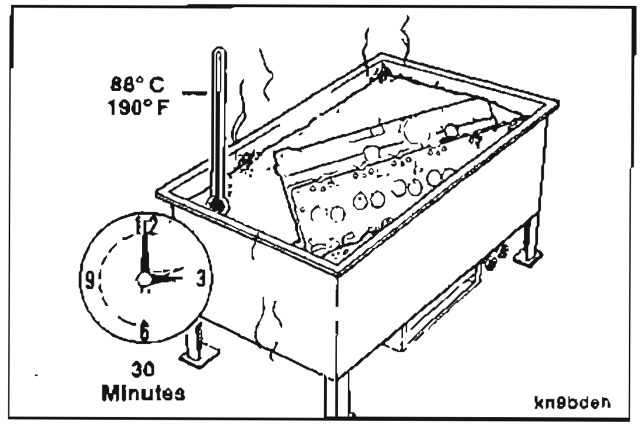
Warning: Wear protective eye covering.

Clean carbon deposits from the valve pockets with a high quality steel wire wheel installed in a drill or a die grinder.

NOTE: An inferior quality wire wheel will loose steel bristles during operation, thus causing additional contamination.

Wash the cylinder head in hot soapy water solution.

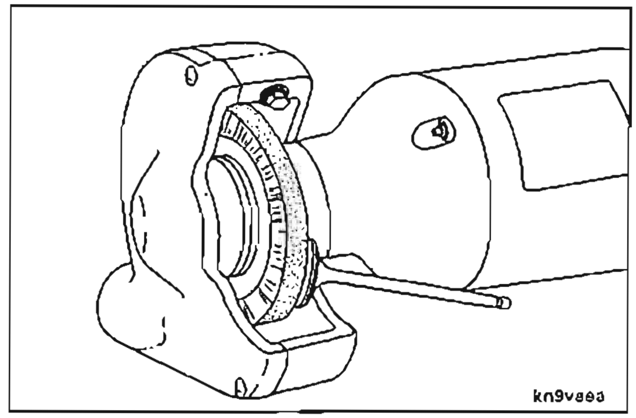
After rinsing, use compressed air to dry the cylinder head.



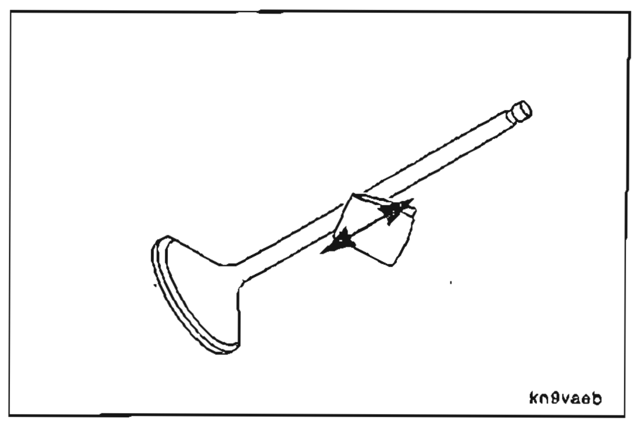
Warning: Wear protective eye covering.

Clean the valve heads with a soft wire wheel.

Keep the valves in a labeled rack to prevent mixing prior to making measurements.

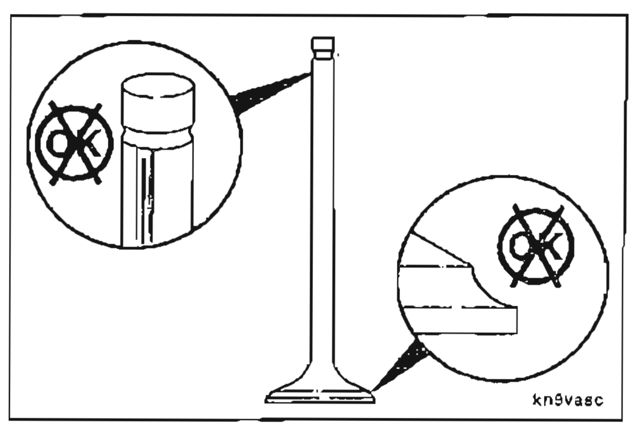


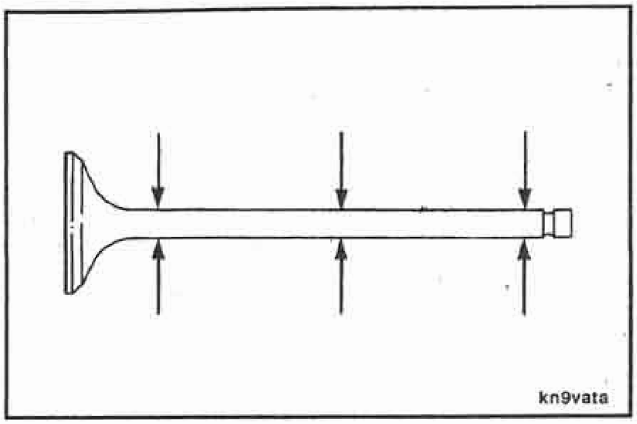
Polish the valve stem with a Scotch-Brite® pad or equivalent cleaning pad and diesel fuel or solvent.



Valve - Inspection (2-04)

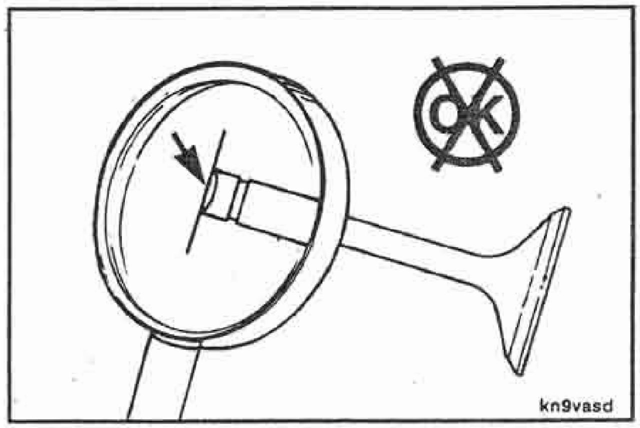
Inspect for abnormal wear on the heads and stems.



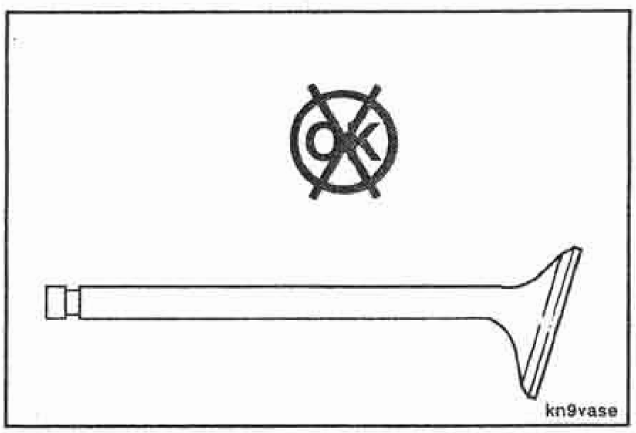


Measure the valve stem diameter.

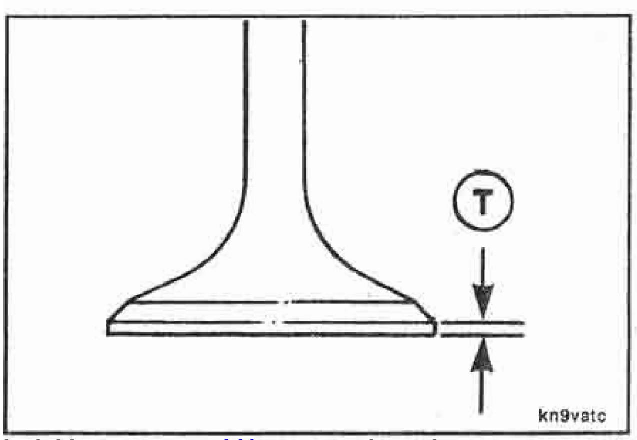
Valve Stem Diameter		
mm		in
7.94	MIN	0.3126
7.98	MAX	0.3142



Check the valve stem tip for flatness.



Visually inspect for bent valves.



Measure the rim thickness to determine if there is enough stock to grind the valve.

Limits

Minimum (T): 0.79 mm [0.031 in].

If the valves are determined to be suitable for resurfacing refer to the valve grinding procedures on page 2-13.

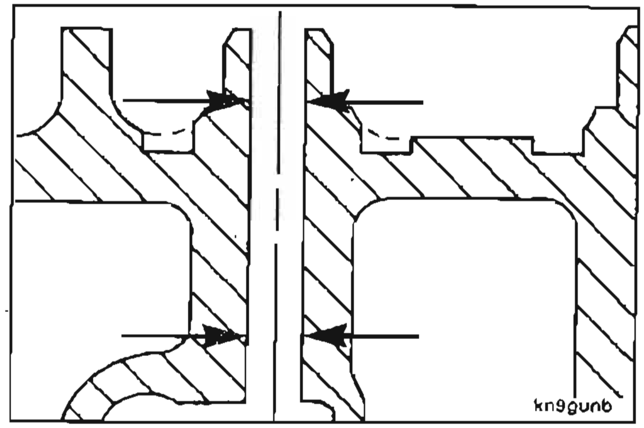
Valve Guide Inspection (2-05)

Inspect the valve guides for scuffing or scoring.

Measure the valve guide bore.

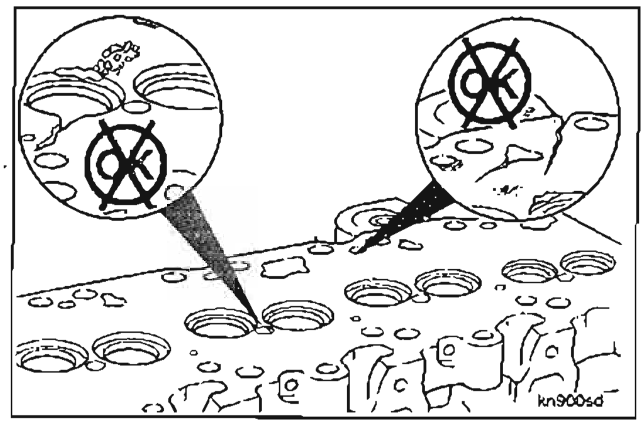
Valve Guide Bore Diameter		
mm		in
8.019	MIN	0.3157
8.090	MAX	0.3185

If the inspection reveals damaged valve guides, refer to the Alternative Repair Manual, Bulletin No. 3810234.



Cylinder Head Combustion Face Inspection (2-06)

Visually inspect the cylinder head combustion surfaces for any irregularities (dents, guttering, fire ring embedment, etc.). If any of these conditions exist, the surface must be machined in accordance with the appropriate procedure from the Alternative Repair Manual, Bulletin No. 3810234.

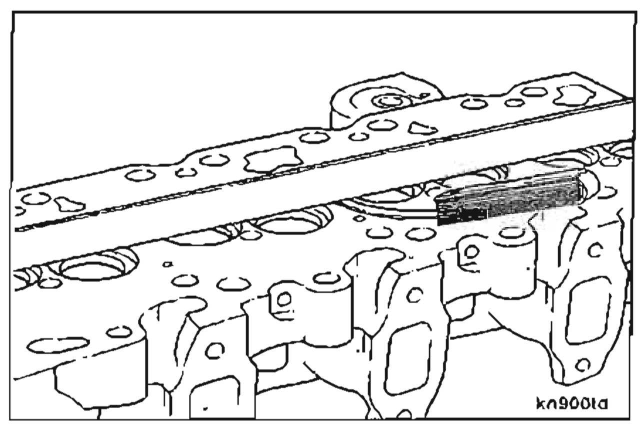


Measure the cylinder head overall flatness:

End-to-End 0.305 mm [0.012 in] (6B)
0.203 mm [0.008 in.] (4B)

Side-to-Side 0.076 mm [0.003 in]

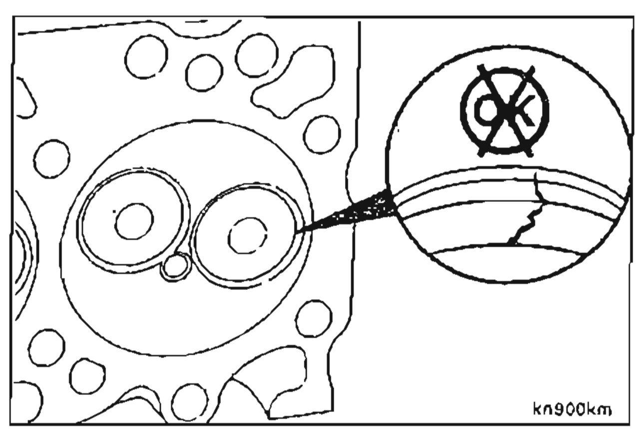
Visually inspect for any localized dips or imperfections. If present, the cylinder head deck must be reground.

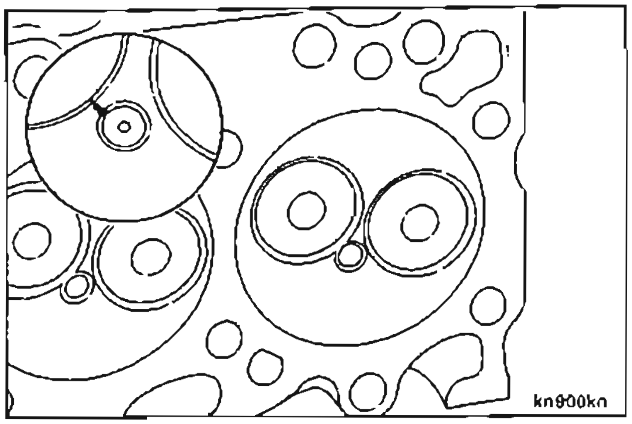


Valve Seat Inspection (2-07)

Inspect the valve seats for cracks or burned spots.

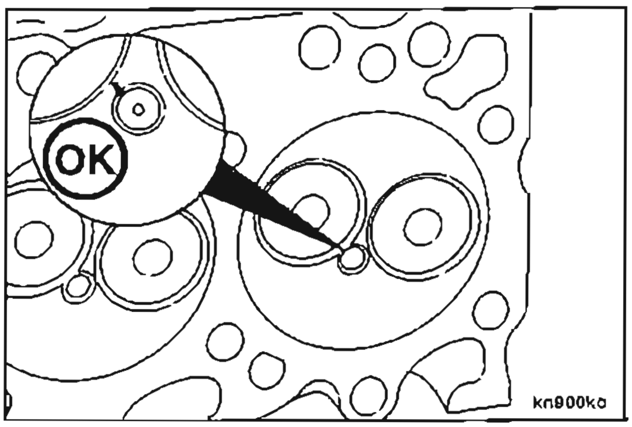
Refer to the following reuse guidelines for any cracks discovered. Service valve seats are available for seats with burned spots that will require more than 0.254 mm [0.010 in] grinding to clean up. Refer to the Alternative Repair Manual, Bulletin No. 3810234, for valve seat installation procedures.





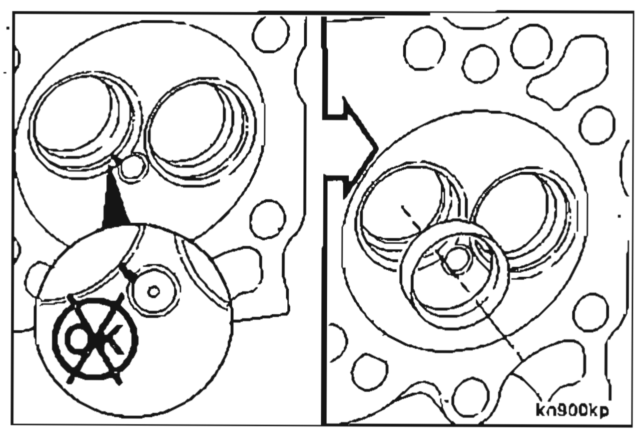
Cylinder Head Cracks - Reuse Guidelines (2-08)

These guidelines apply **only** to cracks extending through the valve seats.

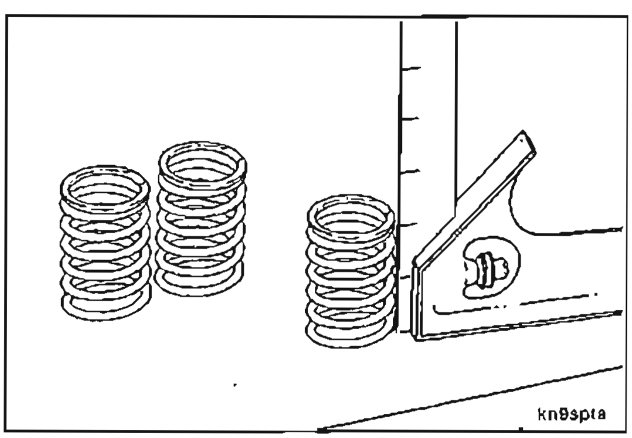


The reuse guidelines for a cylinder head with a crack extending from the injector bore to the valve seat is as follows:

If the crack does not extend into the valve seat, the head is reusable.



If the crack extends into or through the valve seat, the head must be repaired by installing a valve seat insert per the Alternative Repair Manual, Bulletin No. 3810234.



Valve Spring Inspection (2-09)

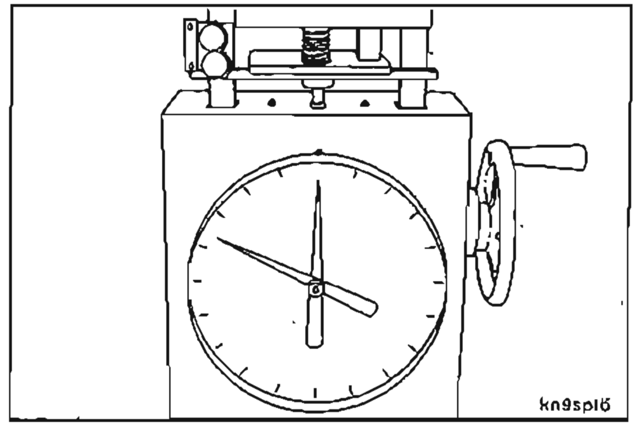
Inspect the Valve Springs.

Measure the valve spring.

Limits	
Approx. Free Length (L)	55.63 mm [2.190 in.]
Maximum Inclination:	1.0 mm [0.039 in.]

Spring Specifications

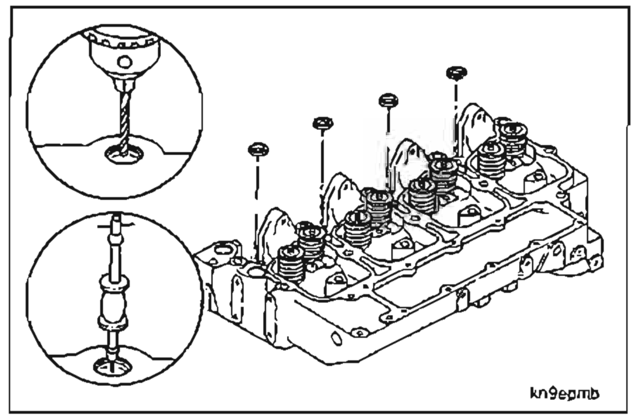
Spring Color	Approximate Free Length	Load at 49.25mm Height
Blue	55.63mm [2.190 in]	289.13 to 321 16 N [65.0 to 72.2 Lbs]
White	70.64mm [2.781 in]	643.2 to 691.2 N [144.6 to 155.4 Lbs]



Cup Plug Replacement (2-10)

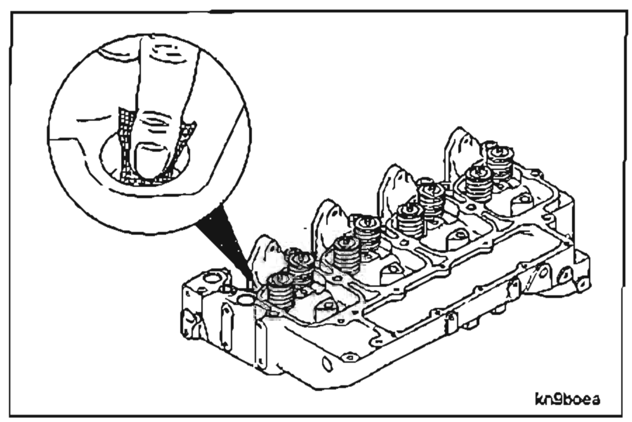
Drill Motor, 3 mm [1/8 inch] drill bit, slide hammer, #10 metal screw.

Remove the cup plugs from the cylinder head.



400 grit sandpaper, Diesel Fuel

Throughly clean the cup plug holes.

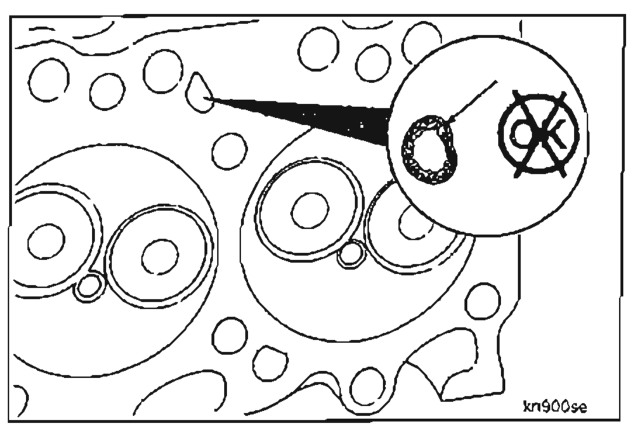


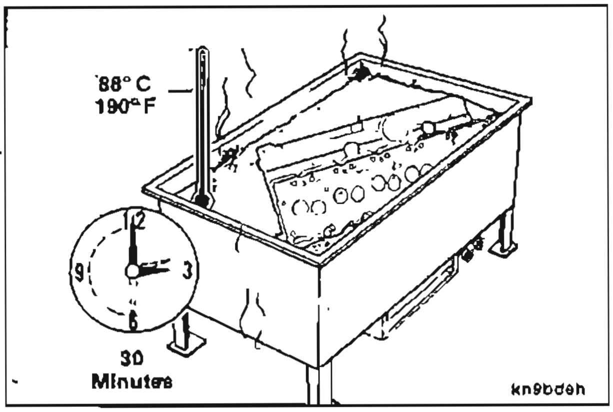
Caution: Use protective clothing to prevent personal injury.

Inspect for build-up of deposits in the coolant passages which can cause engine overheating.

Be sure the coolant passages are clean.

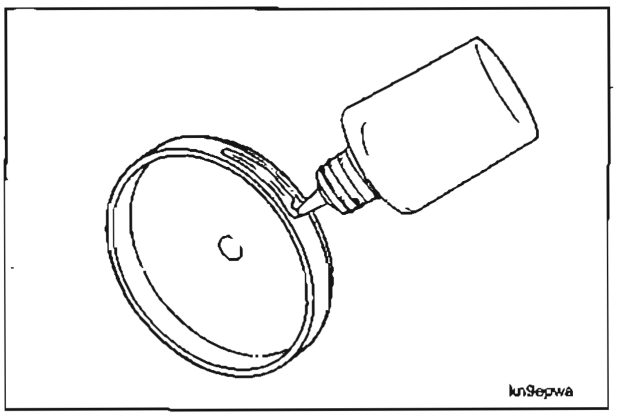
Excessive deposits may be cleaned in an acid tank, but the cylinder head must be disassembled first.





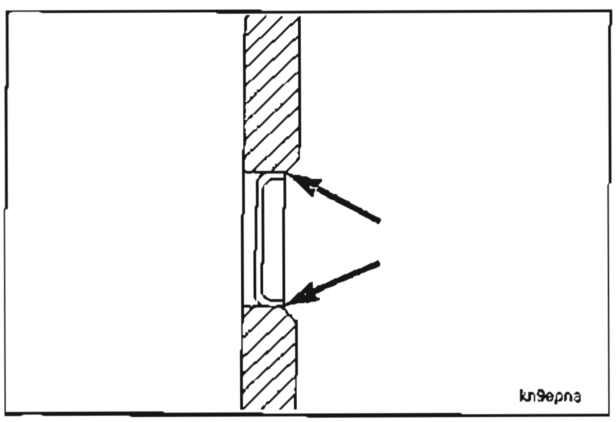
Caution: Use protective clothing to prevent personal injury.

The cylinder head may be cleaned in a hot tank using a soap and water solution.



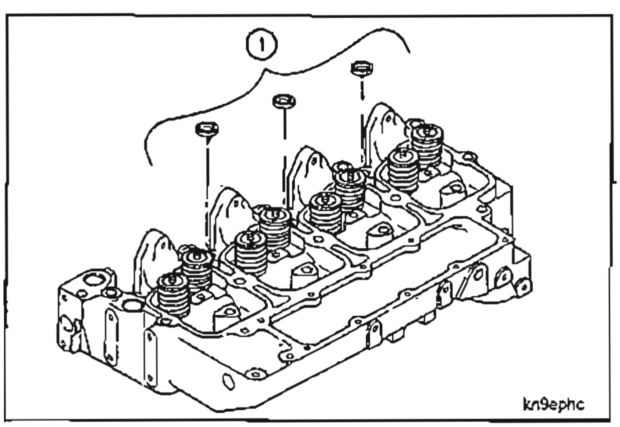
NOTE: The cup plugs and cup plug holes must be clean and free of oil before installing the cup plugs.

Apply a bead of Loctite™ 277 around the outside diameter of all cup plugs before installing.



Cup Plug Driver Part No. 3900965

Drive all cup plugs in until the outer edge is flush with the counter sink.

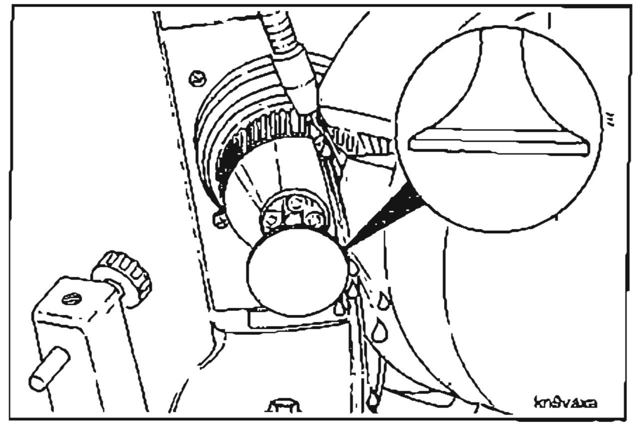


Cup Plug Locations

1 13/16 inch

Valves - Grinding (2-11)

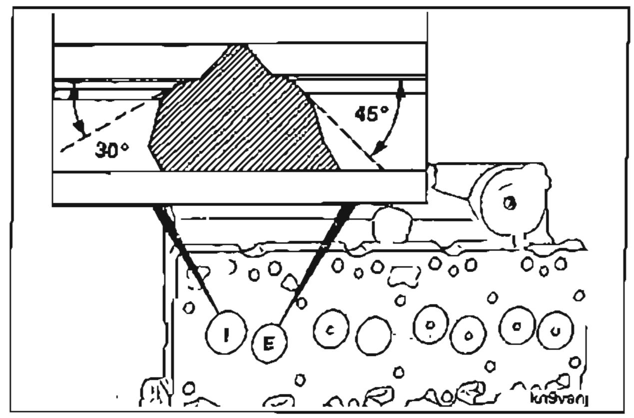
Re-face all reused valves. Check/replace bent valves.



Seat Angle

Intake: 30 Degrees

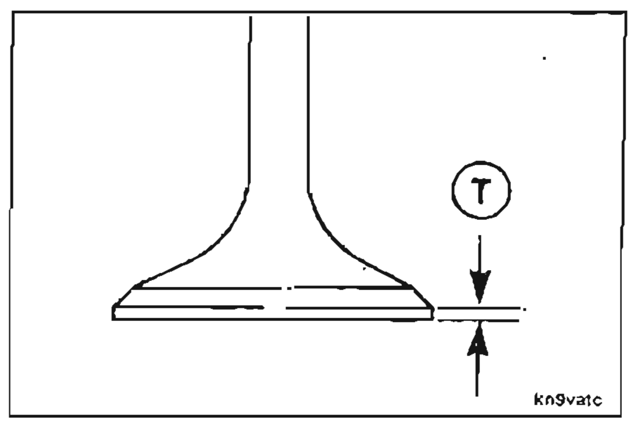
Exhaust: 45 Degrees



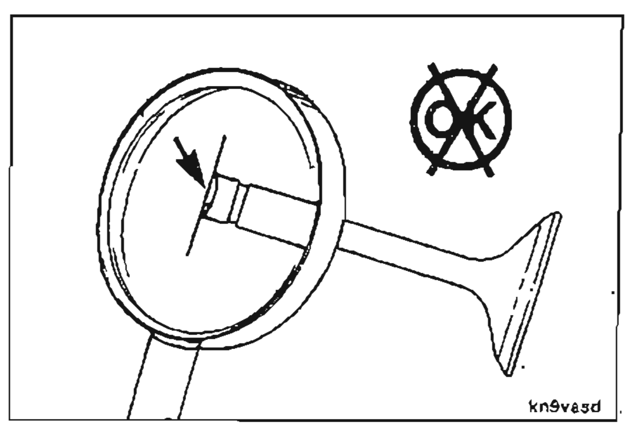
Measure rim thickness.

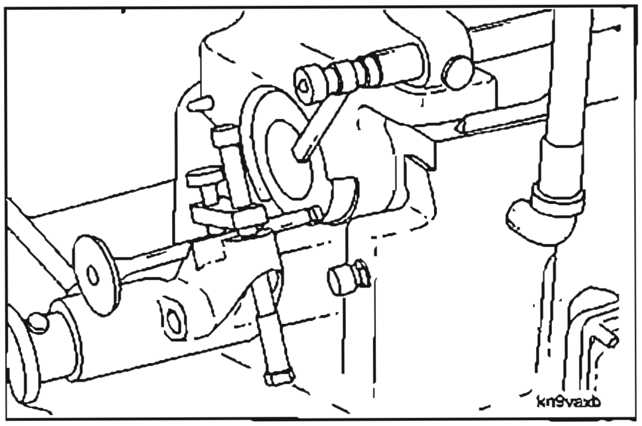
Valve Rim Thickness

Minimum (T): 0.79 mm [0.031 in]

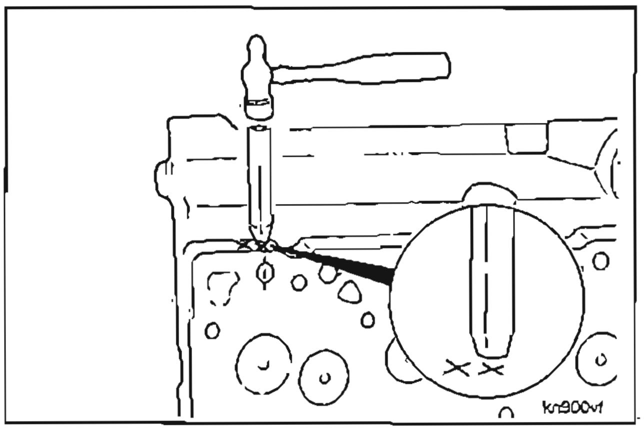


Check the valve stem tip for flatness.





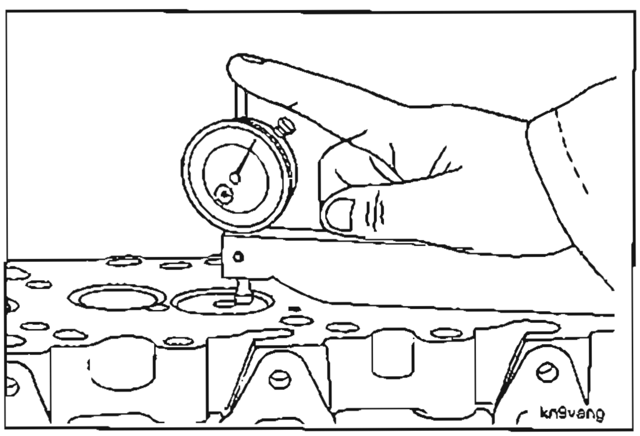
If required, re-surface the tip.



Valve Seats - Grinding (2-12)

The illustrated marks indicate valve seats have been ground previously. Additional grinding will result in grinding past the induction hardened area.

Replace previously re-ground seats will with service seats. Refer to the Alternative Repair Manual, Bulletin No. 3810234.

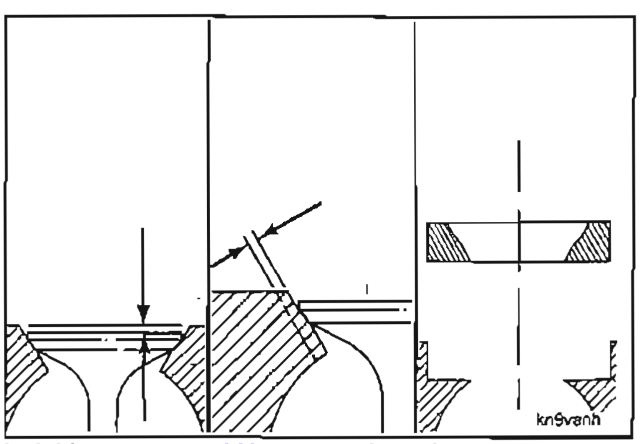


Calculating the Grinding Depth

Measuring the Valve Depth

3823495 Gauge Block

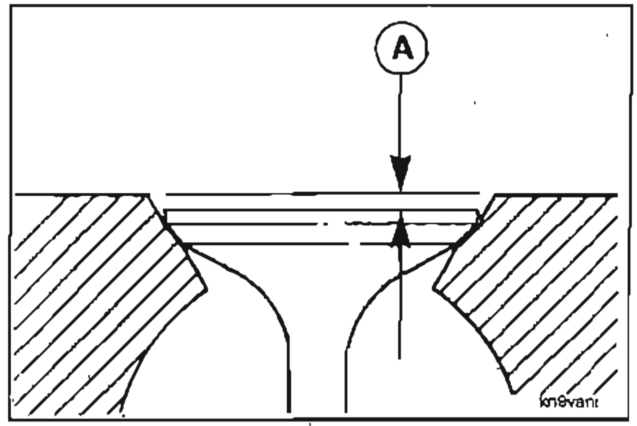
Install the valves in their designated location and measure the valve depth.



There are two valve seat parameters that are critical to the valve grinding process. The first is to comply with the valve depth limits and the second is to not grind through the hardened layer of the valve seat by observing the grind depth limit. If either of these parameters are out of specification, refer to the "Alternative Repair Manual," Bulletin No. 3810234.

The valve depth is the distance from the valve face to the head deck.

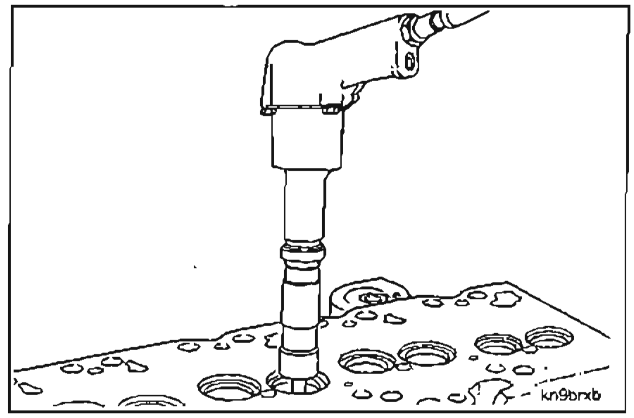
Record the depth of each valve as (A).



Valve Depth		
mm		in
0.99	MIN	0.039
1.52	MAX	0.060

If valve depth does not meet specification the valve seat must be replaced.

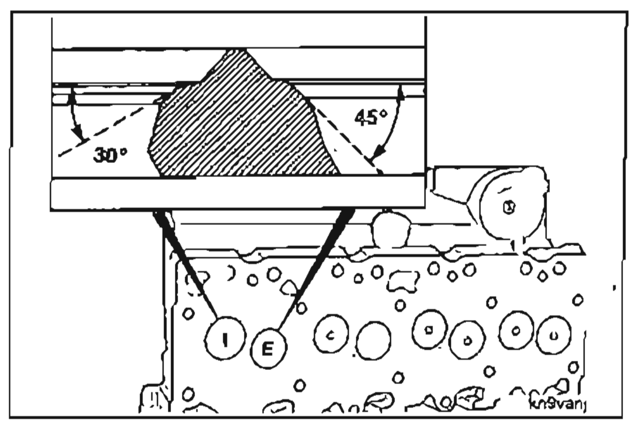
After valves meet initial valve depth criteria, grind the valve seats to remove all scores, scratches and burns.



Seat Angle

Intake: 30 Degrees

Exhaust: 45 Degrees

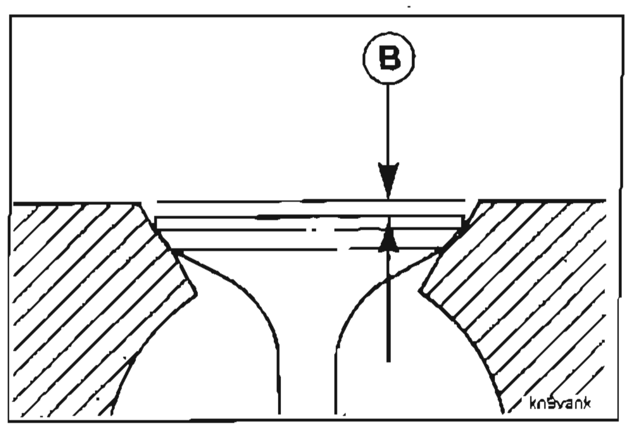


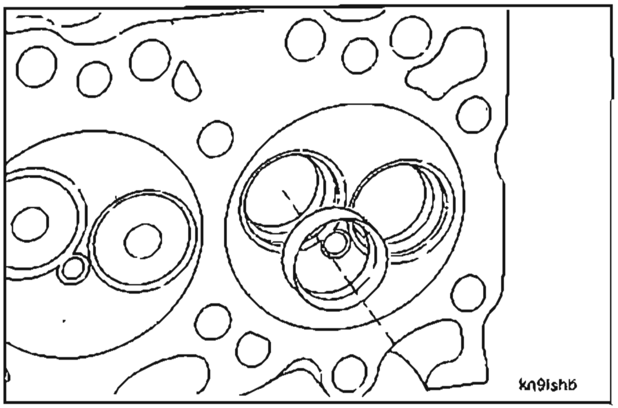
3823495 Gauge Block

Since the seats have been ground, it is necessary to re-measure the valve depth and to calculate the grinding depth.

Install the valves in their respective bores and measure the depth. Record the depth of each valve as (B).

Make sure the seats are clean before you measure the depth.



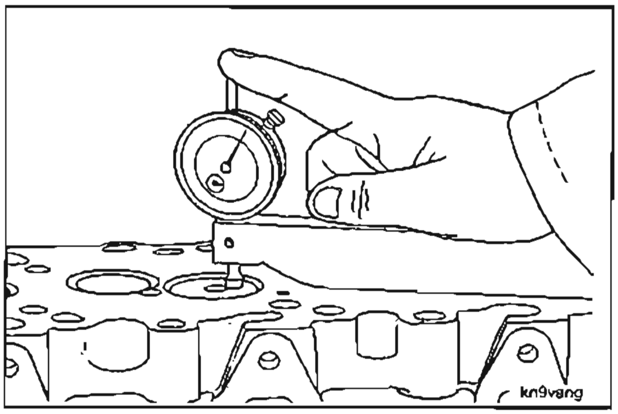


Calculate grinding depth (GD) as follows:
GD = (B) (A)

Seat Grinding Depth Limit

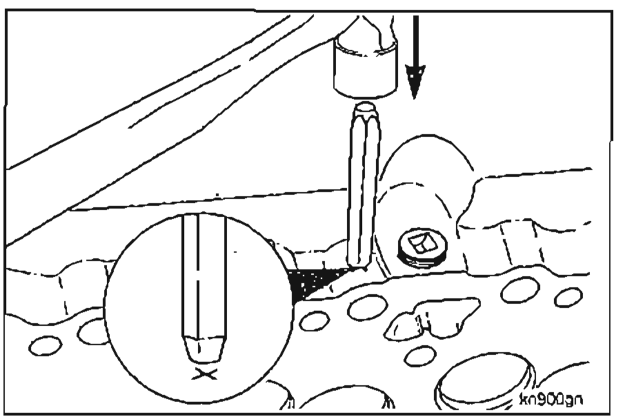
GD: 0.254 mm [0.010 inch]

Service valve seats are available for over the limit seats.

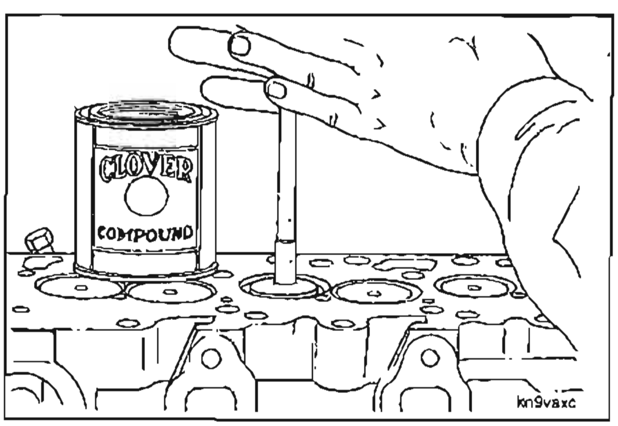


Confirm that the valve depth after grind (B) is still within the original specification.

Valve Depth (A) or (B)		
mm		in
0.99	MIN	.039
1.52	MAX	.060

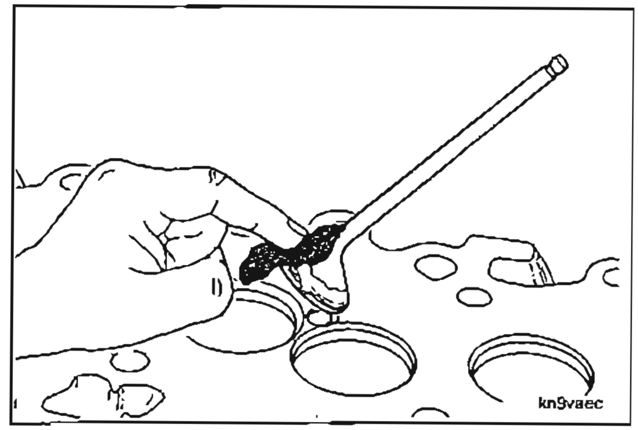


Mark the cylinder head with an (X) to identify each reground valve seat.



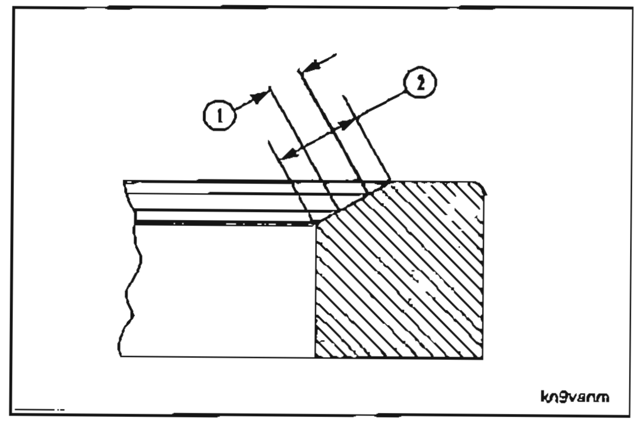
Apply a light coat of valve lapping compound to each valve and lap each valve to its companion seat.

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



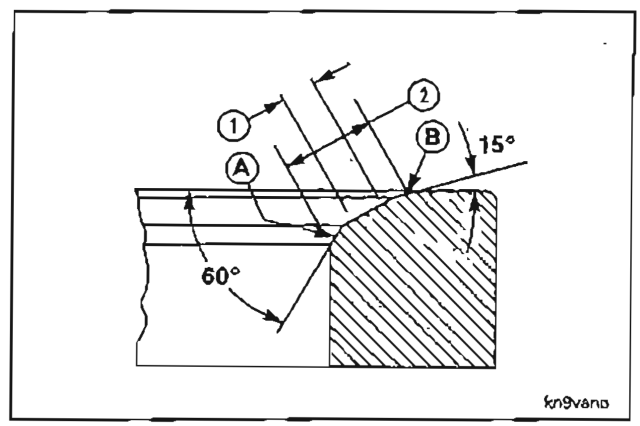
The valve should seat in the center of the valve face. Measure the valve seat width indicated by the lapped surface.

Valve Seat Width Limit		
mm		in
1.5	MIN (1)	0.059
2.0	MAX (2)	0.079



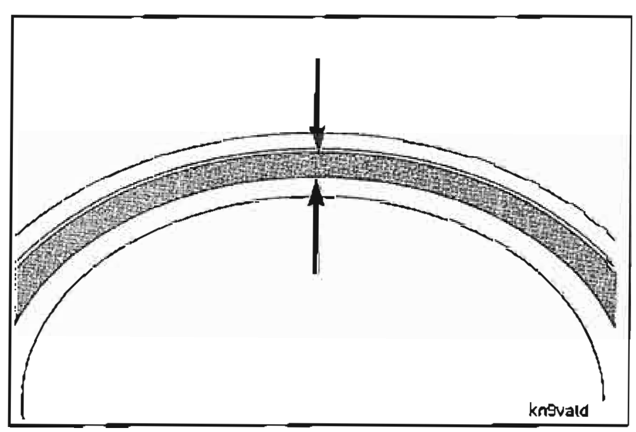
Grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face and obtain the valve seat width limits.

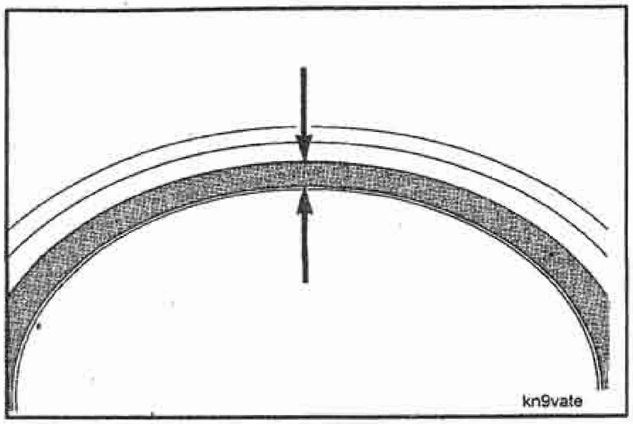
Valve Seat Width Limit		
mm		in
1.5	MIN	.059
2.0	MAX	.079



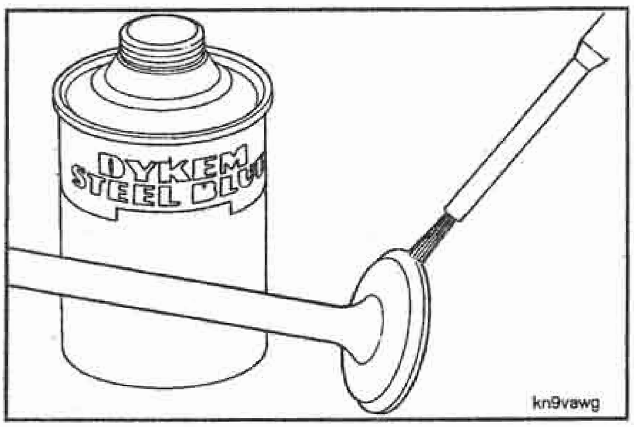
The lapped surface on the valve face is the key to determining how much of each angle to grind.

If the lapped surface is at the bottom of the valve face, the seat will require more grinding with the 60 degree stone than with the 15 degree stone.

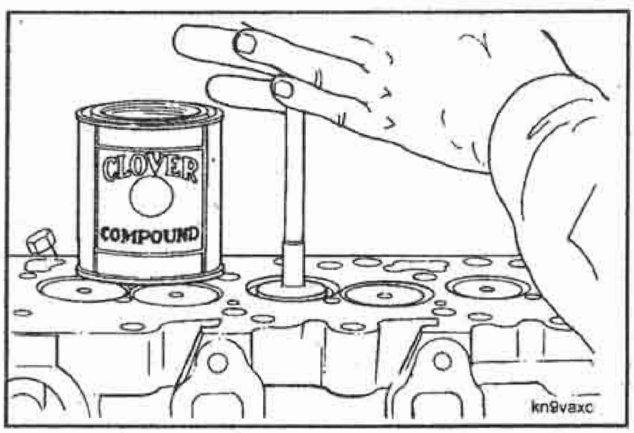




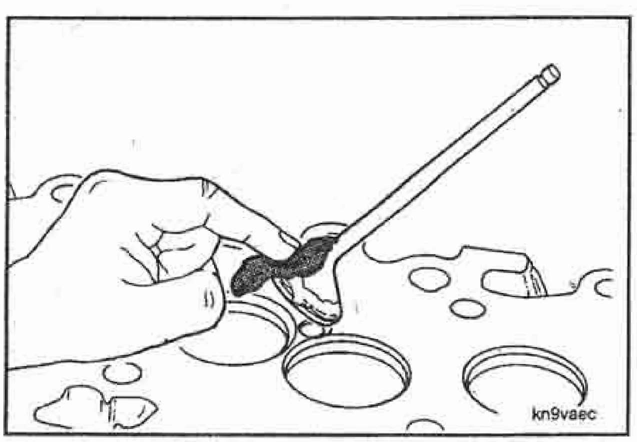
If the lapped surface is at the top of the valve face, the seat will require more grinding with the 15 degree stone than with the 60 degree stone.



After centering the seat on the valve face, coat the valve face with Dykem™ Steel Blue™ and allow to dry.



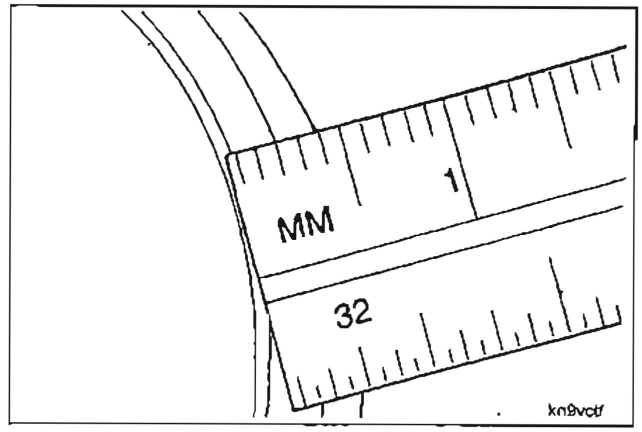
Apply a coat of valve lapping compound to the valve and lap the valve to its companion seat.



Remove the valve and clean the lapping compound from the valve face and seat.

Inspect the valve face for seat width and centering.

Valve Seat Width		
mm		in
1.5	MIN	.059
2.0	MAX	.079

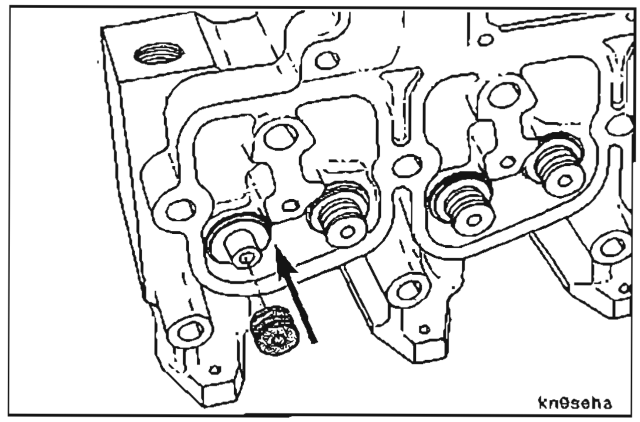


Cylinder Head - Assembly (2-13)

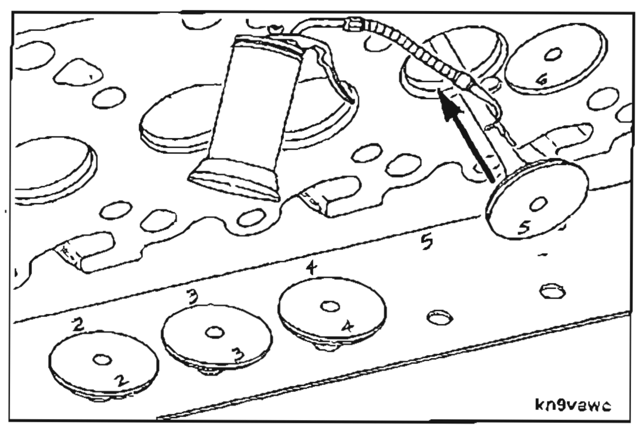
NOTE: Clean all cylinder head components before assembling.

Install the valve stem seals.

The intake and exhaust seals are the same.

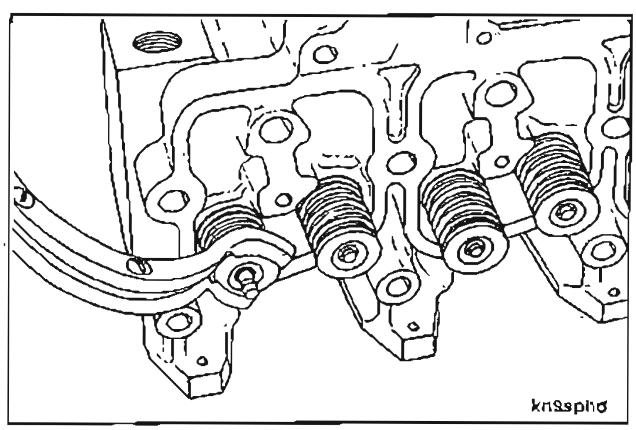


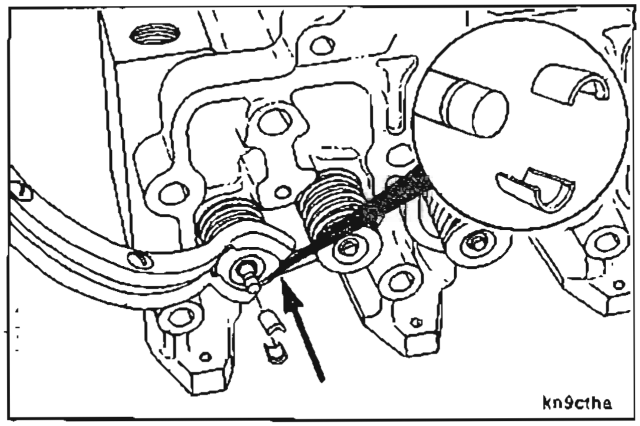
Lubricate the stems with SAE 90W engine oil before installing the valves.



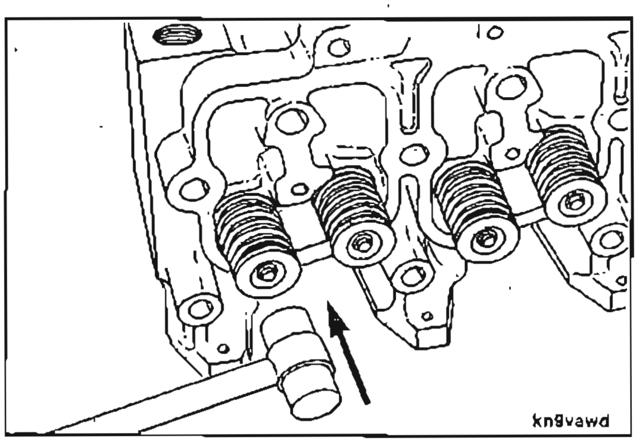
Valve Spring Compressor

Compress the valve spring after assembling the spring and retainer.





Install new valve collets and release the spring tension.



Plastic Hammer

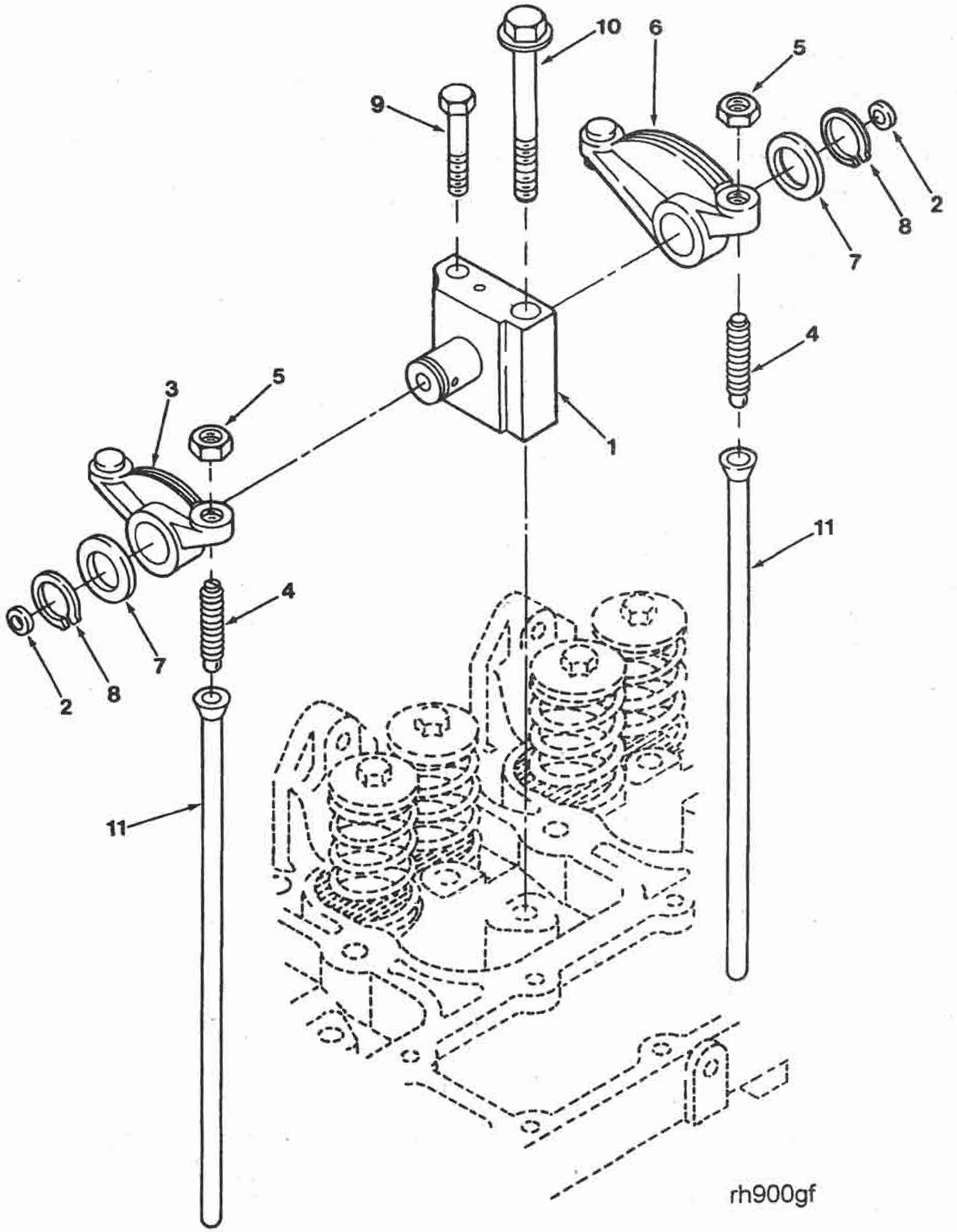
Warning: Wear eye protection. If the collets are not correctly installed, they can fly out when the stems are hit with a hammer.

After assembly, hit the valve stems with a plastic hammer to make sure that the collets are seated.

Section 3 - Rocker Levers - Group 03

Section Contents

Rocker Lever Assembly - Exploded View



Ref. No.	Part Name	Req.	Remarks
1	Support, Rocker Lever	4	
2	Plug, Expansion	8	
3	Lever, Rocker (Intake)	4	
4	Screw, Slotted Set	4	3/8 inch 24 UNF 2A
5	Nut, Regular Hexagon	4	
6	Lever, Rocker (Exhaust)	4	
7	Washer, Plain	8	
8	Ring, Retaining	8	
9	Screw, Hexagon Head Cap	4	M8 1.25 x 75mm
10	Screw, Hexagon Head Cap	4	M12 1.75 x 180mm
11	Rod, Push	8	

Rocker Lever Assembly - General Information

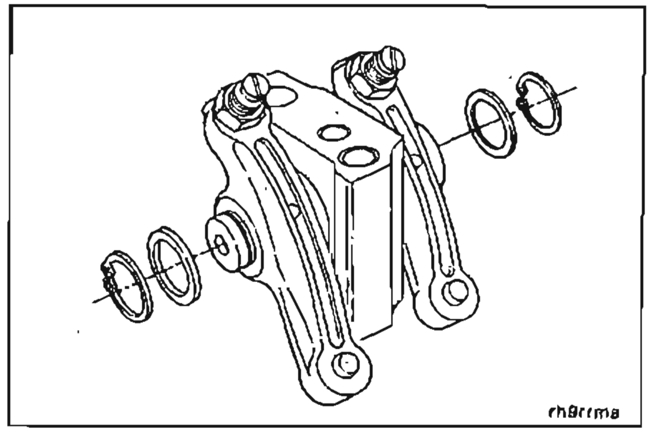
Each cylinder of the engine has a separate rocker lever assembly The assembly consists of the intake rocker lever exhaust rocker lever rocker lever shaft and pedestal support. The pedestal support has drillings to route the oil flow to the shaft and levers.

The levers are push rod actuated and use an adjusting screw to control the clearance between the lever and valve stem. The levers do not use a bushing in the bore for the rocker lever shaft. The lever must be replaced if the bore is damaged or worn beyond the limit.

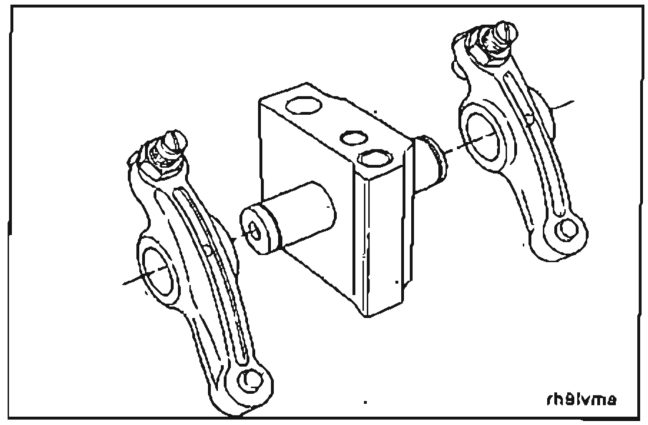
Rocker Levers - Disassembly (3-01)

Snap Ring Pliers

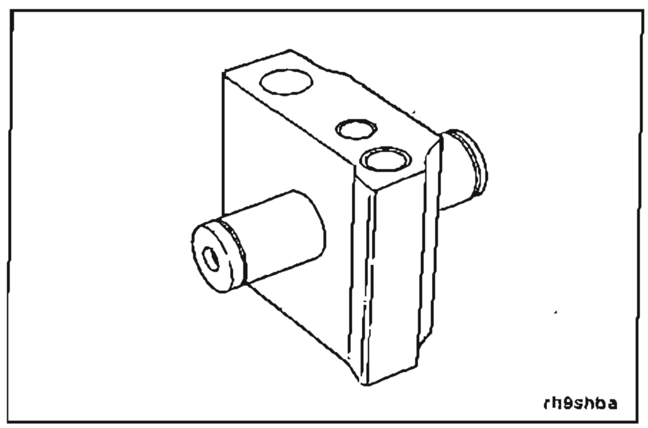
Remove the retaining rings and thrust washers.



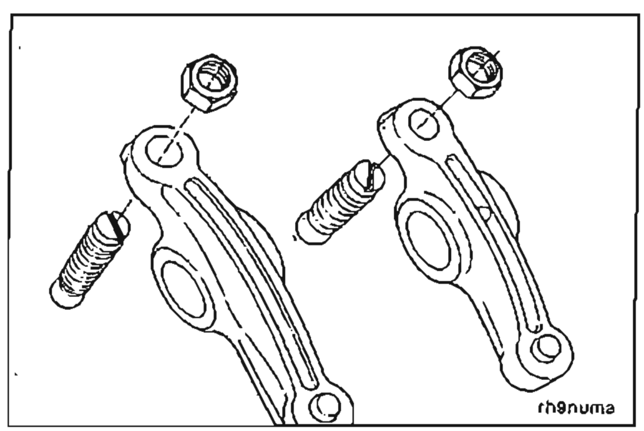
Remove rocker levers

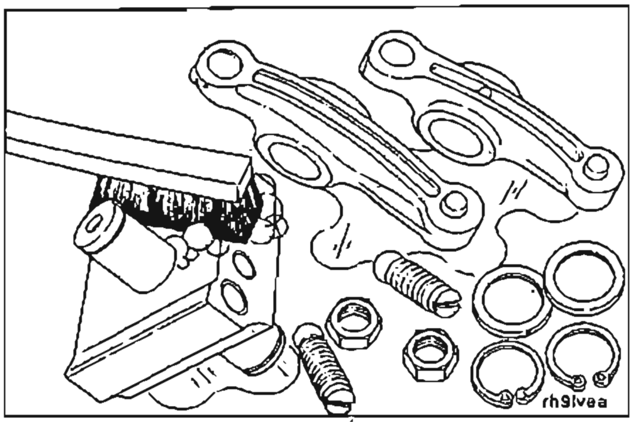


The rocker shaft and pedestals are serviced as an assembly. **Do not disassemble.**



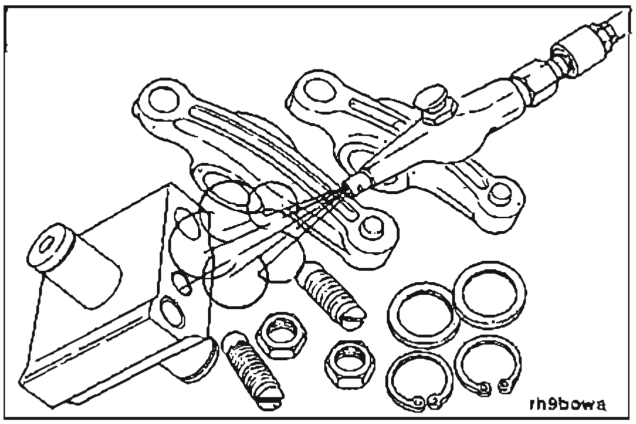
Remove the locknut and adjusting screw.





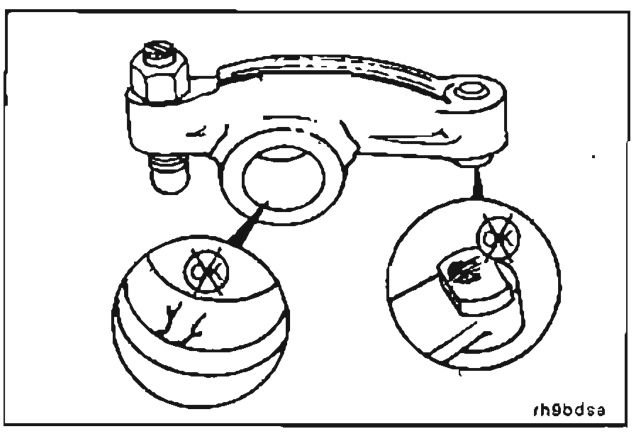
Rocker Levers and Pedestals - Cleaning (3-02)

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



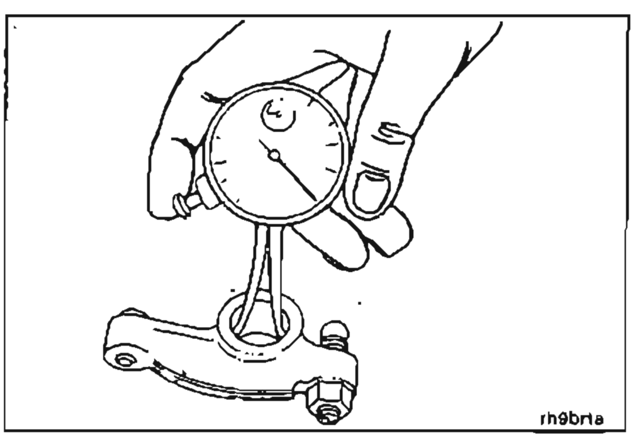
Use compressed air to dry the parts after rinsing in clean, hot water.

NOTE: The pedestals are made from powdered metal and will continue to show wetness after they have been cleaned and dried.



Rocker Lever - Inspection (3-03)

Inspect for cracks and excessive wear in the bore and the contact surface for the valve stem.



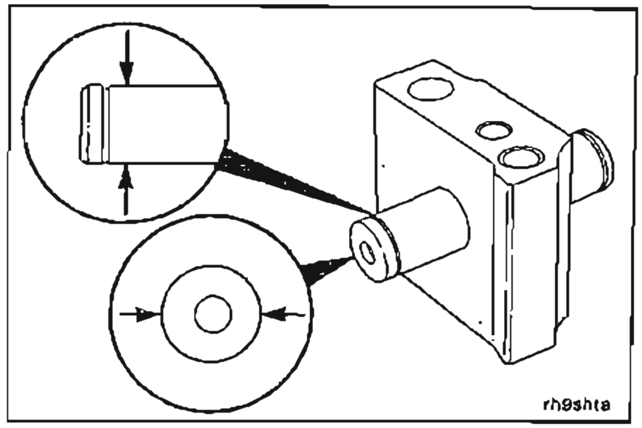
Measure the rocker lever bore.

Diameter		
mm		in
19.000	MIN	[0.7480]
19.051	MAX	[0.7500]

Rocker Lever Pedestals - Inspection (3-04)

Inspect the pedestal and shaft for obvious damage.

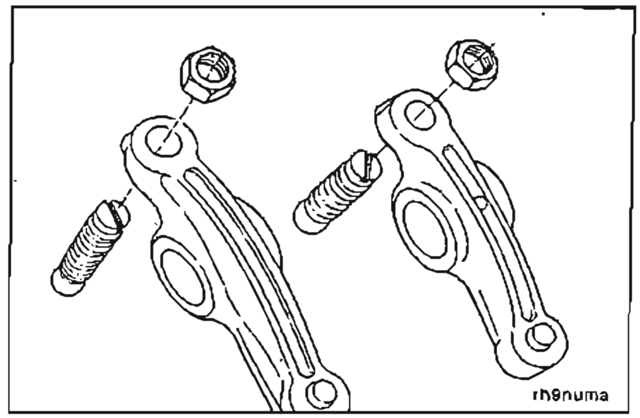
Measure the shaft diameter.



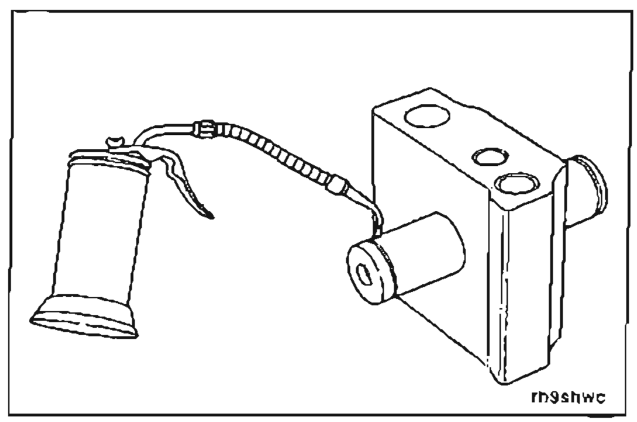
Diameter		
mm		in
18.938	MIN	[0.7456]
18.975	MAX	[0.7470]

Rocker Levers - Assembly (3-05)

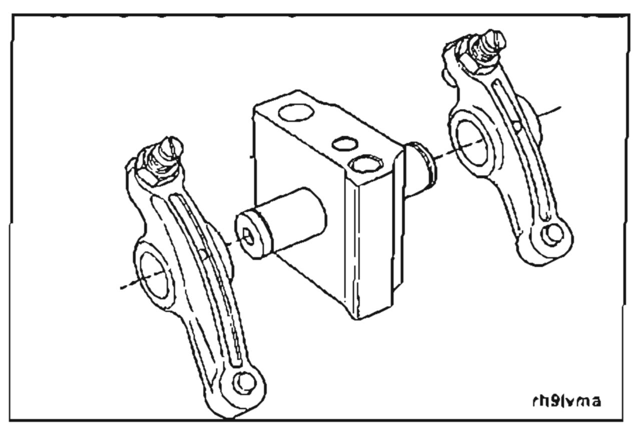
Install the adjusting screw and locknut.

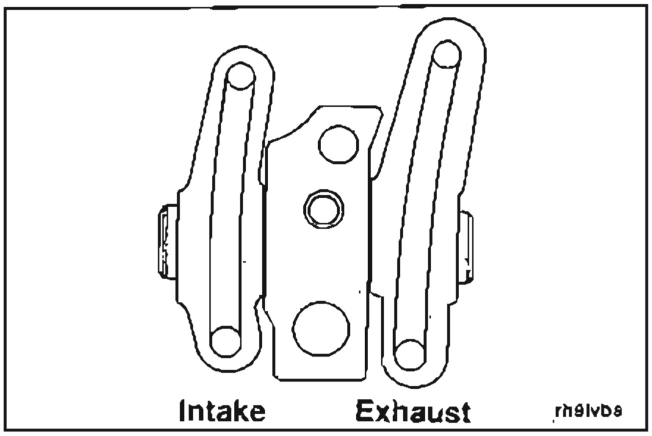


Lubricate the shaft with clean engine oil.

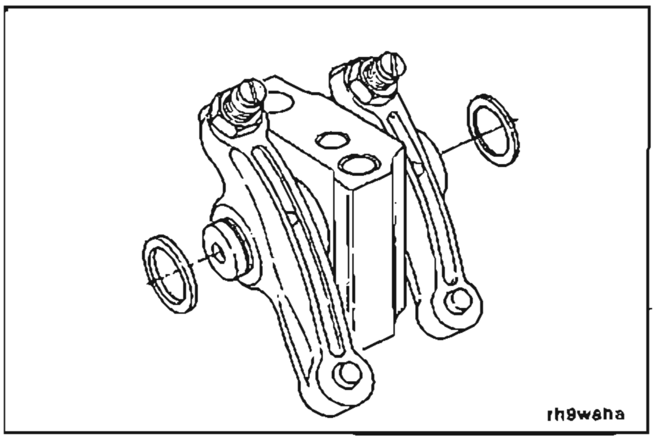


Position the levers on the rocker shaft.

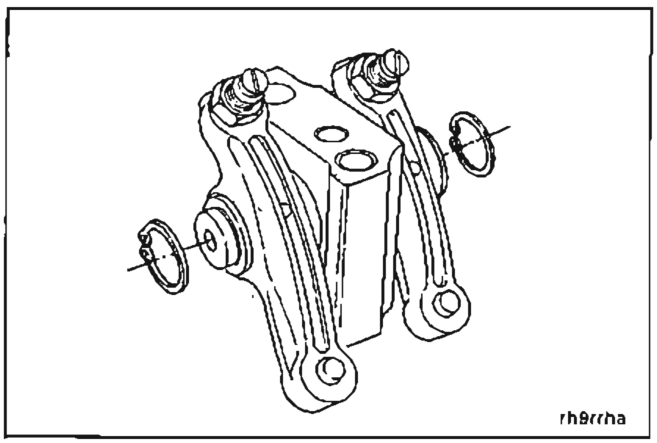




Be sure to assemble the intake and exhaust rocker levers in the correct location.



Install the thrust washers.



Snap Ring Pliers

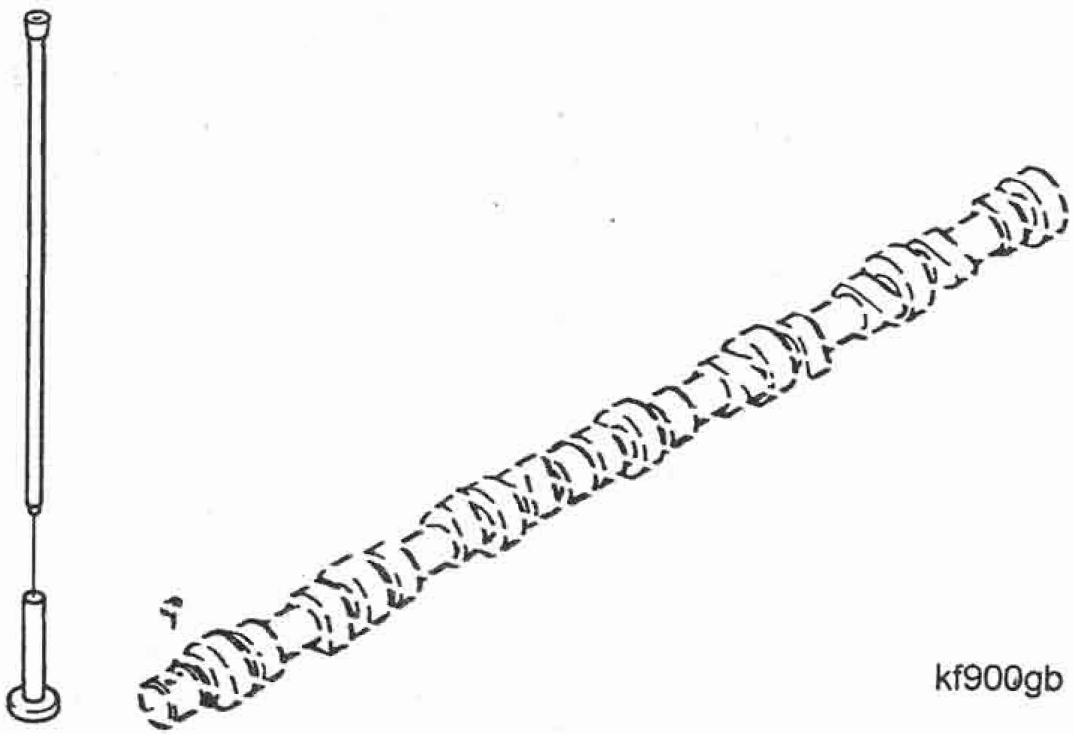
Install the snap rings.

Section 4 - Tappets and Push Rods - Group 04

Section Contents

Page

Tappets and Push Rods - Exploded View



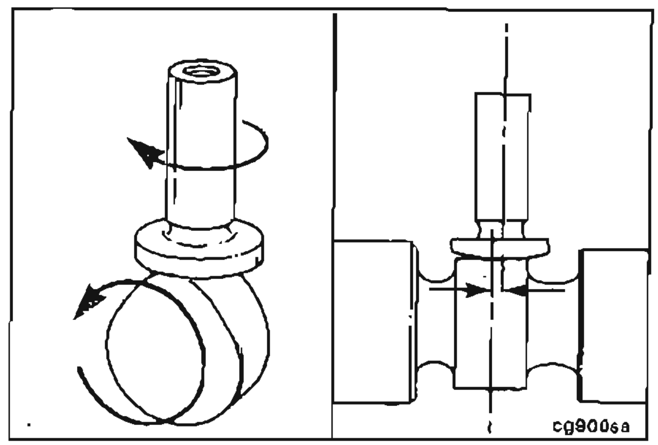
kf900gb

Tappets and Push Rods - General Information

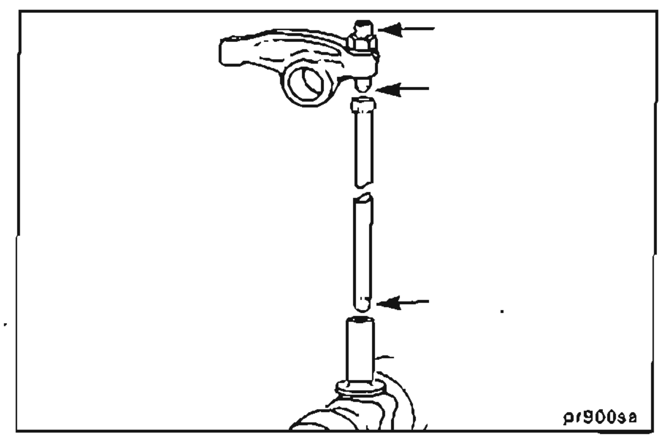
General Information

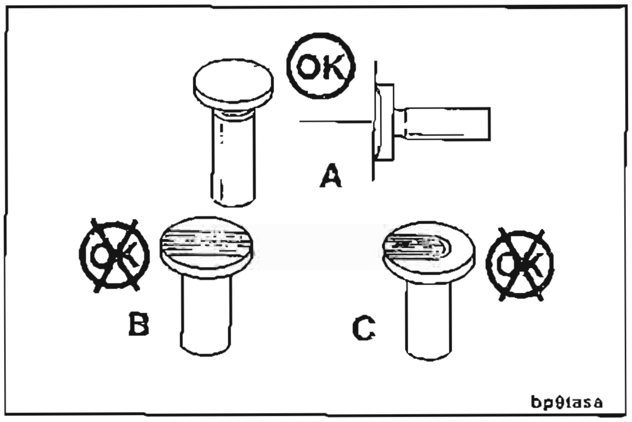
The camshaft has lobes to operate the intake and exhaust valves and a special lobe to drive the lift pump. The valve lobes contact the valve tappets which lift the push rods subsequently opening the valves.

The tappets are mushroom shaped and are positioned so the centerline of the tappet is offset to the centerline of the cam lobe. The offset position causes the tappet to rotate as it lifts the push rod.



The ball end of the push rod fits into the ball socket in the tappet. The other end of the push rod has a ball socket in which the ball end of the rocker lever adjusting screw operates.





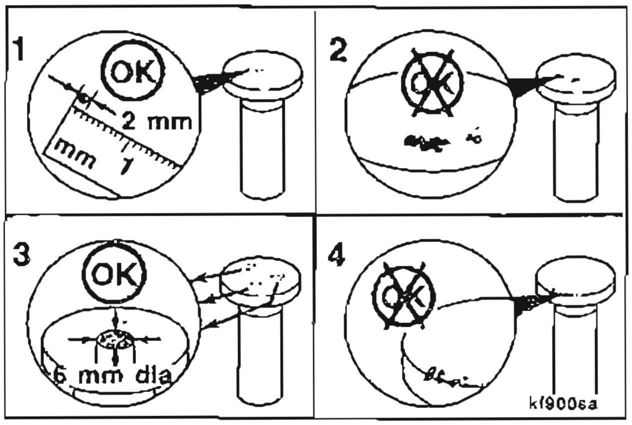
Valve Tappets - Inspection (4-01)

Inspect the socket, stem and face for excessive wear, cracks and other damage.

Visual Limits

(A) Normal Contact

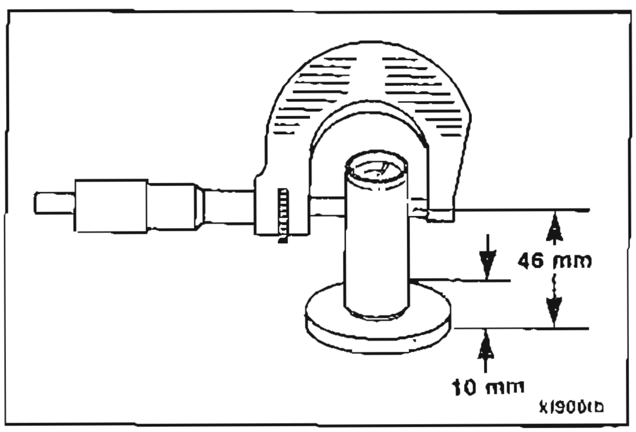
(B) and (C) Irregular Contact: **Do not reuse.**



Pit marks on the tappet face are acceptable.

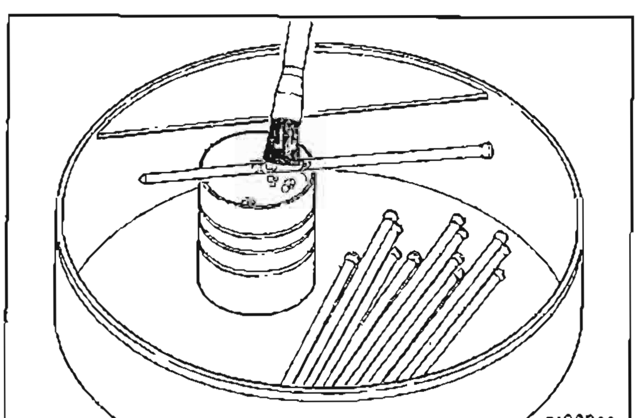
The following criteria definds the size of the pits allowed.

1. A single pit can not be greater than 2 mm [0.079 in].
2. Interconnection of pits is not allowed.
3. Total pits when added together should not exceed 6 mm [0.236 inch] diameter or a total of 4 percent of the tappet face.
4. No pitting is allowable on the edges of the wear face of the tappet.



Measure the valve tappet stem.

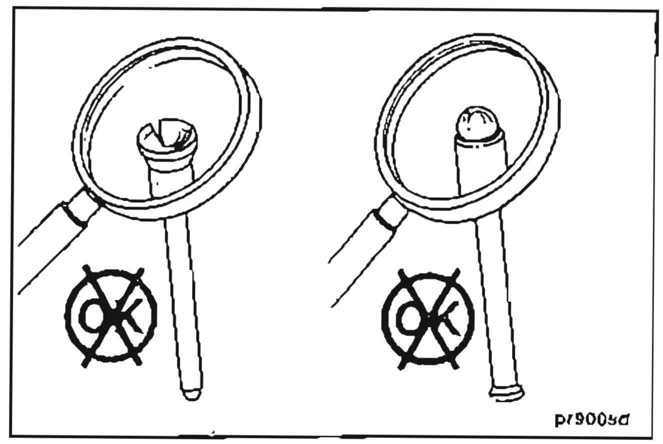
Diameter		
mm		in
15.936	MIN	[0.627]
15.977	MAX	[0.629]



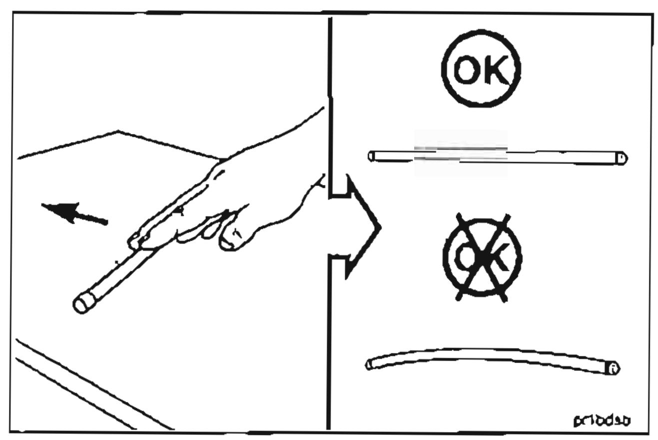
Push Rods - Inspection (4-02)

Clean the push rods in hot soapy water.

Inspect the push rod ball and socket for signs of scoring. Check for cracks where the ball and the socket are pressed into the tube.



Check to see if push rods are round and straight.

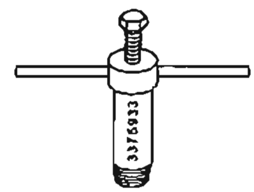
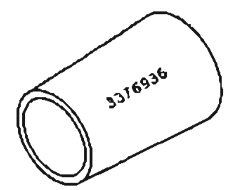
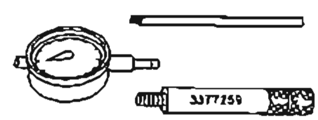
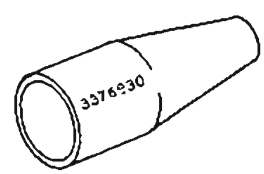
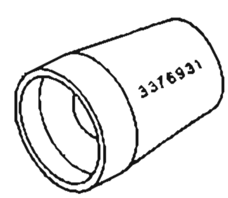


Section 5 - Fuel System - Group 05

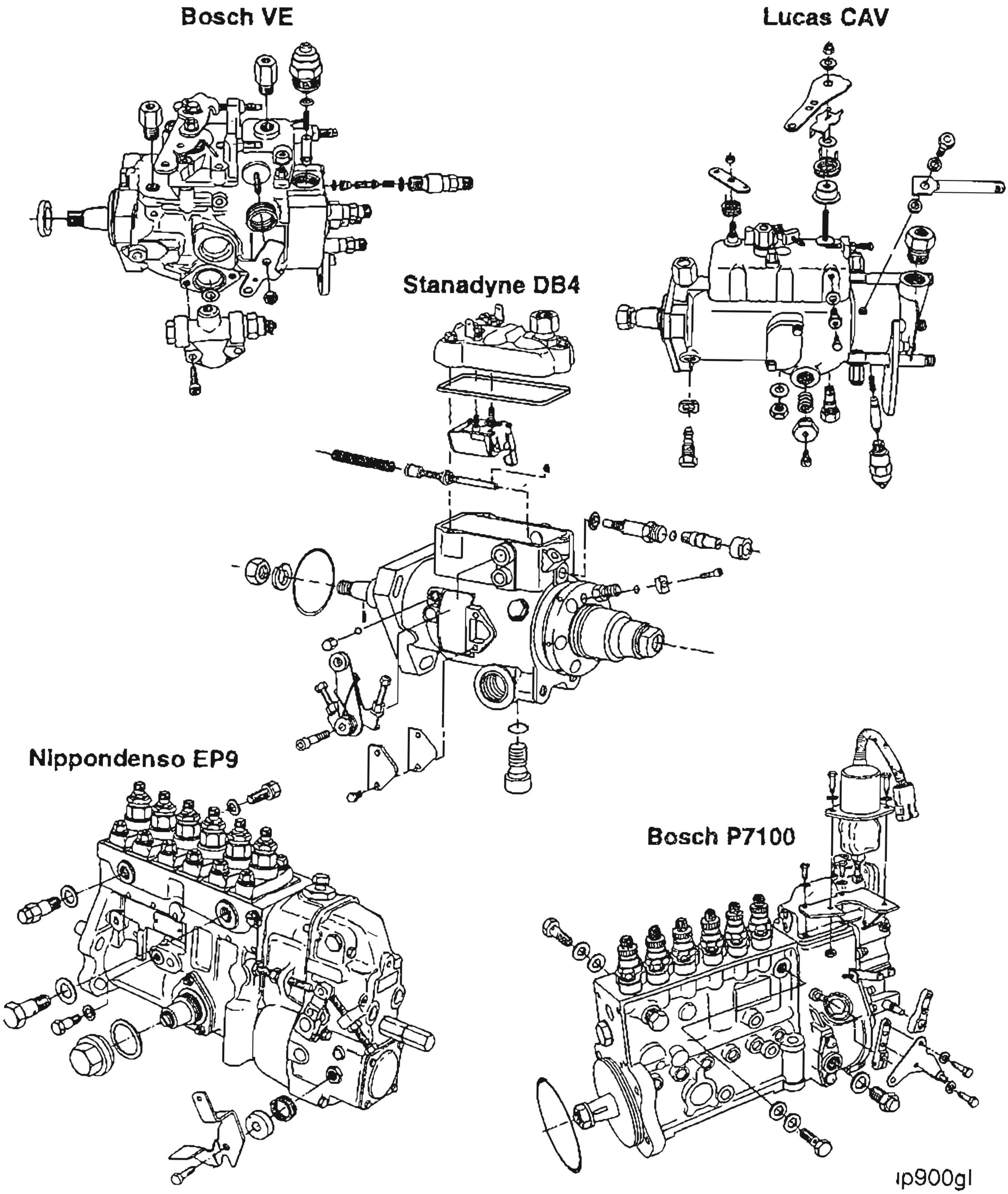
Section Contents

Service Tools - Injection Pump

The following special tools are recommended to perform procedures in Group 05. 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
3376933	**Seal Puller** Used to pull the front drive shaft seal on Bosch VE fuel pump.	 3376933
3376936	**Protective Sleeve** Used to install the front drive shaft seal on the Bosch VE fuel pump.	 3376936
3377259	**Timing Tool** Used to check static timing on the Bosch VE fuel pump.	 3377259
3376930	**Protective Sleeve** Used to replace the o-ring on the shut down solenoid for the Lucas CAV fuel pump.	 3376930
3376931	**Protective Sleeve** Used to replace the o-ring on the pressure end cap of the timing advance mechanism on the Lucas CAV pump.	 3376931

Exploded View - Fuel System



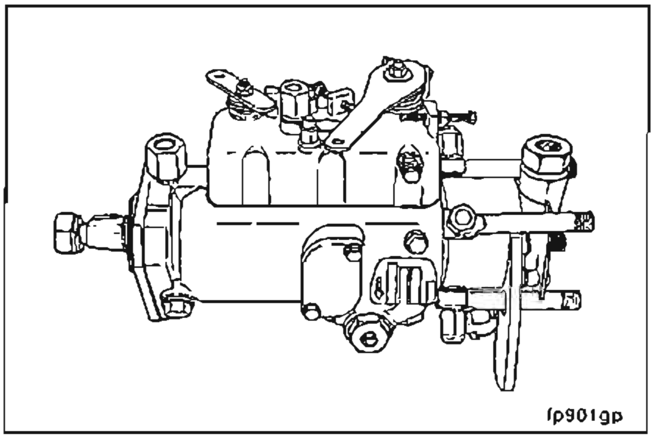
Injection Pump - General Information

Rebuild and calibration of fuel injection pumps should be performed by qualified personnel using the appropriate special equipment. However, there are a number of external repairs that can be performed on the pumps without affecting the calibration. These repairs are included in this section.

During any fuel system repair, cleanliness is of utmost importance. Thoroughly clean all affected parts with solvent and then blow dry with compressed air.

Injection Pump - Identification

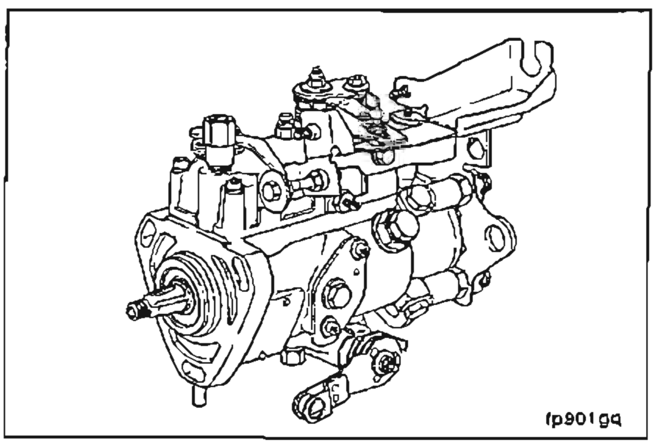
Beginning in 1991 the B Series engine uses five different fuel injection pumps depending on the horsepower rating and application.



fp901gp

The Lucas CAV DPA distributor type injection pump.

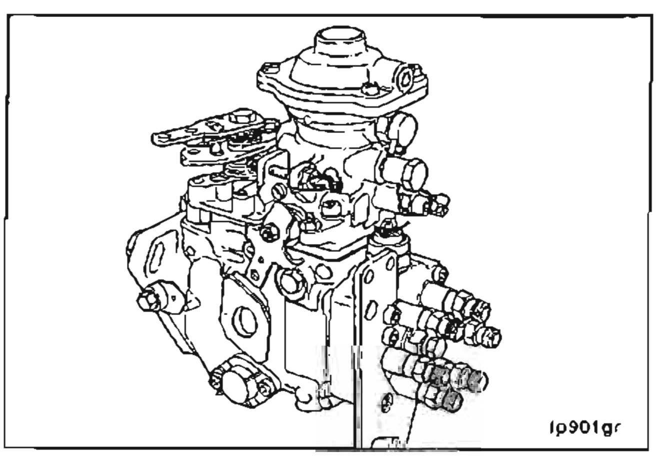
- Gensets
- Marine
- Industrial



fp901gq

The Lucas CAV DPS distributor type injection pump.

- European automotive ratings.



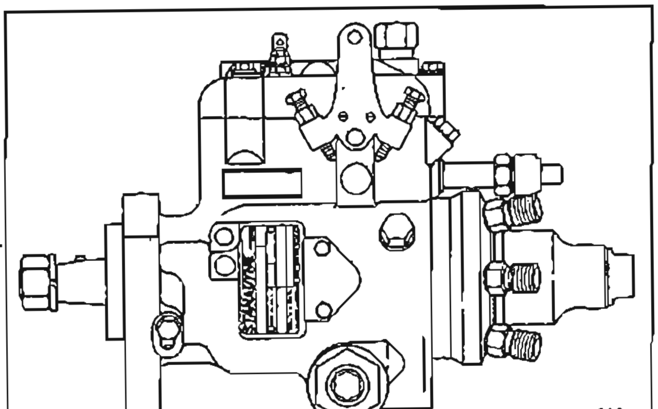
fp901gr

The Bosch VE distributor type injection pump.

- Industrial
- 1991 low horsepower automotive ratings.

The Stanadyne DB4 distributor type fuel injection pump.

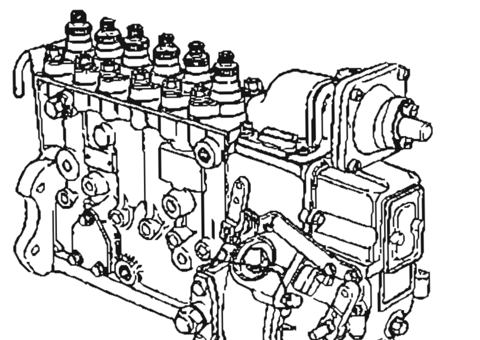
- Gensets



ip900gj

The Bosch P7100 in-line fuel injection pump.

- 1991 high horsepower automotive ratings.
- All 1994 automotive ratings.

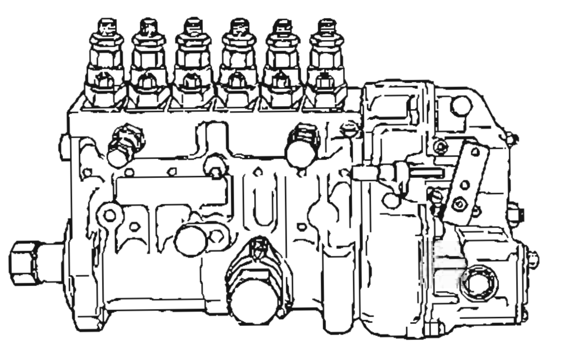


BOSCH P7100
With RQV-K Governor

fp901gs

The Nippondenso EP-9 in-line fuel injection pump with the RSV governor.

- 250, 300 and 315 horsepower marine ratings.
- High horsepower/industrial ratings.



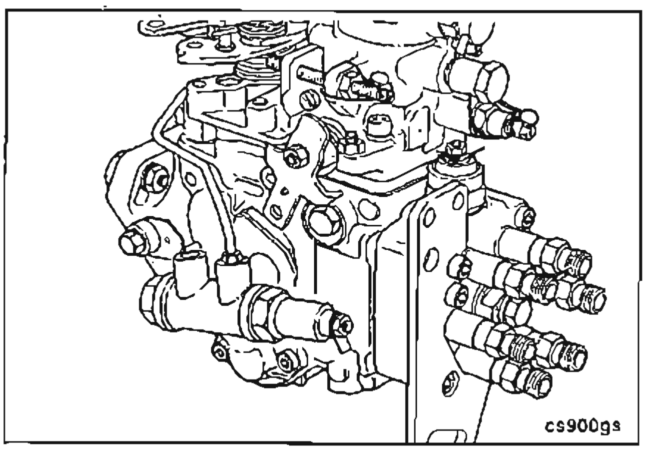
fp901gt

KSB Electrical Solenoid Style - General Information

Cold Start Timing Advance System (KSB) - Electrical Solenoid Style

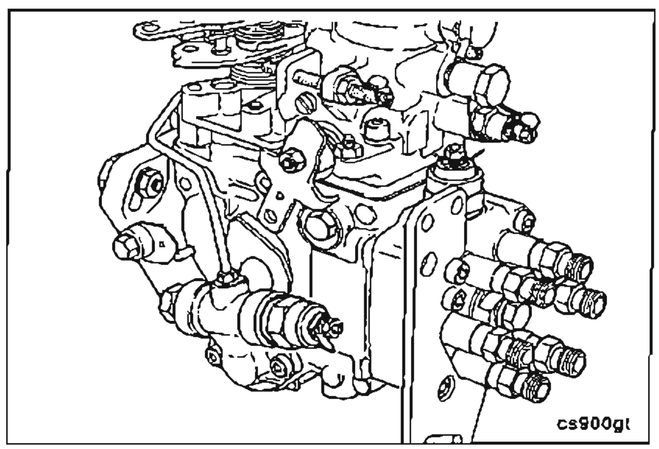
The electrical solenoid style KSB is used on 1991 model and newer B series automotive engine ratings using the Bosch VE fuel pump.

NOTE: The wax motor style KSB is used on pre-1991 B series automotive engine ratings using the Bosch VE fuel pump. Refer to the B Series Shop Manual, Bulletin No. 3810206, for information.



Wax Motor Style KSB (Pre-1991)

Note: Temperature switch is located in coolant jacket.



Electrical Solenoid Style KSB (1991)

Note: Temperature switch is located in intake manifold.

VE Pump Timing Advance Principles (Without KSB)

Pump housing pressure acts on an internal timing piston (1), Figure 1 to partially advance the injection timing at idle, and fully advance the timing when the engine RPM reaches approximately 60% of rated speed. As pump pressure increases, timing advances.

The pump housing pressure is controlled by the pressure regulator valve (2) (a spring loaded slider valve). The valve is shown in the open and closed position.

When housing pressure is low, the spring (3) forces the slider (4) into the closed position. This permits the housing pressure to increase by preventing fuel drainage through the return passage (5).

As housing pressure increases it forces the slider (4) to compress the spring (3). This action opens the return passage (5) and relieves the housing pressure.

A relief port (6) located on the spring side of the slider valve, allows fuel that seeps past the slider (4) to drain. Relief port drainage is necessary to avoid a hydraulic lock of the slider valve, which would render the pressure regulator valve (2) inoperable. In fact, it is this characteristic that is used in conjunction with KSB to advance the timing during cold engine operation.

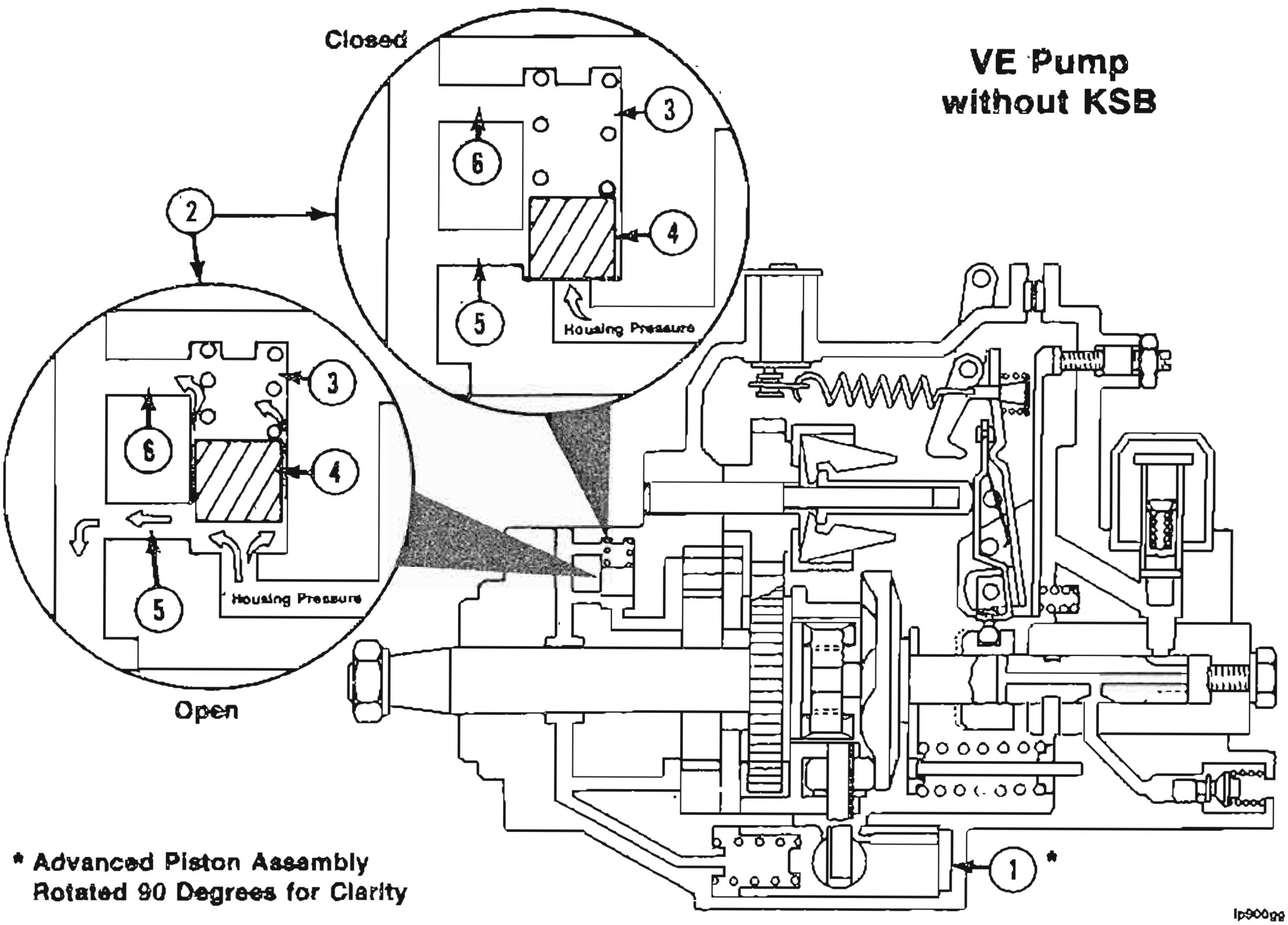


Figure 1, VE pump timing, regulated by opening and closing the pressure regulator valve

VE Pump Timing Advance Principles (With Electrical Solenoid KSB Installed)

The KSB introduces a new fuel line (1), Figure 2, which routes fuel from the relief port (2) of the pressure regulator valve (3) to the plunger end (6), Figure 3, of the electrical solenoid, bypassing the normal return passage (6), Figure 1

With the key switch on, current flows from the key switch line to the 90°F normally closed intake manifold switch to the 12V electrical KSB solenoid (see Figure 2). When the engine starts the pressure regulating valve (3) attempts to regulate fuel pressure as before (without KSB) but the fuel from the relief port (2) now meets a 'dead end' at the plunger of the KSB solenoid (6), Figure 4. With the key switch on, the plunger moves outward and closes off the flow of the fuel (8), Figure 4. This action hydraulically locks (closes) the pressure regulator slider valve (4), Figure 1

Housing pressure (5), Figure 2, is not regulated because the pressure regulator valve (3) is inoperable and so the pressure continues to increase. This action fully advances the timing. The timing remains fully advanced until the plunger (6), Figure 4, is opened and fuel is allowed to drain through fuel drain flow path (8), Figure 4.

When the intake manifold temperature reaches 90°F the 90°F normally closed IMT switch opens and voltage is no longer applied to the KSB solenoid (10). With no voltage applied to the KSB solenoid (13), fuel pressure overcomes the plunger force and pushes the plunger back to open the fuel drain flow path (8).

Fuel from the relief port of the pressure regulating valve now has a drain path (8), Figure 4, past the KSB solenoid plunger (6), Figure 4 (which is now open) to the drain. The pressure regulator valve resumes normal operation and the injection timing is regulated accordingly.

The electrical solenoid style KSB is also equipped with a pressure relief valve (7), Figure 3. If the engine is taken to high idle with the KSB solenoid plunger in the closed position (6), Figure 3, housing pressure can increase enough to rupture the fuel pump housing. The pressure relief valve (7), Figure 3, will pop off its seat before this occurs, however. At a pressure of 4 bar (60 psi), the pressure relief valve (7), Figure 3, opens and allows fuel to drain through an alternate flow path (9), Figure 3.

VE Pump Timing Advance Principles (With Electrical Solenoid KSB Installed)

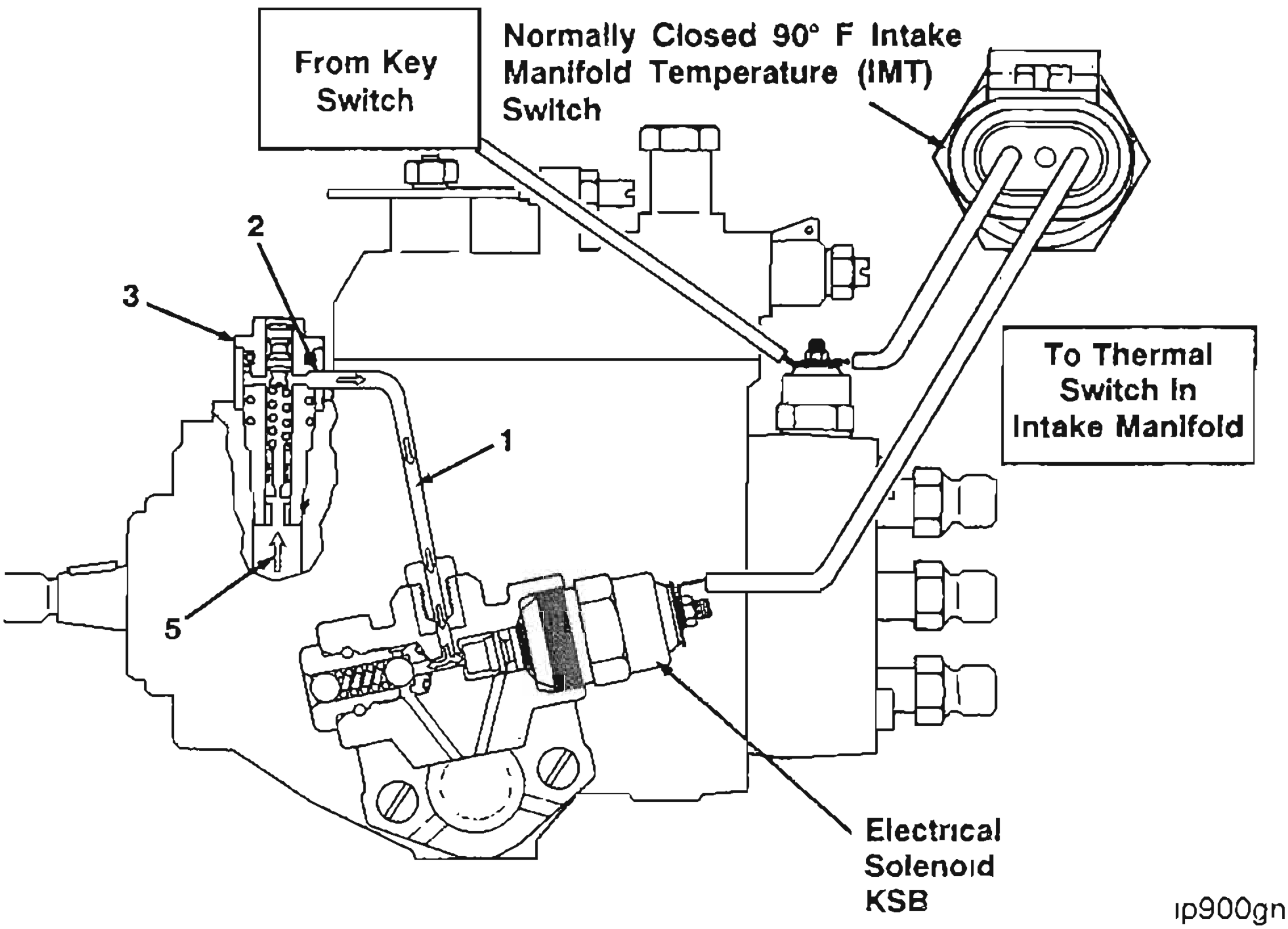


Figure 3: Cold Engine Operation (Less Than 90°F IMT), Advanced Timing

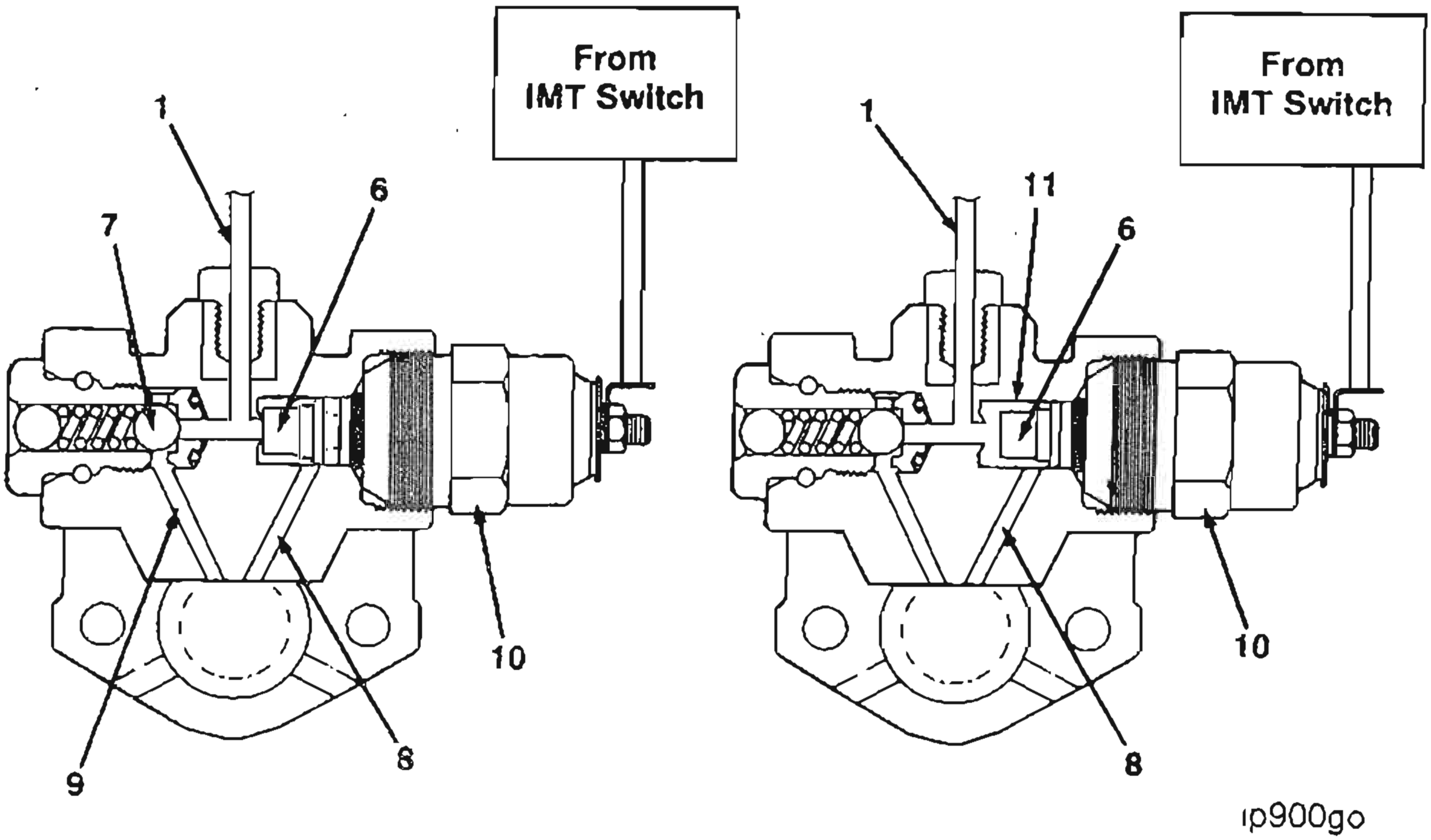
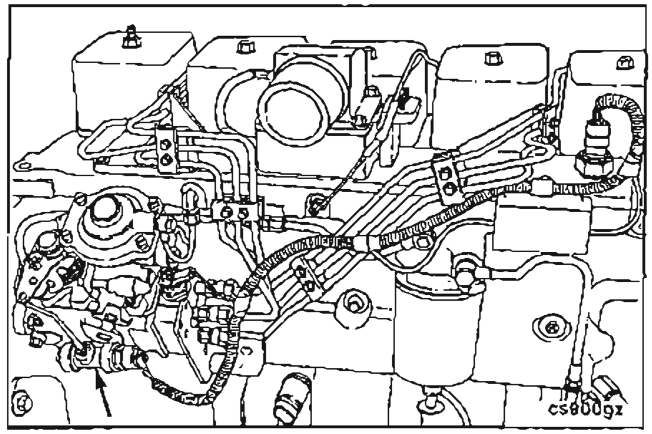


Figure 4: Warm Engine Operation (More Than 90°F IMT), Retarded Timing

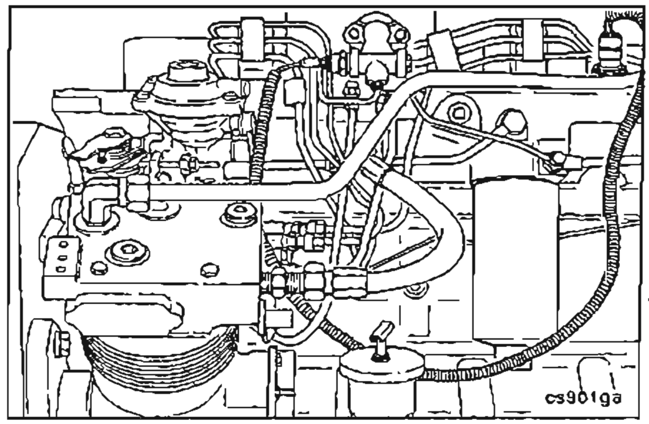
Two types of electrical solenoid style KSB valves are available.

The first type is the pump mounted KSB, as shown.

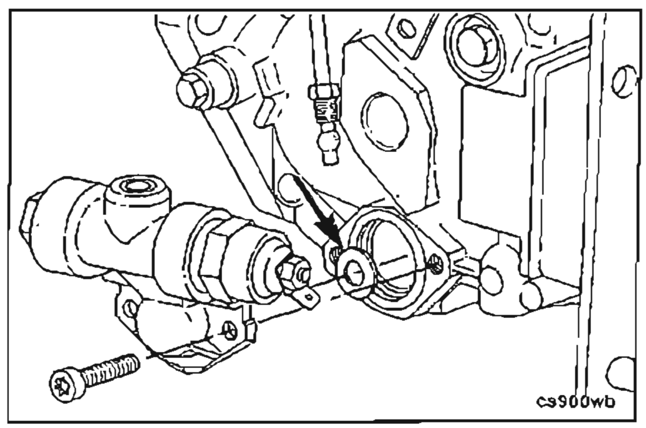


The second type is the remote mounted KSB, as shown.

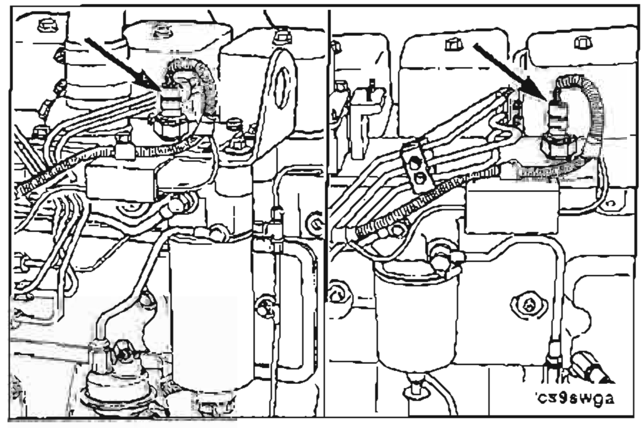
The remote mounted KSB is used on B series automotive engines which have an air compressor.



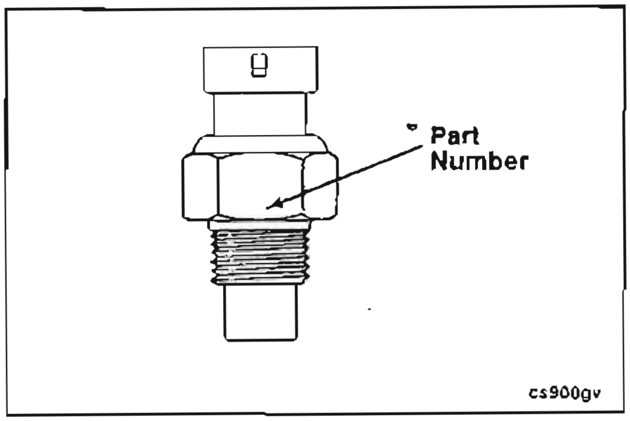
Caution: Most pumps will have a shim between the KSB and the timing piston. This shim must be reassembled between the cover plate and the timing piston. If this shim sticks to the KSB and is installed with the remote mounting hardware, it will block the regulating valve drain path and damage the pump. This damage is usually evidenced by a fuel leak.



Both the 4 and 6 cylinder have the temperature switch mounted in the intake manifold as shown.



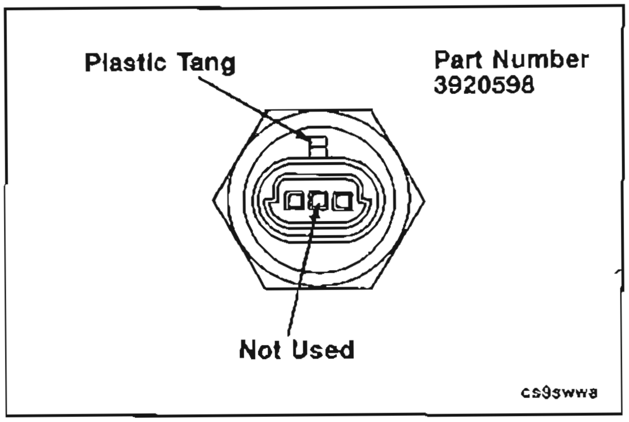
KSB Electrical Solenoid Style - Inspection



Temperature switches are not interchangeable. White smoke will be present if the wrong temperature switch is used.

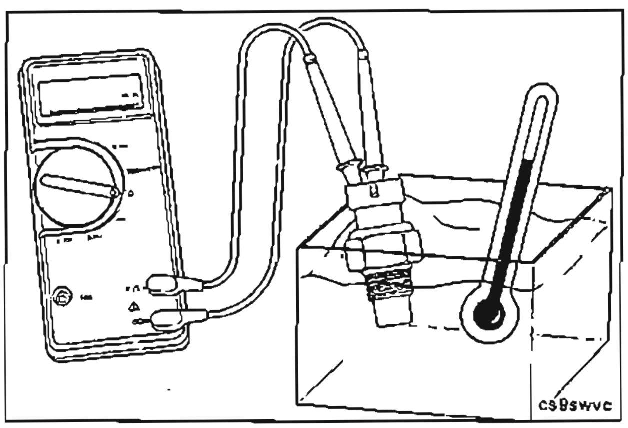
Check the part number to be sure the correct temperature switch is used.

1) The electrical solenoid style KSB (used on 91 models and newer) uses a 90°F [32°C] normally closed intake manifold temperature switch, Part No. 3920598.
2) The wax motor KSB (used on pre-91 engines) uses a 160°F [71°C] normally open coolant temperature switch, Part No. 3921642.



Although the electrical solenoid style KSB uses an intake manifold temperature switch, the operation of the switch can be checked by connecting a volt/ohm meter to the switch, placing the switch in ice water, and then heating the water to 90°F [32°C].

Connect the VOM to the two outside pins of the temperature switch.

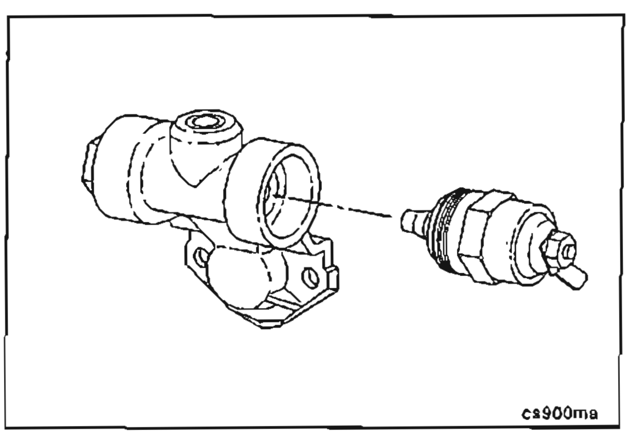


Check the water temperature with a thermometer.

The VOM should indicate a closed circuit below 90°F [32°C] and an open circuit above 90°F [32°C].

Replace the switch if necessary.

KSB Electrical Solenoid - Inspection

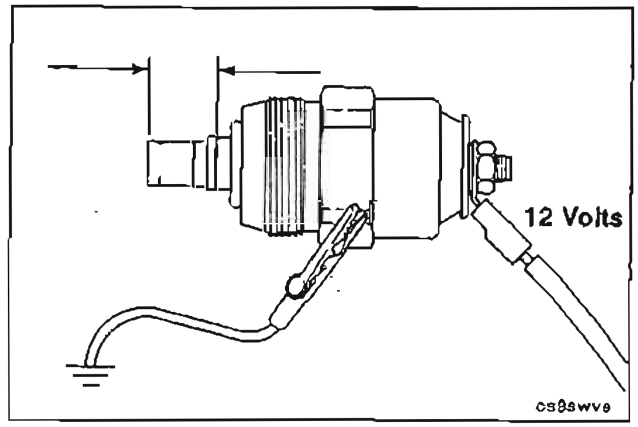


24 mm

Remove the KSB electrical solenoid from the KSB housing.

Apply 12 volts to the electrical terminal and ground the hexagonal portion of the element. The magnetic coil of the solenoid must push the plunger outward.

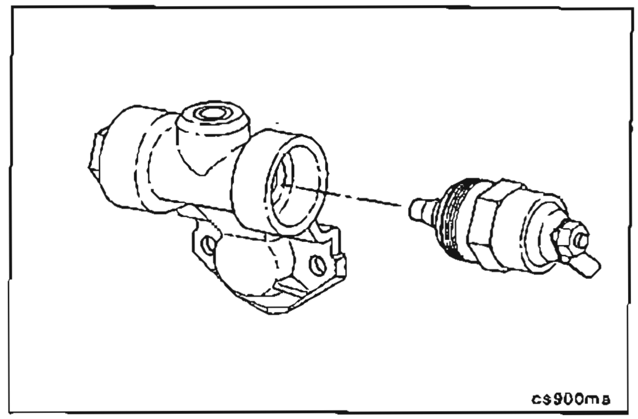
If the plunger does not push outward when voltage is applied, the solenoid is defective and must be replaced.



24 mm

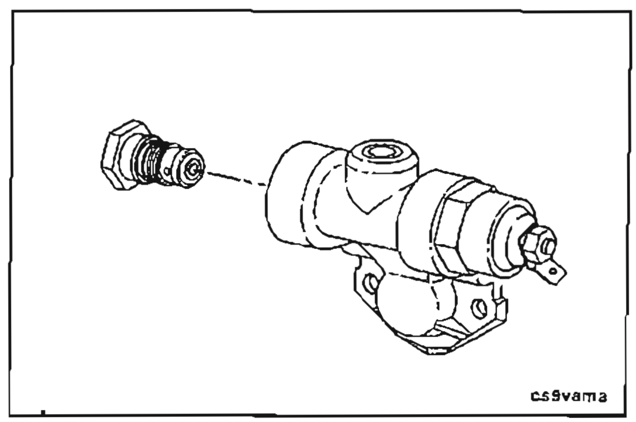
Install the original solenoid or a replacement into the KSB housing.

Torque Value: 22 N•m [16 ft-lb]

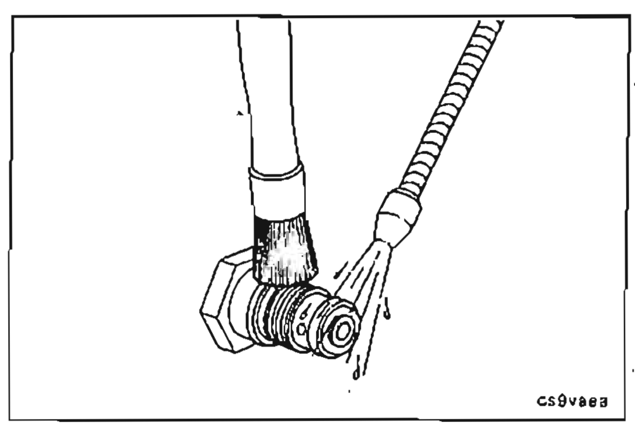


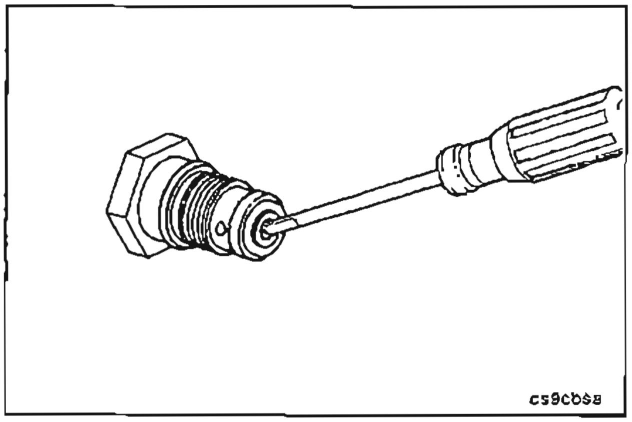
17 mm

Remove the pressure relief valve.



Thoroughly flush the pressure relief valve with cleaning solution.

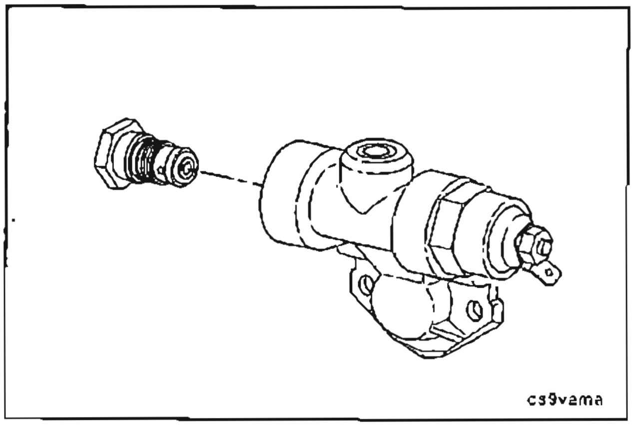




Use a very small screwdriver to be sure the check ball is not sticking.

NOTE: A sticking or malfunctioning pressure relief valve will result in either white smoke or a ruptured fuel pump housing.

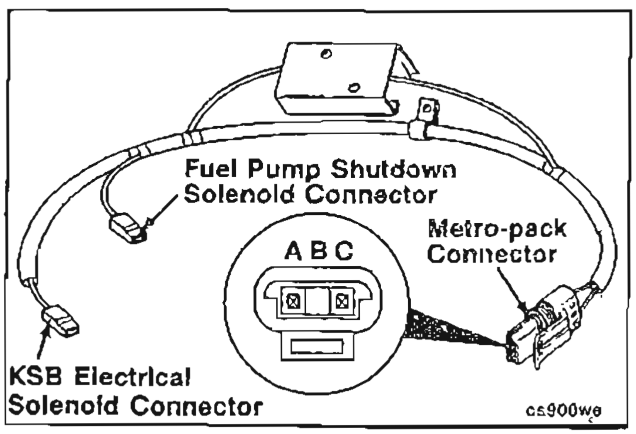
Replace the pressure relief valve assembly if necessary.



17 mm

Install the original pressure relief valve or a replacement into the KSB housing.

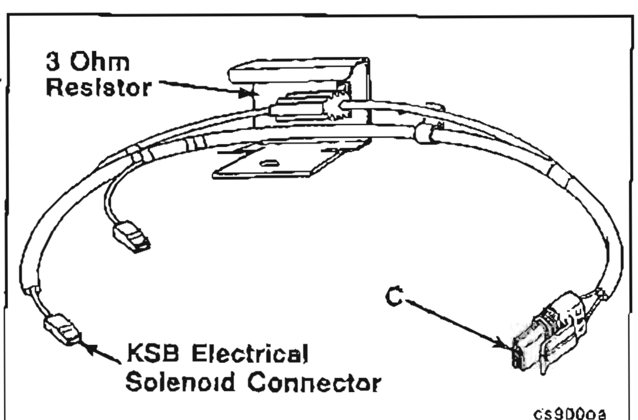
Torque Value: 13 N•m [10 ft-lb]



KSB Electrical Solenoid Style Wiring Harness - Inspection

The wiring harness used on the electric solenoid style KSB can be inspected using a volt-ohm meter.

NOTE: Pin 'B' of the metro-pack connector is blank on the electric solenoid style KSB wiring harness.



The electric solenoid style KSB wiring harness contains a 3 ohm resistor in the wire leading from Port 'C' of the metro-pack connector to the KSB electrical solenoid connector.

The 3 ohm resistor is mounted to a bracket which is used as a 'heat sink' to absorb heat that is generated by the resistor.

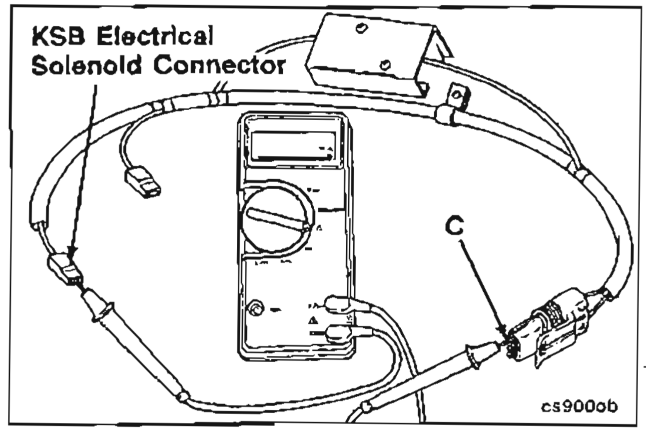
CPL 1351 incorporates the resistor in the wiring harness.

CPL 1579 does not require a resistor.

Use a volt/ohm meter to perform a continuity check between Port 'C' of the metro-pack connector and the KSB electrical solenoid connector.

Repair the wire if there is an open circuit.

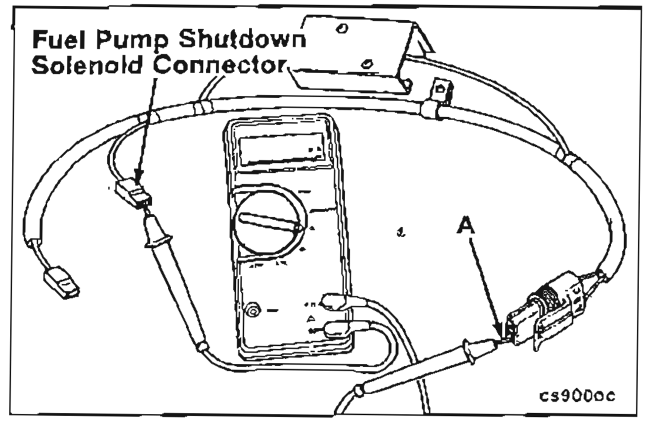
(Spec = Less than 10 ohms).



Use a volt/ohm meter to perform a continuity check between Port 'A' of the metro-pack connector and the fuel pump shut down solenoid connector.

Repair the wire if there is an open circuit.

(Spec = Less than 10 ohms).

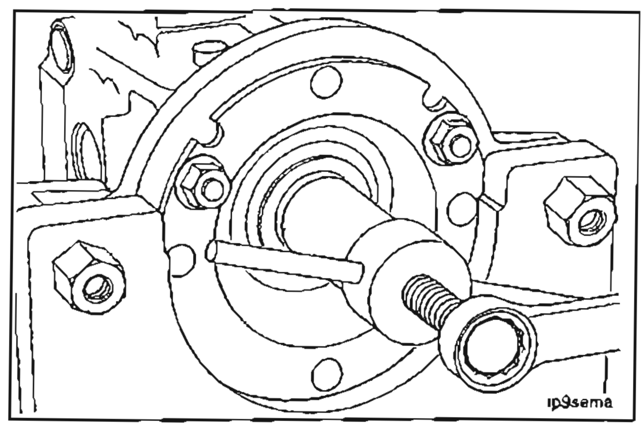


Injection Pump Repairs - Bosch VE (5-01)

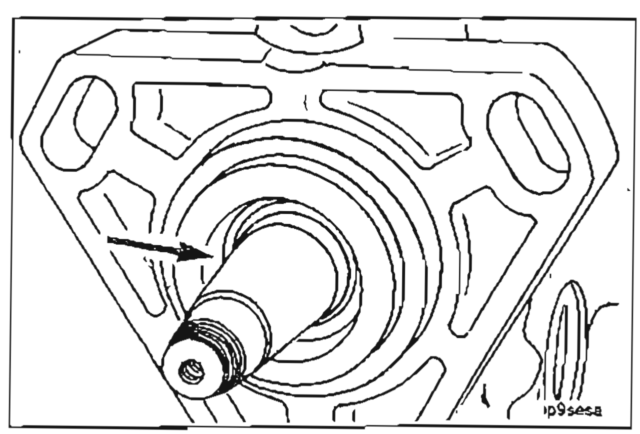
Shaft Seal - Replacement (5-02)

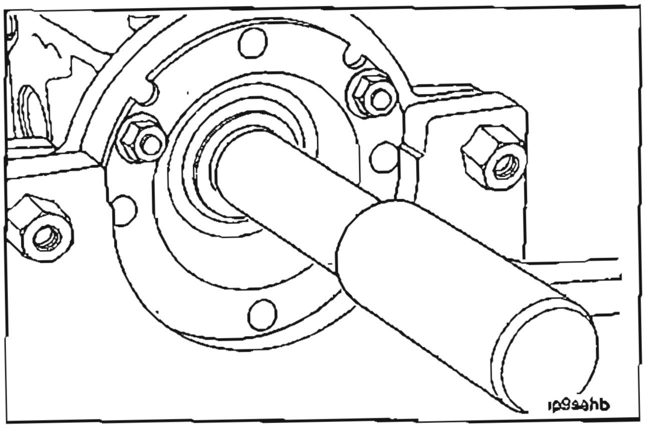
Seal Puller Part No. 3376933

Remove the seal.



Inspect the seal seating area for nicks and burrs. Minor clean-up (deburring) is allowed providing the area is thoroughly flushed with solvent and dried with compressed air.



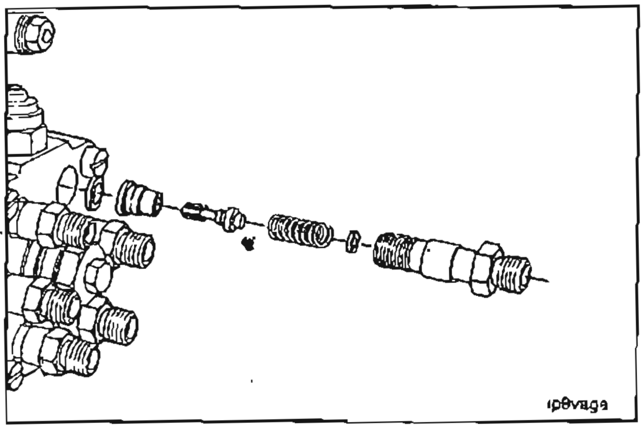


Protective Sleeve Part No. 3376936

Install the new seal onto the shaft using a protective sleeve.

Drive the seal in until it bottoms in the seal bore.

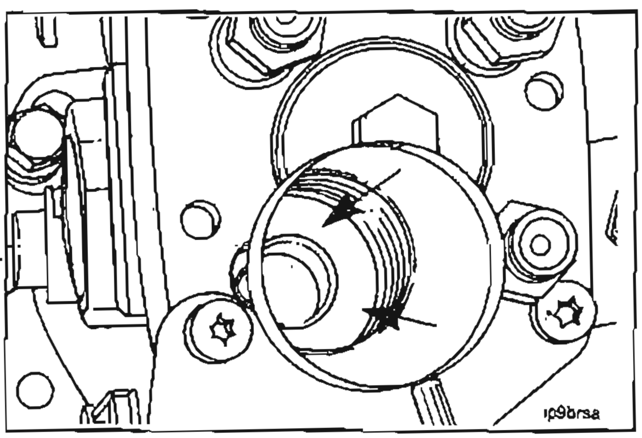
Service Tip: A deep well socket that contacts the outside diameter (metal surface) of the seal will work adequately to drive in the new seal.



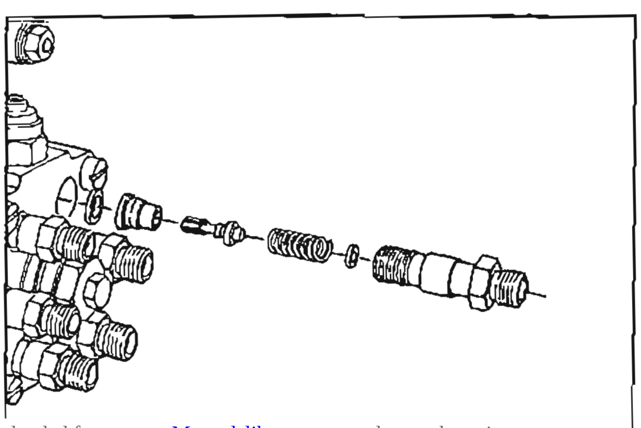
Delivery Valve Holder/Sealing Washer - Replacement (5-03)

14 mm

Remove the delivery valve holder, shim (if used), delivery valve and sealing washer.



Inspect the sealing surfaces on the high pressure head, the delivery valve and the delivery holder.

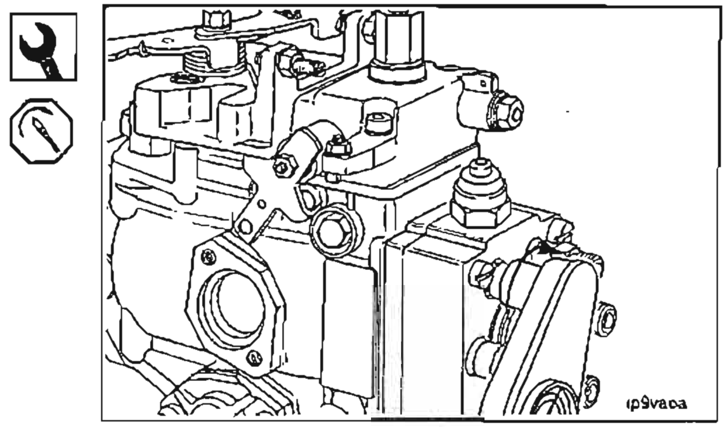


Install the delivery valve holder assembly and new sealing washer as illustrated.

14 mm

Tighten the holder.

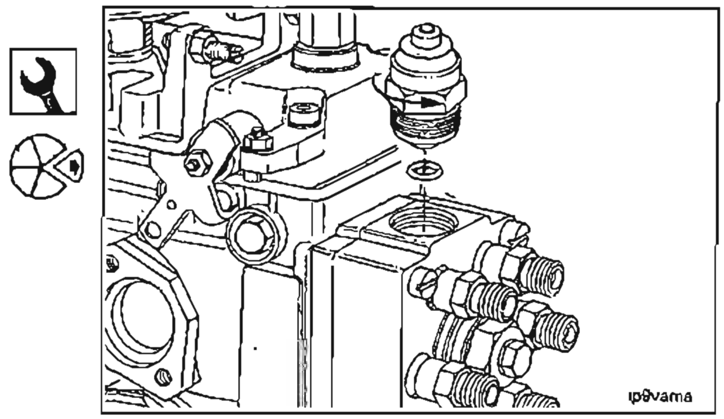
Torque Value: 31 N•m [23 ft-lb]



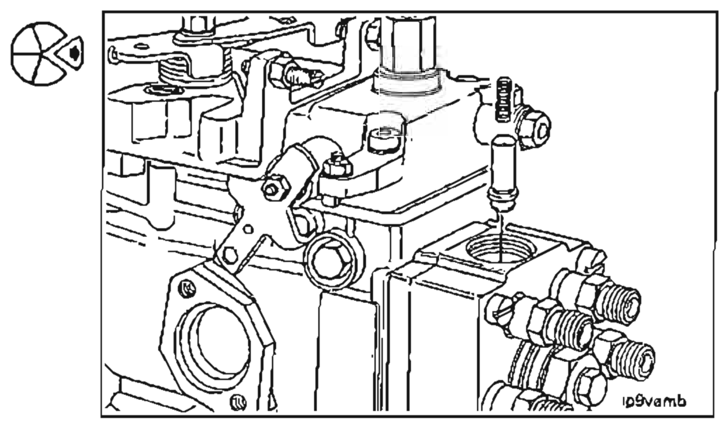
Shutdown Solenoid - Replacement (5-04)

24 mm

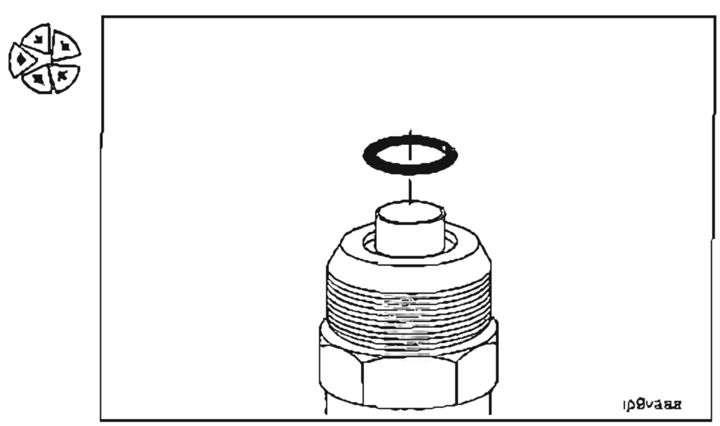
Remove the solenoid and o-ring.

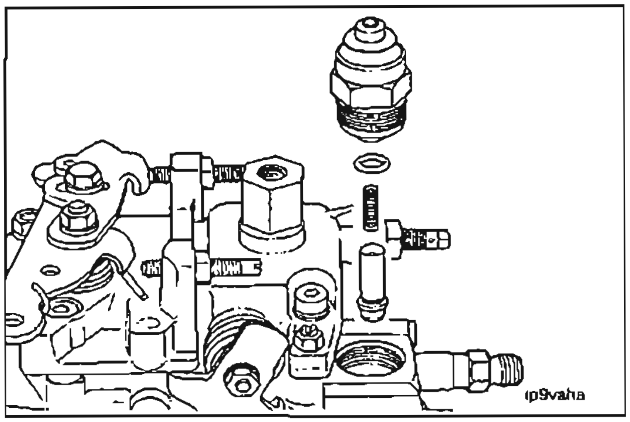


Remove the plunger and spring. Clean the plunger seat in the injection pump.



Place a new o-ring on the replacement fuel solenoid.



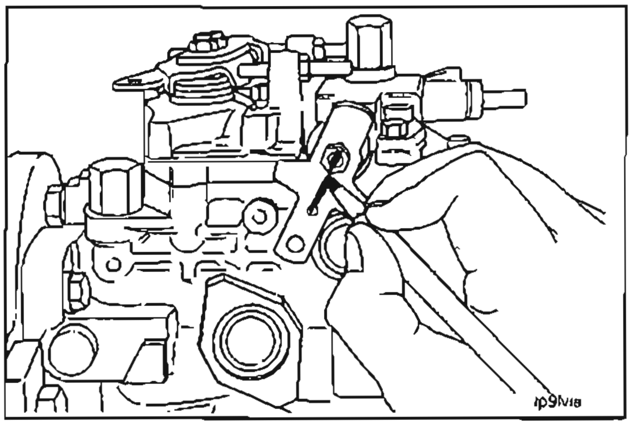


24 mm

Install the new fuel solenoid, plunger and spring into the distributor head.

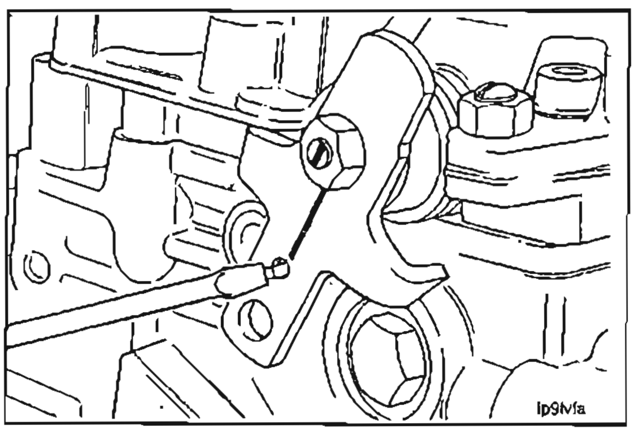
Tighten the solenoid securely.

Torque Value: 43 N•m [32 ft-lb]

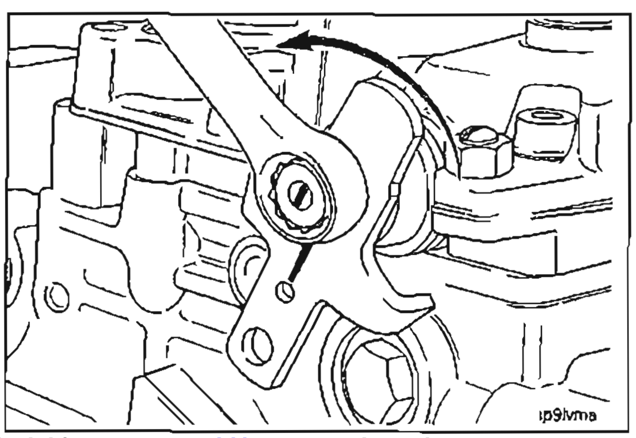


Shutdown Lever/Spring - Replacement (5-05)

Caution: Mark the shutdown lever so it can be installed in the same position. Failure to do so will result in incorrect installation.



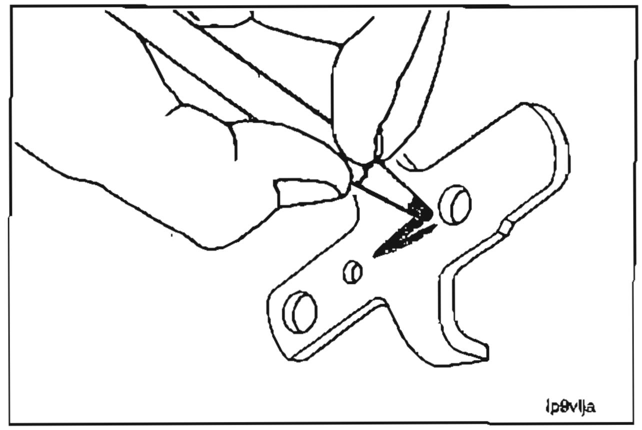
Disconnect the return spring.



10 mm

Remove the lever and spring.

Use the removed lever as a pattern and mark the replacement lever so it can be installed in the same position as the removed lever.

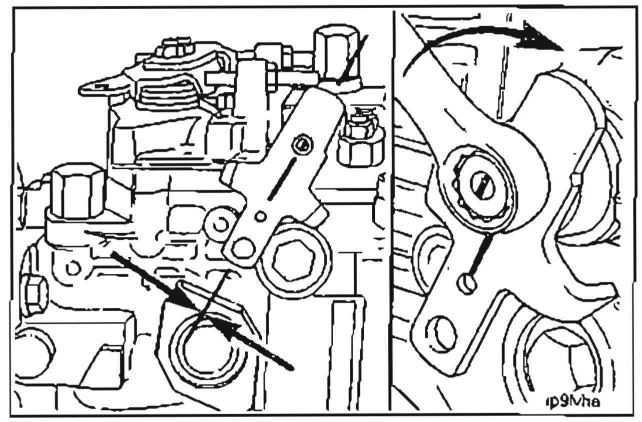


10 mm

Align the marks and install the spring and lever.

Install and tighten the lock washer and nut.

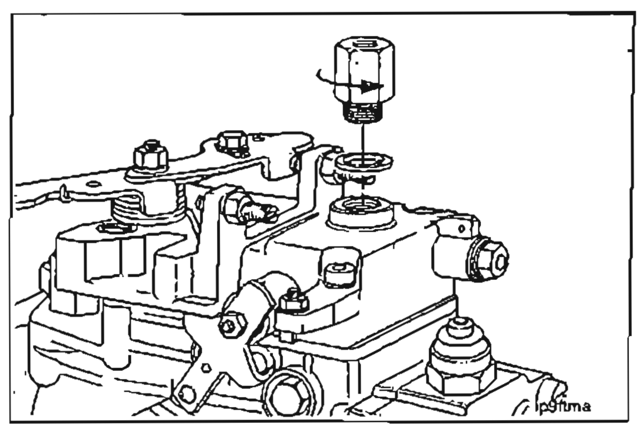
Torque Value: 5-10 N•m [4-7.5 ft-lb]



Overflow Adapter/Sealing Ring - Replacement (5-06)

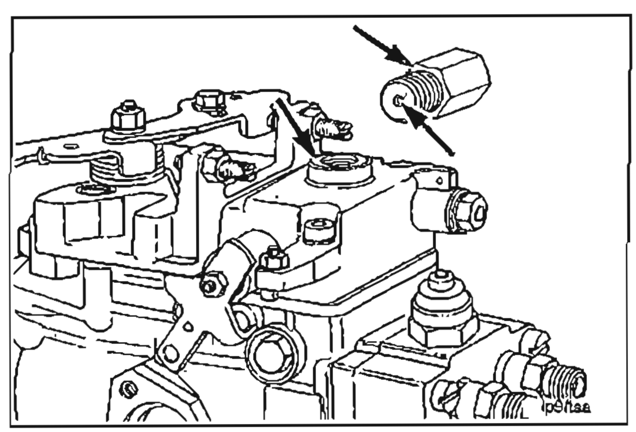
19 mm

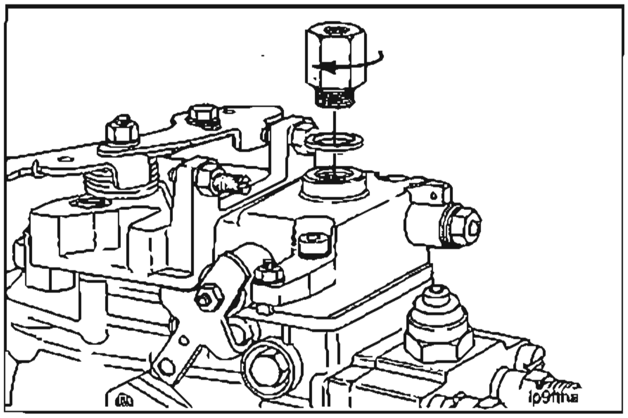
Remove the overflow adapter.



Inspect the sealing surfaces on the adapter and the pump.

Be sure orifice in the adapter is open.



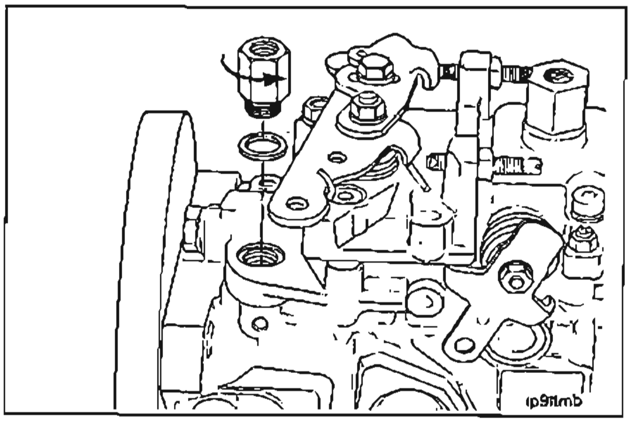


19 mm

Install a new sealing washer and tighten the adapter.

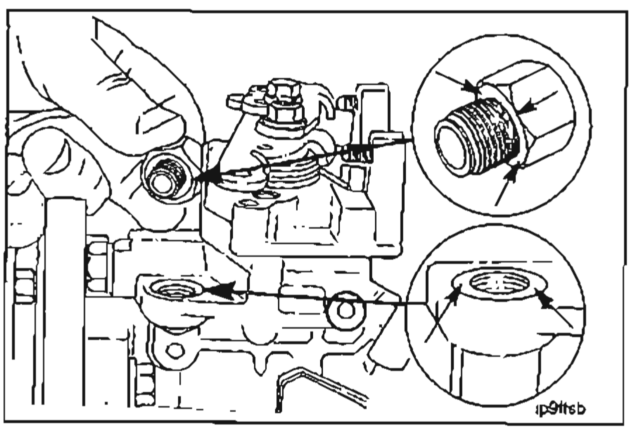
Torque Value: 23 N•m [17 ft-lb]

Fuel Inlet Adapter/Seal - Replacement (5-07)

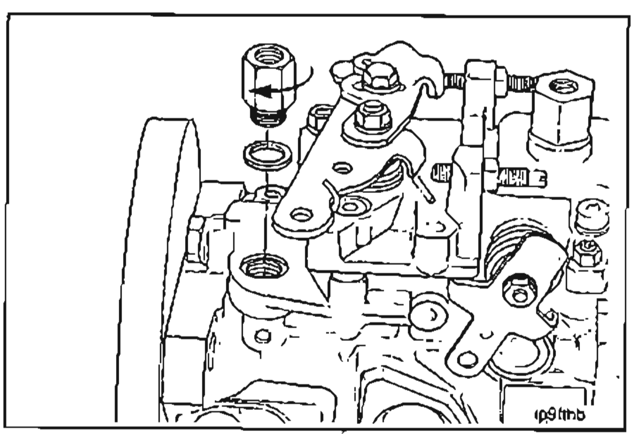


19 mm

Remove the adapter and sealing washer.



Inspect the sealing surfaces.



19 mm

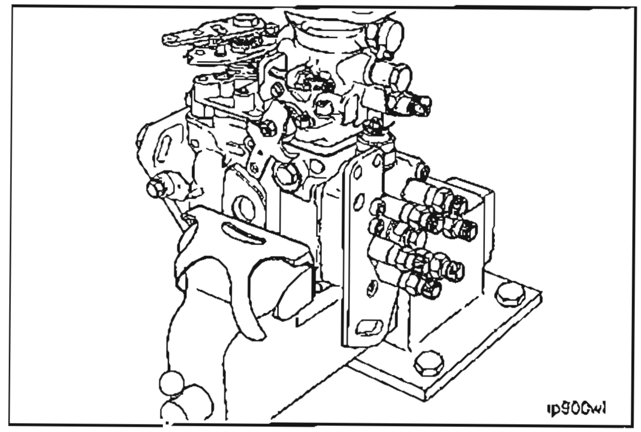
Install a new sealing washer and tighten the adapter.

Torque Value: 23 N•m [17 ft-lb]

Injection Pump Timing - Bosch VE (5-08)

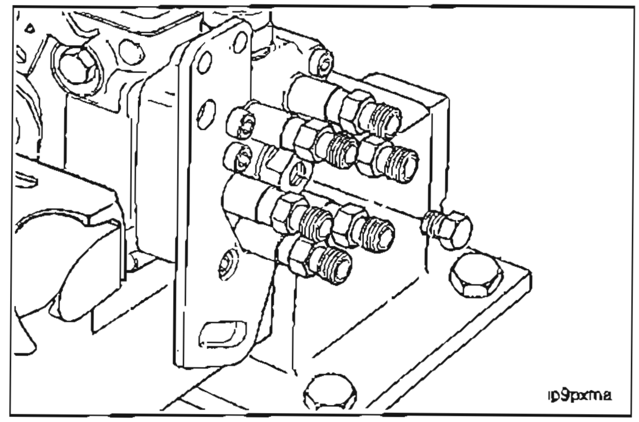
Secure the pump in a vise.

Caution: Do not over tighten the vise or position the pump in the vise in such a way as to damage the pump housing.


ip90Owl

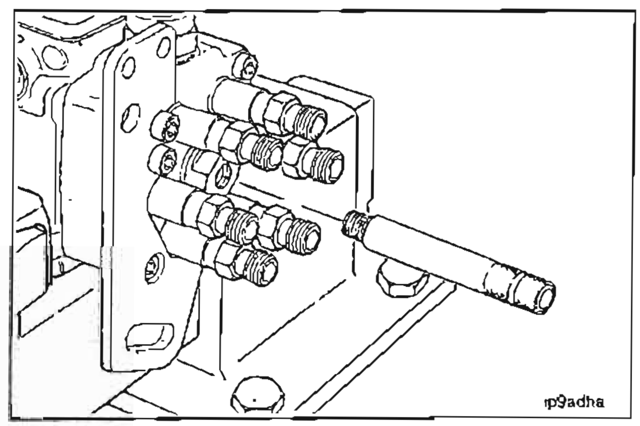
12 mm

Remove the access plug from the rotary head central screw assembly.

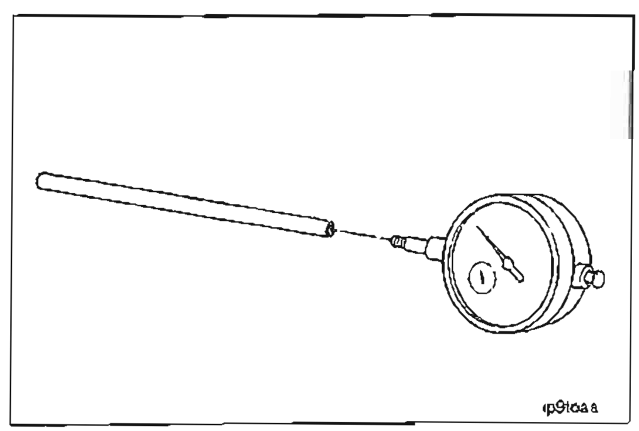

ip9pxma

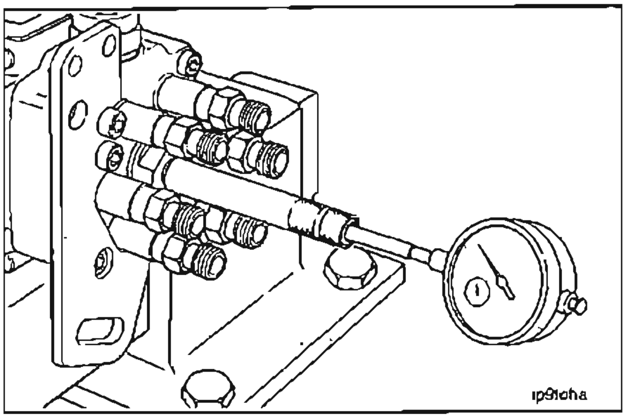
Timing Tool Part No. 3377259

Thread the timing tool extension into the access plug hole. Finger tighten.

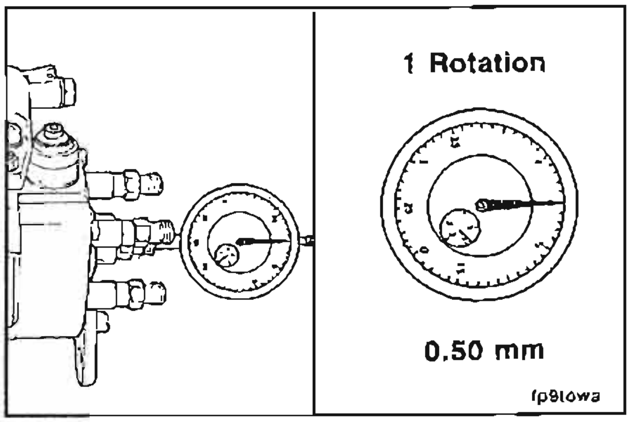

ip9adha

Thread the dial indicator tip extension into the dial indicator. Finger tighten.


ip9toaa

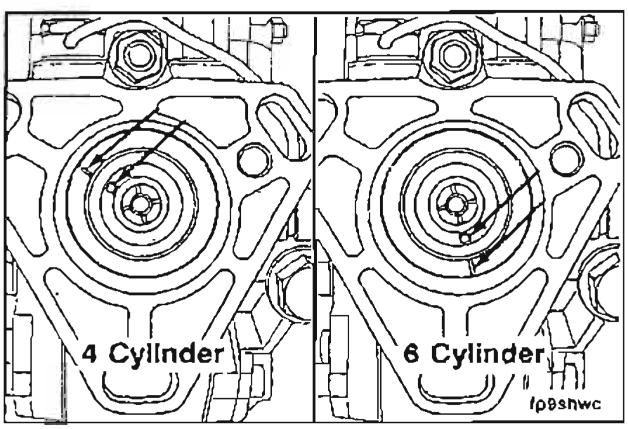


Install the dial indicator into the timing tool extension.



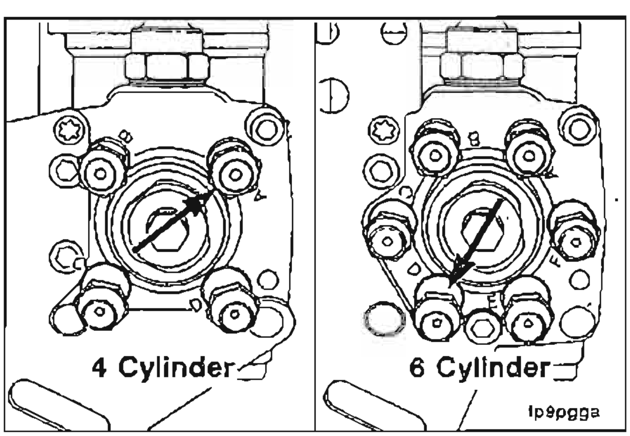
Set the indicator to allow at least 3.0 mm travel. Tighten the locking sleeve finger tight.

NOTE: The indicator travel should be set with the pump unlocked.



At the point of injection the key way of the shaft will align with the delivery valve receiving the injection, and the illustrated hash mark on the seal housing.

NOTE: The illustrated mark is for **reference only** and should not be used for setting the pump timing.



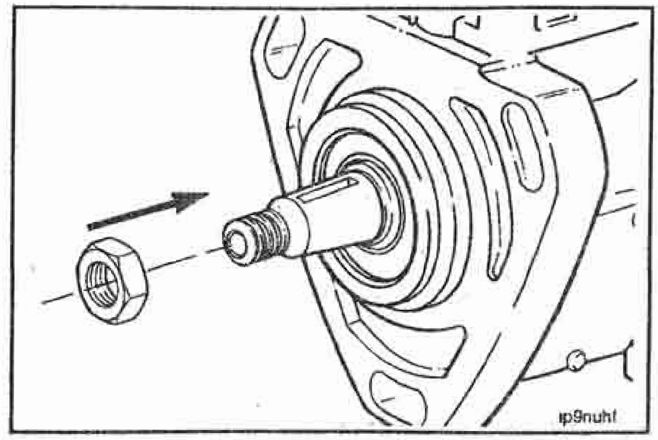
The number one cylinder delivery valve is marked as illustrated.

4 cylinder = A
6 cylinder = D

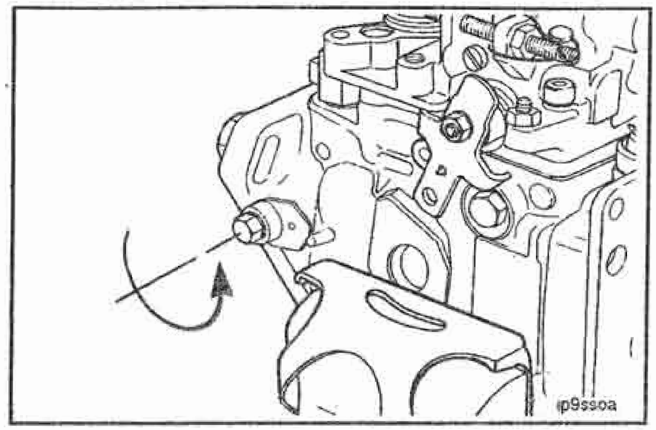
Firing Order

4 Cylinder	6 Cylinder
A = 1	D = 1
B = 3	E = 5
C = 4	F = 3
D = 2	A = 6
	B = 2
	C = 4

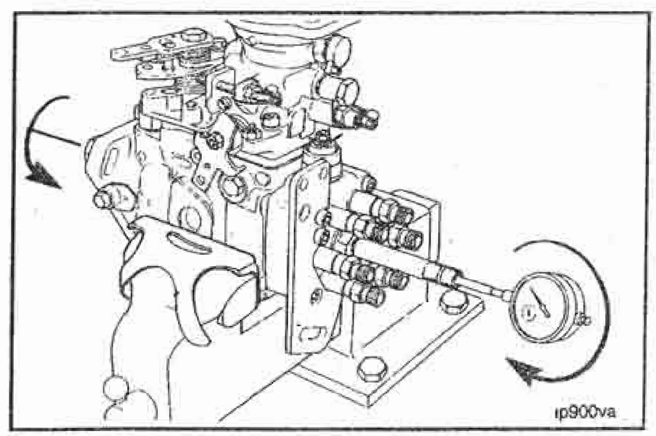
Install the drive gear retaining nut on the pump drive shaft.



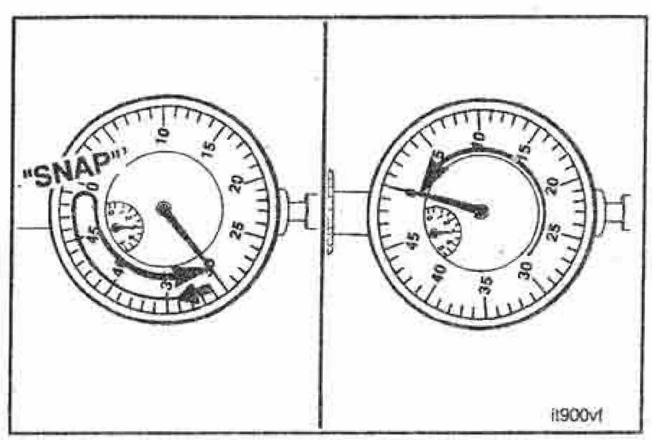
Make sure the pump is unlocked.

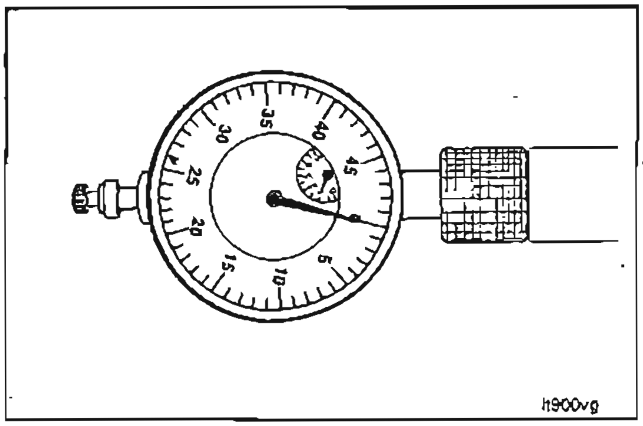


Rotate the drive shaft clockwise. As the pump is rotated the gage will rotate in a clockwise direction.

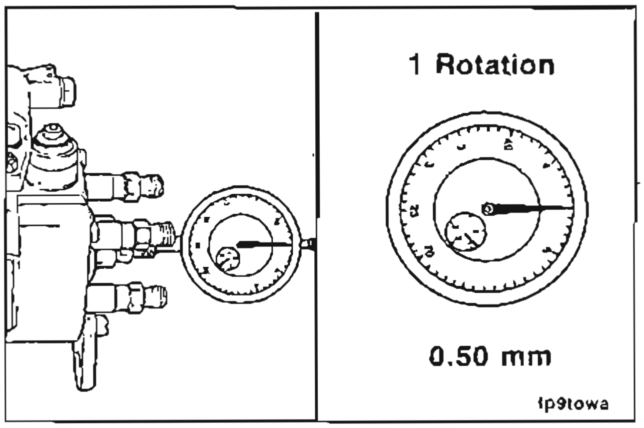


As injection is completed to the respective ports the pump will snap. At this point the gage will reverse direction to counterclockwise. Zero the gage at the point the needle stops and reverses to clockwise again.

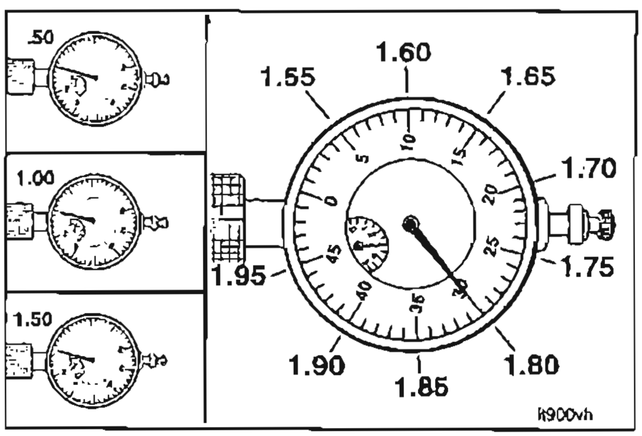




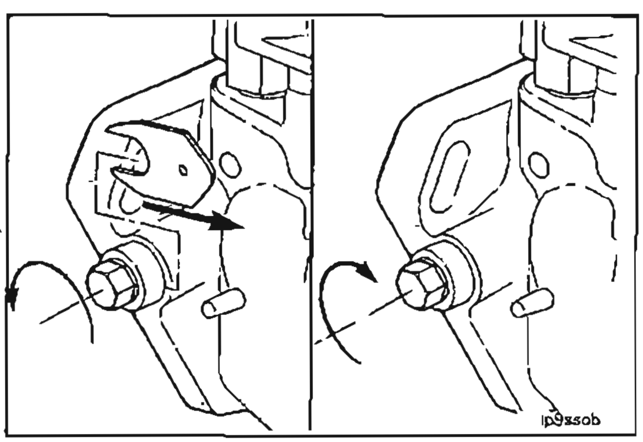
Continue to rotate the pump clockwise until the keyway is preparing to align with the number one delivery valve. Verify the gage is properly zeroed.



Continue rotating the pump clockwise while watching the gauge. Count the revolutions. Each revolution equals 0.50 mm.



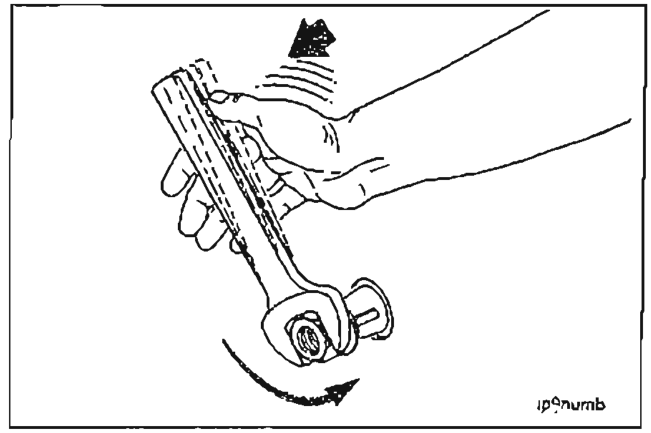
Three revolutions equal 1.50 mm. This illustration gives an example of the indicator readings for the various plunger lift values.



10 mm

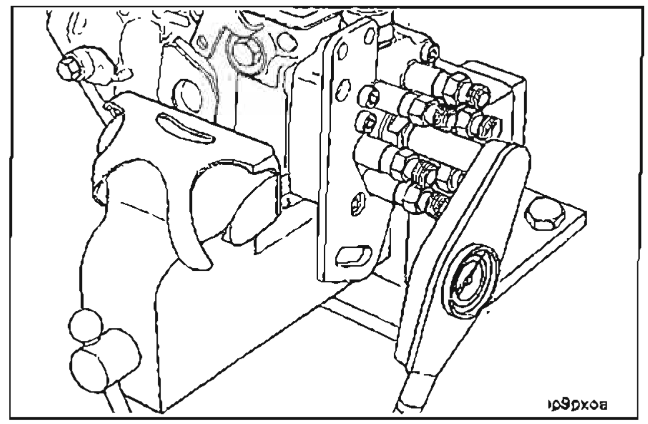
Lock the pump at the desired plunger lift.

Remove the nut from the drive shaft by striking the wrench with a sharp blow in a counterclockwise direction.



12 mm

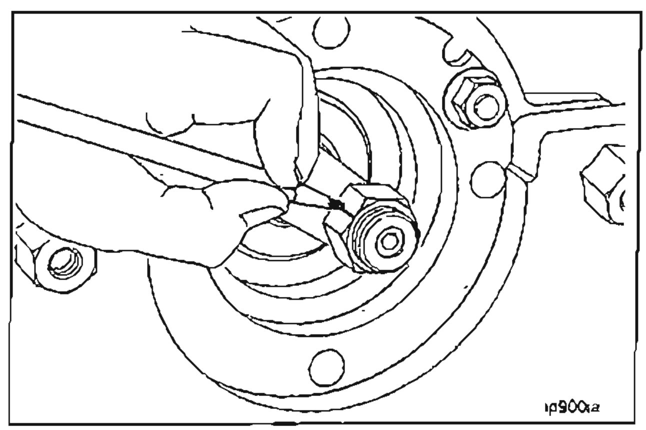
Remove the dial indicator assembly and install the access plug. Tighten to 8-10 N•m [6-7.5 ft. lb].



Injection Pump Repairs - Lucas CAV DPA (5-09)

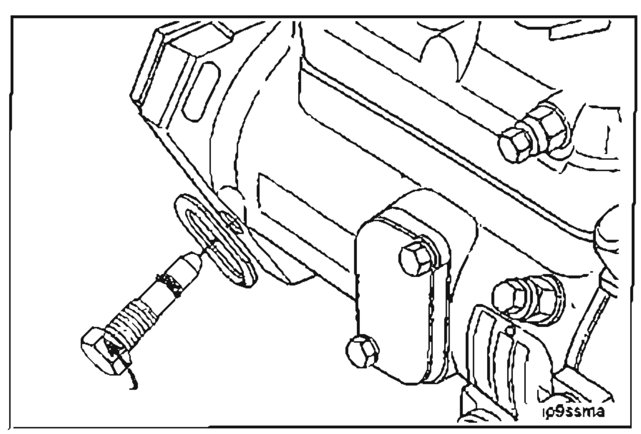
Locking Screw/O-Ring - Replacement (5-10)

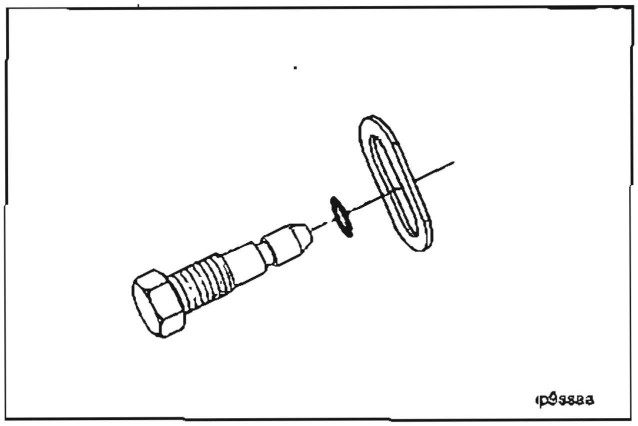
Precisely mark the shaft position **before** removing the locking screw.



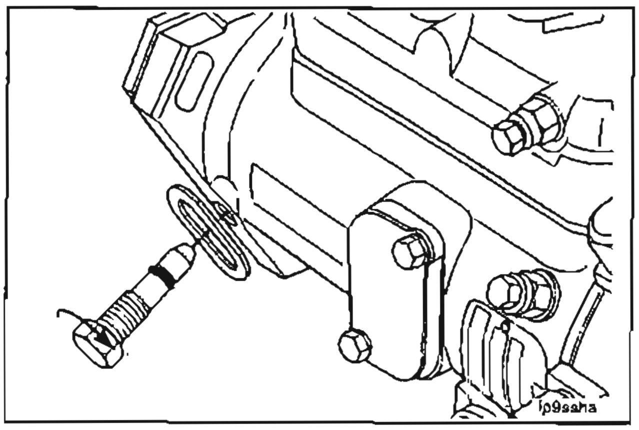
15 mm

Remove the locking screw and washer.





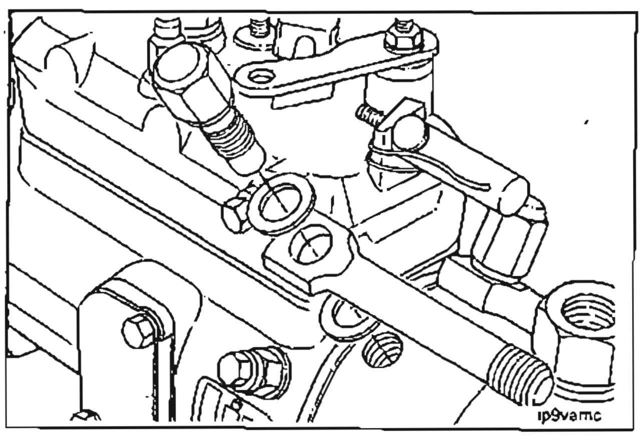
Install a new o-ring. Replace special washer, if required.



15 mm

Verify the shaft is still aligned and install the locking screw assembly.

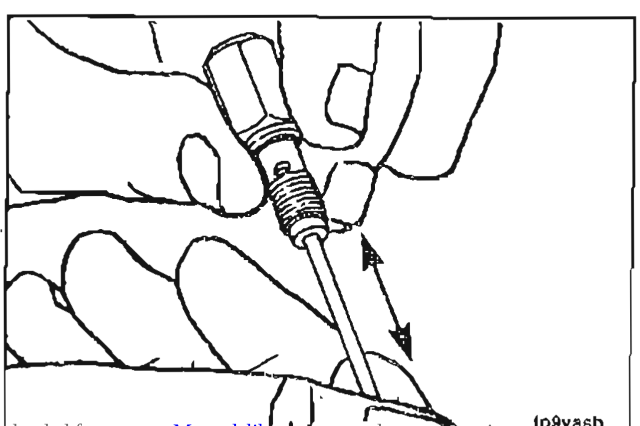
Torque Value: 30 N•m [22 ft-lb]



Back Leakage Valve - Replacement/ Inspection (5-11)

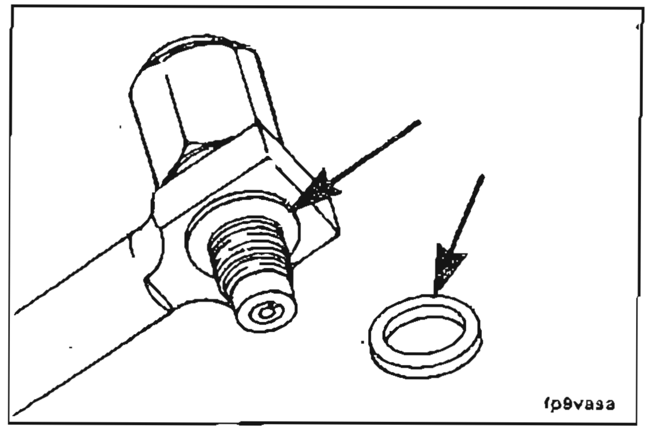
16 mm

Remove the back leakage valve and sealing washer.



Inspect the valve to be sure it is not stuck.

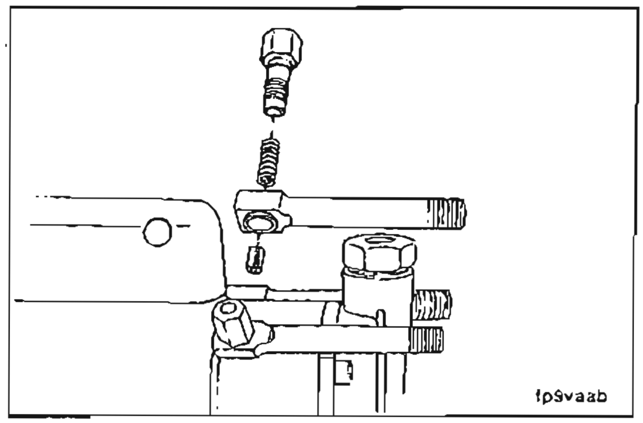
Inspect the sealing surfaces for possible leak paths.



16 mm

Assemble the back leakage valve and new washers.

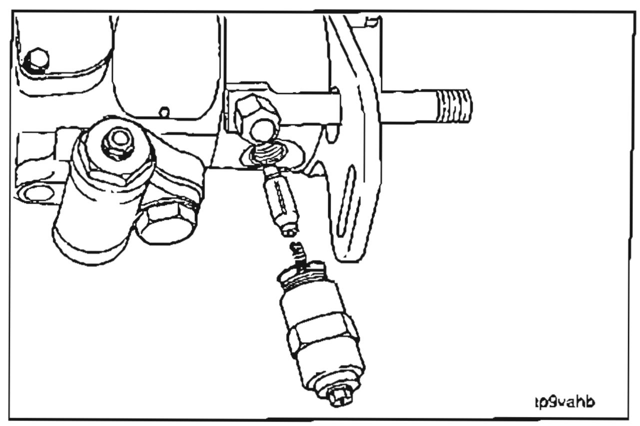
Torque Value: 31 N•m [23 ft-lb]



Shutdown Solenoid - Replacement (5-12)

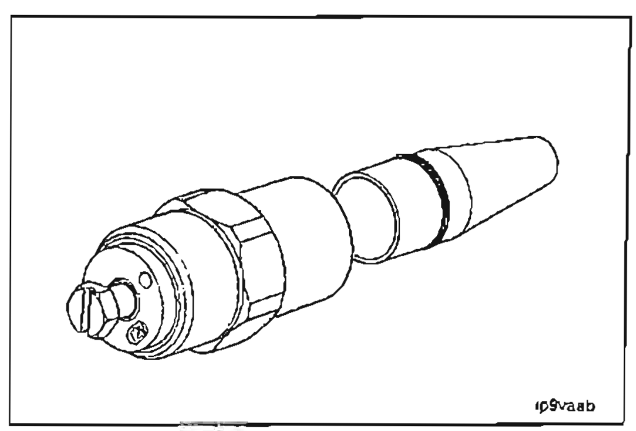
24 mm

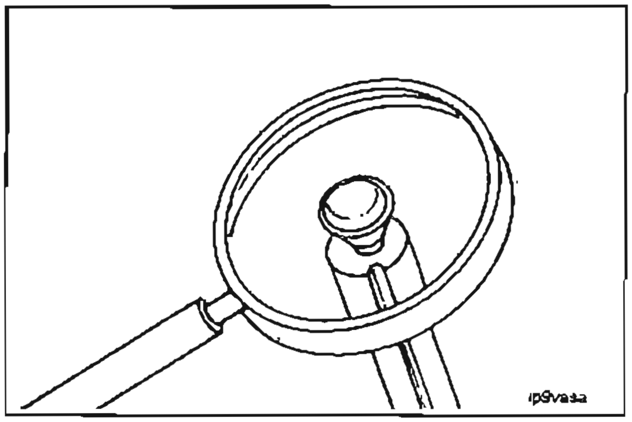
Remove the solenoid, o-ring, spring and plunger.



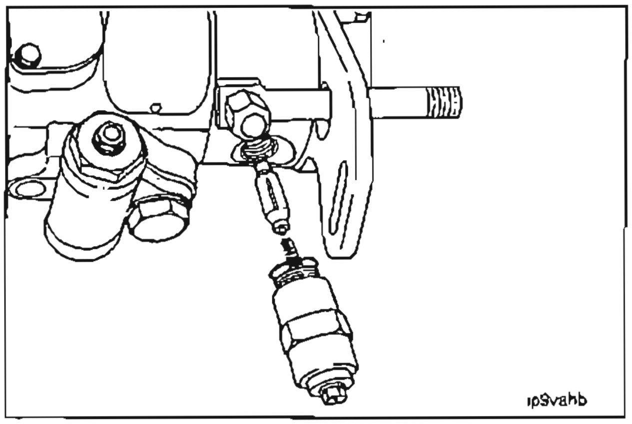
Part No. 3376930 14.7 mm Protective Sleeve

Replace the o-ring. Use the protective sleeve to prevent cutting the o-ring.





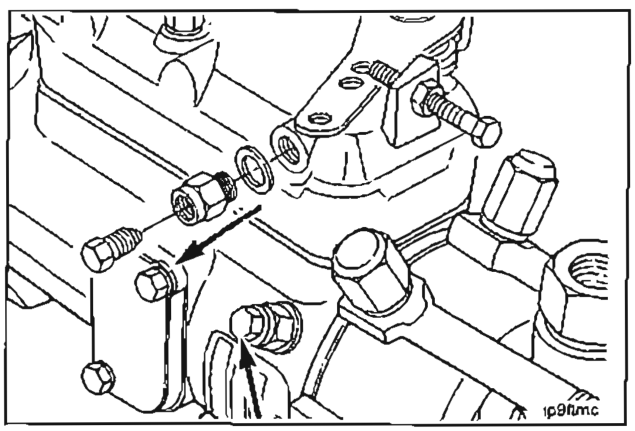
Inspect the plunger tip. If the tip is damaged or deformed, replace the solenoid assembly.



22 mm

Install the plunger, spring, solenoid and o-ring.

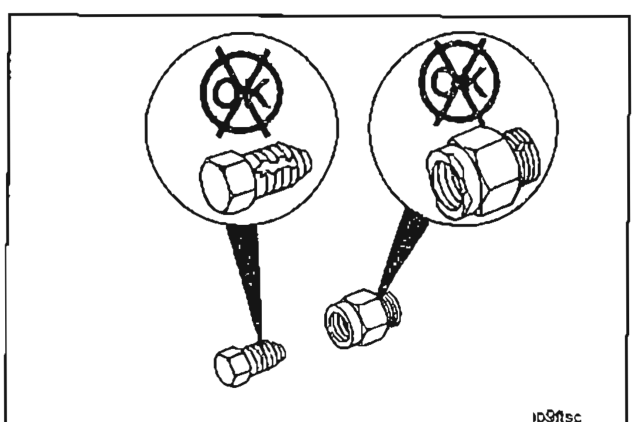
Torque Value: 15 N•m [11 ft-lb].



Bleed Screws/Sealing Washers - Replacement (5-13)

8 mm, 11 mm

Remove the screw, fitting and washer.



Inspect the threads and sealing surfaces.

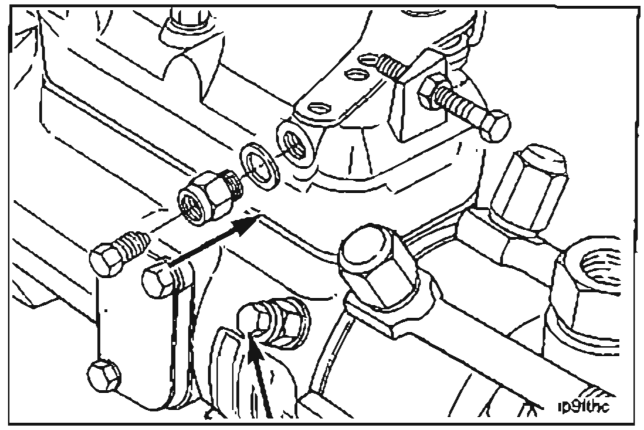
If the fitting or bleed screw is damaged, replace the damaged components.

8 mm, 11 mm

Install the bleed screw, fitting and new sealing washer.

Torque Value: (Fitting) 7.3 N•m [65 in-lb]

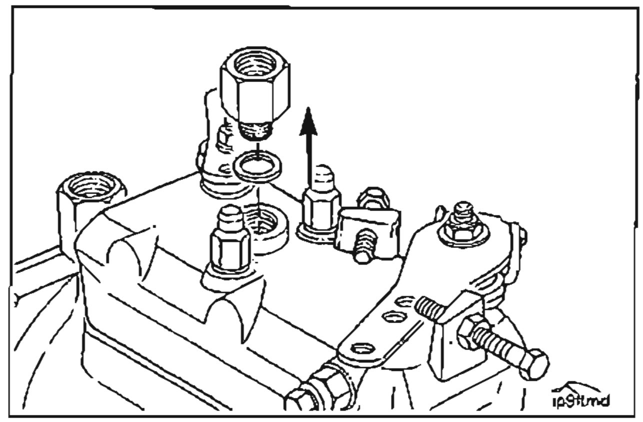
Torque Value: (Bleed Screw) 4.5 N•m [40 in-lb]



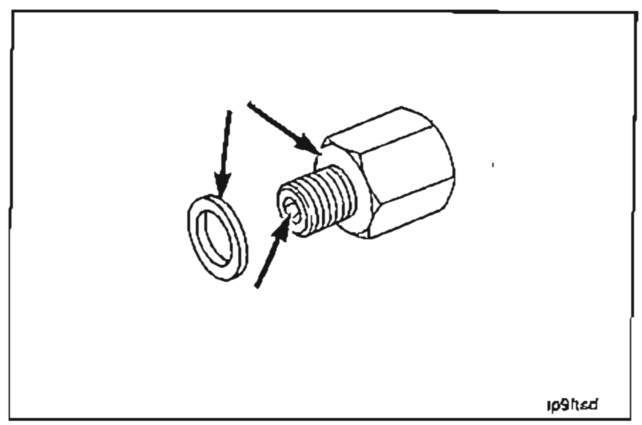
Vent Fitting/Sealing Washer - Inspection/ Replacement (5-14)

16 mm

Remove the fitting and washer.



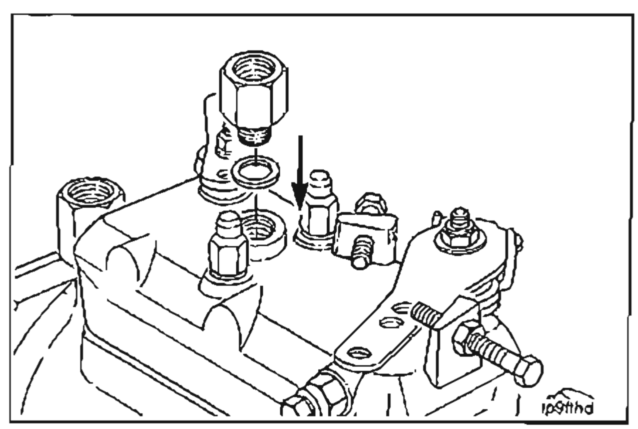
Inspect the sealing surfaces and verify that the orifice is open.

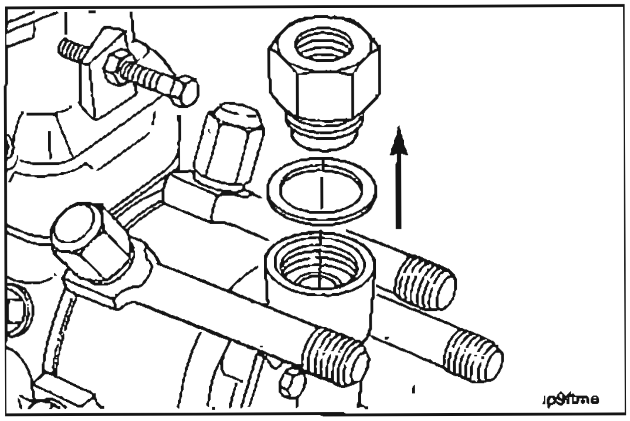


16 mm

Install a new washer and vent fitting.

Torque Value: 20.6 N•m [15 ft-lb]

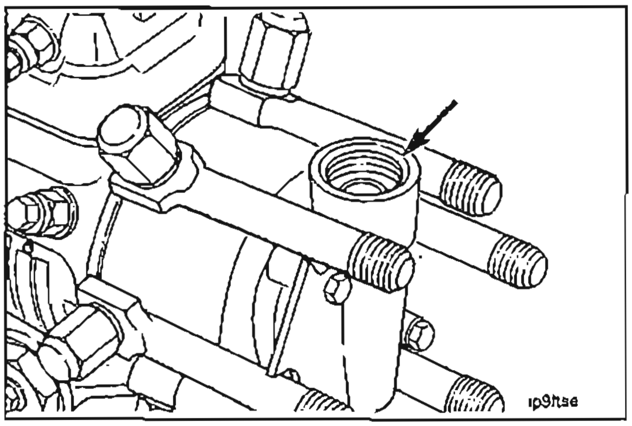




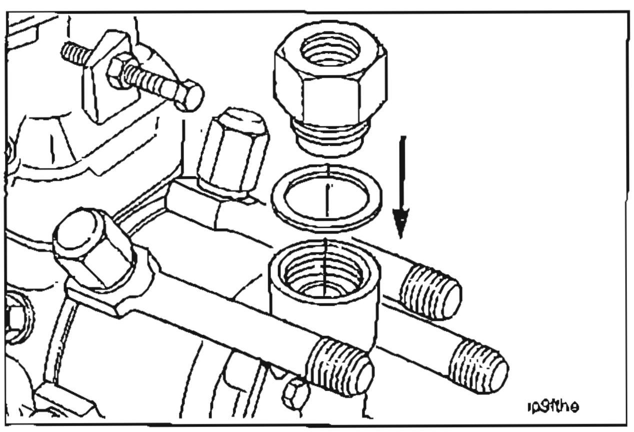
Fuel Inlet Fitting/Sealing Washer - Replacement (5-15)

24 mm

Remove the fitting and washer.



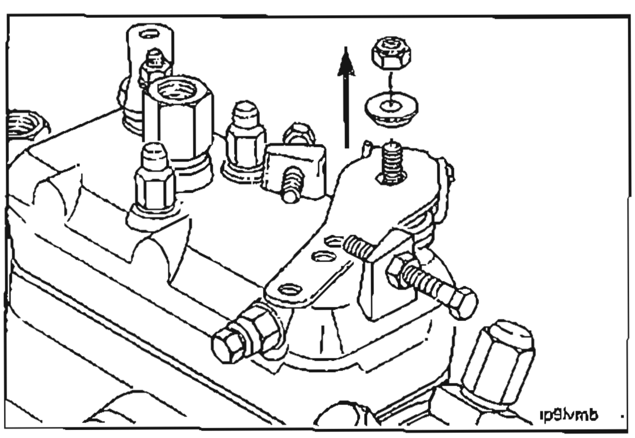
Inspect the surface for a leak path.



24 mm

Install a new washer and fitting.

Torque Value: 51 N•m [38 ft-lb]



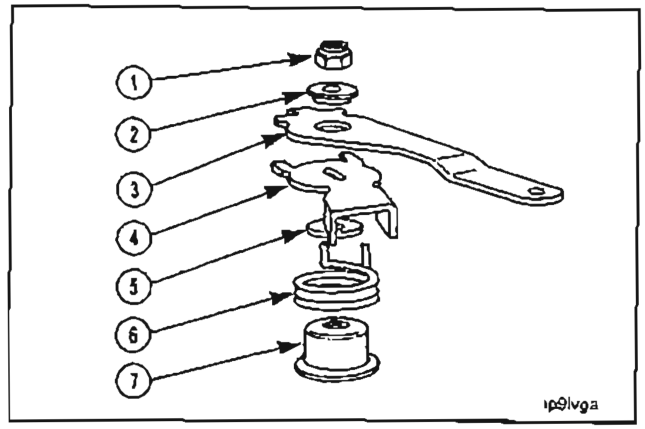
Control Lever - Replacement (5-16)

8 mm

Remove the locknut.

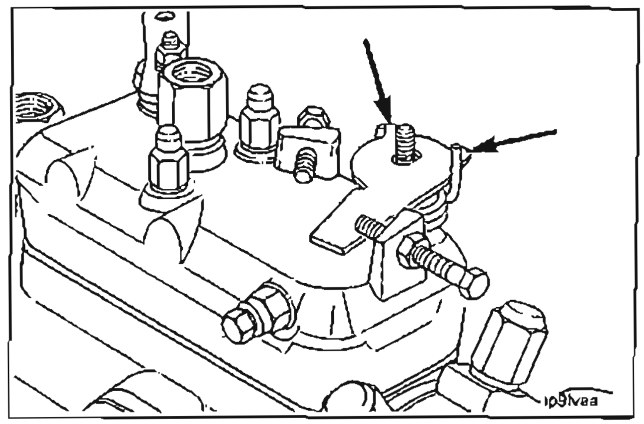
Inspect the lever components:

1 Locknut
2. Bushing
3. Throttle Lever
4. Stop Arm
5. Washer
6. Torsion Spring
7 Spring Guide



Assemble the spring guide, torsion spring, washer and stop arm.

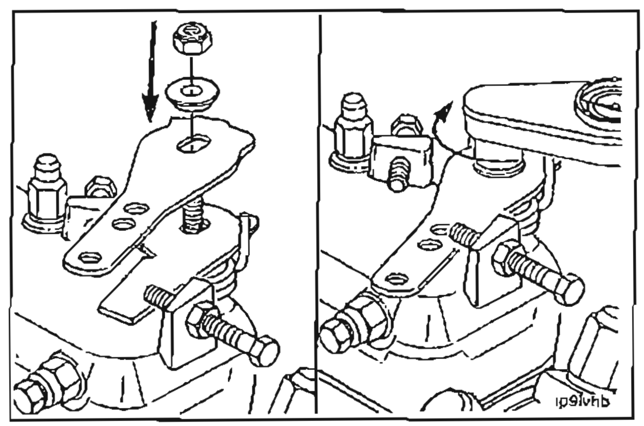
The stop arm must slide over flats of the shaft.



8 mm

Install the lever, bushing and locknut.

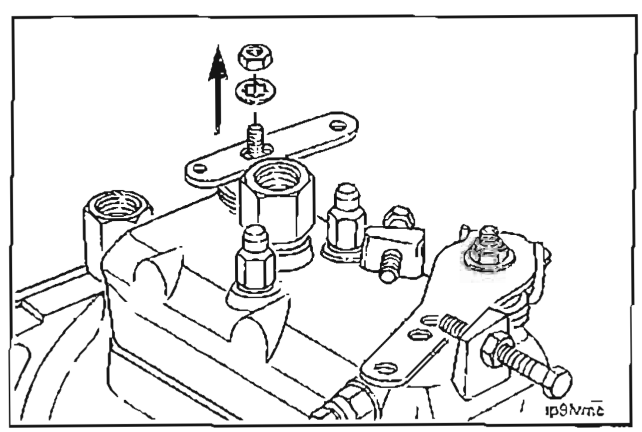
Torque Value: 3.4 N•m [30 in-lb]

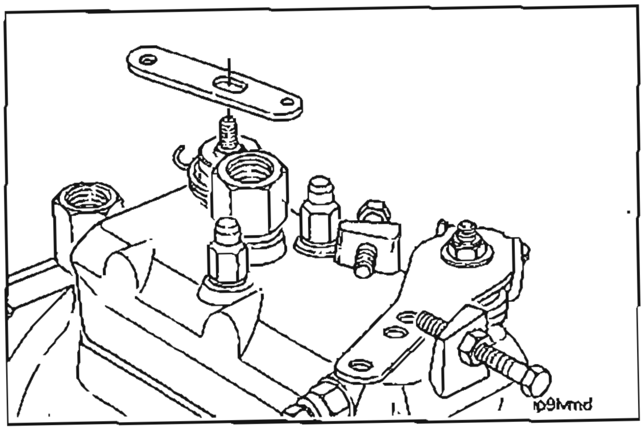


Shutdown Lever/Spring - Replacement (5-17)

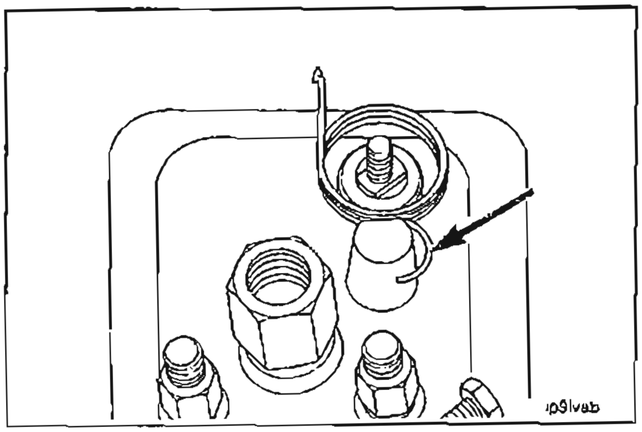
8 mm

Remove the locknut and washer.

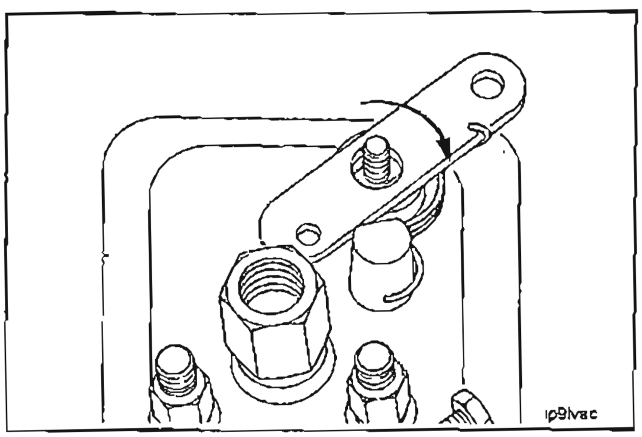




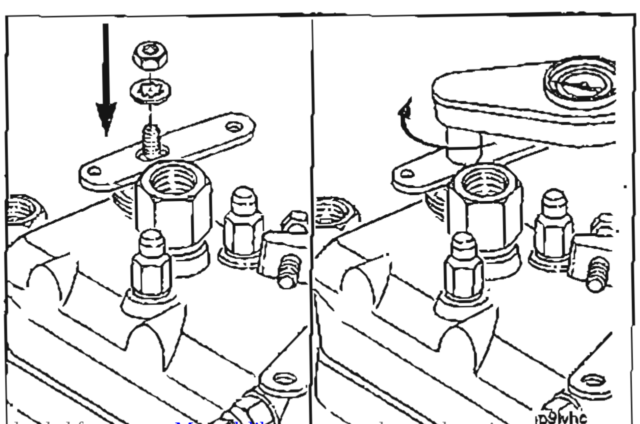
Lift off the lever while allowing the return spring to unwind.



Position the return spring with one end of spring contacting the boss on the governor cover.



Hook the free end around the shut off lever and rotate the lever in a clockwise direction until it engages with the flats on the shut off shaft.



8 mm

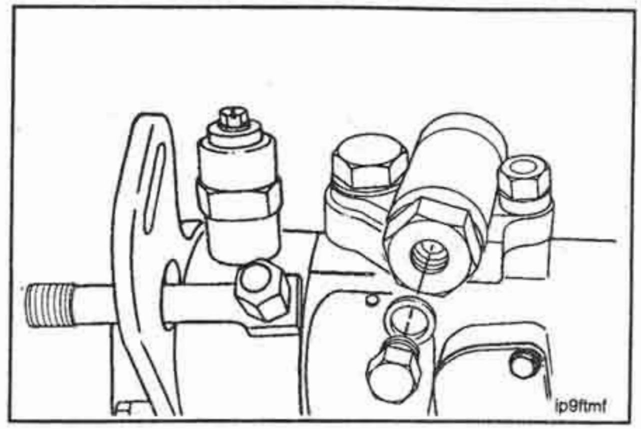
Install the nut with a new lock washer.

Torque Value: 3.4 N•m   [30 in-lb]

Automatic Timing Advance - Disassembly (5-18)

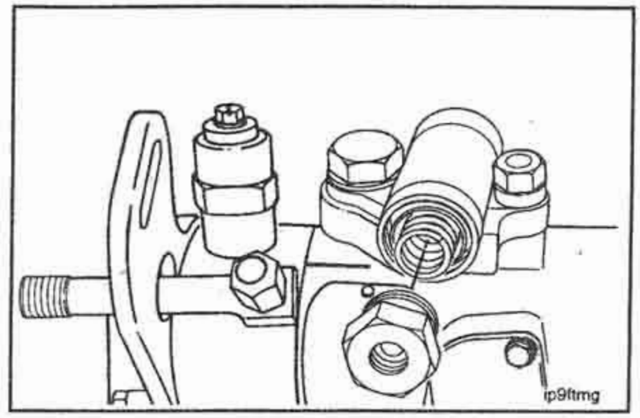
8 mm

Remove the small plug and washer.

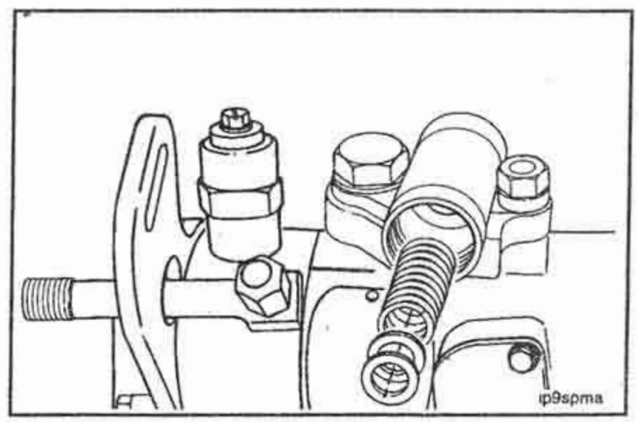


24 mm

The spring cap is under spring tension; remove the cap slowly.

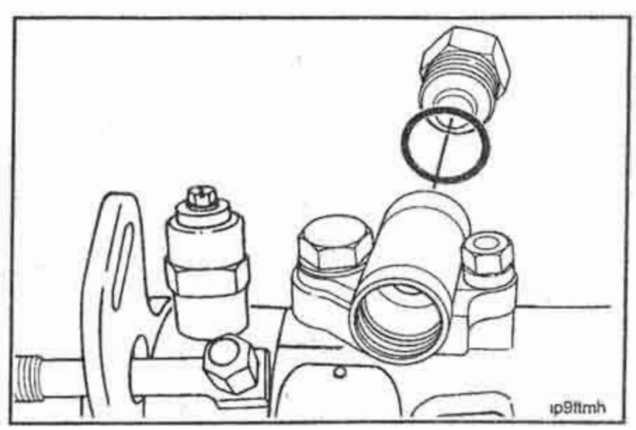


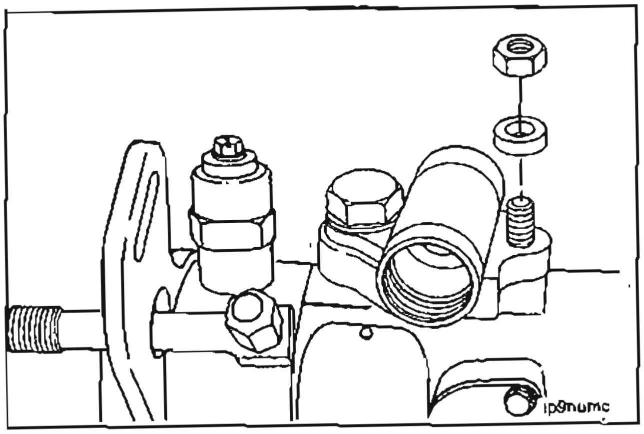
Remove the shims and springs.



24 mm

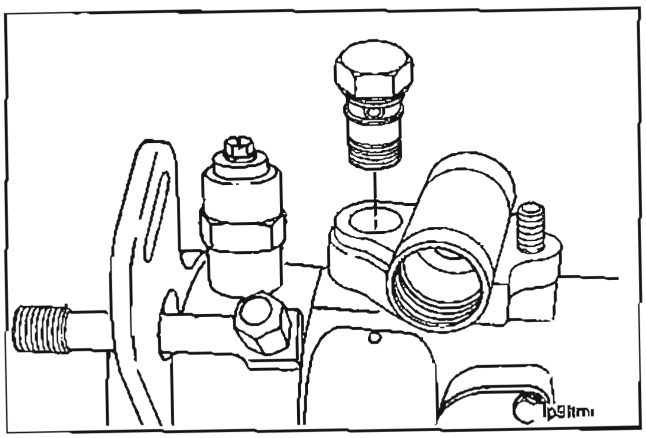
Remove the pressure end plug and o-ring.





13 mm

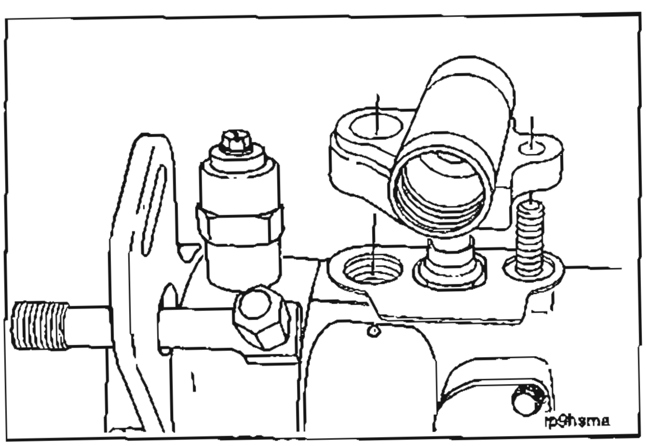
Remove the cap nut and sealing washer.



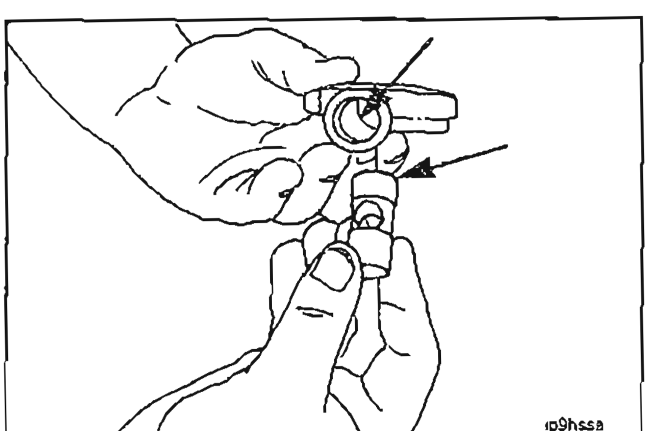
19 mm

Remove the head/locating fitting assembly.

Do not lose the check ball.



Remove the housing and slide the advance piston from the bore.

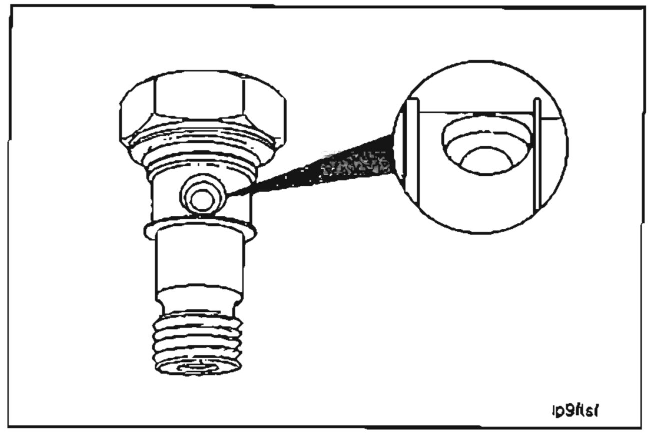


Timing Advance Components - Inspection (5-19)

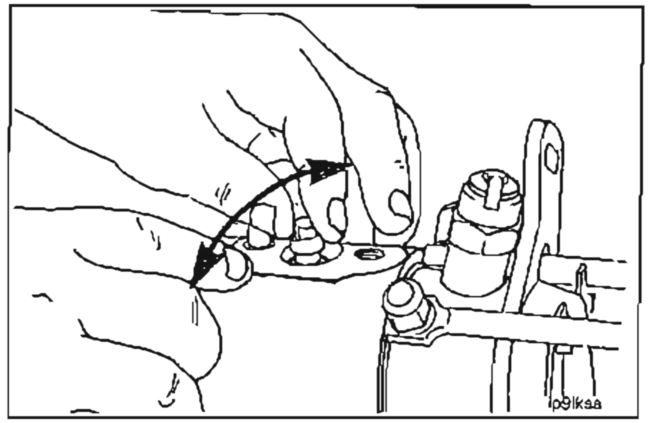
Inspect the advance piston and housing for scoring.

Inspect the check ball and seat for erosion. Make sure the ball can move freely on the seat.

Be sure the orifice in the side of the seat in the head locating fitting is open.

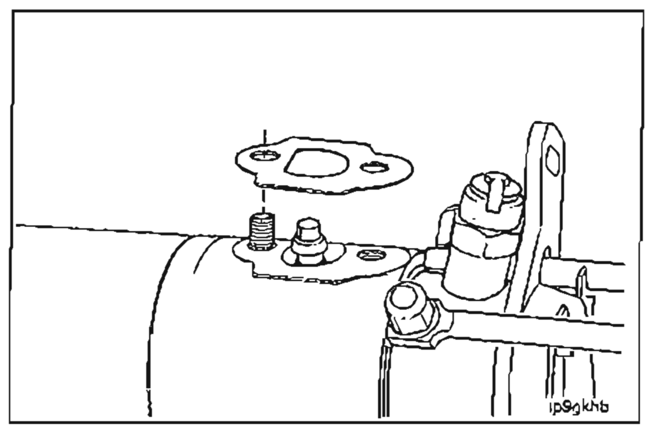


Check that the cam ring is free to move in the fuel pump.

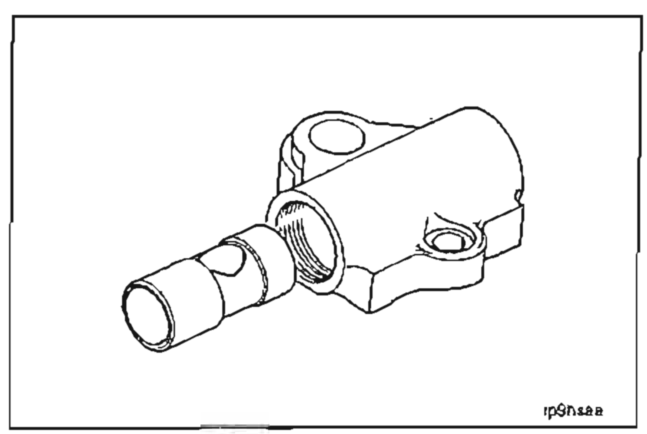


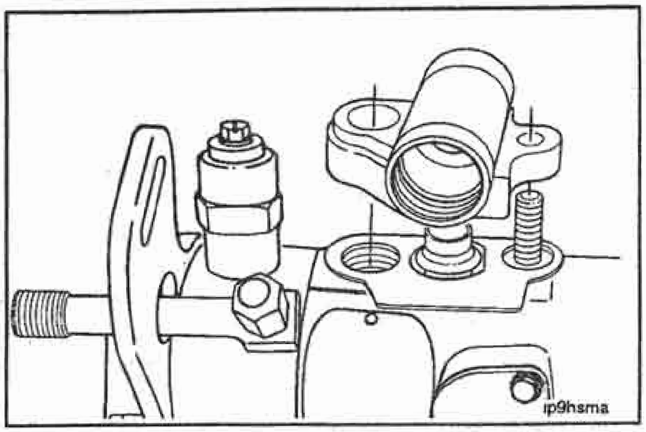
Timing Advance - Assembly (5-20)

Position a new gasket on the injection pump housing.

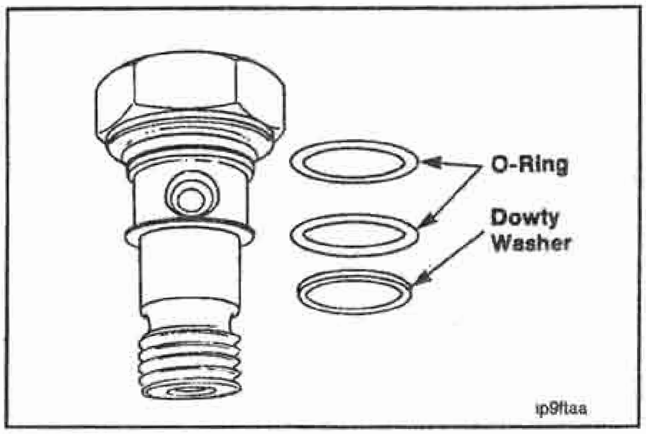


Insert the advance piston into the housing with the blank end toward the oil feed hole in the bore.

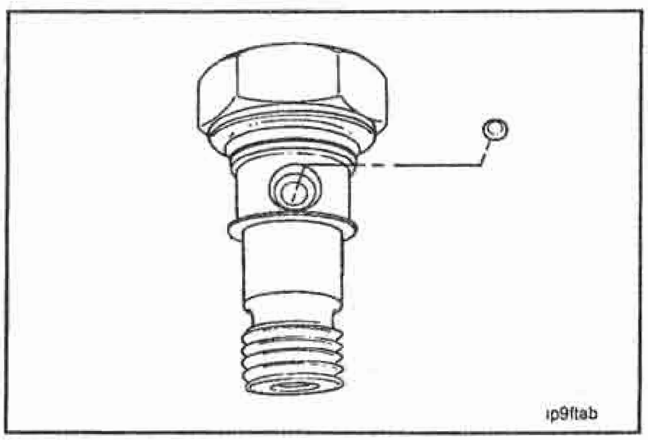




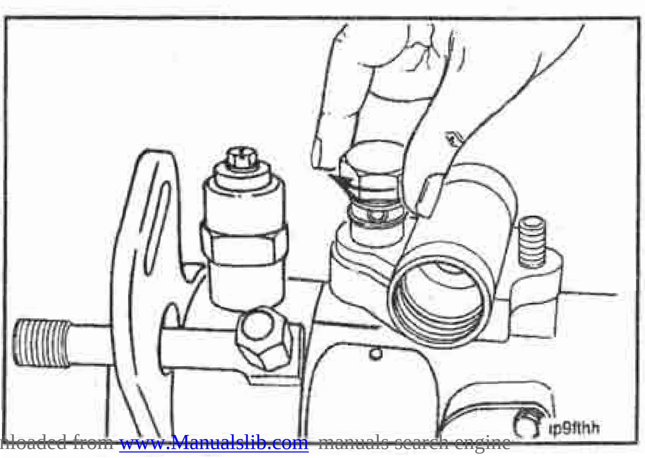
Position the advance housing over the stud in the injection pump with the cam advance screw positioned into the center bore in the piston.



Install new o-rings on the head locating fitting.



Position the check ball in the head/locating fitting.

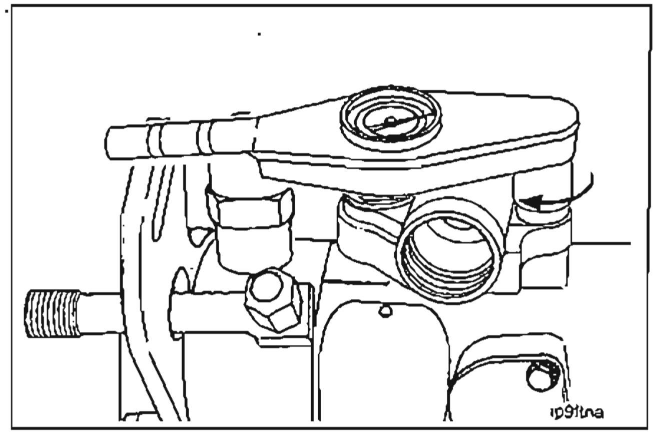


Position head/locating fitting through the advance housing and hand tighten.

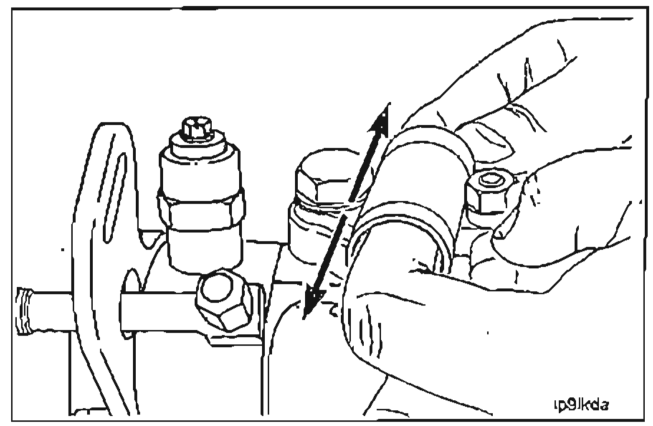
13 mm, 19 mm

Install cap nut and a new washer. Tighten the cap nut and head locating fitting progressively and evenly.

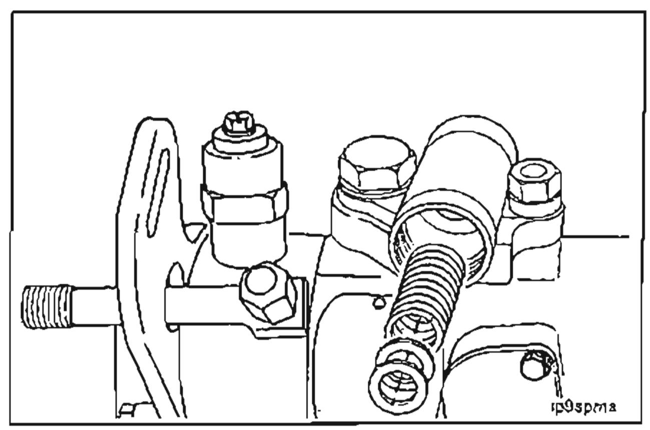
Torque Value		
(Cap Nut)	30 N•m	[22 ft-lb]
(Locating Fitting)	40 N•m	[29 ft-lb]



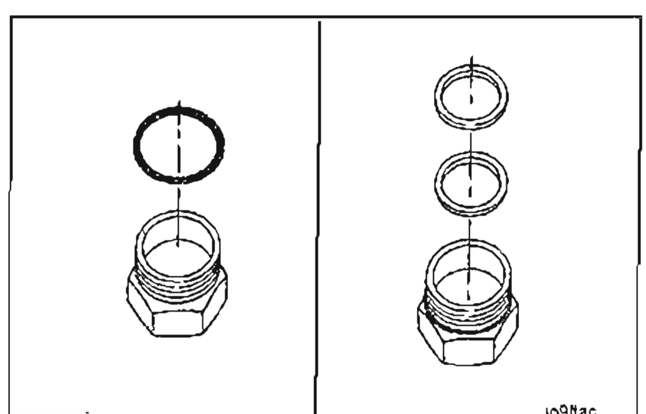
Verify that the piston moves freely in the bore.

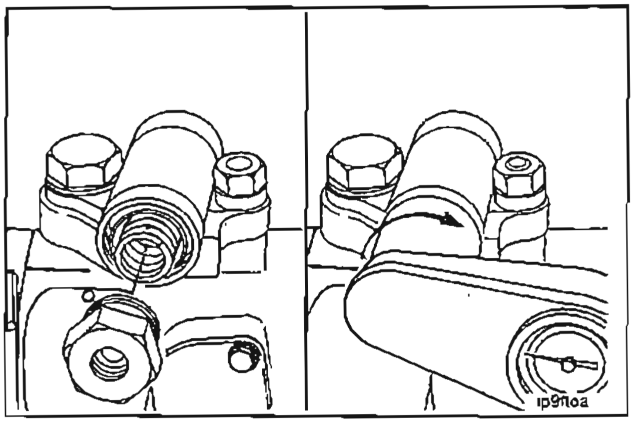


Install the springs and shims into the pocket end of the advance piston.



Install a new o-ring on the spring cap and place the shims in the pocket.

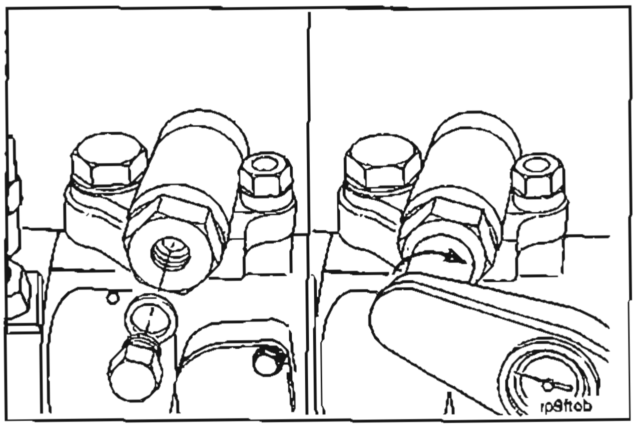




24 mm

Install and tighten the spring cap on the advance housing.

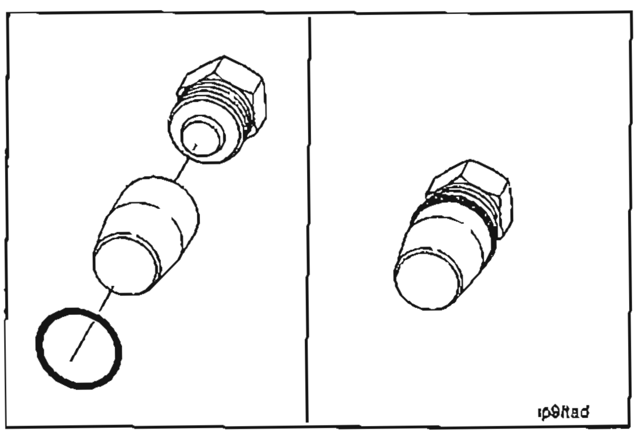
Torque Value: 24 N•m [17.5 ft-lb]



8 mm

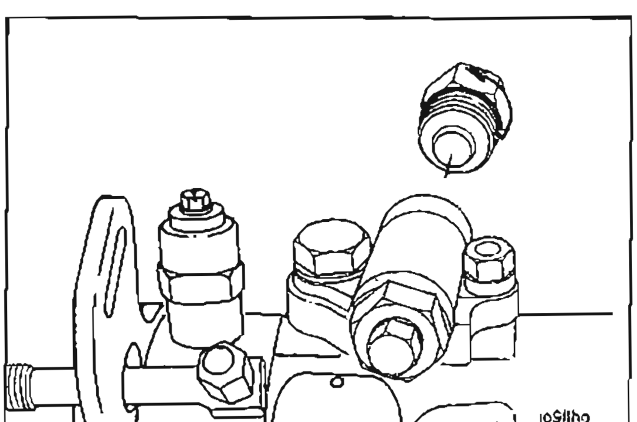
Use a new washer and install the spring cap plug.

Torque Value: 2.3 N•m [20 in-lb]



21 mm Protective Sleeve Part No. 3376931

Install a new o-ring on the pressure end cap. Use the protective sleeve to avoid damaging the o-ring.



24 mm

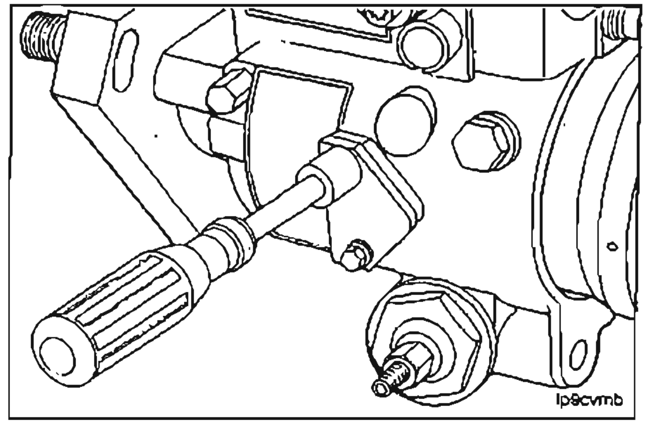
Install and tighten the cap.

Torque Value: 24 N•m [17.5 ft-lb]

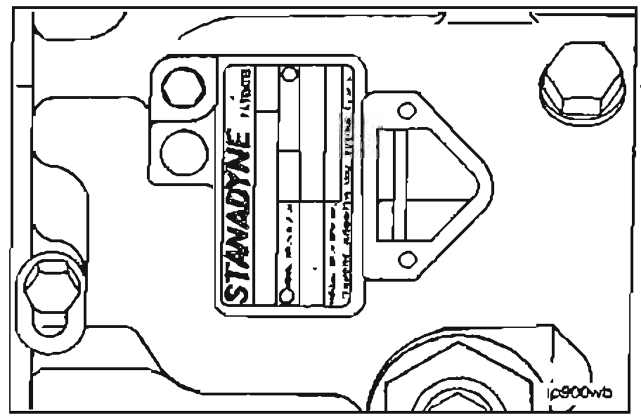
Injection Pump Repairs (5-21)

Injection Pump Timing - Stanadyne DB4 (5-22)

Remove the timing line cover from the injection pump.

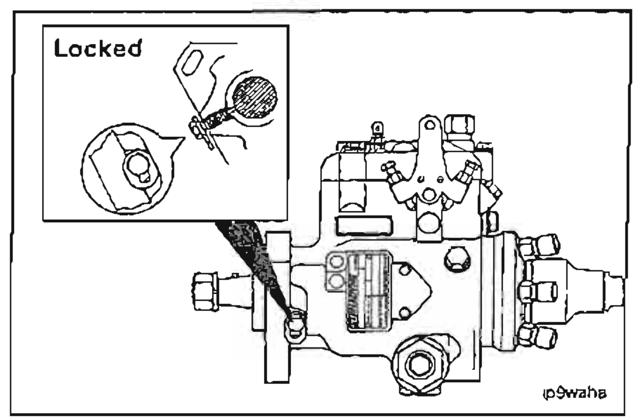


Rotate the driveshaft in the direction of rotation and align the timing line on the weight retainer hub with the line on the cam ring.

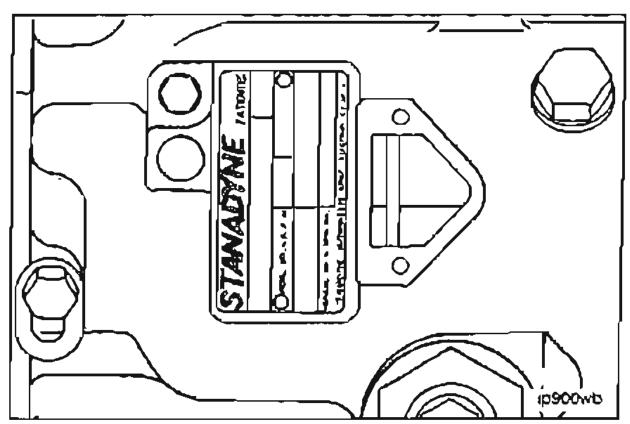


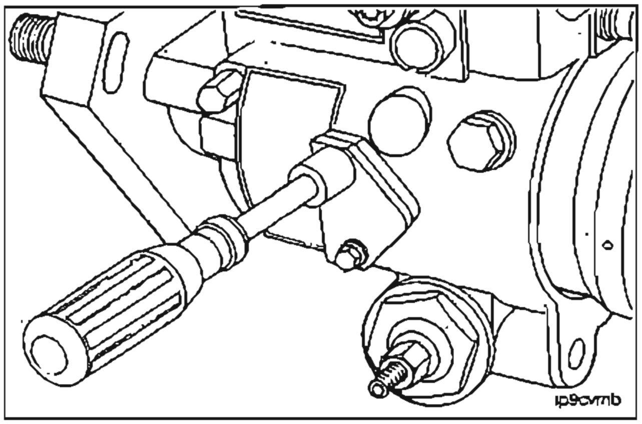
Tighten the drivehsaft locking screw to hold the injection pump in the lock timed position.

Torque Value: 12 N•m [106 in-lb]



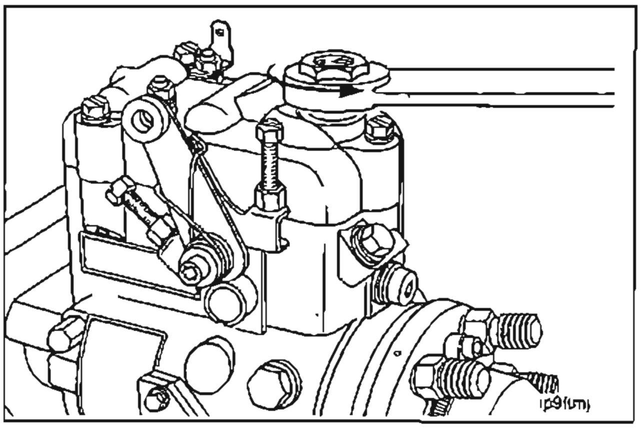
Verify the timing marks are aligned after tightening the locking screw. If the alignment is not correct, loosen the locking screw and readjust.





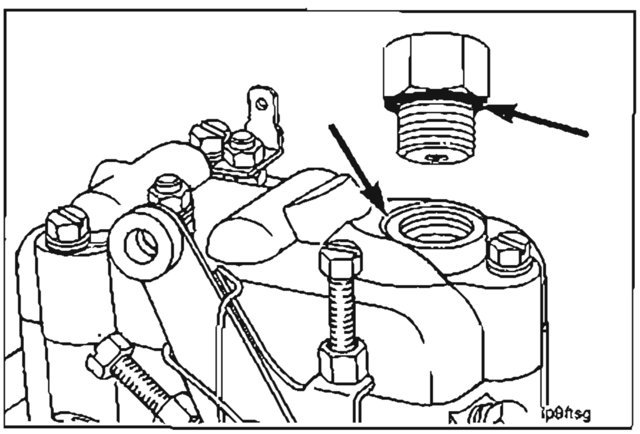
Install the timing line cover.

Torque Value: 2 N•m [17 in-lb]

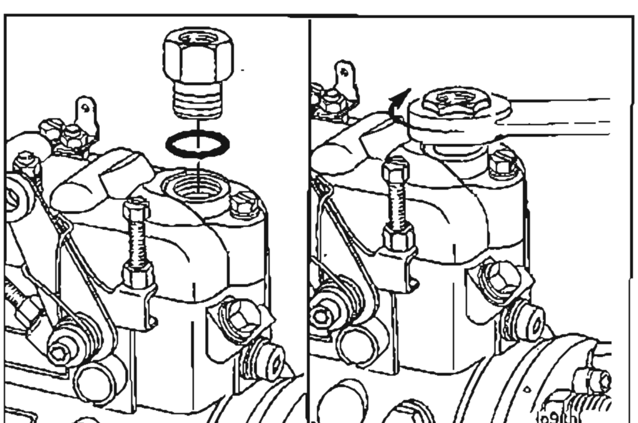


Return Connection Replacement, Stanadyne DB4 (5-23)

Remove the fuel return connection.



Inspect the sealing surfaces on the connection and the pump. Inspect the sealing o-ring and check ball.

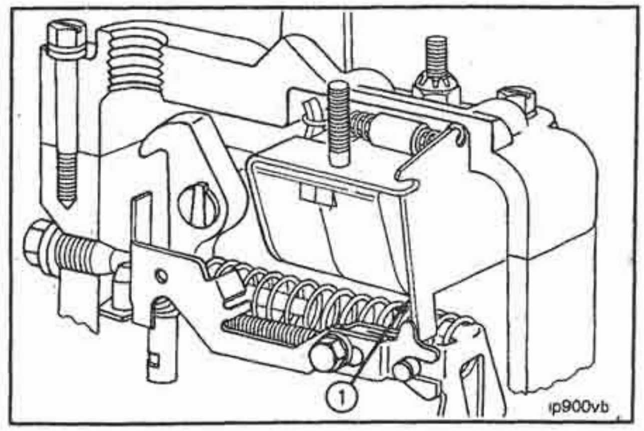


Install a new sealing o-ring and tighten the return connection.

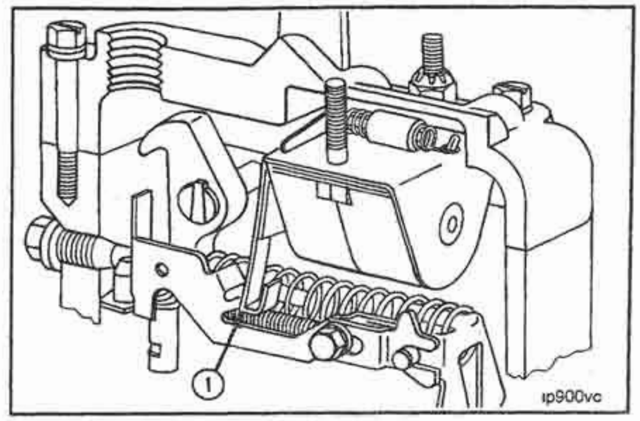
Torque Value: 11 N•m [97 in-lb]

Shutoff Solenoid Replacement, Stanadyne DB4 (5-24)

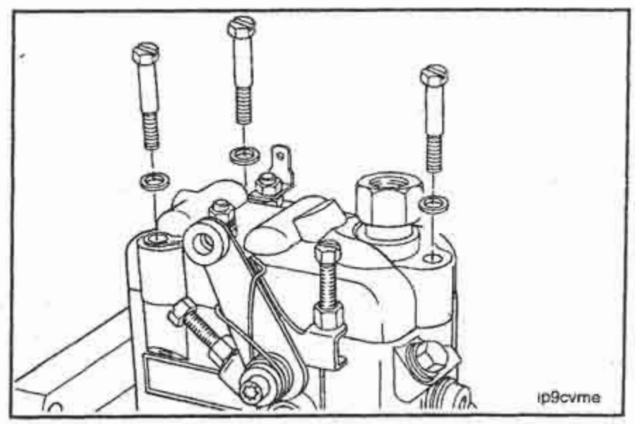
The Stanadyne injection pump is equipped with one of two types of electrical shutoff devices. Energized to run (ETR) solenoids are the most common. They are energized continuously while the engine is running and when de-energized will cause the engine to shut off. Note the location of the solenoid arm (1) in the illustration.



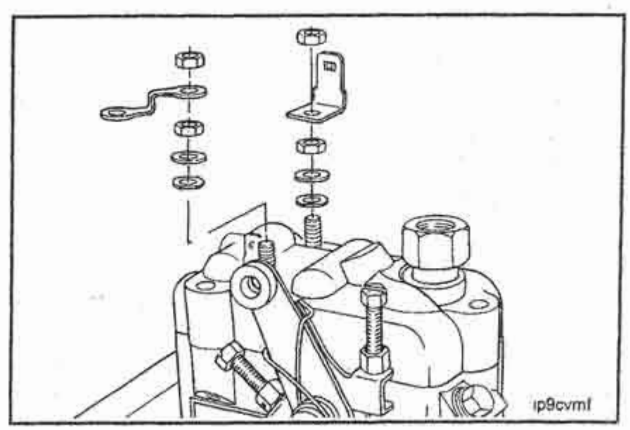
The energized to shutoff (ETSO) solenoids are used less frequently. These are designed to be energized only momentarily when engine shutoff is desired. Note the location of the solenoid arm (1) in the illustration.

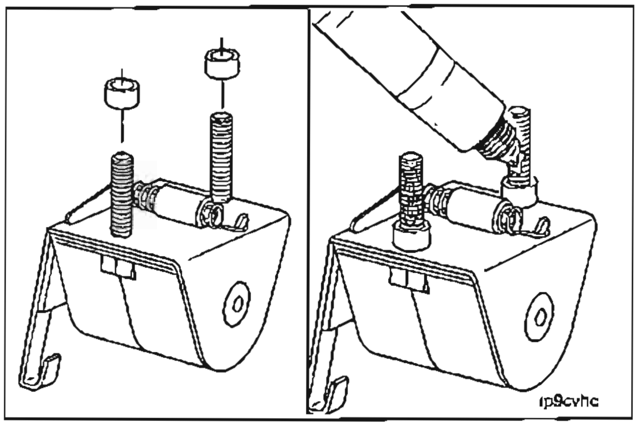


Remove the top cover mounting screws.

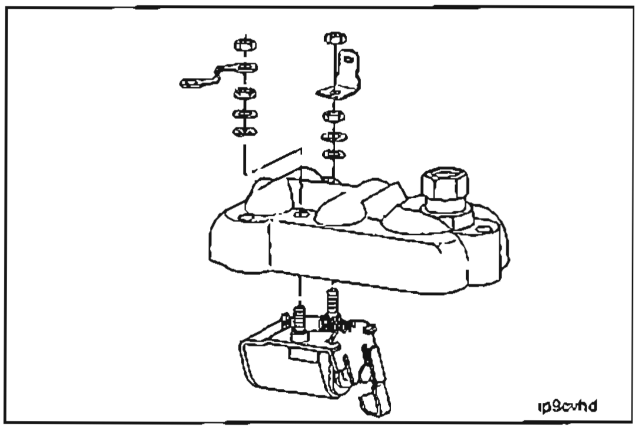


Remove the four solenoid mounting nuts, grounding strap, washers and terminal.



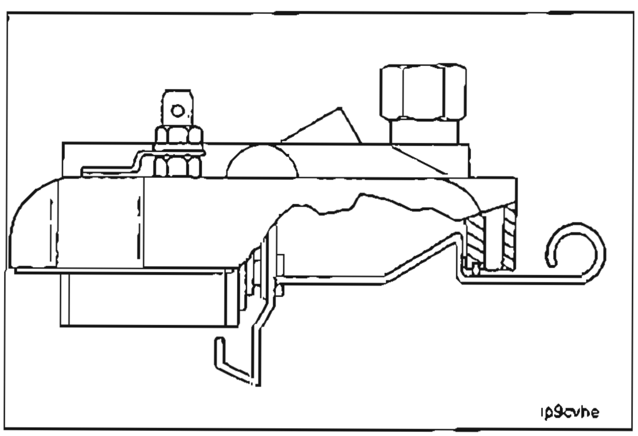


Install new insulating tubes onto the terminal studs of the new solenoid. Apply dielectric grease to the terminal studs and to the area the solenoid will come into contact with the top cover.

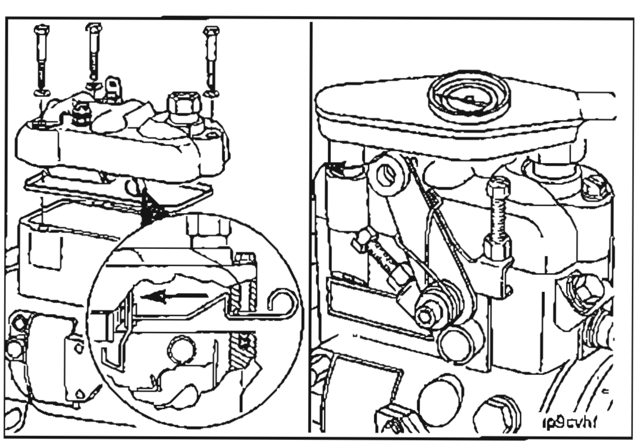


Install the solenoid to the top cover.

Torque Value: 14 N•m [12 ft-lb]



Use the Stanadyne ETR solenoid arm retaining tool to make sure the arm is in the correct position during the top cover installation.



Install the top cover and gasket to the injection pump. Twist the retaining tool to release it from the arm. Slide the tool out from between the top cover and pump.

Torque Value: 4.6 N•m [41 in-lb]

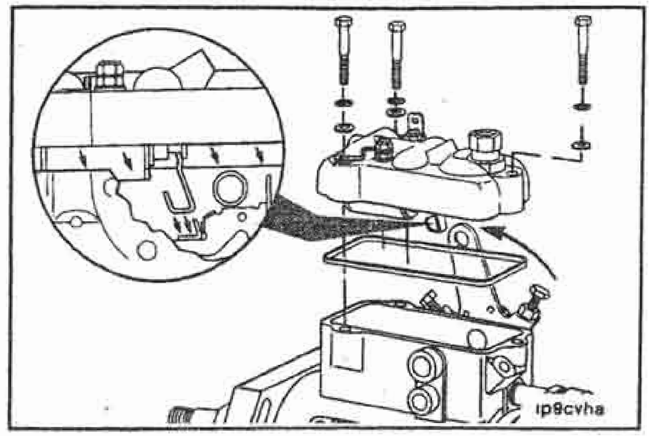
In the event that the retaining tool is not available, install the top cover as follows:

Move the shutoff lever to the stop position.

NOTE: Extreme care must be taken in assembling the cover to the pump to make sure the shutoff arm is in correct contact with the linkage hook tab.

Install the cover to the pump at a downward angle from the drivehsaft end of the pump, then slide the cover horizontally into position.

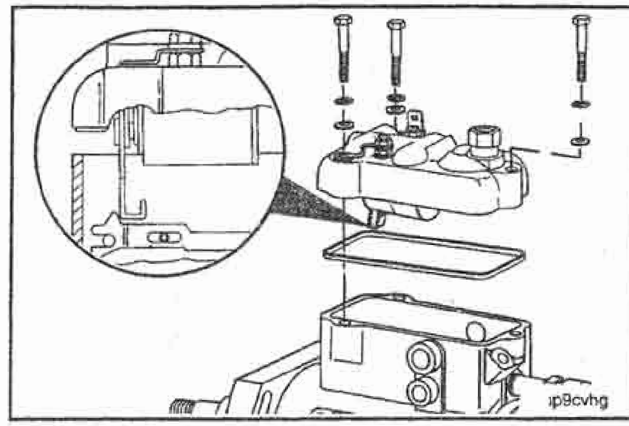
Torque Value: 4.6 N•m [41 in-lb]



Install the top cover, ETSO solenoid and gasket to the injection pump.

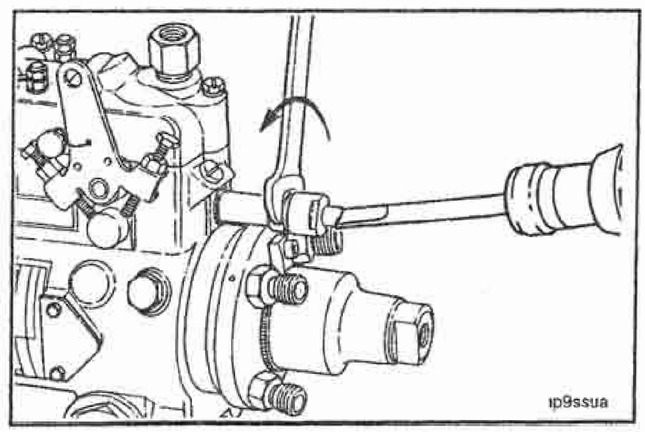
Make sure the solenoid arm is between the pump housing and linkage tab as shown in the illustration.

Torque Value: 4.6 N•m [41 in-lb]



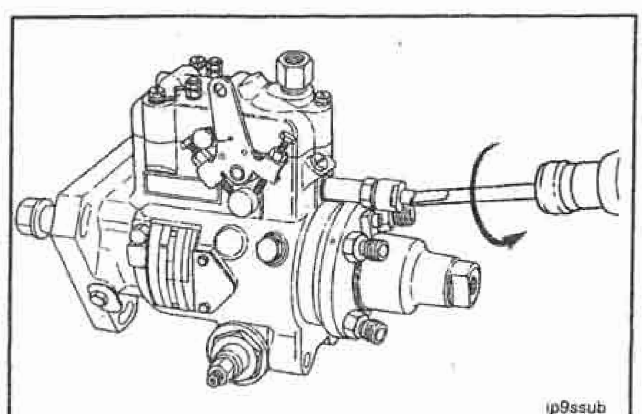
Speed Droop Adjustment Off Engine - Stanadyne DB4 (5-25)

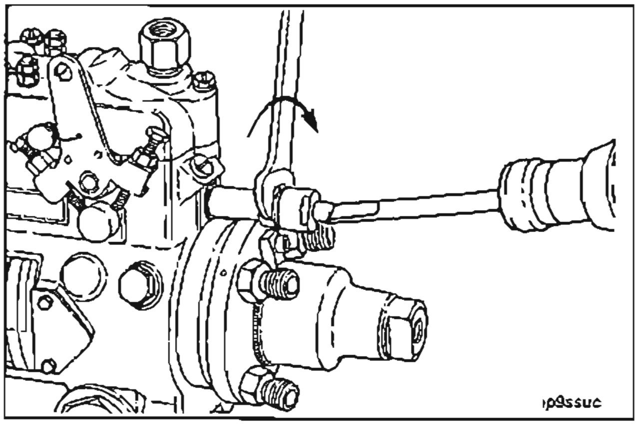
Loosen the speed droop adjustment locking cap.



Turn the droop adjustment screw counterclockwise until it stops. Then, turn the screw five complete revolutions in the clockwise direction.

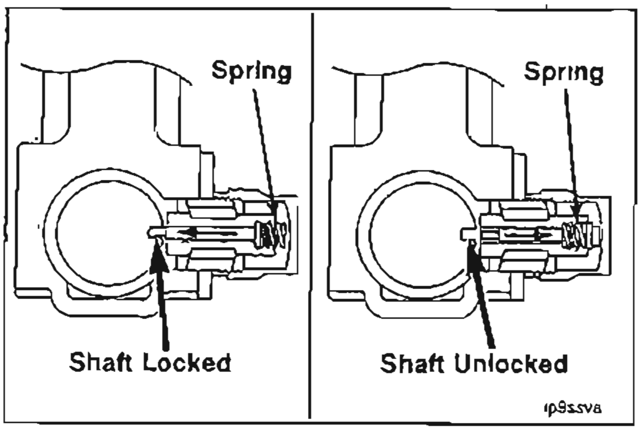
The governor is now adjusted to minimum droop. Adjustments to increase or decrease governor sensitivity can be made after the injection pump is installed to the engine.





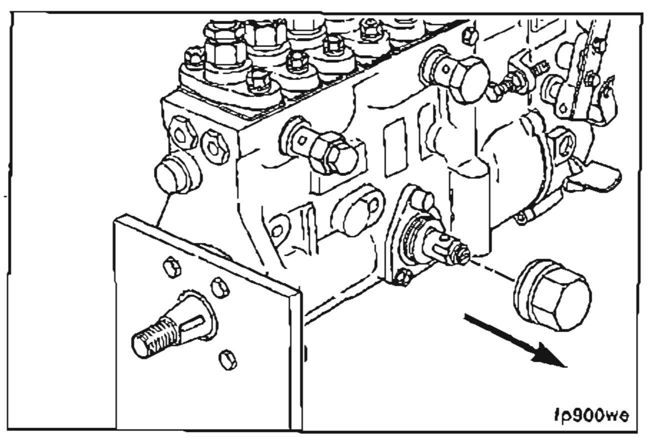
Tighten the droop adjustment locking cap. Hold the adjustment screw with a screwdriver to prevent movement when the locking cap is tightened.

Torque Value: 7.5 N•m [65 in-lb]



Injection Pump Timing - Nippondenso EP9 (5-26)

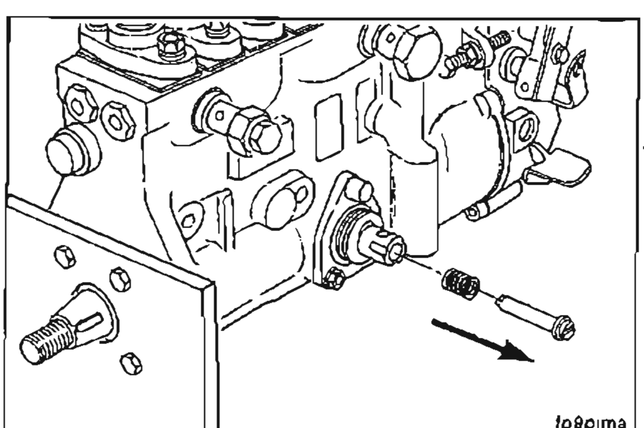
The injection pump has a plastic timing pin and spring located under the cap on the outboard side of the pump. This pin locates the pump shaft to correspond with TDC for cylinder No. 1 After the pump is installed, the spring is placed **under** the head of the timing pin and the cap is installed.



34 mm

Mount the pump on a suitable bracket.

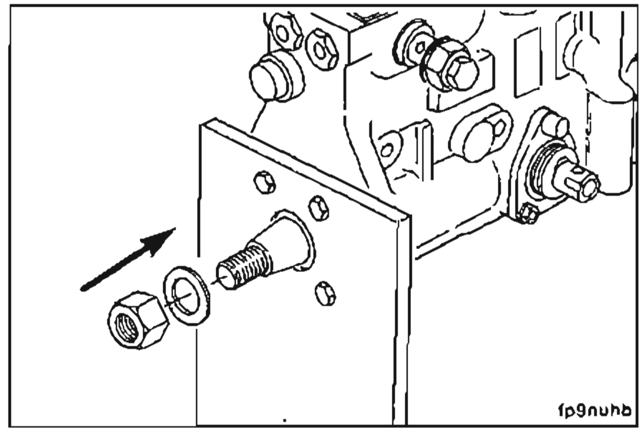
Remove the cap from the pump locking device. The cap is located on the outboard side of the pump.



Remove the plastic timing pin and spring.

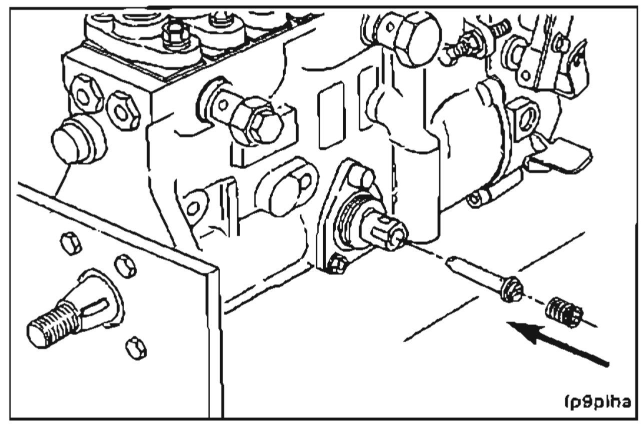
27 mm

Install the nut on the pump shaft.



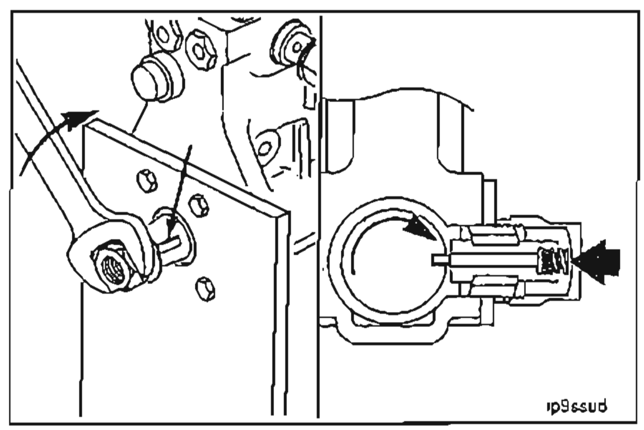
Install the timing pin first, then the spring.

Service Tip: Use the slot in the end of the timing pin as a reference for properly positioning the timing pin. The slot must be horizontal to the pump in order for the pin to engage the slot in the pump shaft.

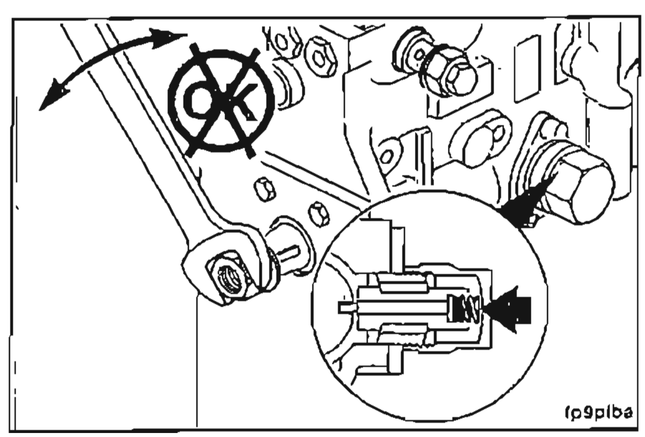


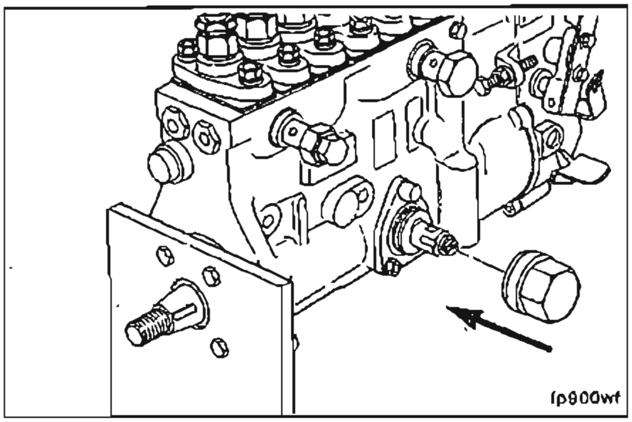
27 mm

Depress the spring and rotate the pump shaft until the tip of the timing pin goes into the slot in the pump shaft. **The keyway in the shaft will be at approximately the 2 o'clock position.**

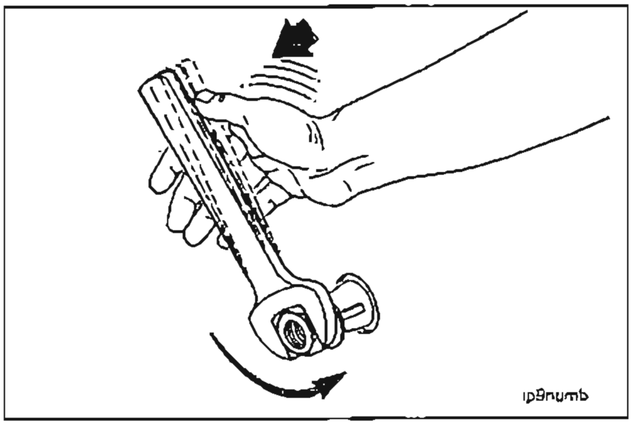


Caution: Although unlikely, it is possible that the timing pin will match the pump notch when the timing pin is first inserted. If so, the pump will be locked. Do not exert more than 7 N•m [10 ft-lb] torque to turn the pump shaft. If the pump shaft does not turn with 7 N•m [10 ft-lb] torque, remove the spring and timing pin, then rotate the pump slightly. Repeat the previous step again.



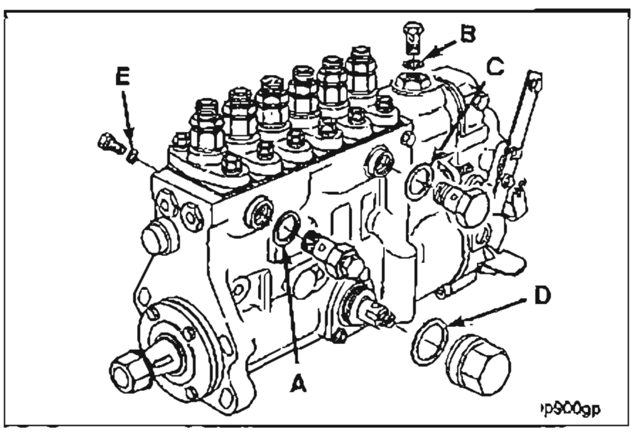


Install the cap loosely (finger tight).



27 mm

Remove the nut from the pump drive shaft by striking the wrench with a sharp blow in a counterclockwise direction.



Seals Replacement, Nippondenso EP9 (5-27)

Item Type of Seal Torque

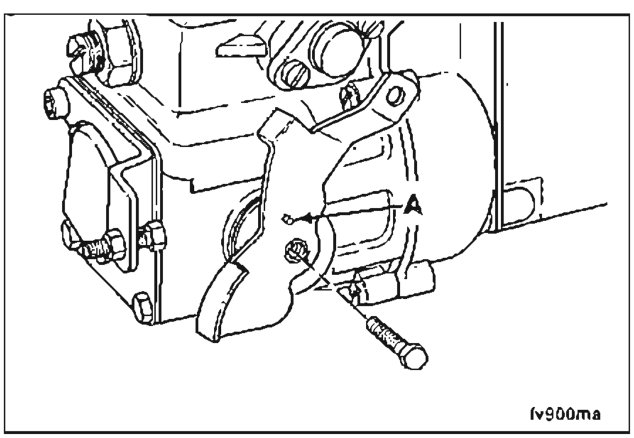
A = Sealing washer, 24 N•m [18 ft-lb]

B = Sealing washer, 14 N•m [10 ft-lb]

C = Sealing washer, 27 N•m [20 ft-lb]

D = Copper washer only, 70 N•m [50 ft-lb]

E = Copper washer (Bleed screw), 5 N•m [36 in-lb]

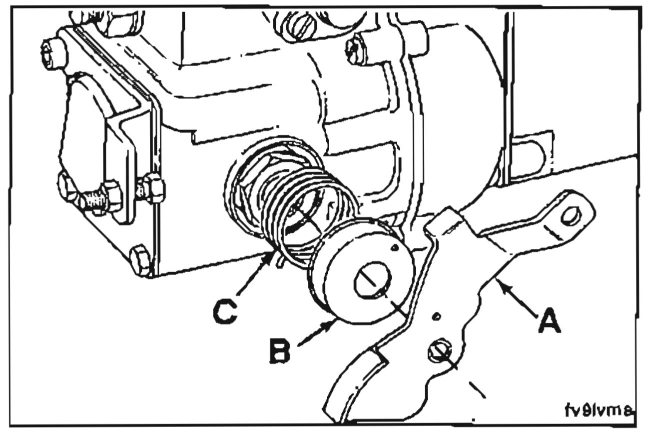


Shut Down Lever or Spring Replacement, Nippondenso EP9 (5-28)

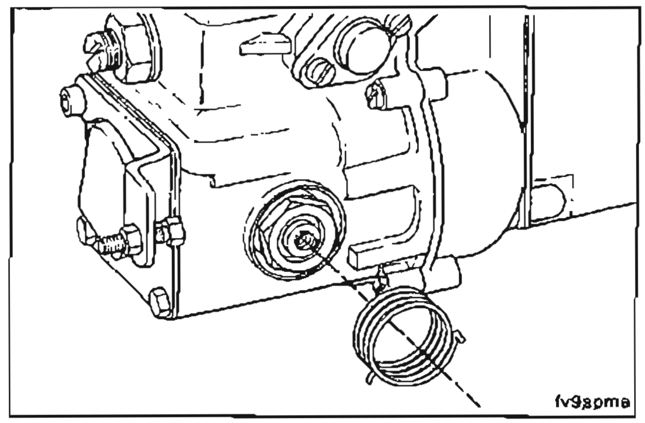
10 mm

Remove the retaining screw.

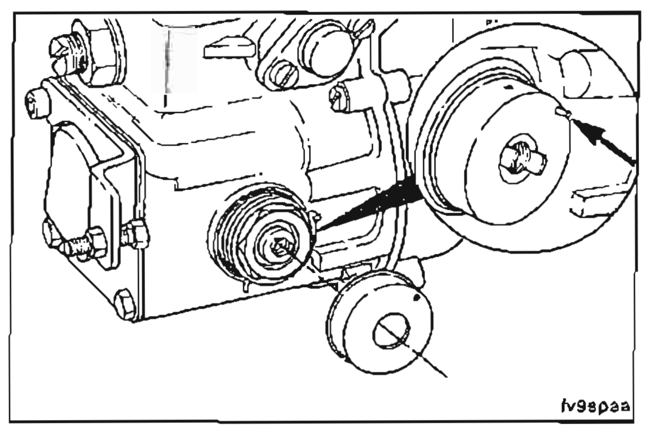
Remove the shut down lever (A) spring housing (B) and return spring (C).



Install the spring as illustrated.

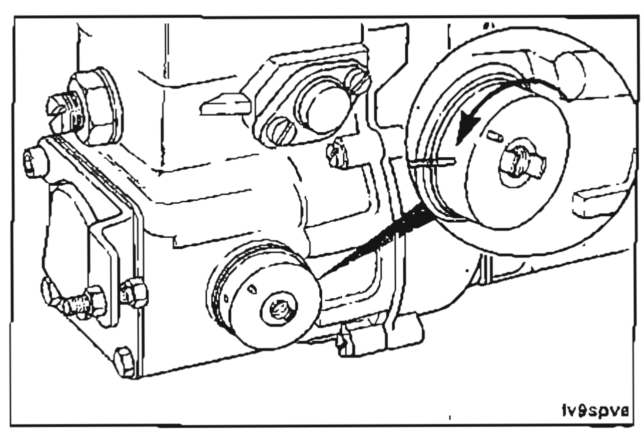


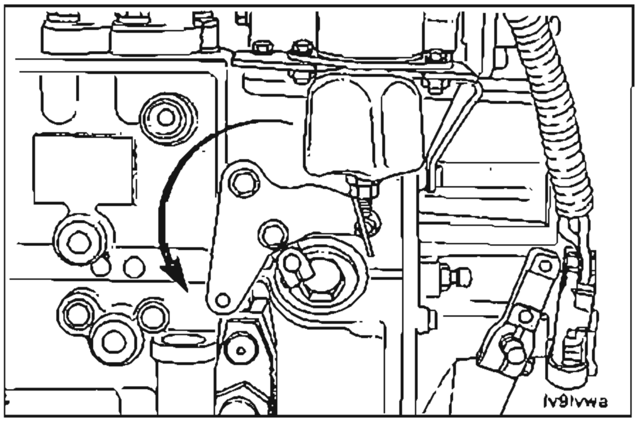
Install the spring housing over the spring aligning the spring with the illustrated hole in the housing.



Metal awl or pick

Load the spring by rotating the spring/housing counter-clockwise approximately 1/4 turn.

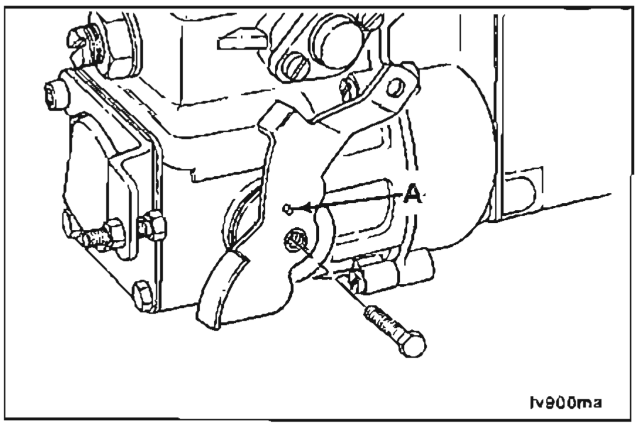




10 mm

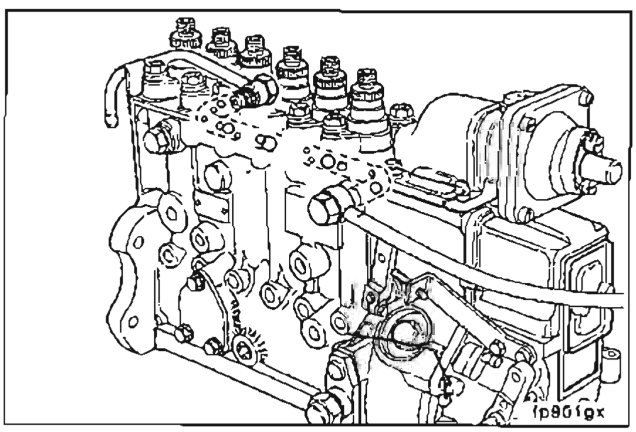
Hold the spring in the loaded position and install the lever.

NOTE: If the shutdown shaft slides into the housing, thread the retaining screw into the shaft and slide the shaft to its original position. Visually inspect the o-ring for distortion or damage.



10 mm

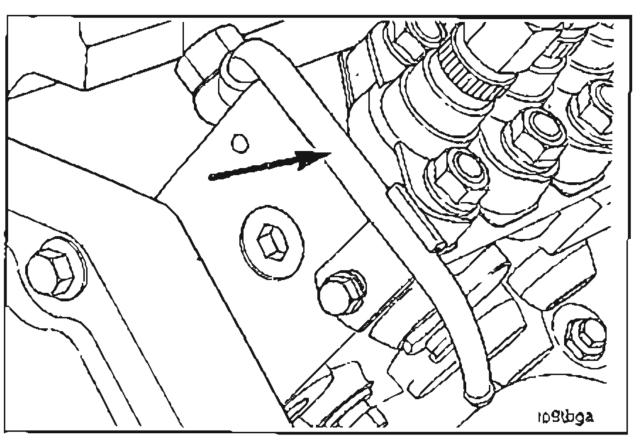
Install the retaining screw making sure the spring aligns to the hole in the lever.



Pressure Relief Valve and Sealing Washer Replacement, Bosch P7100 (5-29)

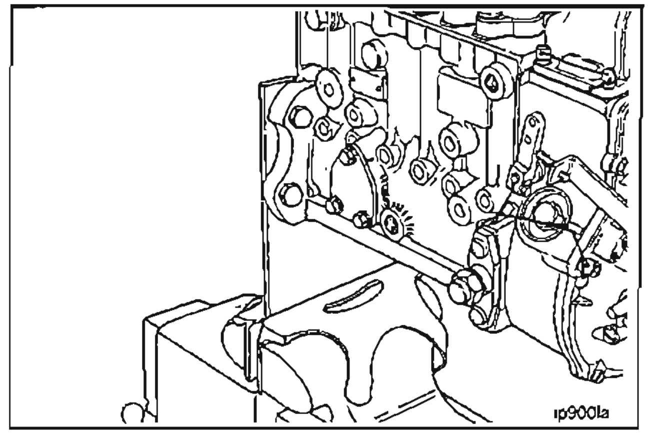
The pressure relief valve arrangement on the Bosch P7100 injection pump in the supply side of the fuel circuit creates a self-bleeding system for air introduced during replacement of the supply side components.

A sticky or malfunctioning relief valve can result in engine miss, low power or hard starting.



The Bosch P7100 injection pump has a jump-over tube to route return fuel and entrapped air from the pressure relief valve directly to the supply tank.

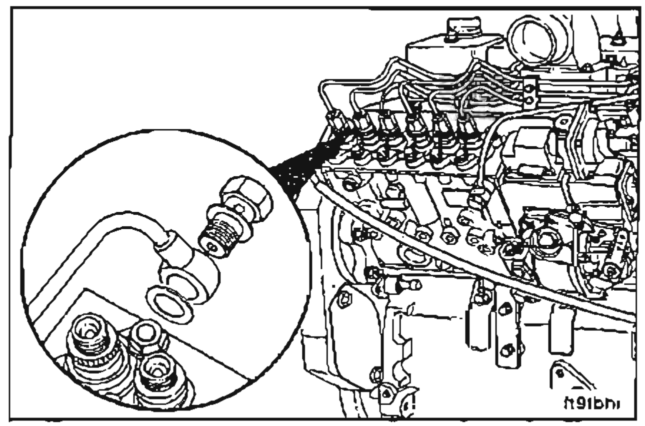
Mount the pump in a suitable bracket and hold pump with a vise.



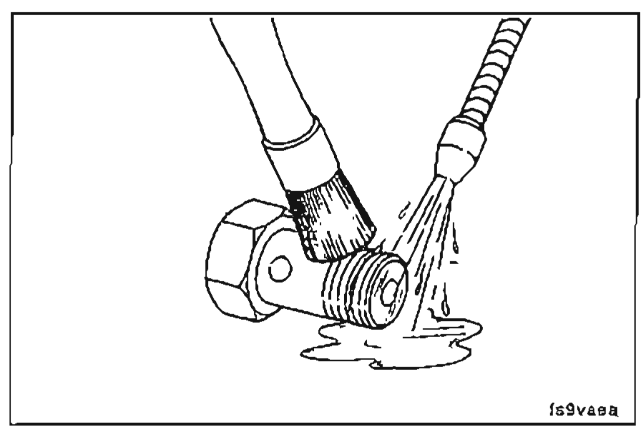
19 mm

Remove the pressure relief valve and sealing washers.

Remove the jump-over tube.



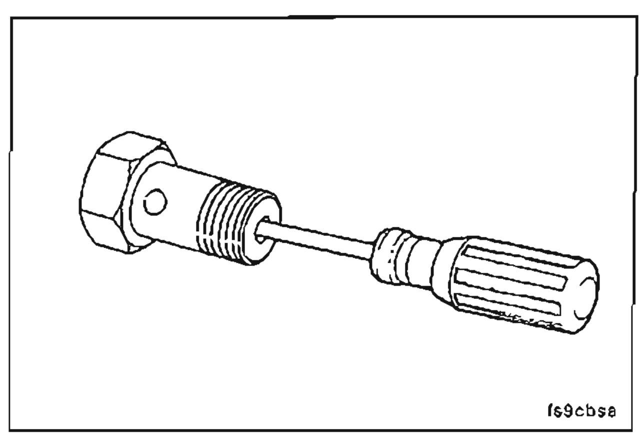
Thoroughly flush the pressure relief valve with a cleaning solution.

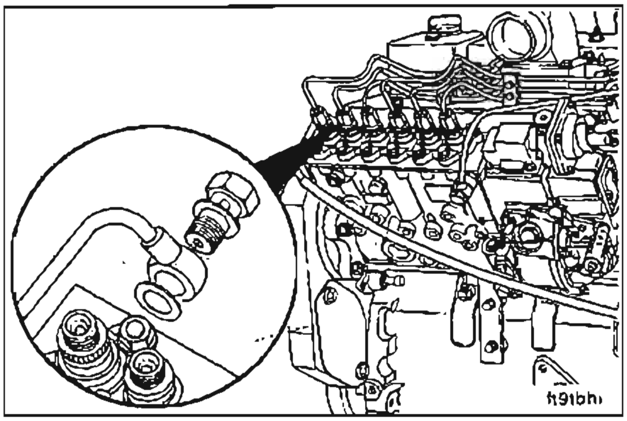


Use a small screwdriver to check that the check ball is not sticking in the pressure relief valve assembly.

A sticky check ball will result in engine low power and hard starting.

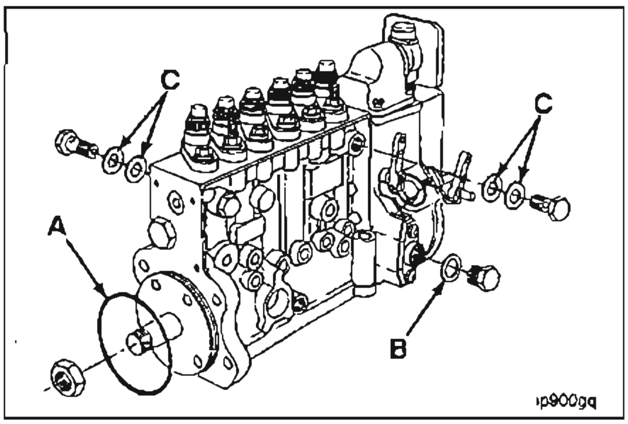
Replace the relief valve assembly if necessary.





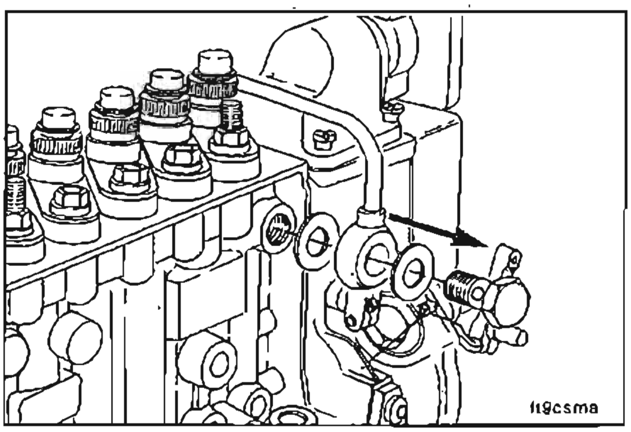
19 mm

Install the pressure relief valve, jump-over tube, and sealing washers in the reverse order of removal.



Seal Replacement, Bosch P7100 (5-30)

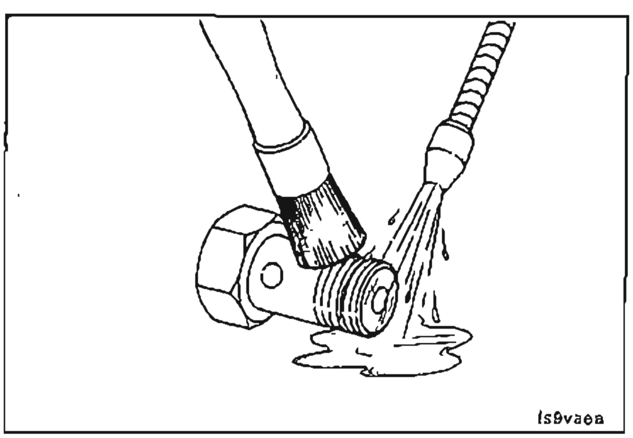
Item	Type of Seal
A	O-Ring Seal
B	Sealing Washer
C	Sealing Washers (Rubber Coated)



Fuel Inlet Banjo Connector Replacement, Bosch P7100 (5-31)

19 mm

Remove the fuel inlet banjo connector and sealing washers.

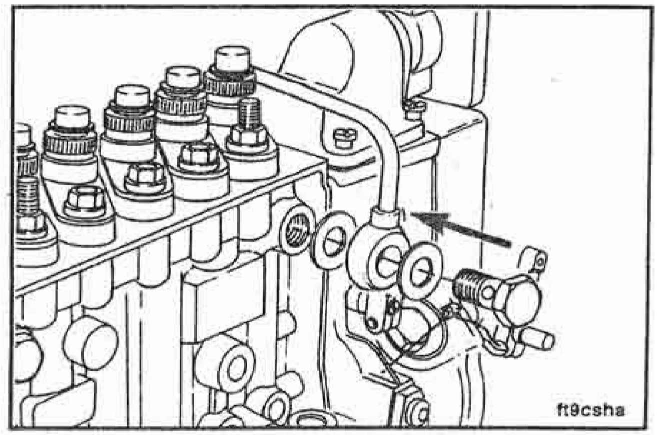


Thoroughly flush the inlet connector with a cleaning solution to ensure it is not blocked with foreign debris.

Replace the fuel inlet banjo connector if the threads are ruined.

19 mm

Install the fuel inlet banjo connector and new sealing washers in the reverse order of removal.

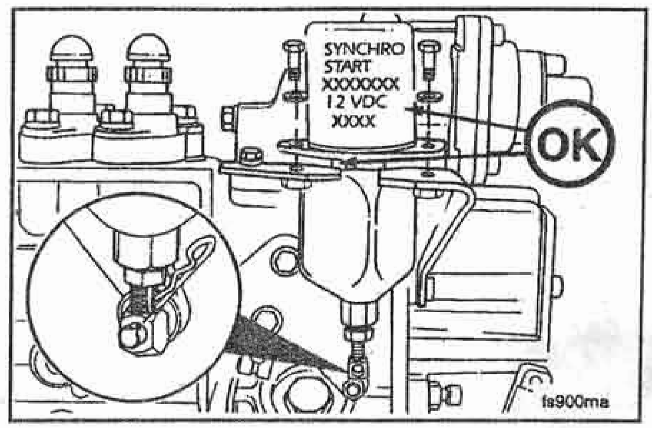


Fuel Shut Off Solenoid Replacement, Bosch P7100 (5-32)

10 mm

Remove and replace the shut off solenoid with the part number facing outward as illustrated.

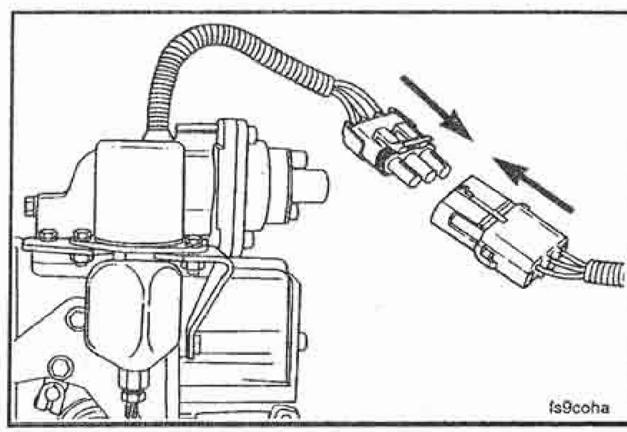
Torque Value: 9 N•m [7 ft-lb]



Fuel Shut Off Solenoid Adjustment, Bosch P7100 (5-33)

NOTE: The fuel pump solenoid must be adjusted on the vehicle to access the voltage supply.

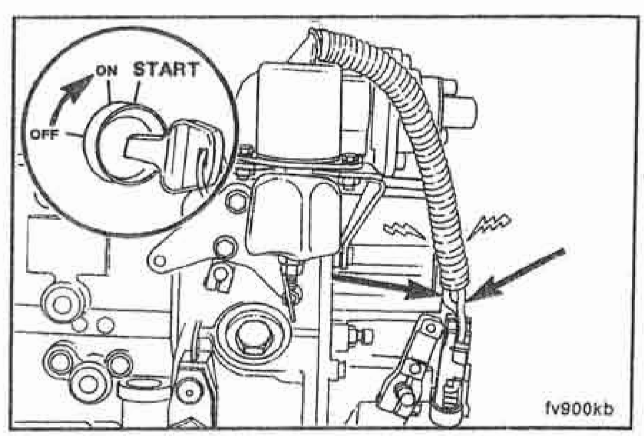
Connect the solenoid wiring harness to the vehicle wiring harness.

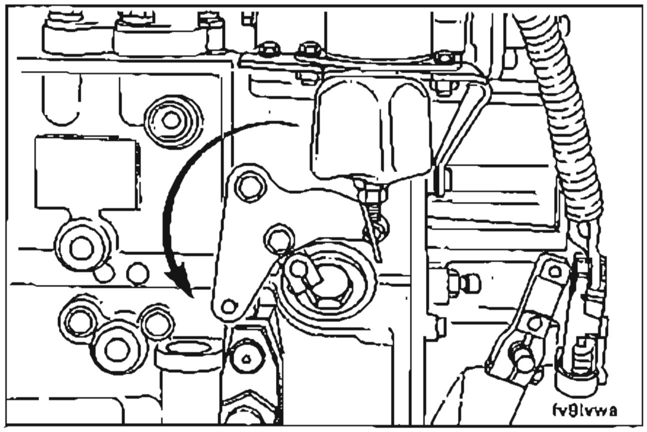


Turn the key to the "ON" position. This will energize the red (hold) wire and black (common) wire.

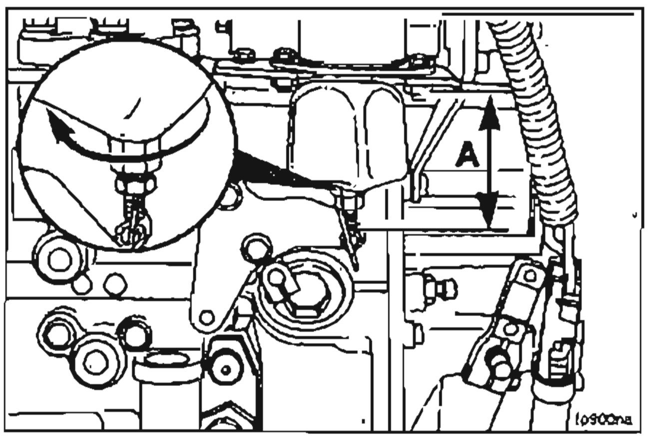
This is the low current hold-in coil and must be energized continuously during this adjustment.

NOTE: Do not turn the key to the "START" position at this time. This will energize the white (pull-in) wire.





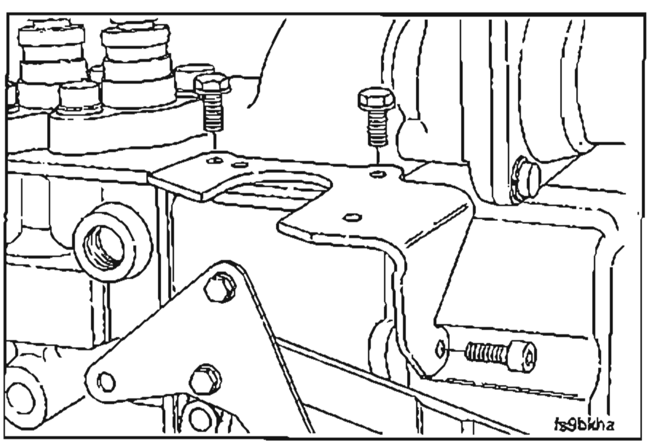
Move the shut off lever by hand to the full run position.



10 mm, 16 mm

Adjust the solenoid linkage to dimension A. Dimension A is measured from the bottom surface of the solenoid mounting bracket to the top of the pivot pin. When properly adjusted the plunger is magnetically held in with the shut off lever in the absolute full run position. Turn the large hex on the end of the plunger to make adjustments.

Solenoid Run Dimension
A = 66.9 mm [2.6 in]



Fuel Shut Off Solenoid Bracket Replacement, Bosch P7100 (5-34)

Preparatory Step:

Remove shut off solenoid.

8 mm, 5mm Allen

Remove and replace the bracket as illustrated.

Torque Value: Top Capscrews (2) 7 N•m [5 ft-lb]
Side Capscrew (1) 10 N•m [7 4 ft-lb]

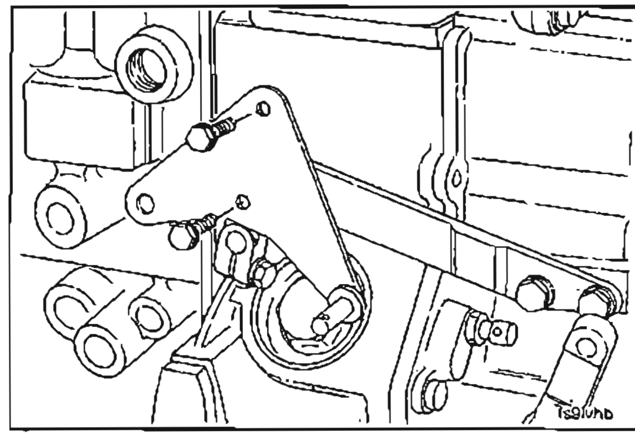
Fuel Pump Shut Off Lever Replacement, Bosch P7100 (5-35)

Preparatory Step:

Remove the shut off solenoid.

8 mm, 10 mm

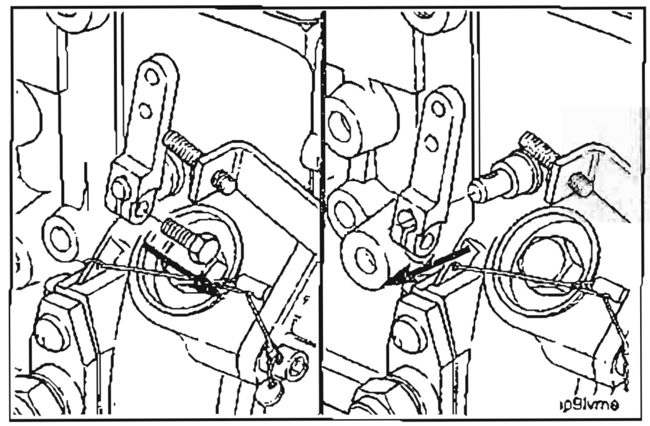
Remove the capscrews holding the lever bracket to the lever.

8 mm

Remove the capscrew holding the shut off lever to the shut off shaft.

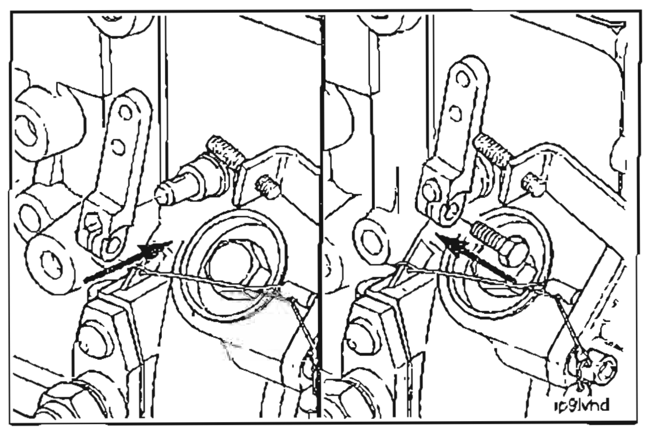
NOTE: The shut off lever is indexed to the shaft with a Woodruff key.

8 mm, 10 mm

Install in the reverse order of removal.

Adjust the shut off solenoid. Refer to Procedure (5-29).

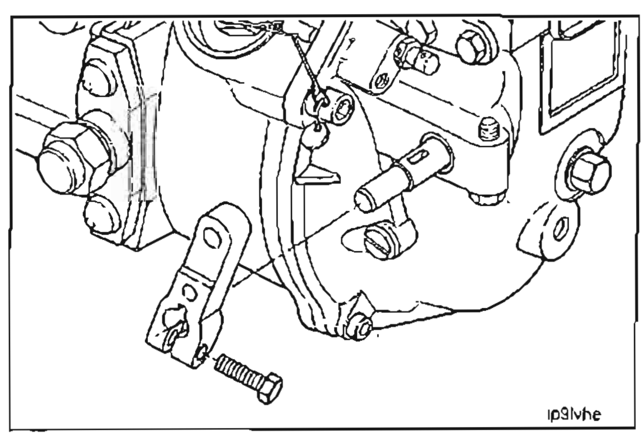



Throttle Lever Replacement, Bosch P7100 (5-36)

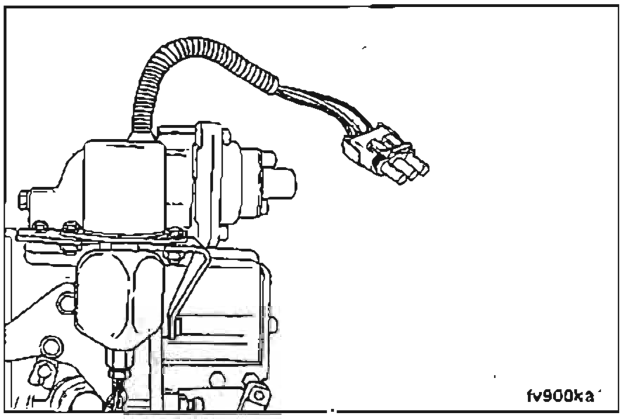
8 mm

Remove and replace the throttle lever as illustrated.

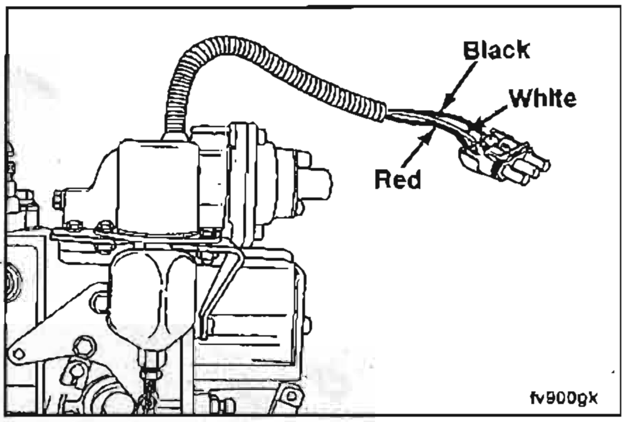
NOTE: The throttle is indexed on the throttle shaft with a Woodruff key.

Shutdown Solenoid Inspection, Bosch P7100 (5-37)

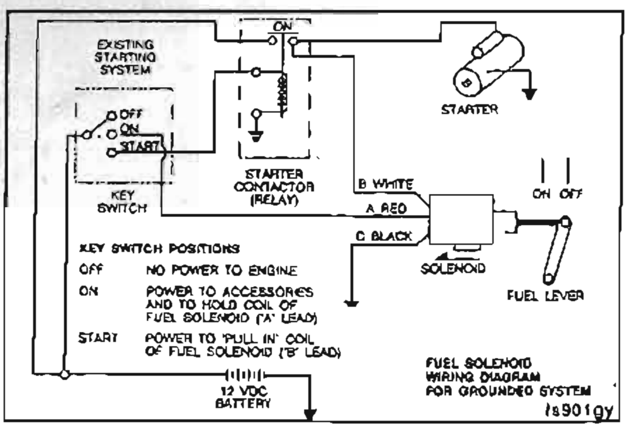


Engines using the Bosch P7100 fuel injection pump with the RQVK governor are equipped with the synchro-start fuel shut off solenoid to actuate the shut off lever. Both 12 volt and 24 volt external fuel shut off solenoids are available.



The synchro-start has a weatherpack connector with 3 wires in it.

Color	Description	Weatherpack Port
Black	Ground	'C'
White	Pull In	'B'
Red	Hold In	'A'



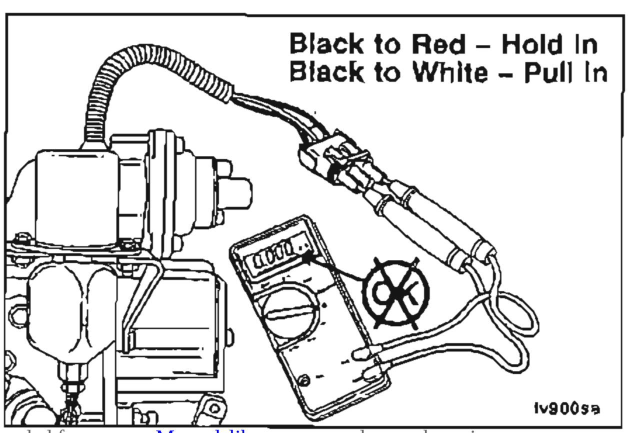
Wiring Guidelines

Refer to the chart below to find the correct gauge size and length of continuous wire for the white (pull-in) wire, which connects to the solenoid wiring.

	Length of Wire		
	0-4.5 ft	0-7.0 ft	0-11 ft
Gauge	14	12	10

NOTE: 14 gauge wire is required for the red (hold-in) wire, which connects to the "Run" terminal on the ignition switch.

NOTE: The black (ground) wire must be the same size as the white (pull-in) wire.



Solenoid Resistance Check

The synchro-start solenoid can be checked using a volt-ohmmeter. Check the solenoid resistance.

Solenoid Voltage	Resistance Min Ohms Pull-In	Resistance Min Ohms Hold-In
12	0.22	11 1
24	0.82	41.3

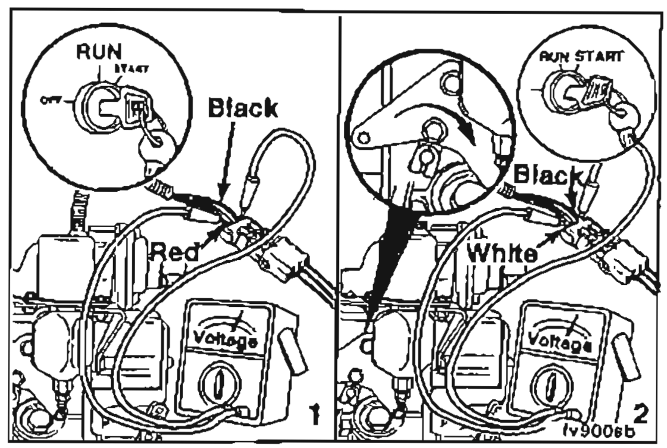
Solenoid Voltage Check

If the Synchro-Start solenoid checks good, the problem is with the wiring circuit to the solenoid.

To perform the solenoid voltage check, connect the wiring harness and apply voltage to the solenoid with the ignition key as follows:

1. With the key in the run position, check the voltage hold-in.
2. With the shut-down lever held in the shut down position, move the key to the start position and check the pull-in voltage.

Battery Voltage	Min Voltage Pull-In	Hold-In
12	6.5	4.0
24	13.0	8.0



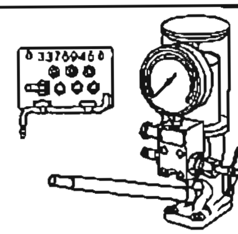
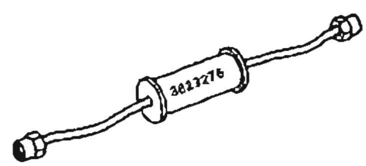
Section 6 - Injectors - Group 06

Section Contents

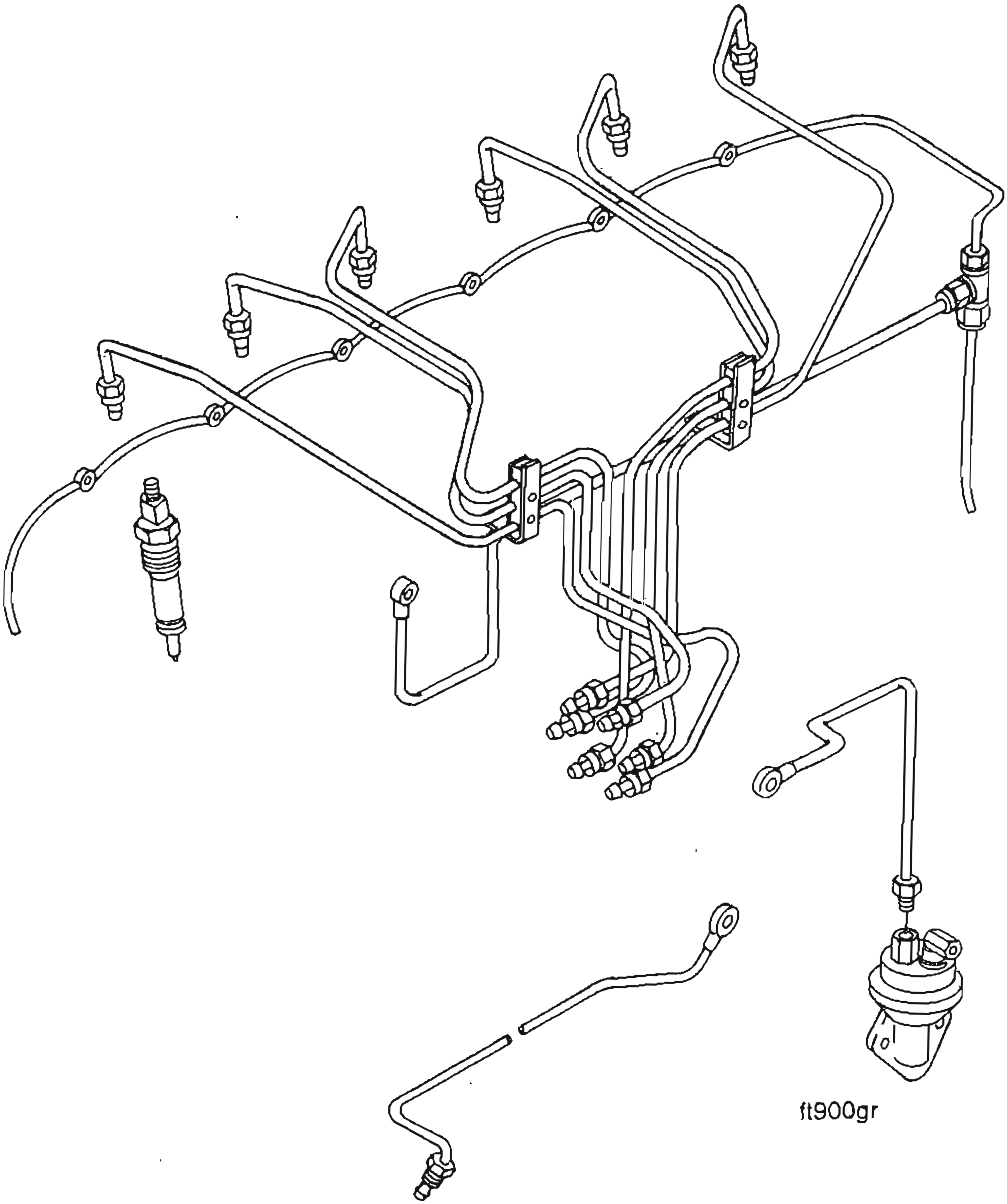
Page

Injector - Service Tools

The following special tools are recommended to perform procedures in Group 06. 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
3376946	Injector Tester	
3376947	Nozzle Cleaning Kit	
3823276	Flexible Injector Puller	

Injector Group - Exploded View



ft900gr

General Information - Injectors

The injector needle valve and the nozzle tip are machined to a very precise tolerance. Never replace only the needle valve. Never mix the needle valves and nozzle tips, they are matched sets.

This group provides instructions for disassembly cleaning, assembly and test of the injectors. Also included are cleaning and inspection procedures for the fuel lines, fuel transfer pump, and fuel filter head.

Fuel Transfer Pump - General Information

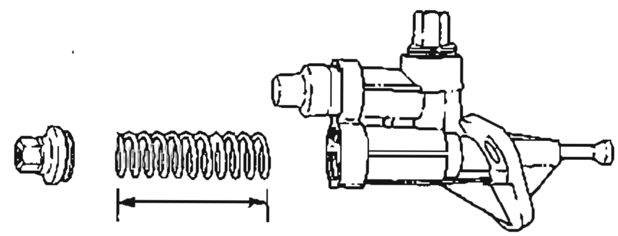
Fuel Transfer Pump - Identification

The B series engine uses three different piston style, and one diaphragm style, transfer pumps. The diaphragm style transfer pump cannot be rebuilt.

Piston style transfer pump, Part No. 3918076, is offered as an option on B series engines equipped with distributor type fuel injection pumps.

NOTE: Part No. 3918076 and 3918000 are identical in appearance. The pumping spring free length can be measured to identify the pump.

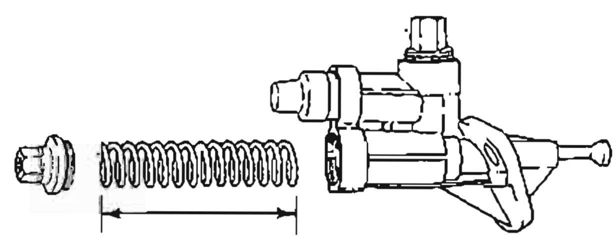
Fuel transfer pump 3918076 spring free length 53.5 mm [2 7/64 in].


fs9sp1a

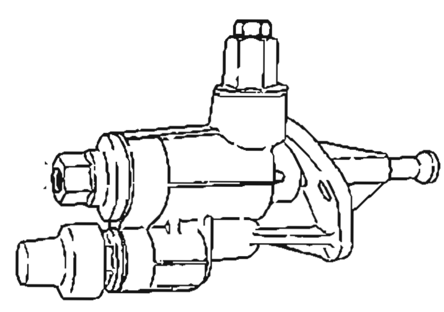
Piston style transfer pump, Part No. 3918000, is used on the 300 HP marine B series engine.

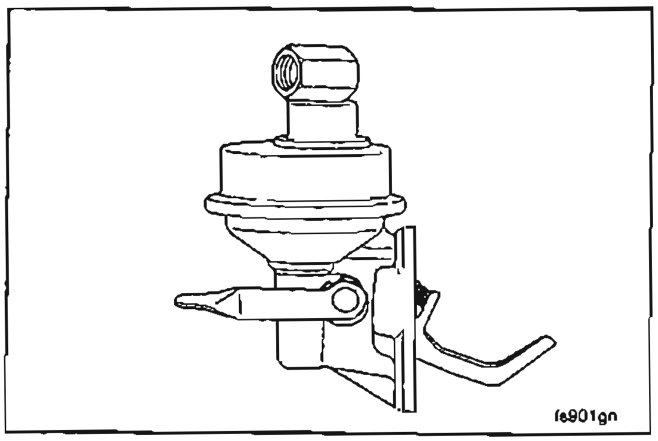
NOTE: Part No. 3918076 and 3918000 are identical in appearance. The pumping spring free length can be measured to identify the pump.

Fuel transfer pump 3918000 spring free length 58 mm [2 9/32 in].


fs9sptb

Piston style transfer pump, Part No. 3917334 and 3921550, is used on the 91 B series engine equipped with the Bosch P7100 in-line injection pumps.

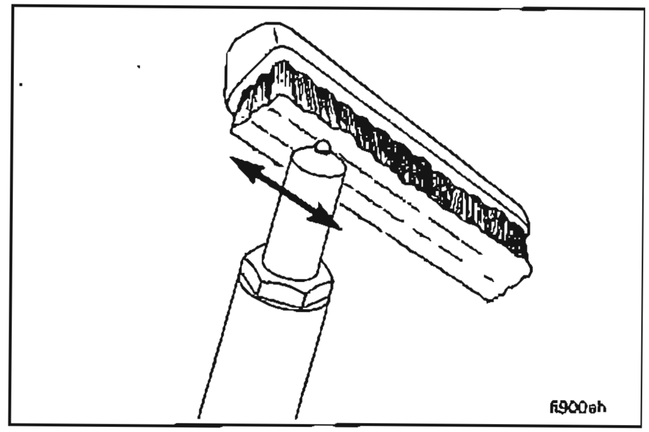

fs901gu


fe901gn

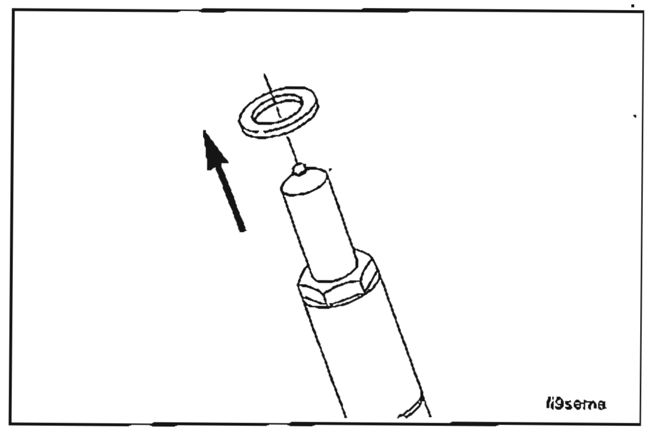
Diaphragm style transfer pump.

Injector - Disassembly

Clean the carbon residue from the nozzle. Use a brass wire brush and a piece of hardwood dipped in test oil.

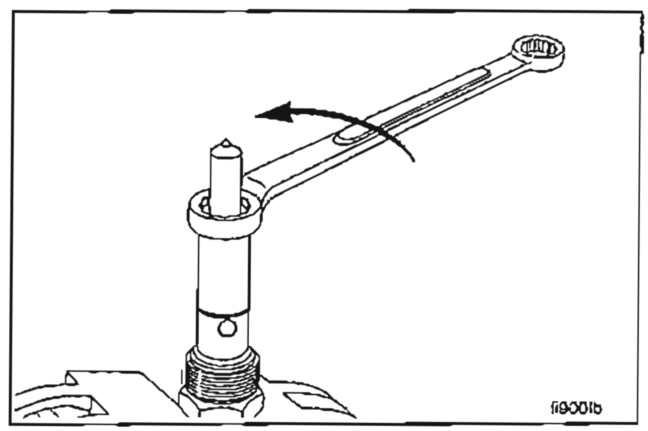


Remove the copper sealing washer and discard.



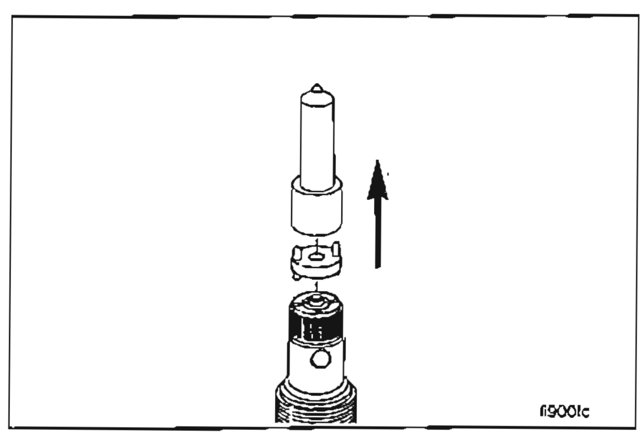
15 mm

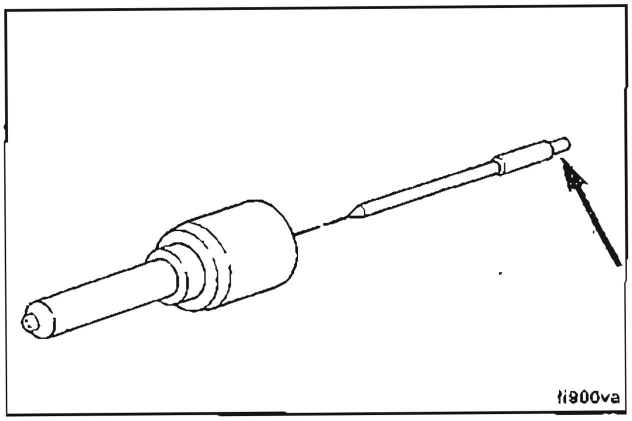
Clamp the nozzle holder in a soft jawed vise and remove the nozzle nut.



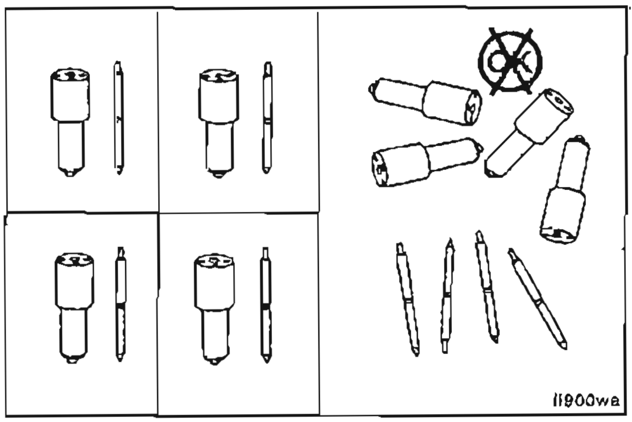
Remove the nozzle needle valve and intermediate plate.

NOTE: To avoid damage place injector nozzle and needle valve in a suitable bath of clean test oil.

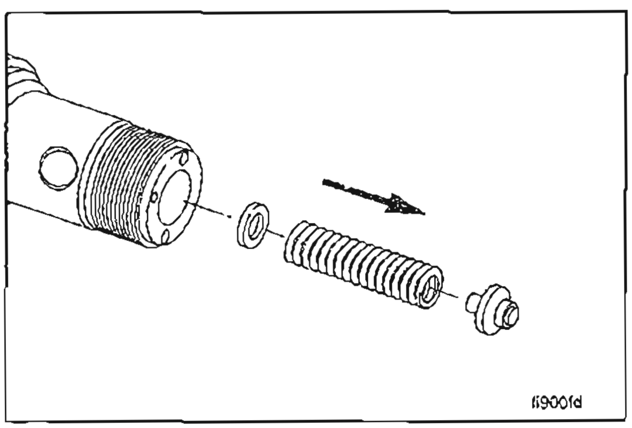




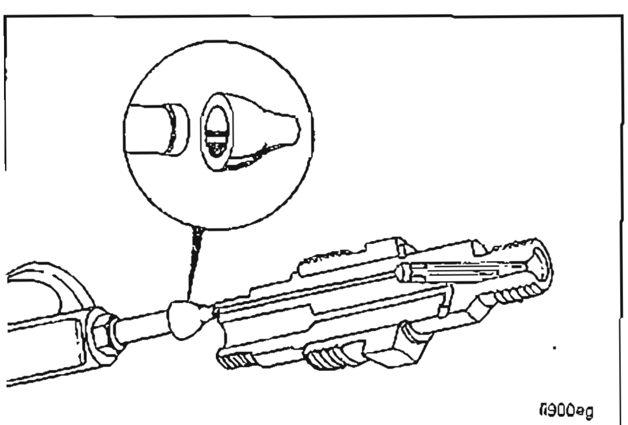
Caution: Hold the needle valve by the stem only. Skin oils will corrode the finely lapped surfaces.



Caution: The needle valve and nozzle tip are matched for fit. They must not be intermixed.



Remove the nozzle holder from the vise; then remove the pressure spindle, pressure spring and shims.



Injector - Clean and Inspect

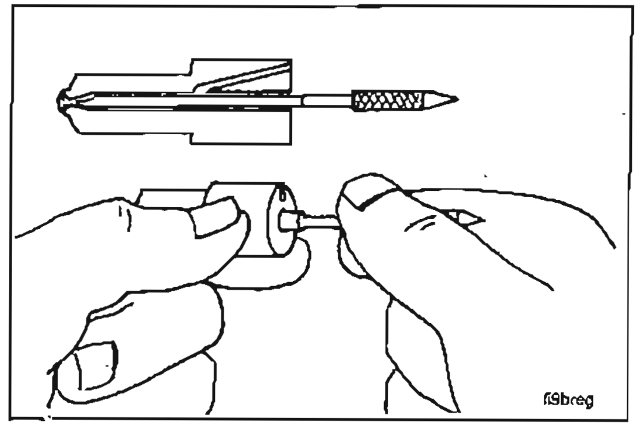
Edge-type filters may be cleaned by applying compressed air to the fuel passage from the nozzle side of the nozzle holder. Edge-type filters are not removable for service.

Rinse new nozzle bodies and needle valves in solvent to thoroughly flush and completely remove all protective coating material.

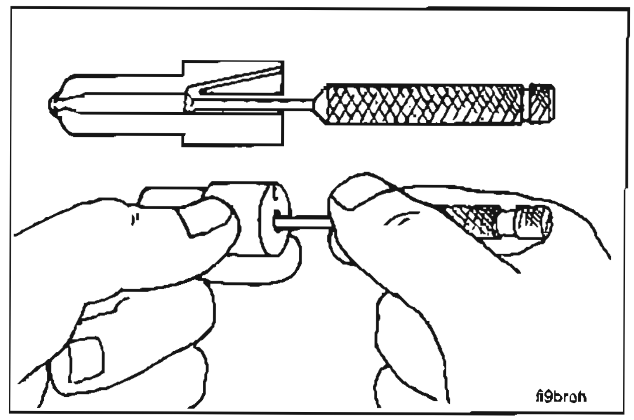
Nozzle Cleaning Kit 3376947

Caution: Never use emery paper or any other metal scraper to clean the nozzle.

Clean the nozzle seat with scraper as shown dipped in test oil. Polish the needle seat with the piece of hardwood dipped in test oil.

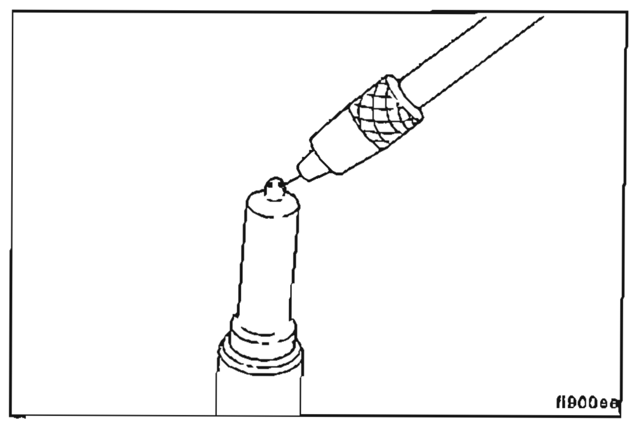


Clean the interior ring groove of the nozzle with the scraper as shown. Rinse in solvent to remove all dirt and carbon residue and dip in clean test oil.



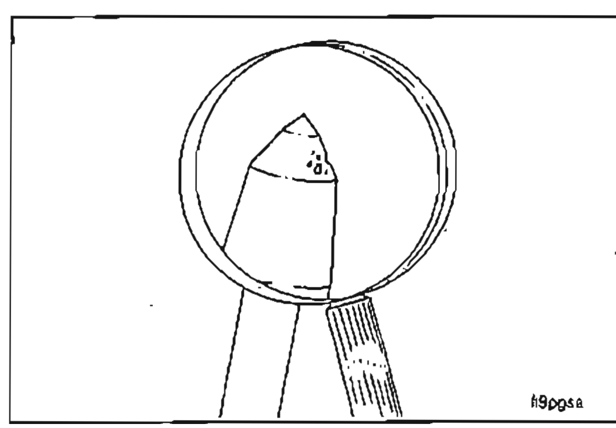
Clean the spray holes of hole type nozzles as shown with the appropriate size cleaning needle.

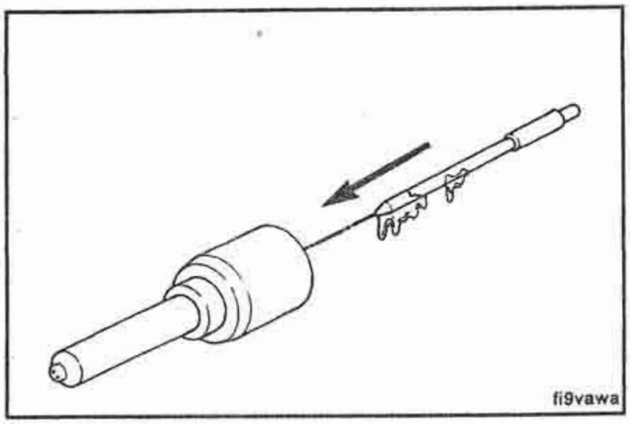
Remove burned-on combustion deposits on all nozzles with a commercially available cleaner. Rinse all parts in clean test oil.



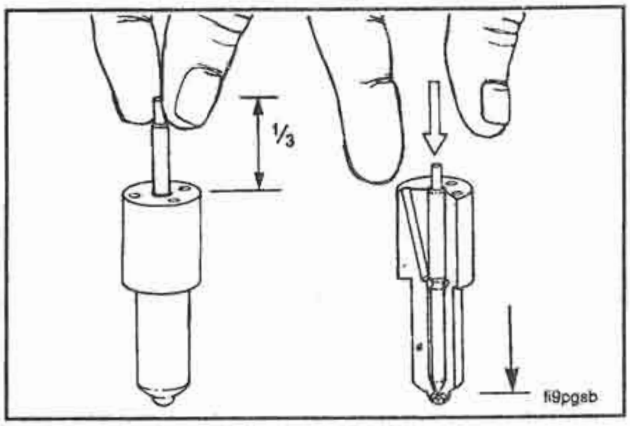
Clean the needle valve tip with a brass brush. Then, inspect for rough surfaces or erosion. The pressure shoulder will normally have a rough machined appearance.

NOTE: Deteriorated needle valves must be replaced as a matched unit with their compatible nozzle body.





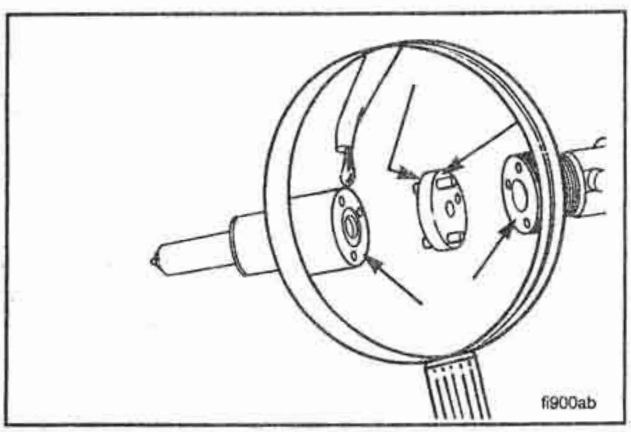
Dip the needle valve in clean test oil and insert the needle valve all the way into the nozzle body.



Caution: Any needle valve and nozzle body assembly which cannot pass this test must be replaced.

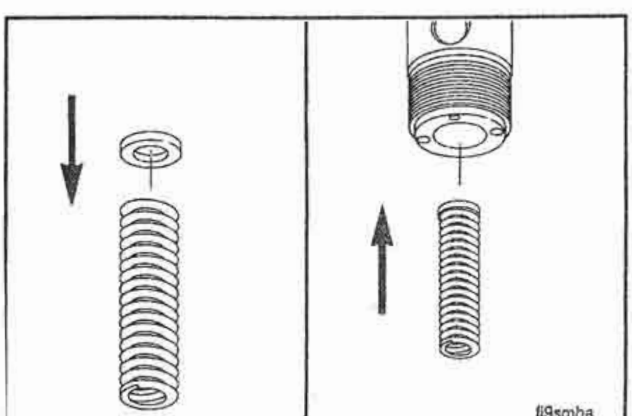
Pull the needle valve one-third of the way out of the nozzle body. The needle valve must slide all the way back into the nozzle body under its own weight.

If the nozzle fails the slide test, clean the nozzle again and retest it.



Injector - Assembly

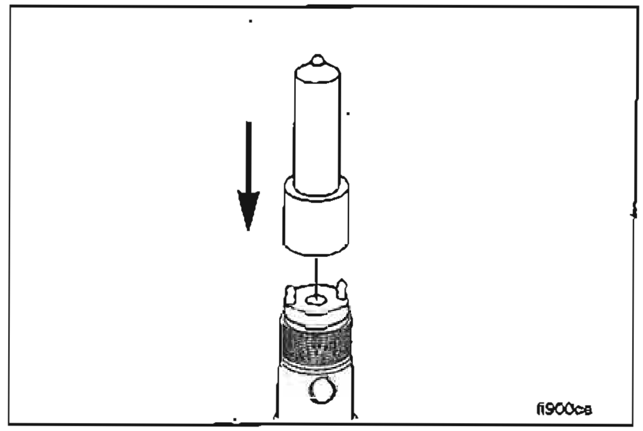
NOTE: Make sure all mating surfaces and pressure faces are absolutely clean and lubricated with fuel oil before assembled.



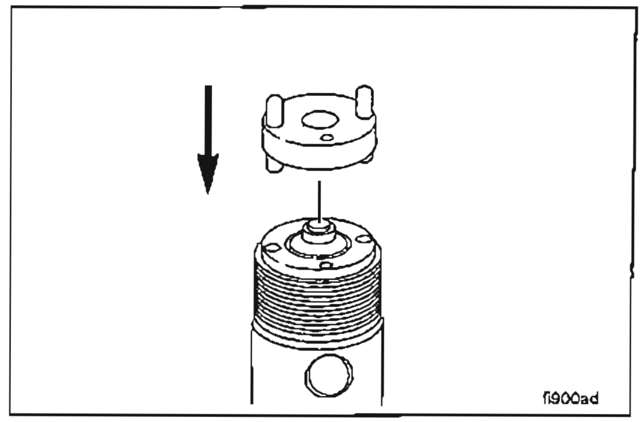
Caution: Install the same thickness of shims that were removed in disassembly. Use the pressure spring to make sure the shims are installed flat.

Install the shims.

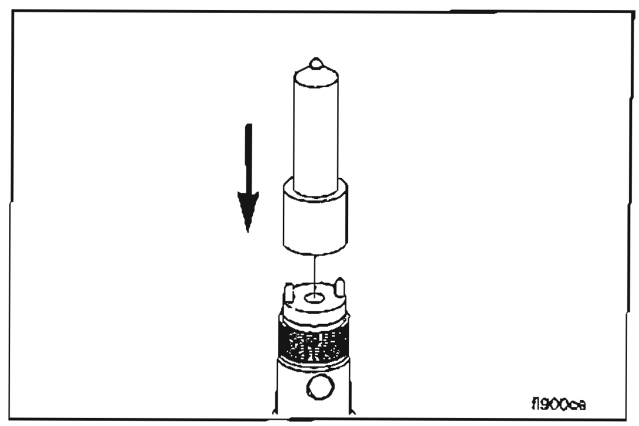
Clamp the nozzle holder in a soft jawed vise and install the spindle.



Install the intermediate plate.



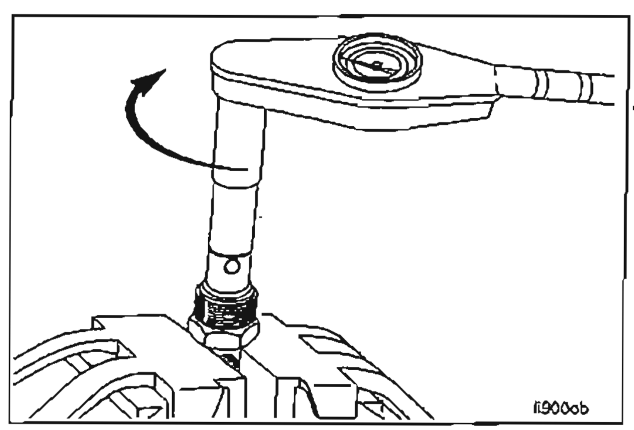
Install the needle valve and nozzle assembly.

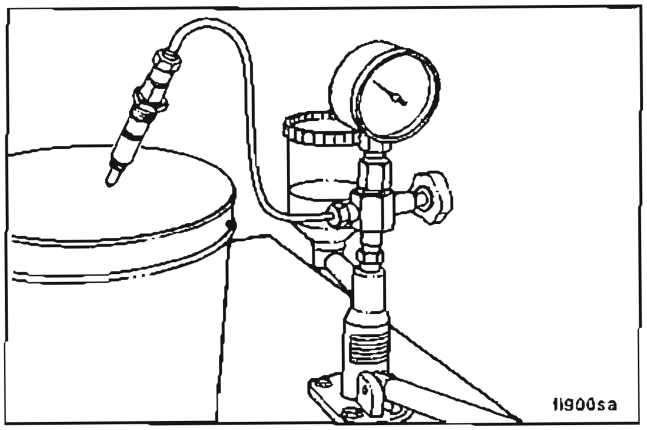


15 mm

Install the nozzle nut.

Torque Value: 30 N•m [22 ft-lb]

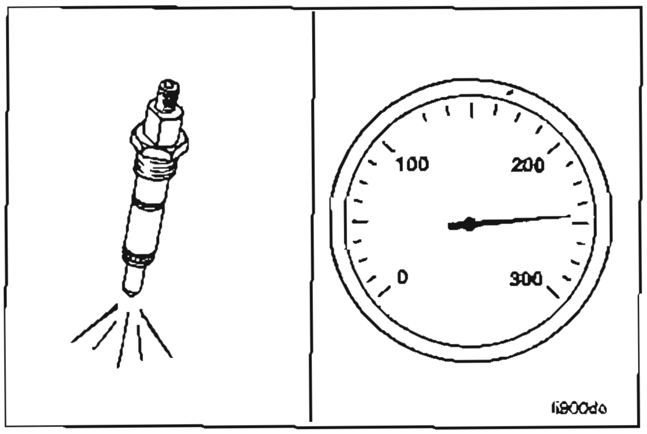




Injector - Testing

Warning: Keep your body clear of test spray. Fluid can be injected into the bloodstream causing blood poisoning and possible death.

All nozzles must be tested for opening pressure, chatter and spray pattern.

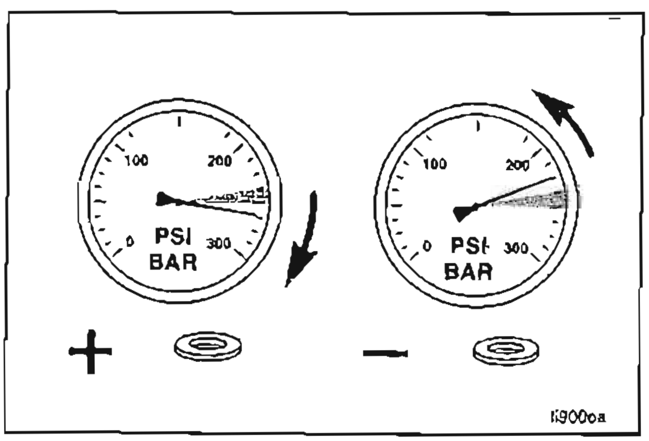


Check the opening pressure.

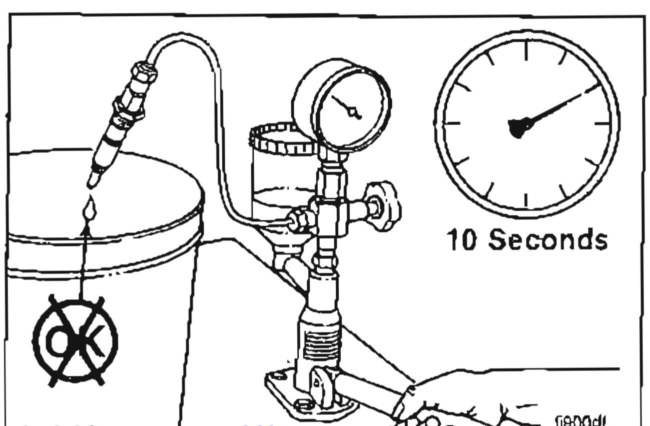
a. Open valve.

b. Operate lever at one stroke per second.

c. Read pressure indicated when spray begins.



If the opening pressure is out of specification, then change the shim pack. Adding shims will increase pressure.



Leakage Test:

a. Open valve.

b. Operate lever to hold pressure 20 bar [290 psi] below opening pressure.

c. No drops should fall from the tip within 10 seconds.

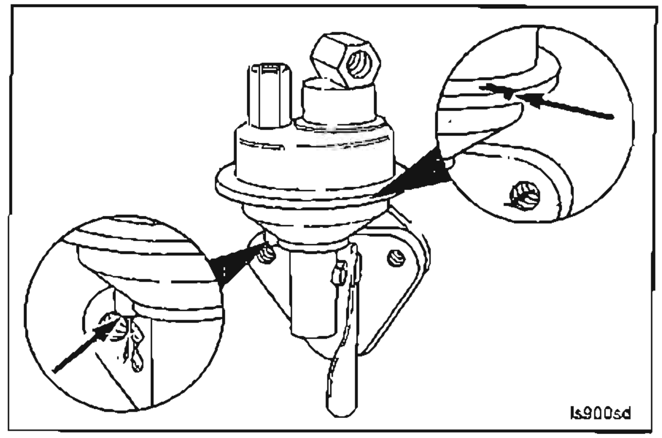
Chatter Test

The chatter test indicates the ability of the needle valve to move freely and correctly atomize the fuel. You should hear the valve open and should see a well atomized spray pattern.

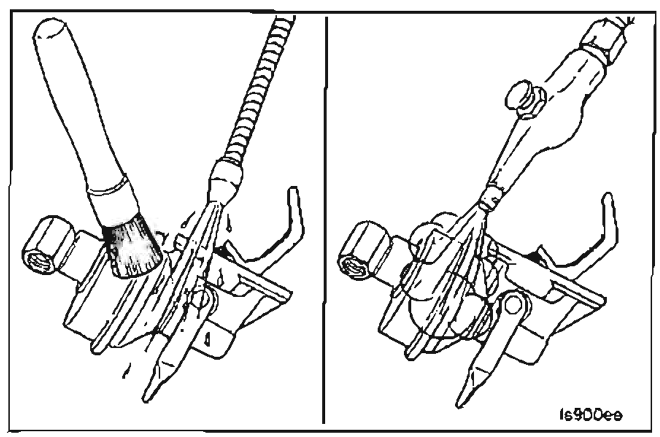
Used nozzles should not be evaluated for chatter at lower speeds. A used nozzle can generally be used if it passes the leakage test, chatters audibly at high lever speeds and uniformly atomizes the fuel.

Fuel Transfer Pump - Cleaning and Inspecting

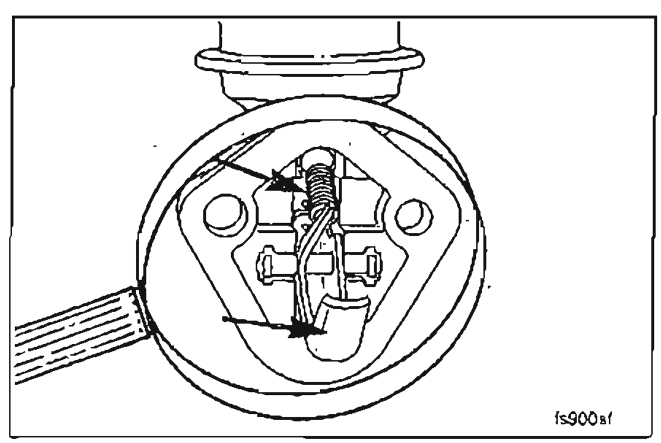
Visually inspect the fuel transfer pump for obvious cracks or damage that would prohibit reuse. Inspect the weep hole area for signs of fuel leakage.

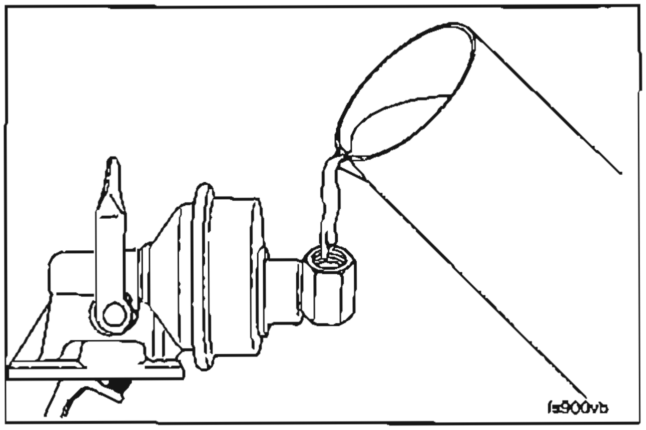


Clean the pump in mineral spirits. Blow dry with compressed air.

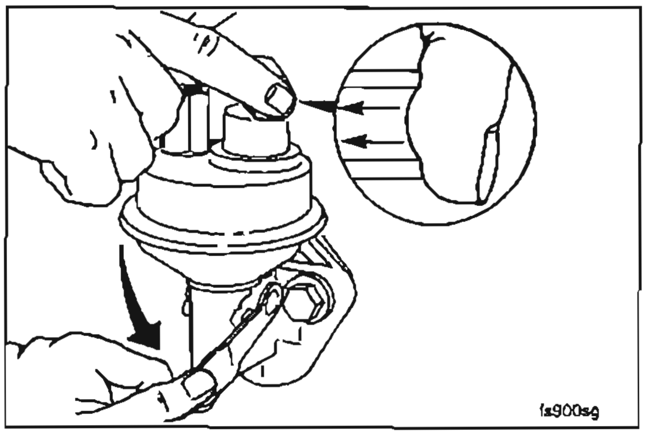


Inspect the camshaft lever and the return spring for excessive wear.





To inspect the transfer pump, pour clean diesel fuel or engine oil into the inlet connection and perform the following test:



Inspect the diaphragm by blocking the fuel inlet line with your finger and operating the priming lever.

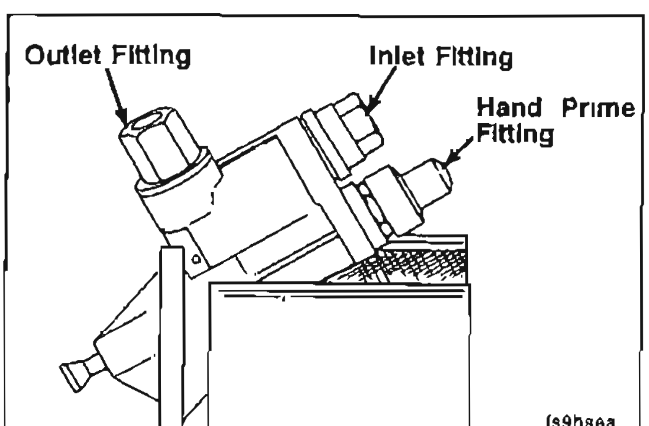
A good pump will have suction that will not bleed down until the finger is removed from the inlet.

On diaphragm style fuel transfer pumps, parts replacement is not practical; the pump is serviced as an assembly. An optional piston style pump is available which can be cleaned and repaired with a minor repair kit.

Fuel Transfer Pump - Piston Style Rebuild

Preparatory Step:

- Clean debris from the fuel line fittings and the fuel transfer pump.



20 mm, 26 mm Wrench

Caution: The hand-prime fitting and inlet fitting are spring loaded. Sudden removal of these two fittings can cause personal injury.

Secure the pump in a vise, taking care not to damage the pump housing.

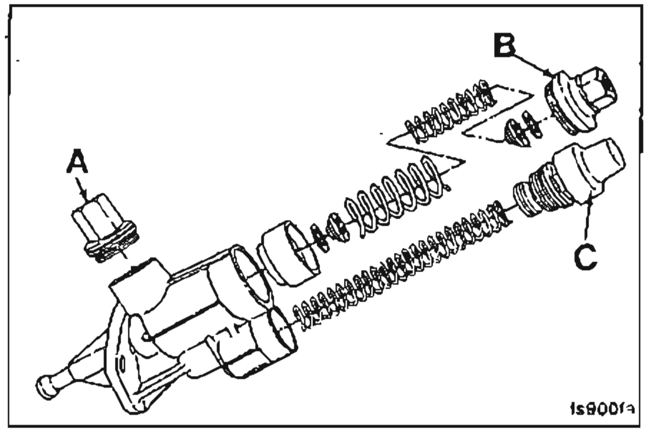
Remove the rubber boot from the hand-prime fitting.

Remove the three illustrated fittings.

Remove all internal components of the pump.

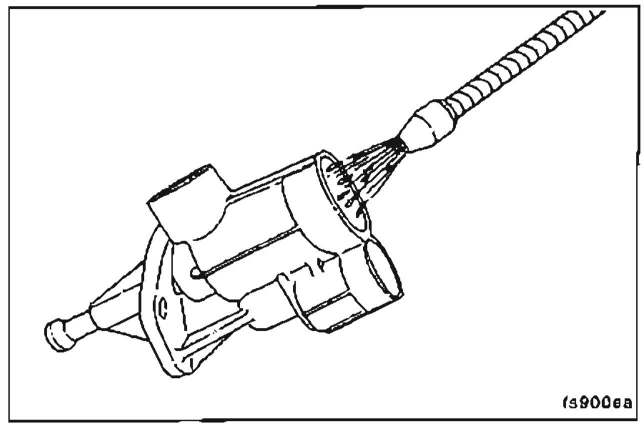
NOTE: Make sure the check valve gaskets are removed from the inlet fitting.

(A) Outlet Fitting
(B) Inlet Fitting
(C) Hand Primer Fitting



Cleaning

Thoroughly flush the pump with a cleaning solution to remove any debris.



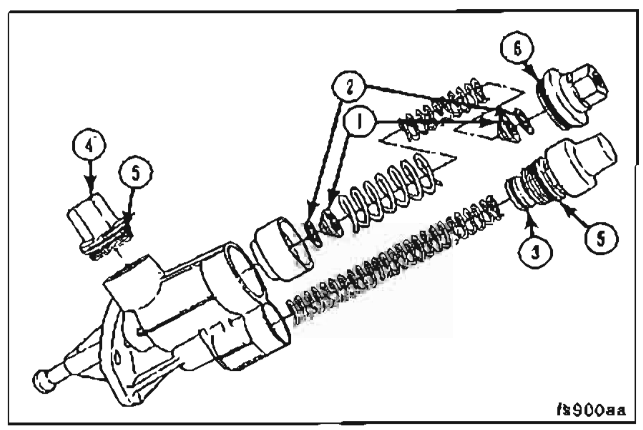
Assembly

20 mm, 26 mm Wrench

Assemble the pump with the new components supplied in the rebuild kit.

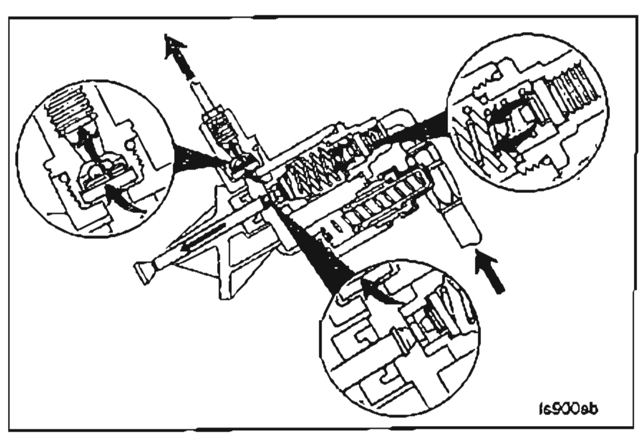
1. Check valves
2. Check valve gaskets
3. O-ring seal
4. Outlet fitting/check valve
5. *O-ring seal (25 mm)
6. *O-ring seal (30 mm) or (25 mm)

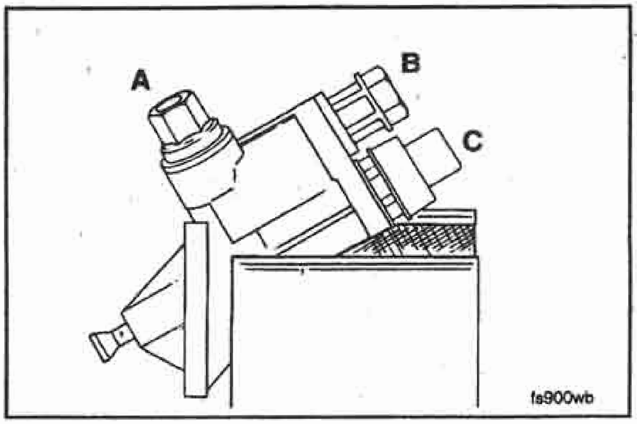
* O-ring required is determined by the size of the inlet fitting. Discard unused o-ring.



NOTE: Extreme caution must be used to make sure the check valves are installed to open in the direction of the fuel flow.

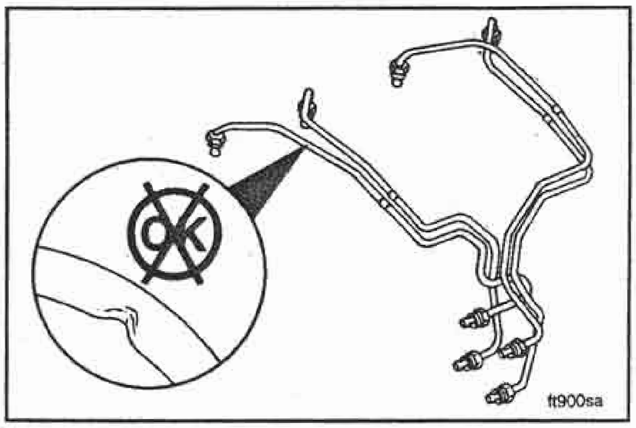
Improper installation of the check valves will result in low power from the engine.





Place the pump in a vise and torque the fittings to the following values:

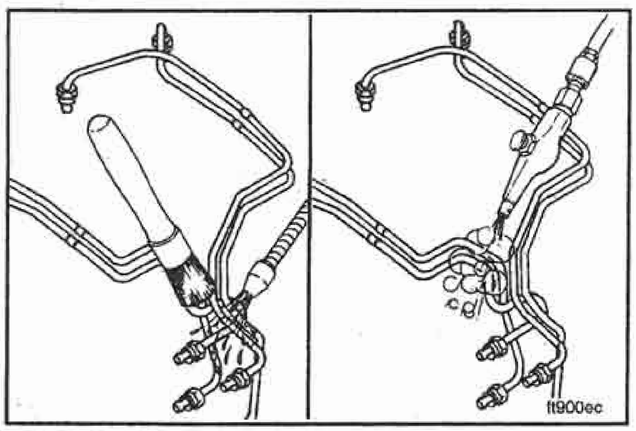
(A) Outlet Fitting	30 N•m	[22 ft-lb]
(B) Hand-Prime Fitting	30 N•m	[22 ft-lb]
(C) Inlet Fitting	30 N•m	[22 ft-lb]



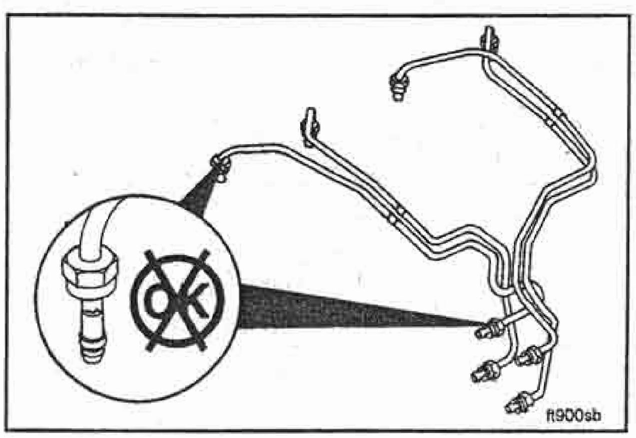
Fuel Lines - Clean and Inspect

High Pressure Fuel Lines

Visually inspect the high pressure fuel lines for obvious damage such as lines that have bent to facilitate injector removal. High pressure pulses expand and contract the injector lines which result in internal flaking at the bent areas. Bent lines should be replaced.

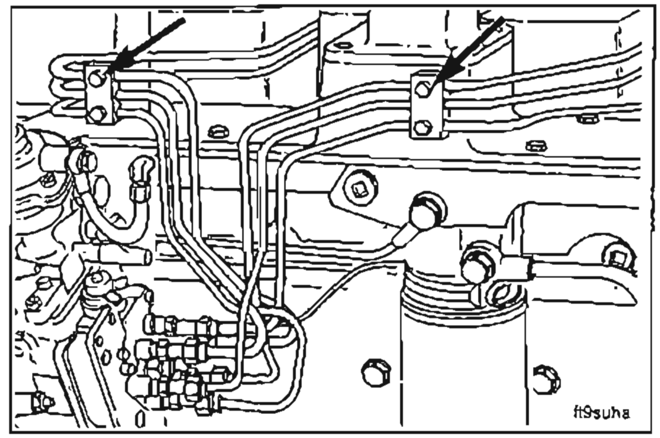


Wash the fuel lines in clean solvent and blow dry with compressed air. Make sure all paint chips are removed.

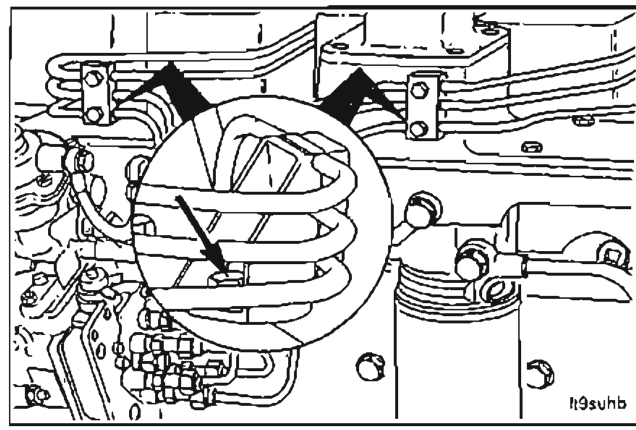


Visually inspect for cracks at both ends of the fuel lines.

Caution: The high pressure lines must be clamped securely and routed so they do not contact each other or any other component. Inspect for areas of contact that have worn the material thin.

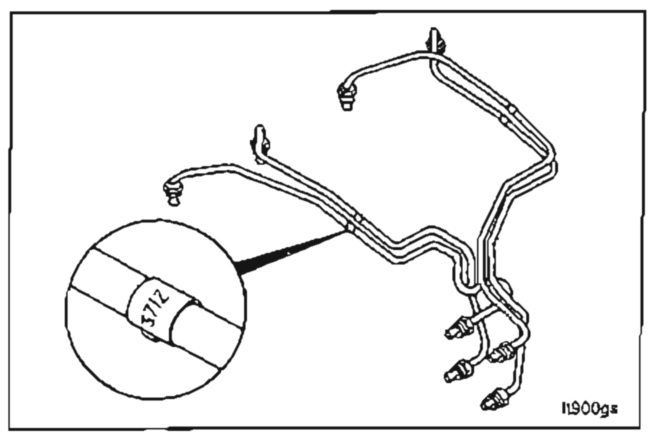


Inspect the vibration isolators (clamps). Make sure all the vibration isolators are positioned and tightened properly. Missing or improperly installed isolators will almost certainly result in fuel line failure.



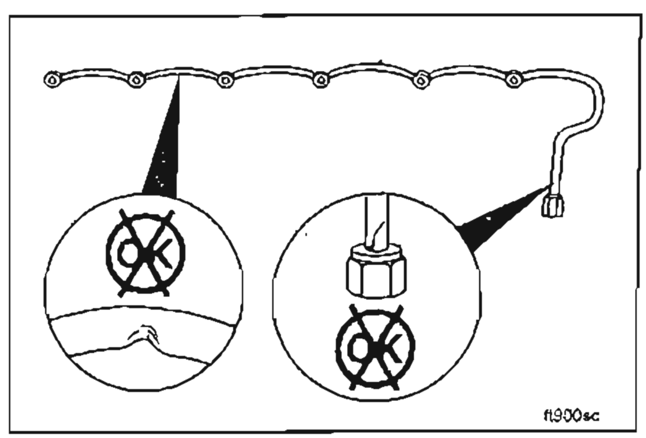
Caution: Do not weld or substitute lines; use only the specified part number for the engine.

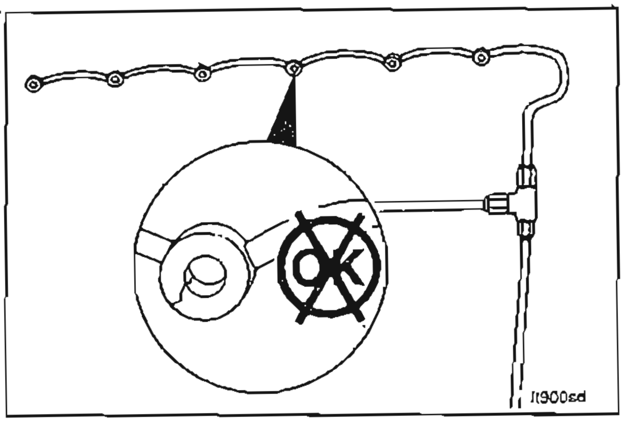
The length, internal size and rigidity of the lines is critical to smooth engine operation. An attached metal tag is used to identify each line with a part number.



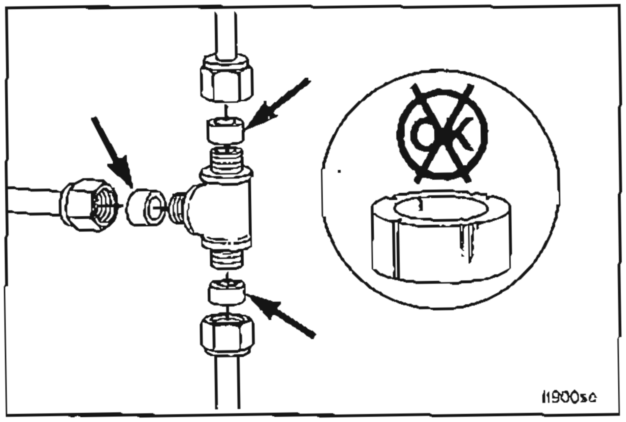
Fuel Drain Manifold

Inspect the fuel drain manifold for cracks and obvious damage.





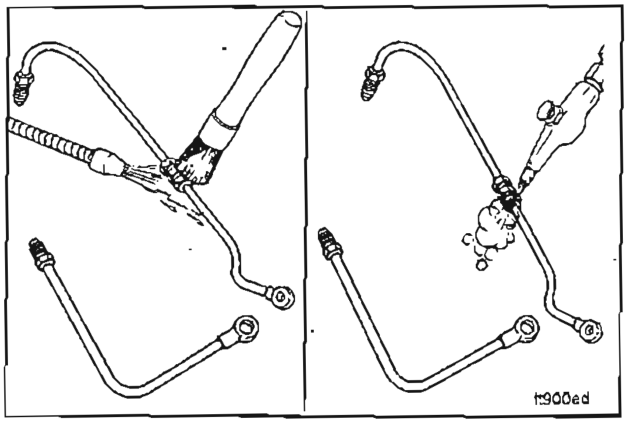
Inspect the sealing surfaces for leak paths.



13 mm

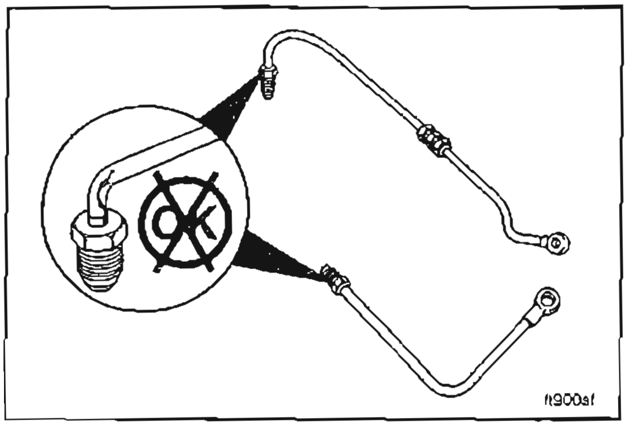
Inspect the rubber seals. Replace any damaged seals or seals that are hard or brittle.

Service Tip: Lubricating the seals with clean engine oil will facilitate the installation.



Low Pressure Fuel Lines

Wash the low pressure fuel lines in clean solvent. Blow dry with compressed air.

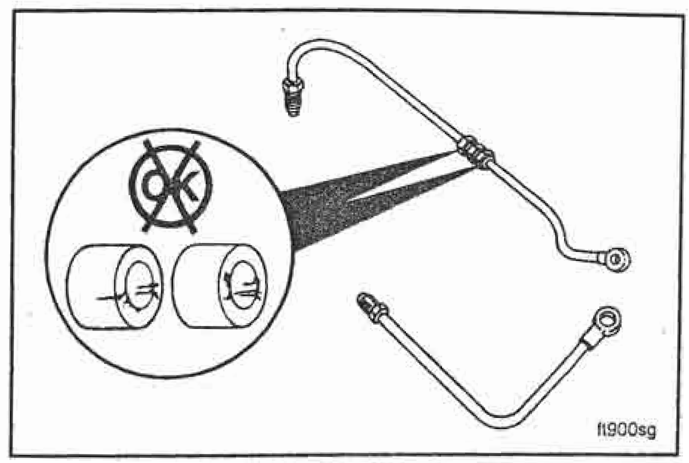


Visually inspect the lines for obvious damage such as cracks or worn areas.

17 mm, 16 mm

Inspect the rubber seals. Replace any damaged, hard, or brittle seals.

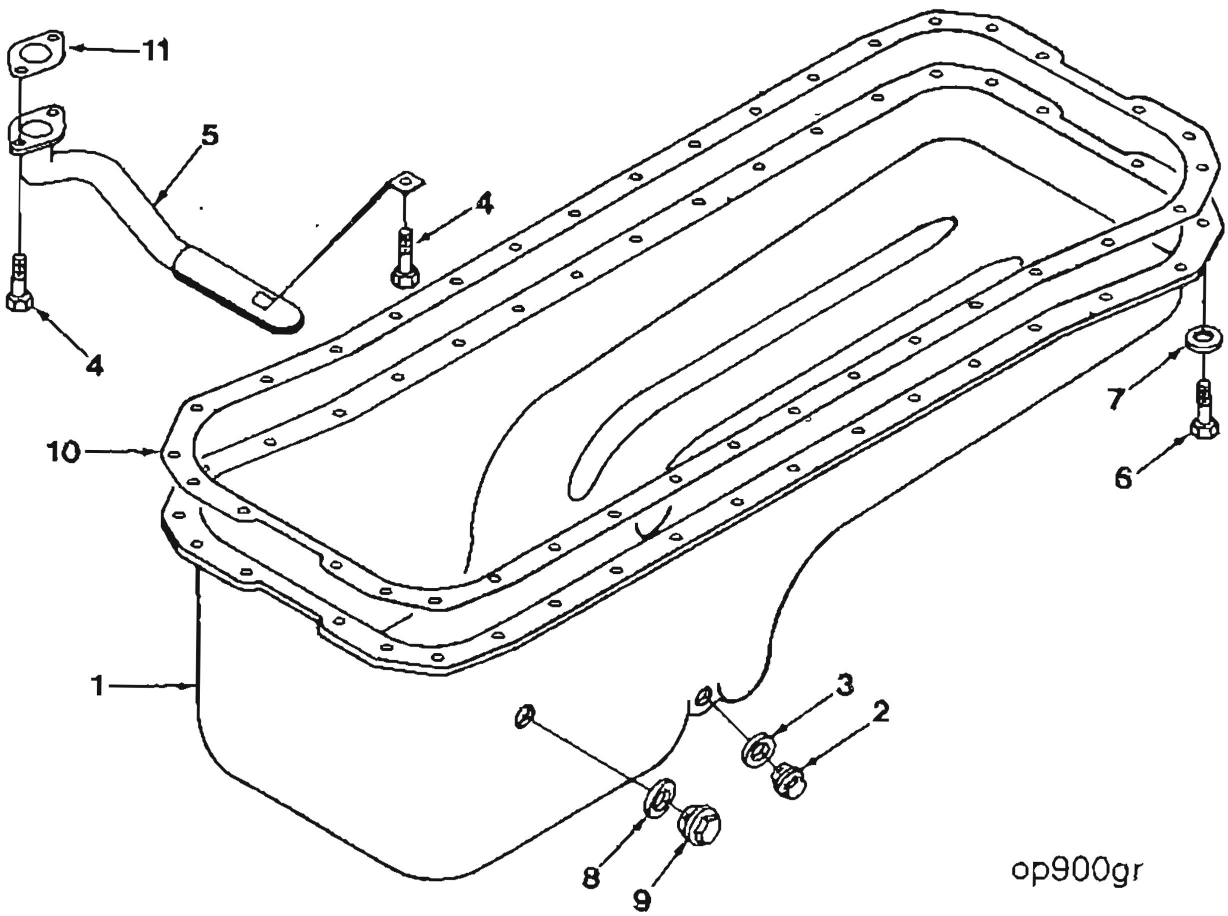
Service Tip: Lubricating the seals with clean engine oil will facilitate the installation.



Section 7 - Lubrication Oil System - Group 7

Section Contents

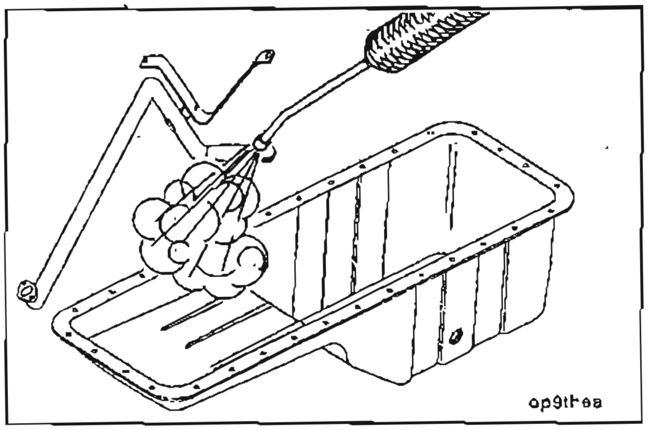
Oil Pan and Suction Tube - Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Pan, Oil	1	
2	Plug, Threaded	1	M18 1.5 x 12mm
3	Washer, Sealing	1	1.5mm thick, 18.40 I.D.
4	Screw, Hexagon Head Cap	3	M8 1.25 x 16mm
5	Connection, Oil Suction	1	
6	Screw, Hexagon Head Cap	36	M8 1.25 x 20mm
7	Washer, Spring	36	
8	Washer, Sealing	1	22.2 I.D. x 1.5mm thick
9	Plug, Threaded	1	M22 x 1.5 mm
10	Gasket, Oil Pan	1	
11	Gasket, Flange	1	

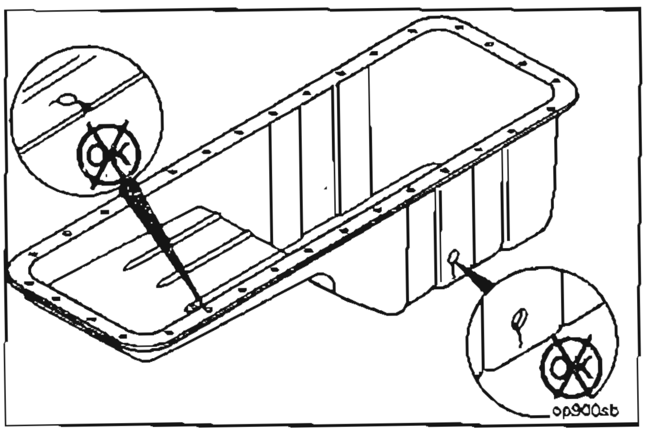
Oil Pan and Suction Tube - General Information

The B Series engine is available with various oil pan/suction tube configurations based on the customer's needs; i.e., oil capacity angularity limits, drain plug location, etc. However all the oil pans fall into two basic types, center sump and front or rear sump. Both types of oil pans can be rotated front to back to meet various installation requirements such as moving a drain plug to a specific side or front and rear sump requirements.

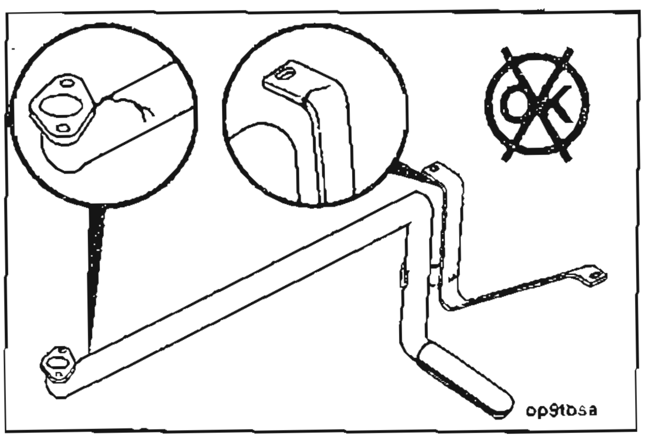


Oil Pan and Suction Tube - Cleaning and Inspection (7-01)

Steam clean the pan and suction tube.



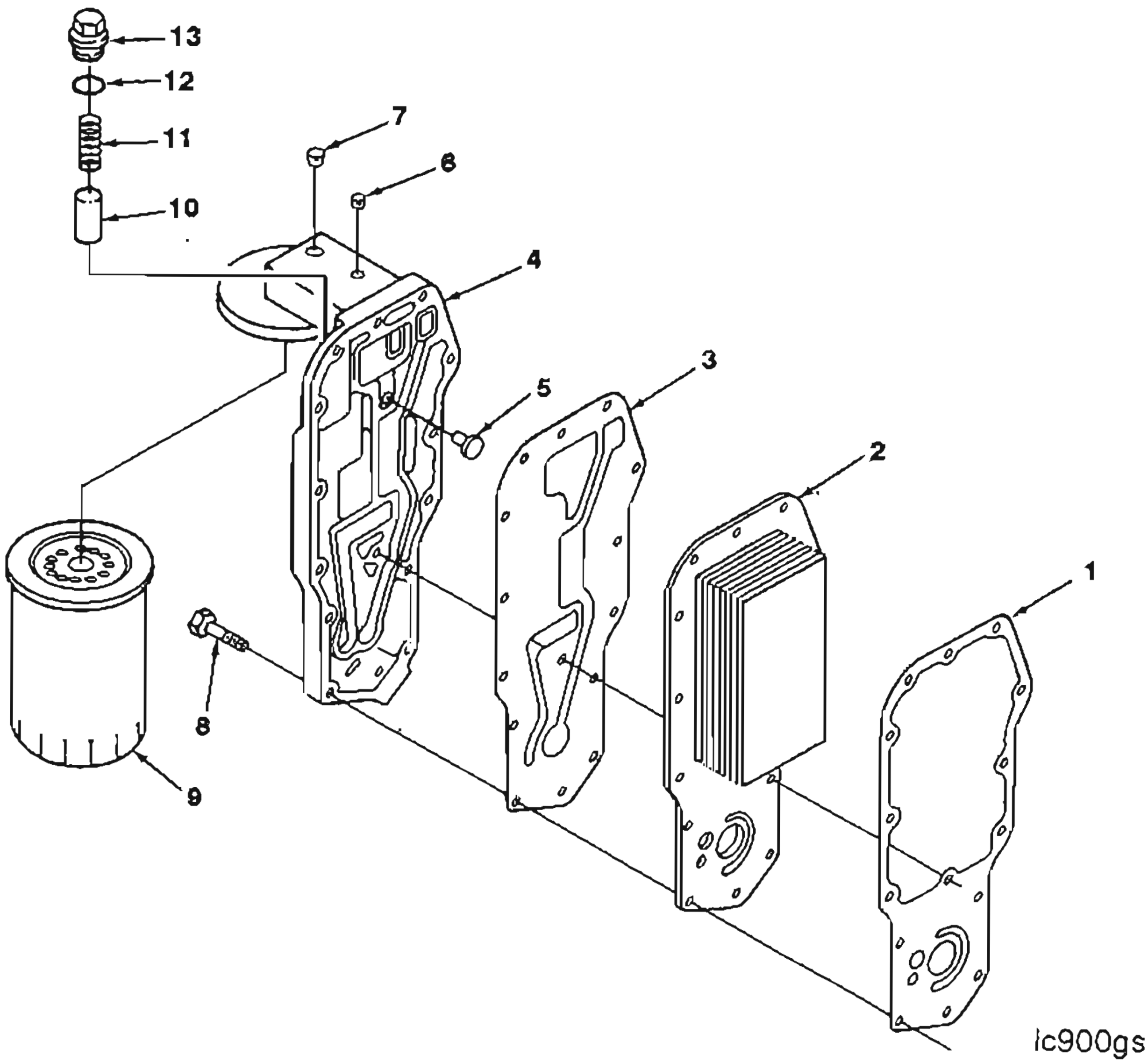
Inspect the pan for cracks and damaged threads.



Inspect the oil suction tube and brace for cracks. Do not reuse a cracked oil suction tube or brace.

Also check the block mounting surface for damage.

Lubricating Oil Cooler - Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Screw, Hex Flange Head Cap	14	M8 x 1.25 x 35
2	Valve, Bypass	1	
3	Spring, Compression	1	
4	Plug, Pipe	1	1/8 NPT
5	Head, Lub Oil Filter	1	
6	Adapter, Filter Head (Not Replaceable)	1	
7	Core, Cooler	1	
8	Gasket, Filter Head	1	
9	Plug, Threaded	1	M22 x 1.50
10	Seal, O Ring	1	
11	Plunger, Prs Regulator	1	
12	Gasket, Oil Cooler Core	1	
13	Cartridge, Lub Oil Filter	1	

General Information - Lubrication System

Oil Cooler Core

The B Series engine uses a full flow plate type oil cooler The oil flows through the element where it is cooled by engine coolant flowing past the plates of the element.

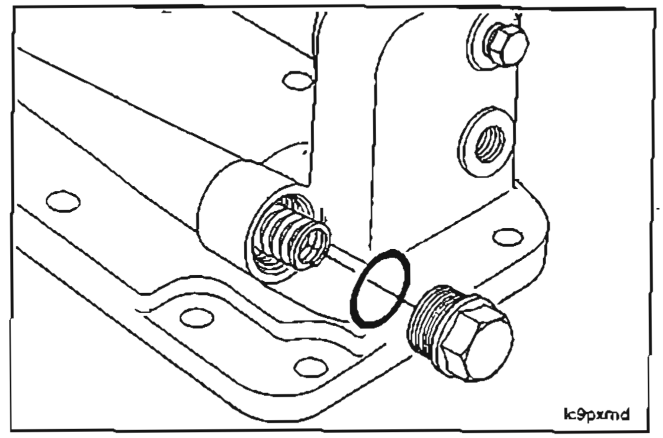
The four cylinder engine uses five plates. The six cylinder engine uses seven plates.

NOTE: Some engines use a jumper plate in place of an oil cooler

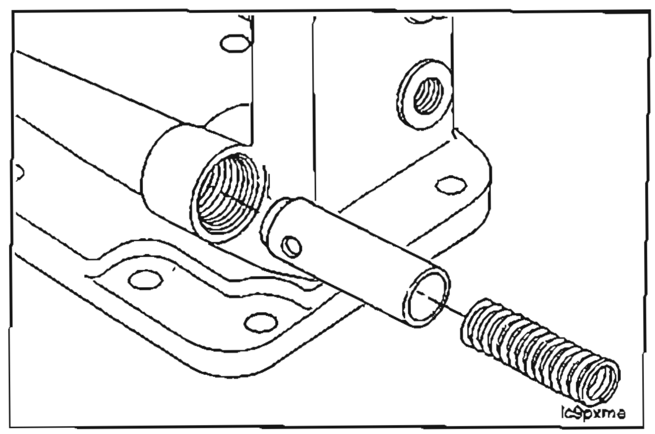
Pressure Regulator Valve - Disassembly (7-02)

19 mm

Remove the plug and sealing washer.



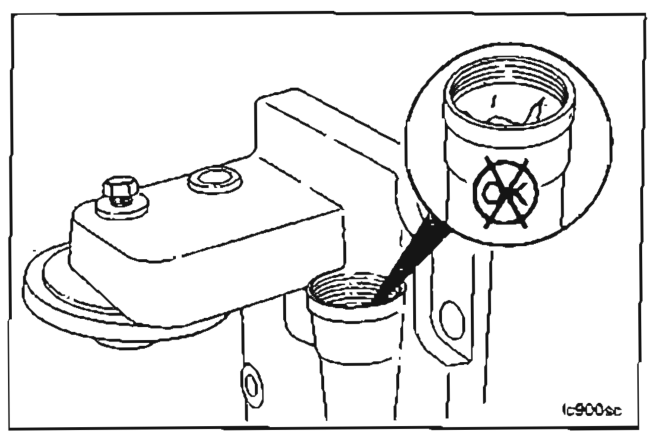
Remove the spring and plunger.

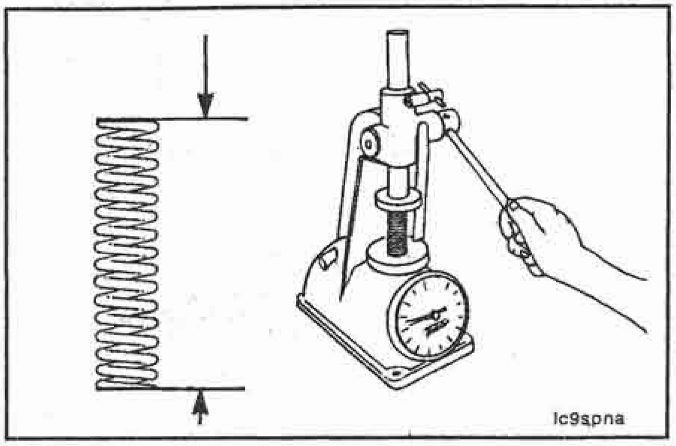


Pressure Regulator Valve - Inspection (7-03)

Inspect the plunger bore for nicks or scratches.

The plunger must move freely in the bore.




lc9spna

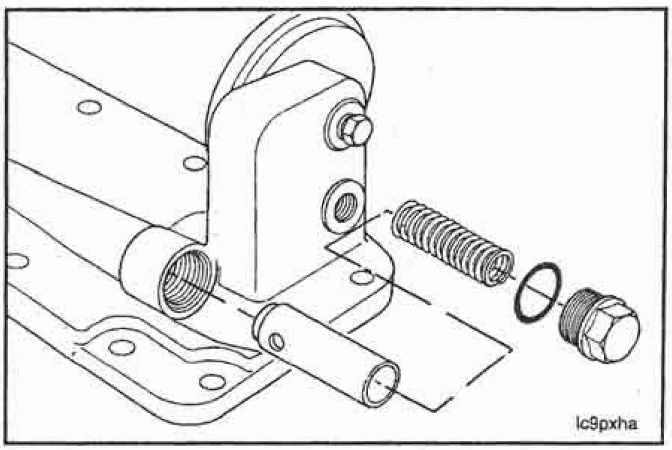
Check the pressure regulator spring at the following two heights.

Free Length 60.6 mm [2.38 in]
Limit
1991

- 44.5 mm [1 752 in] Min. Load 105 N [23.6 lb] (regulator valve opens)
- 41.25 mm [1.624 in] Min. Load 142 N [32 lb] (regulator valve seated)

Free Length 66 mm [2.59 in]
(1994)

- 44.5 mm [1.752 in] Min. Load 116 N [26.1 lbf] (regulator valve opens)
- 41.25 mm [1.624 in] Min. load 137 N [30.8 lbf] (regulator valve seated).

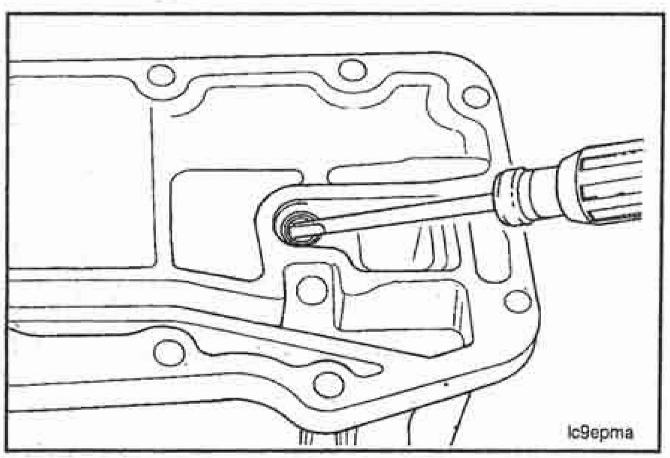

lc9pxha

Pressure Regulator Valve - Assembly (7-04)

19 mm

Install the valve.

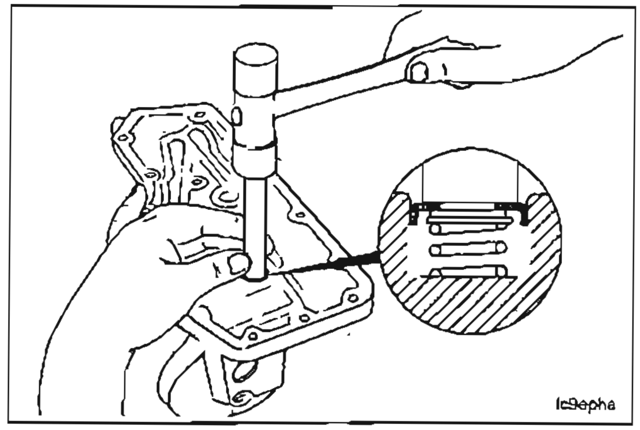
Torque Value: 80 N•m [59 ft-lb]


lc9epma

Filter Bypass Valve - Replace (7-05)

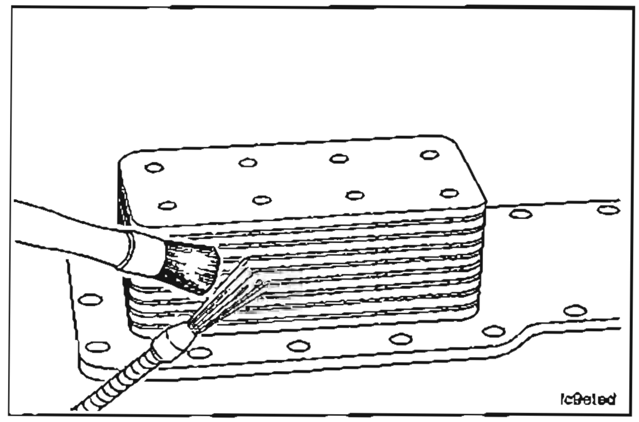
Remove the valve from the cooler cover.

Drive the new valve in until it bottoms against the step in the bore.



Oil Cooler - Cleaning (7-06)

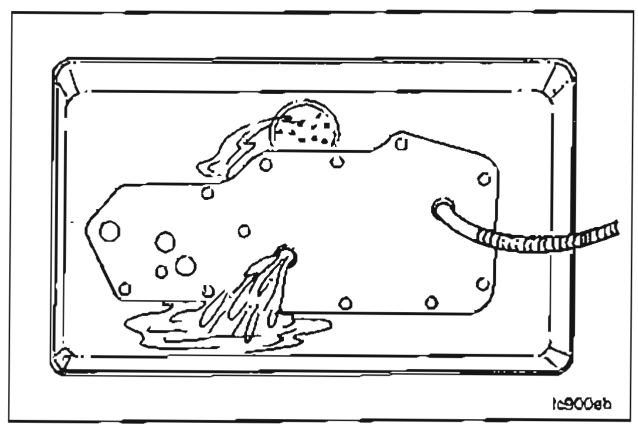
Plug the cooler and soak it in a cleaning solution to remove the coolant deposits.



Remove the plugs and soak the cooler in solvent.

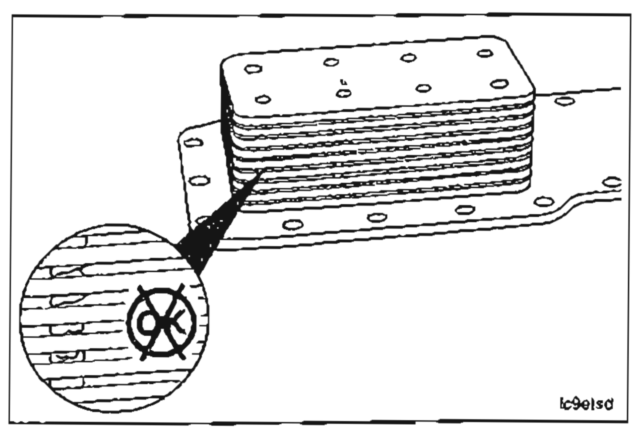
The cooler can be cleaned in a hot tank.

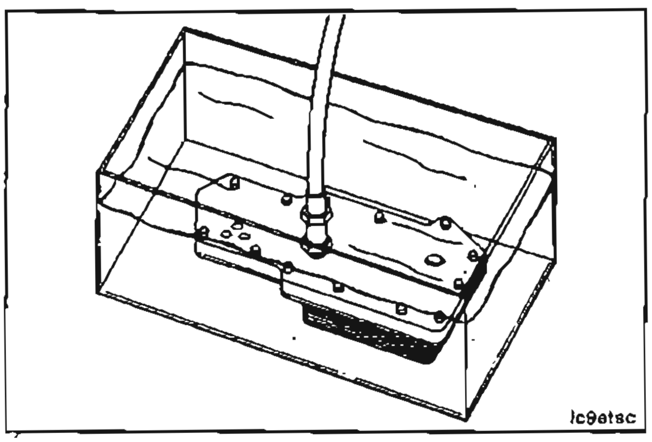
Back flush the oil passages with clean solvent and use compressed air to dry.



Oil Cooler - Inspection (7-07)

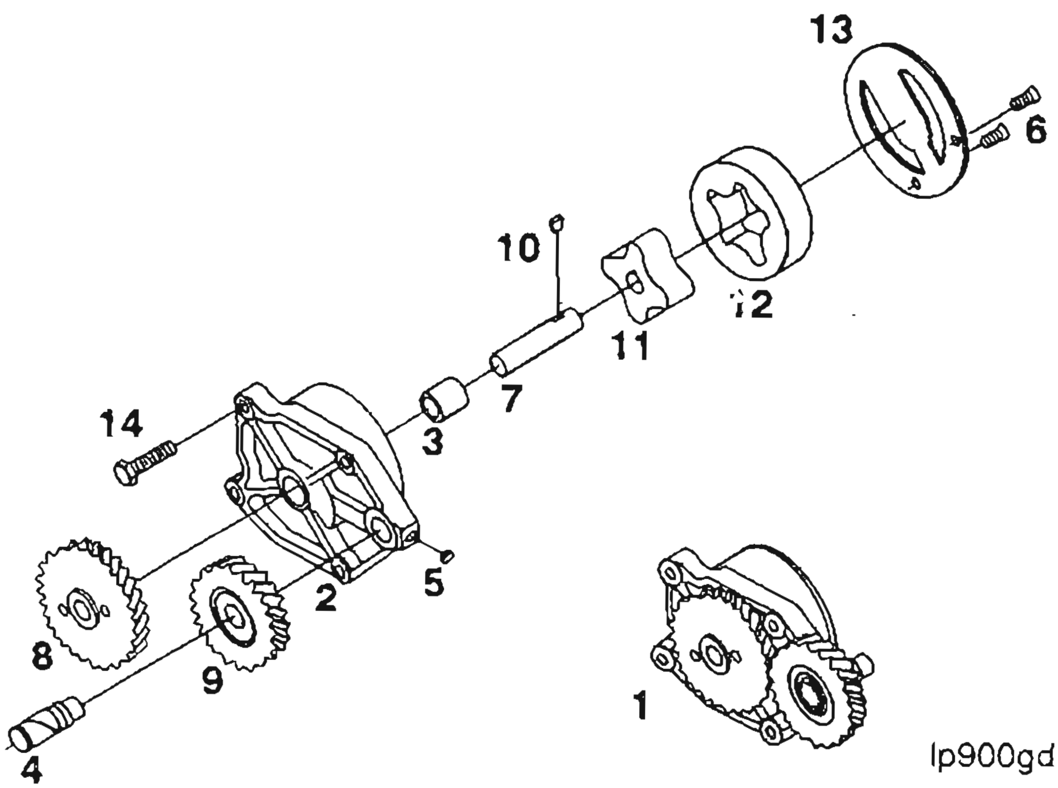
Inspect the soldered joints for corrosion or cracks.





Pressurize the cooler to 483 kPa [70 psi] and check for leaks by submerging in water.

Lubricating Oil Pump - Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Pump, Lube	1	(Note 1)
2	Body, Lube Pump	1	
3	Bearing, Sleeve	1	
4	Shaft, Lube Pump Idler	1	
5	Plug, Oil Rifle	1	
6	Screws	2	
7	Shaft, Lube Pump	1	
8	Gear, Lube Pump Drive	2	
9	Gear, Lube Pump Idler	1	
10	Key, Woodruff	1	
11	Gerotor, Driver	1	
12	Gerotor, Planetary	1	
13	Plate, Lube Pump Back	1	
14	Screw, Hex Hd Cap	4	M8-1.25x30

Note 1 Item 1 is available as an assembly only. Exploded view is shown for information purposes.

Lubrication Oil Pump - General Information

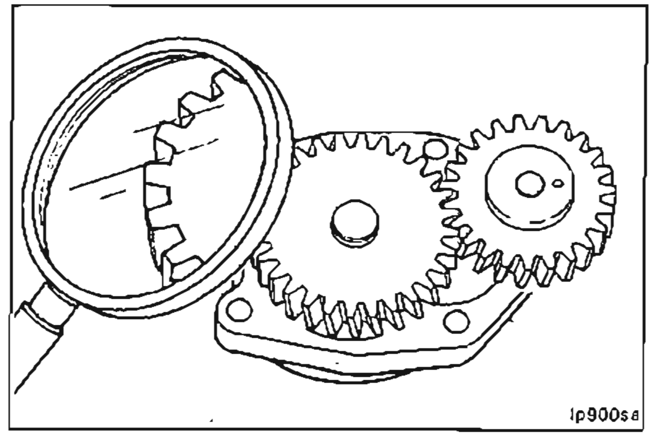
It is not practical to rebuild the gerotor pump. It can be reused if it meets the inspection criteria.

There are two basic B Series lubrication pumps one for the four cylinder and one for the six cylinder.

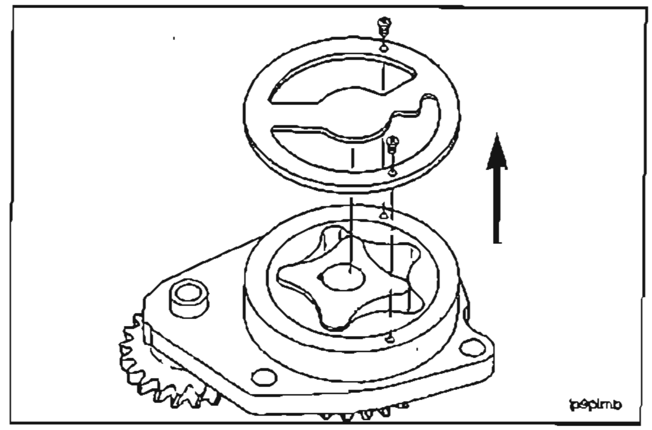
The gerotor width on the four cylinder pumps is narrower than in the six cylinder pumps.

Oil Pump - Inspection (7-08)

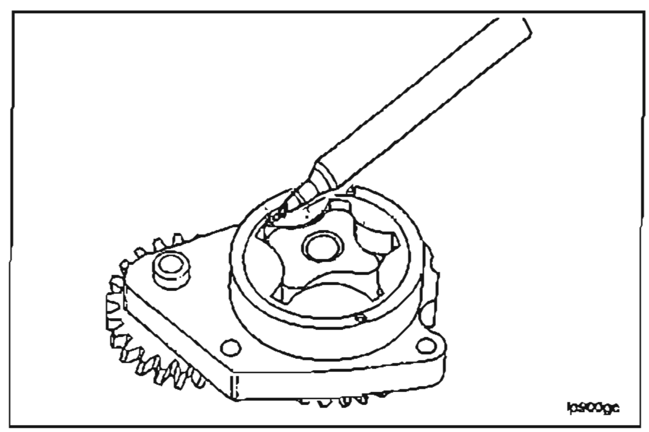
Visually inspect the lube pump gears for chips, cracks, or excessive wear.



Remove the sealing plate.

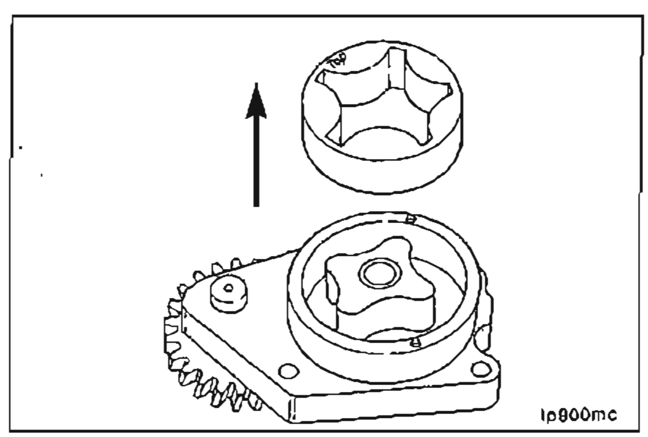


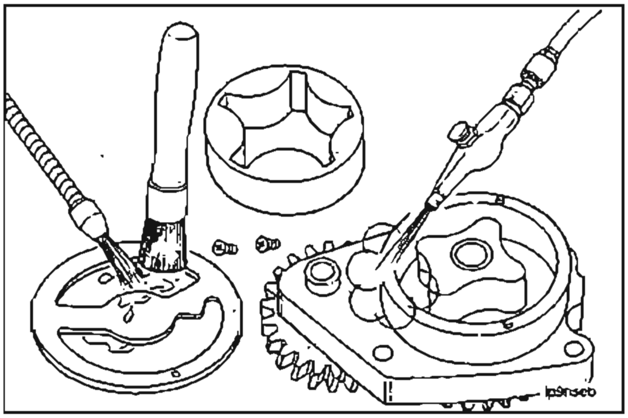
Mark "top" on the gerotor planetary.



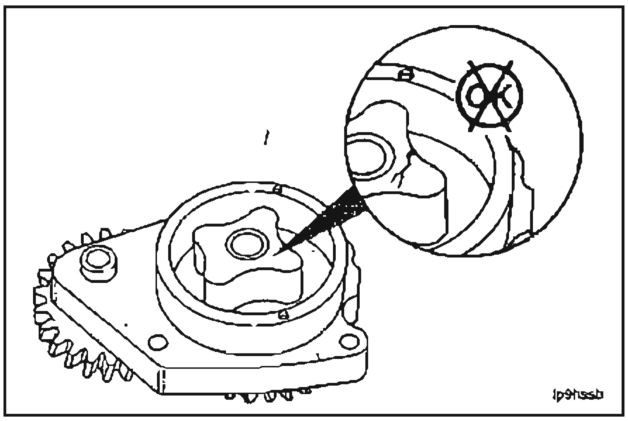
Remove the gerotor planetary.

Inspect for excessive wear or scoring.

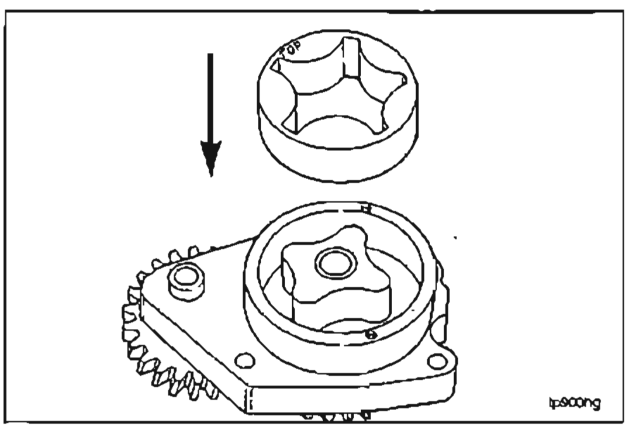




Clean all parts in solvent and use compressed air to dry.

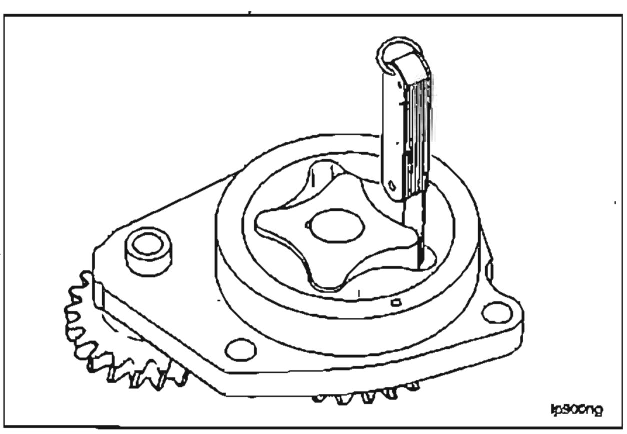


Inspect the pump housing and gerotor drive for damage and excessive wear.



Be sure the gerotor planetary is installed in the original position.

Install the gerotor planetary.

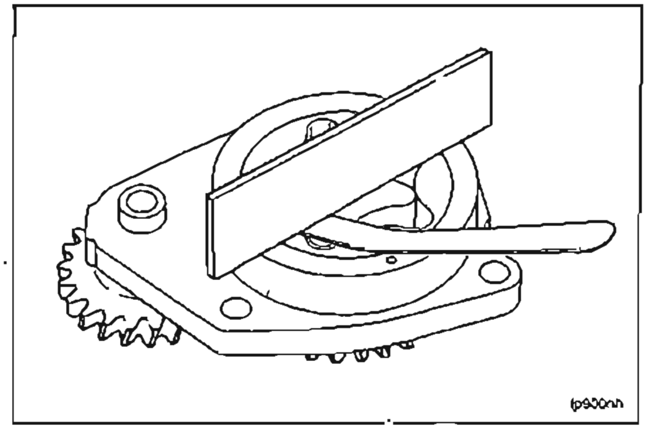


Measure the tip clearance.

Tip Clearance		
mm		in
0.1778	MAX	[0.007]

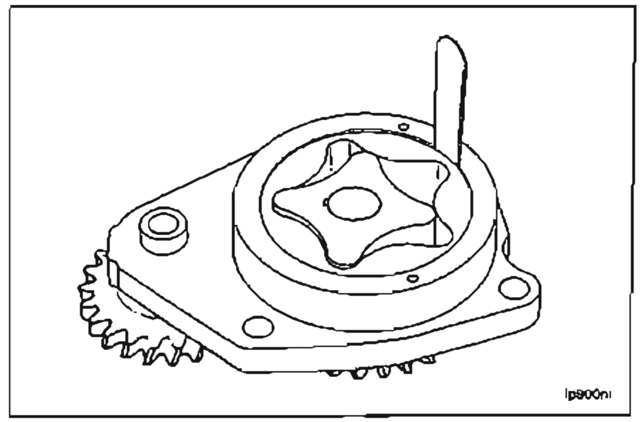
Measure the clearance of the gerotor drive/gerotor planetary to port plate.

Port Plate Clearance		
mm		in
0.127	MAX	[0.005]



Measure the clearance of the gerotor planetary to the body bore.

Body Bore Clearance		
mm		in
0.381	MAX	[0.015]

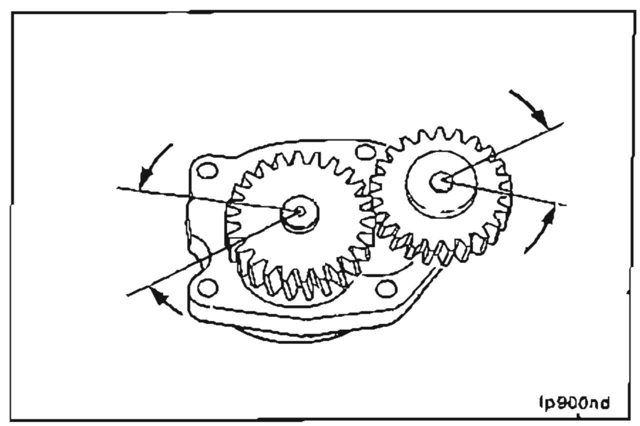


Measure the gears backlash.

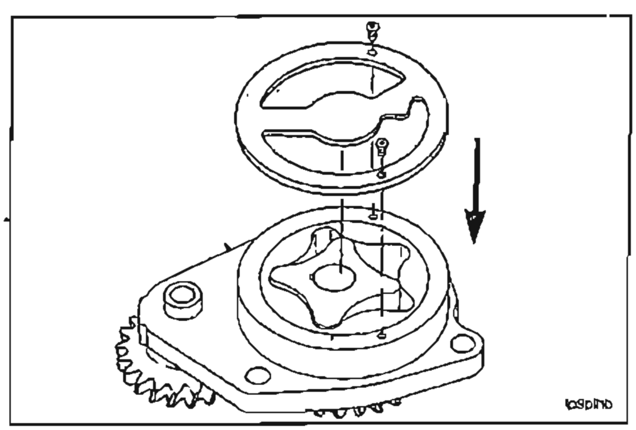
Limits for a "Used Pump"

0.076 0.33 mm
[0.003 0.013 in]

NOTE: Prevent movement of the adjoining gear when checking backlash or the reading will be the total of both gears.



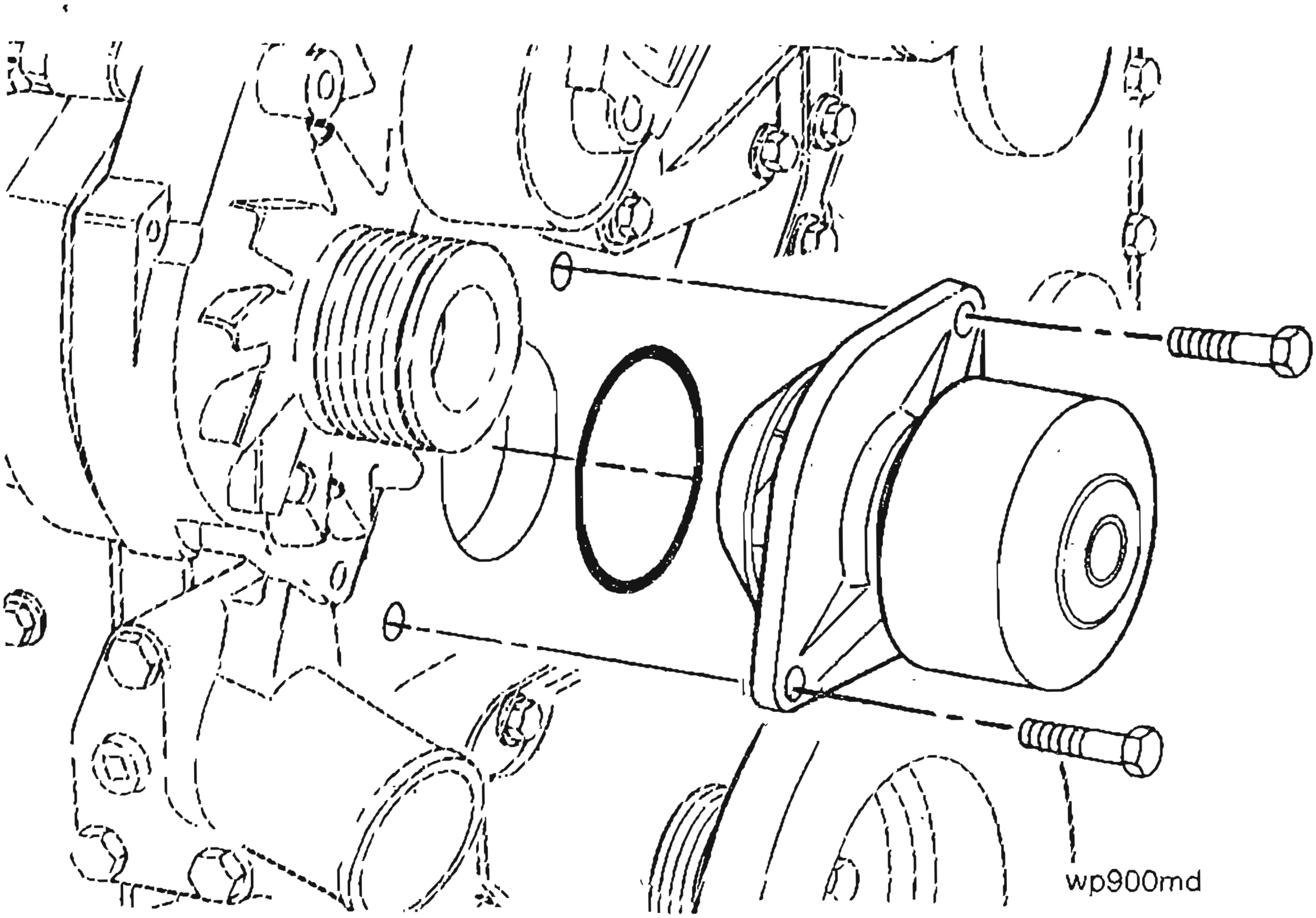
Install the lube pump back plate.



Section 8 - Cooling System - Group 8

Section Contents

Water Pump - Exploded View



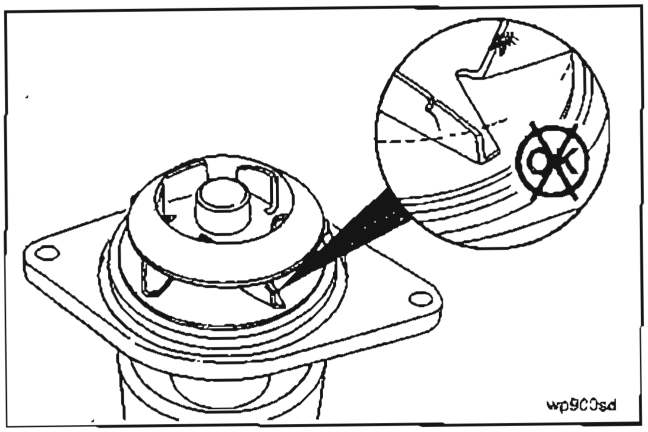
Ref. No.	Part Name	Qty.	Remarks
1	Pump, Water	1	
2	Seal, Rectangular Ring	1	5.16 mm Thick
3	Screw, Hex Hd Cap	2	M8-1.25x22

Water Pump - General Information

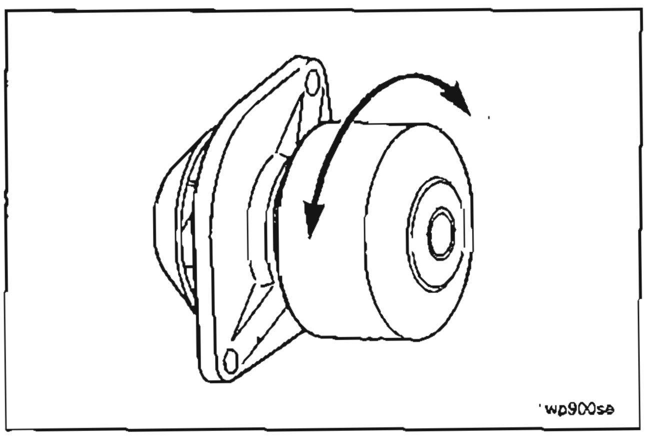
The water pump is a belt driven, centrifugal type pump with the inlet and bypass line as an integral part of the cylinder block.

It is not practical to replace the parts in the pump, the water pump is serviced as an assembly ReCon® water pumps are available from Cummins Distributors and Dealers.

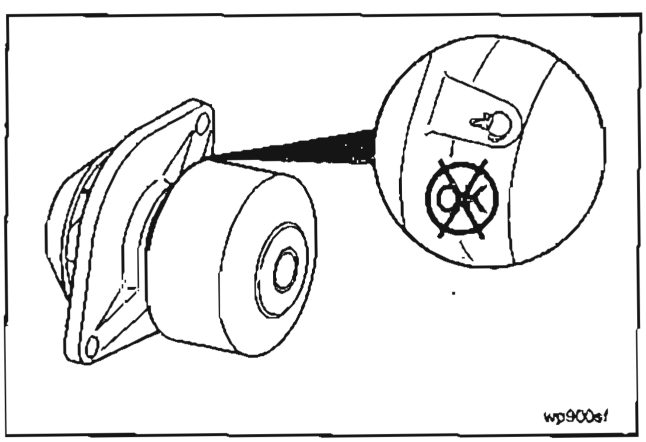
Water Pump - Inspection (8-01)



Inspect the impeller blades for wear or corrosion.



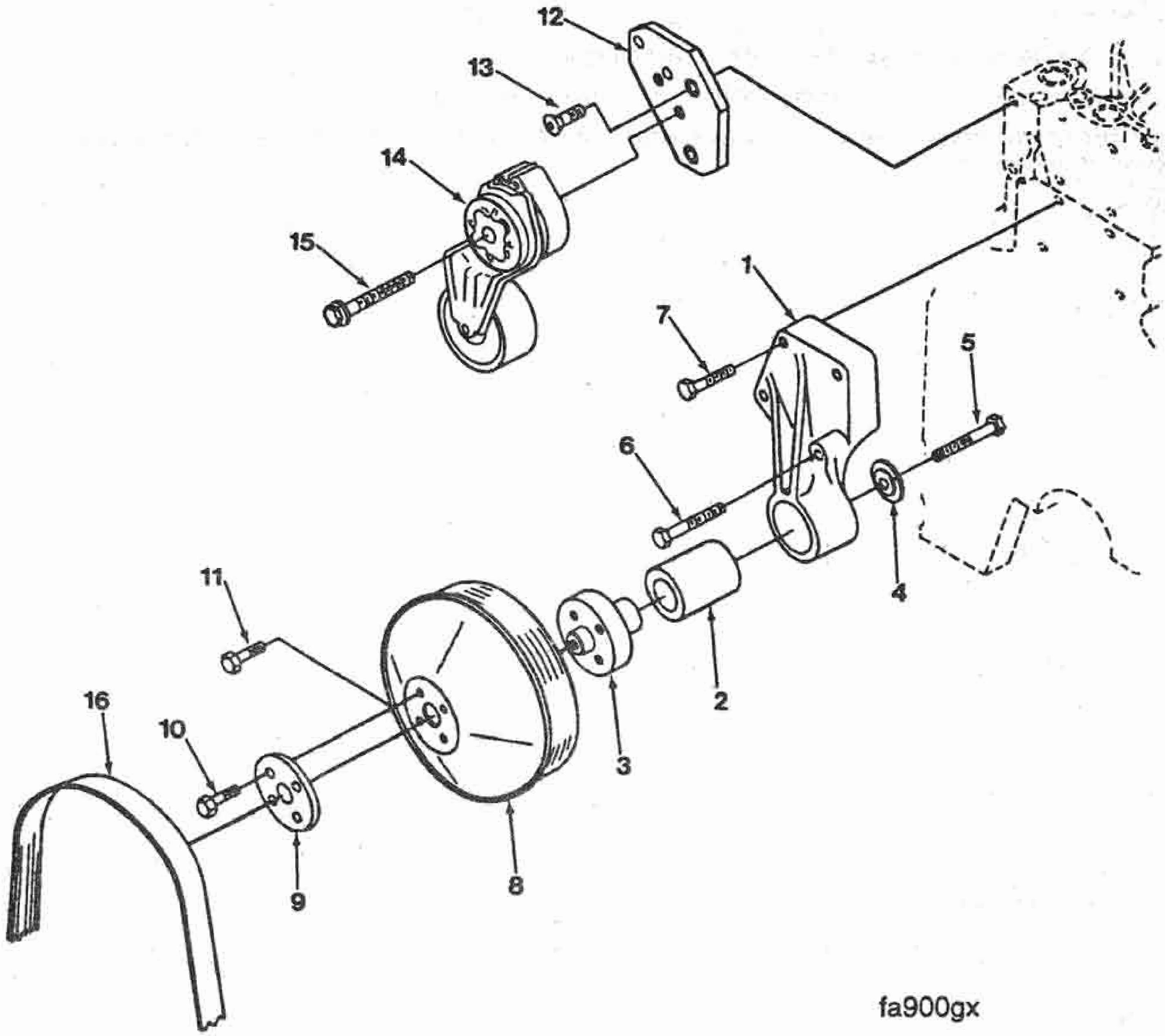
Inspect for free rotation of the pump.



Check the weep hole for evidence that the seal has been leaking.

Parts replacement is not practical: the water pump is serviced as an assembly.

Belt Tensioner and Fan Hub - Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Support, Fan	1	Mounts to block.
2	Bearing, Ball	1	
3	Hub, Fan	1	27.0 mm Thick, 25.4 mm Dia. Shaft
4	Retainer, Fan	1	
5	Screw, Hex Hd Cap	1	M12-1.75x70 mm
6	Screw Hex Hd Cap	1	M8-1.25x75 mm
7	Screw, Hex Hd Cap	3	M8-1.25x30 mm
8	Pulley, Fan	1	
9	Plate, Clamping	1	
10	Screw, Cap	4	M8-1.25x20 mm
11	Screw, Cap	4	M8-1.25x16 mm
12	Bracket, Belt Tens.	1	
13	Screw, Flat Head Cap	2	M8-1.25x25
14	Tensioner, Belt	1	
15	Screw, Hex Hd Cap	1	M10-1.5x61.86 mm
16	Belt, V-ribbed	1	1524 mm Long

Belt Tensioner and Fan Hub - General Information

Belt Tensioner

The only practical repair for tensioners is pulley replacement.

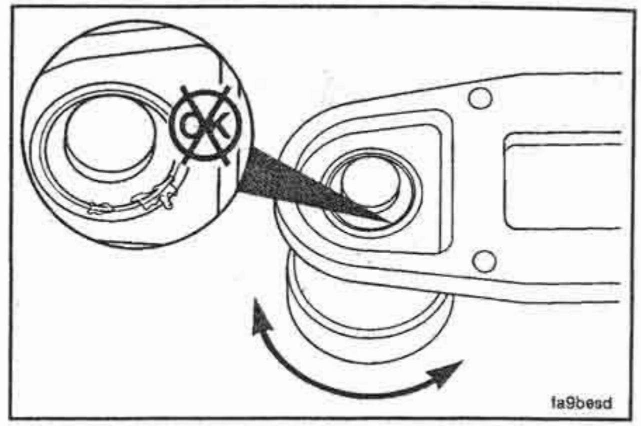
Slight variations exist in the pulley removal and installation for each pulley version.

If the pulley exhibits excessive wear a special service tensioner is available which features a hardened pulley with increased resistance to wear

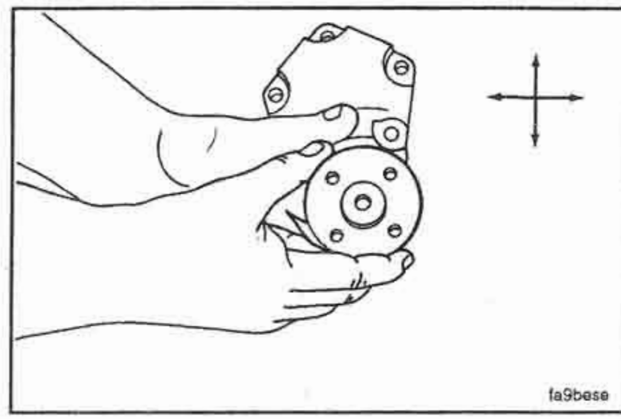
Fan Hub - Inspection (8-02)

Inspect for free rotation of the fan hub shaft.

Check the end of the bearing for evidence that the lubricant has leaked. Rebuild or replace as required.



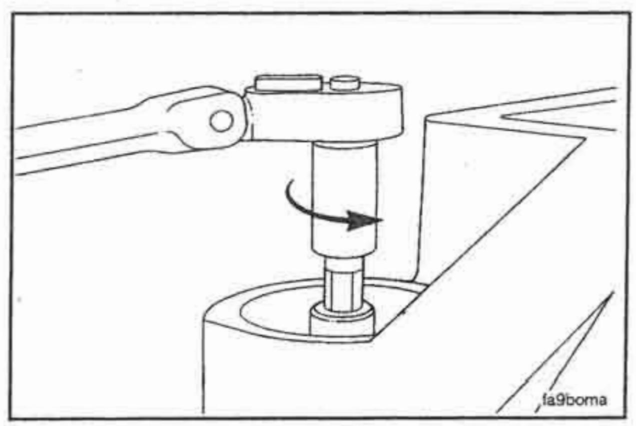
Inspect the fan hub bearing for wear. The bearing should have a minimal amount of side to side or end play movement. Replace the bearings if more than a minimal amount can be felt.



Fan Hub - Disassembly (8-03)

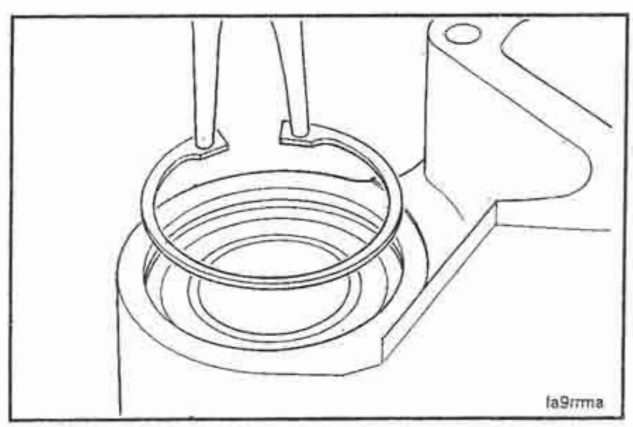
16 mm

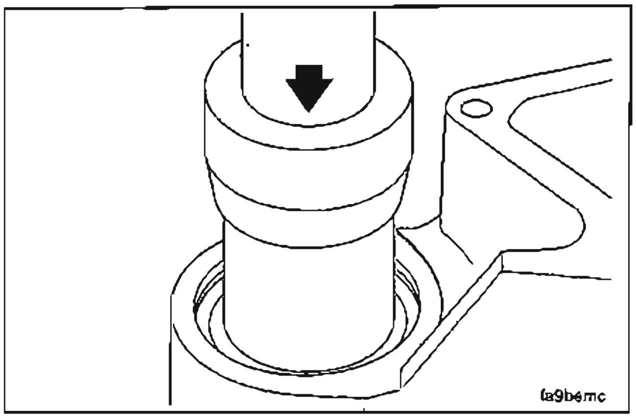
Secure fan hub and remove the center bolt and retainer.



Snap Ring Pliers

If the assembly is equipped with snap rings, remove the snap ring as illustrated.

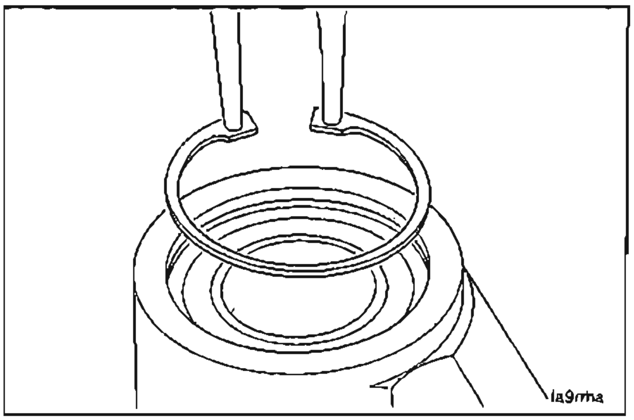




1 inch Drift

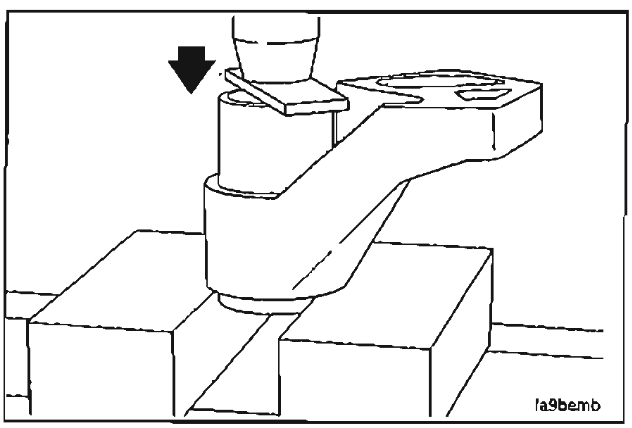
Support the fan hub bracket housing and press out the shaft/hub.

Approximately 6 tons of pressure is required.



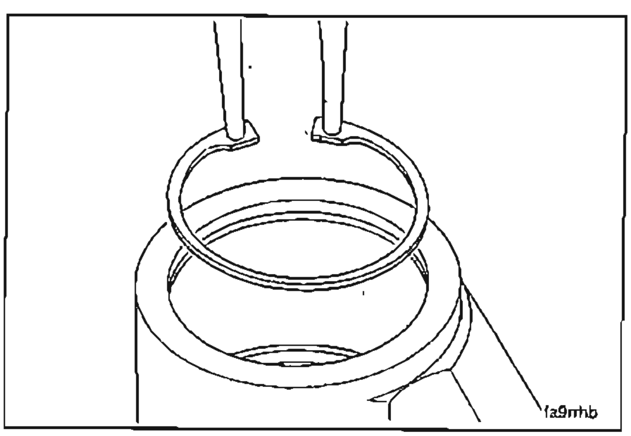
Snap Ring Pliers

Turn the bracket housing over and remove the snap ring if so equipped.



2 Inch Pipe

Press on the O.D. of the bearing to remove from the housing.



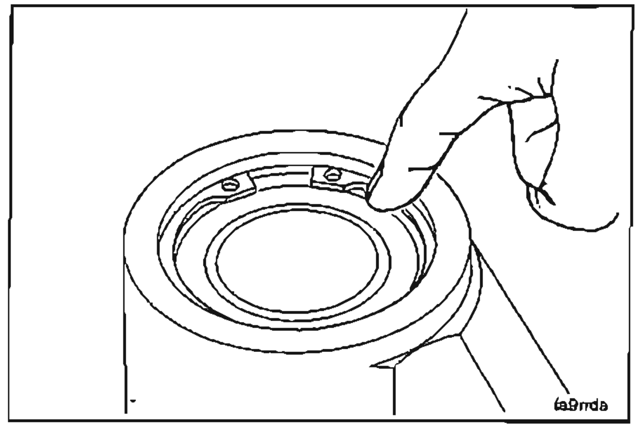
Fan Hub Assembly (8-04)

Snap Ring Pliers

If the bracket housing is equipped for snap rings, install the front snap ring.

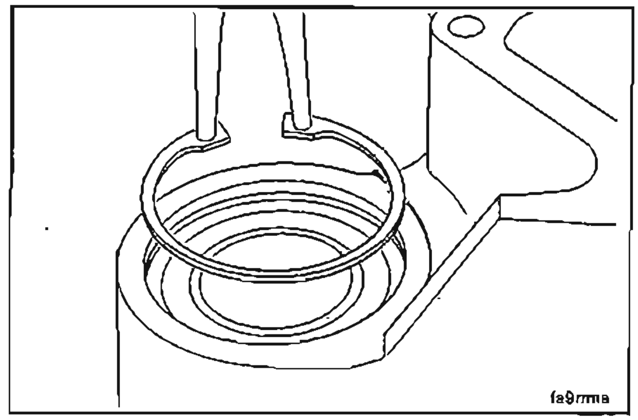
2 Inch Pipe

Press the bearing flush with the front of the housing or to the snap ring.

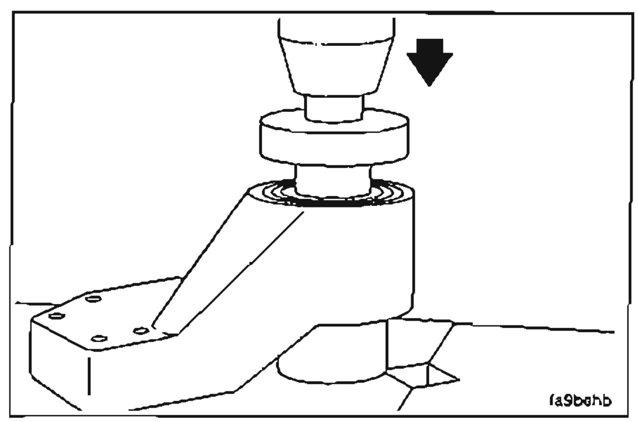


Snap Ring Pliers

Install the second snap ring if so equipped.

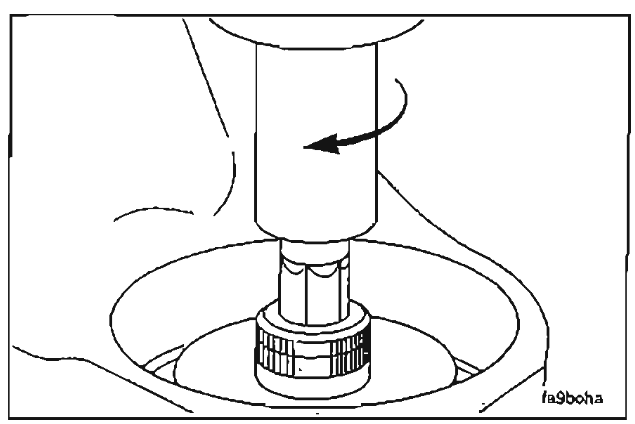


Supporting the bearing inner race with a 1.25 inch pipe coupling, press the hub/shaft in until it bottoms on the bearing.

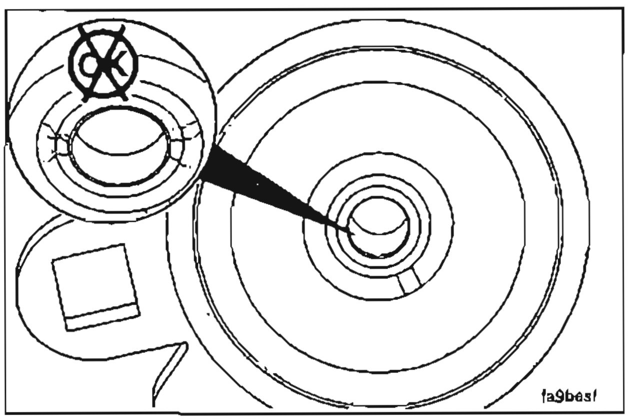


16 mm

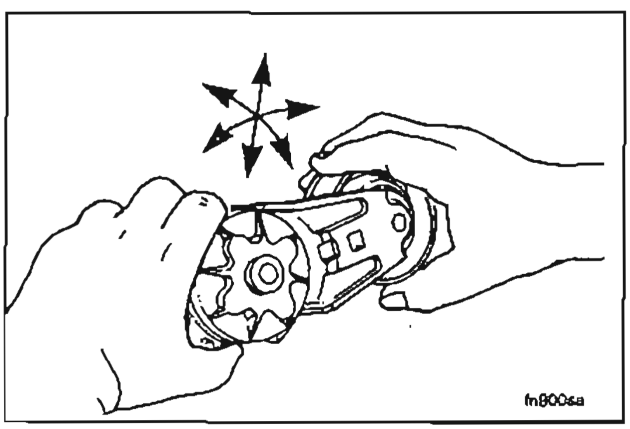
Secure the assembly and install the retainer and center bolt. Tighten to 77 N•m [57 ft-lb].



Belt Tensioner - Inspection (8-05)

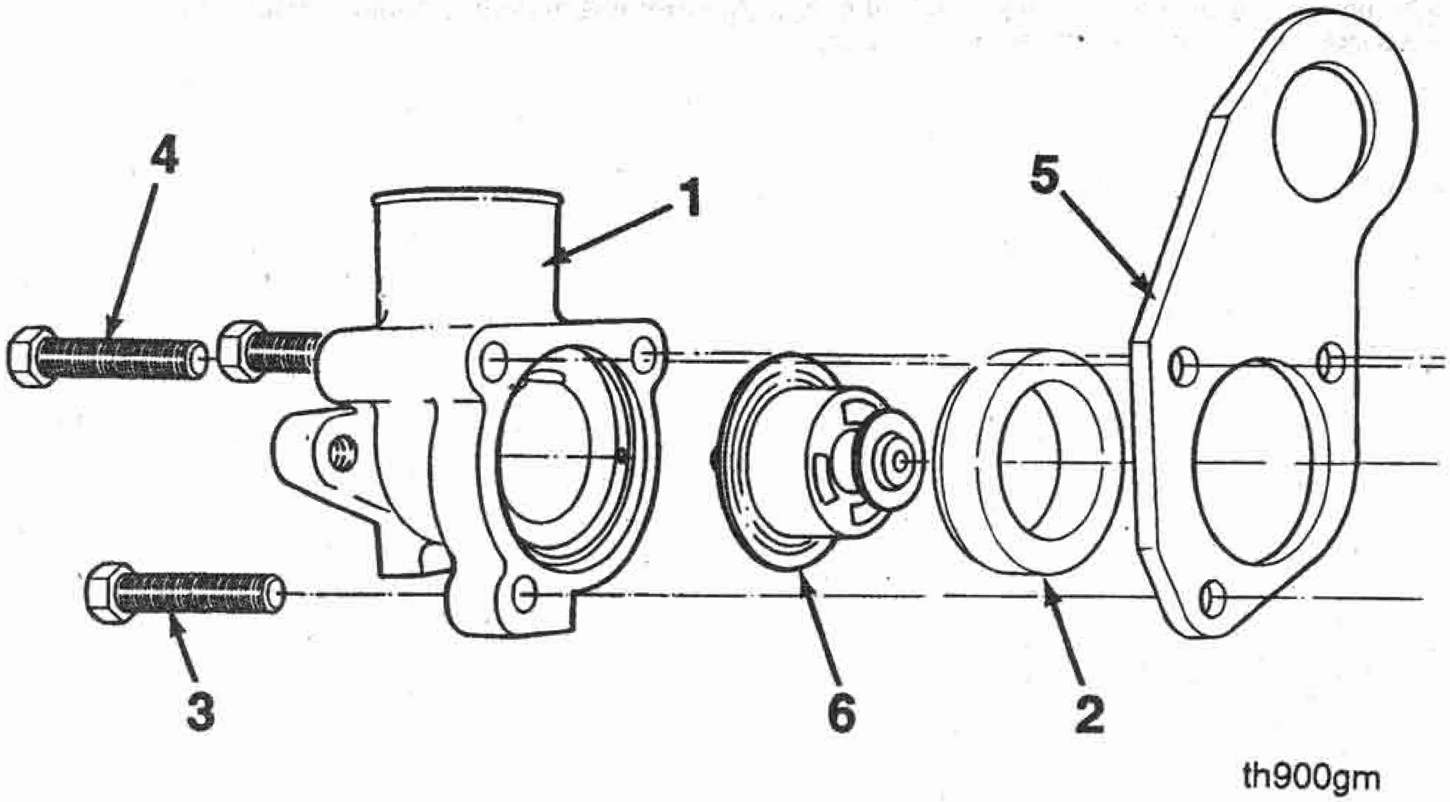


Inspect the pivot tube area of the tensioner for excessive wear evidenced by an elongated hole. If the tensioner exhibits excessive wear, it must be replaced.



Roll the bearing and check that it rotates freely with no rough spots.

Thermostat Housing Assembly - Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Housing, Thermostat	1	
2	Gasket, Thermostat Housing	1	
3	Screw, Hex Hd Cap	1	M8-1.25x35
4	Screw, Hex Hd Cap	2	M8-1.25x70
5	Bracket, Lifting	1	
6	Thermostat Coolant	1	

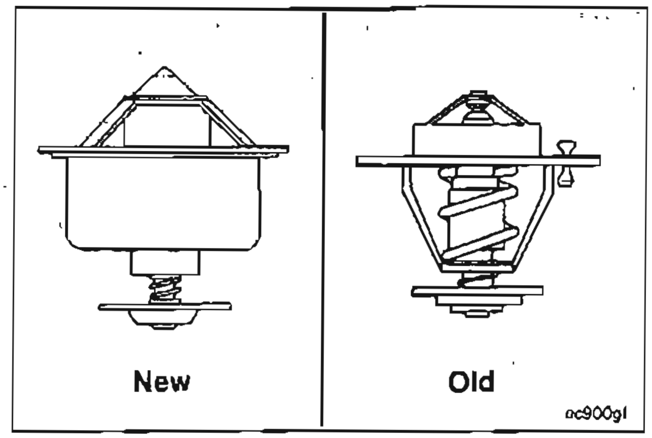
Thermostat Housing Assembly - General Information

A pressure balanced thermostat is used on the B Series.

No special orientation is required with the new thermostat. The thermostat is compatible with thermostat housings which have a groove cut for the old thermostat tang.

Thermostat - Inspection (8-06)

Visually inspect the thermostat for obvious damage such as obstructions caused by debris, broken springs, or stuck or missing vent pins.

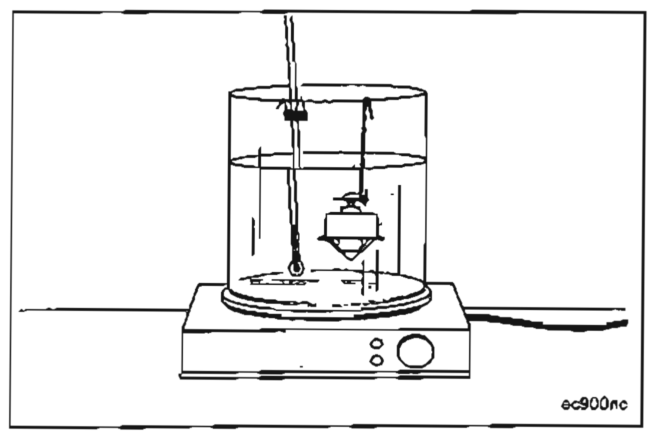


The thermostat can be checked for correct operation.

Requirements

Start to open at 83°C [181°F].

Fully open at 95°C [203°F].



General Information About Fans

Warning: Never attempt to rotate the engine by pulling or prying on the fan. This practice can result in serious personal injury and damage to the fan. Use only the proper engine barring techniques to manually rotate the engine.

Check the fan for missing balance weights at each regular maintenance interval. Do not attempt to repair broken or bent fans, or fans with missing balance weights.

Most equipment that has a Cummins engine uses a radiator and a fan. The radiator and fan transfer heat from the cooling water to the atmosphere. The fan selection process **must** conclude that the fan, the fan mounting arrangement, and the fan drive system are designed and matched for compatibility

Upon request, Cummins Application Engineering Department will assist in determining the proper selection. Refer any fan changes other than the direct replacement of a fan with precisely the same Cummins part number to the Cummins Application Engineering Department for prior approval.

Examples that require approval are,

1. Using an approved fan from one engine model on a different engine model.
2. Using an approved fan on an engine with a different fan mounting arrangement.
3. Using an approved fan on an engine with a different fan drive arrangement.
4. Converting an engine from one market model to another An example is the conversion of a G-drive engine to a power unit application.
5. Converting an engine model to a different model. An example is converting a 6BT5.9 to a 6BTA5.9.

This list is **not** inclusive. **Always** contact Application Engineering for assistance.

At times an existing fan can yield ONLY marginal cooling capability when being considered for a new application.

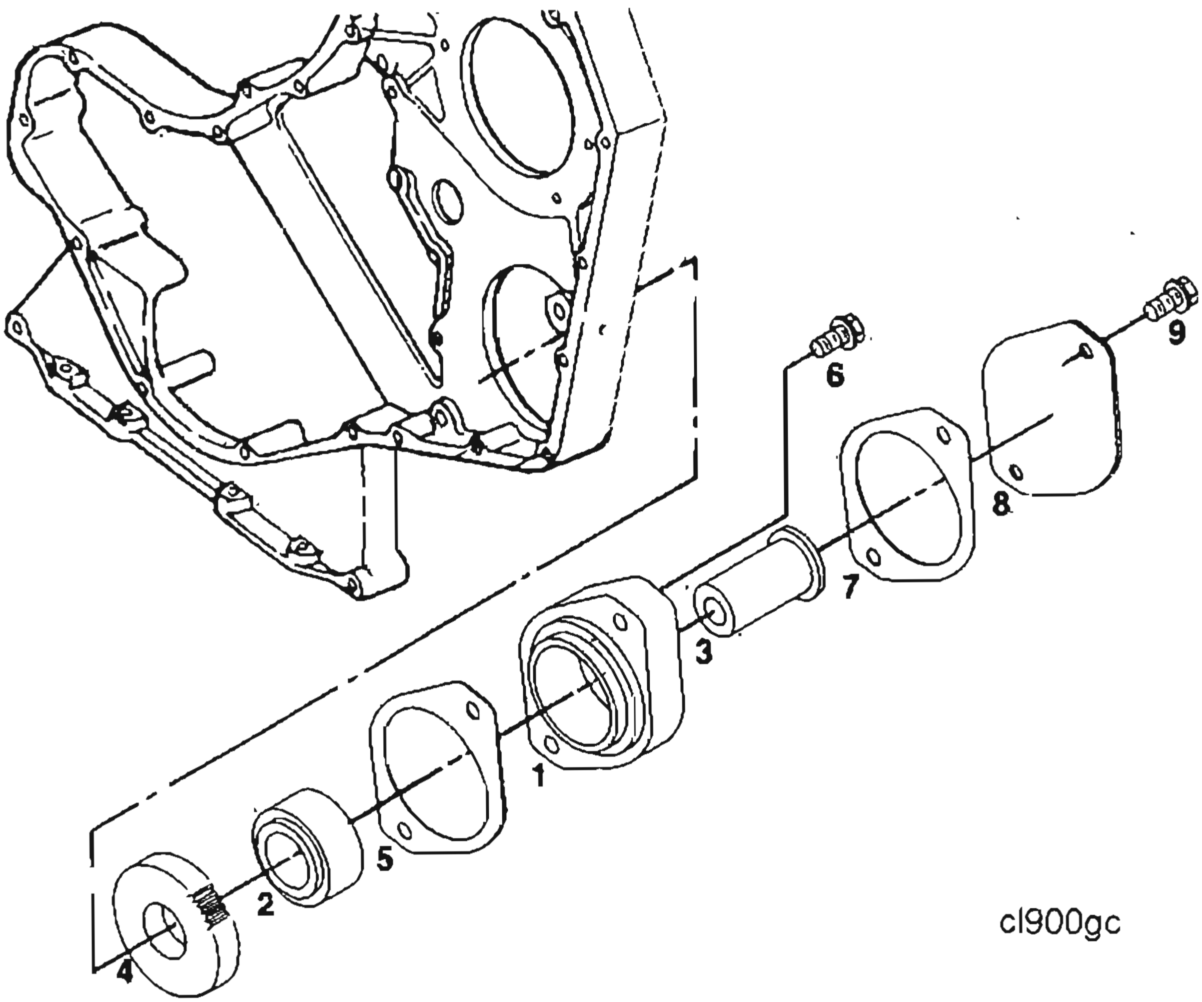
Caution: Never repitch (bend) the blades to obtain additional air delivery. Bending the blades or spider creates stress in the material used for the construction of the fan. Repitching (bending) will cause fan failure. The proper diameter fan must be selected. Never modify an existing fan.

Application Engineering will provide assistance in the selection of a fan with the correct pitch and diameter for proper cooling.

Section 9 - Drive Units - Group 9

Section Contents

Accessory Drive Adapter - Exploded View

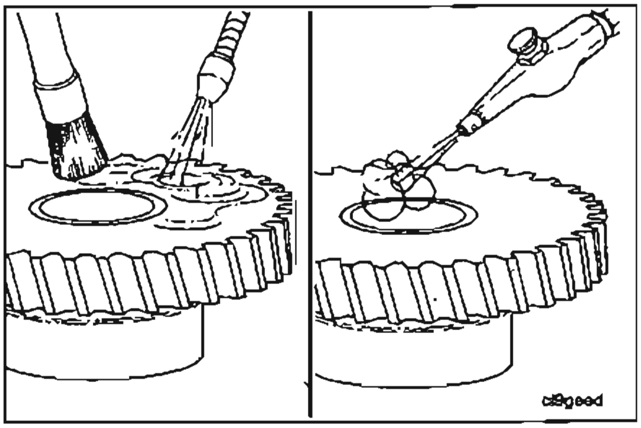


Ref. No.	Part Name	Qty.	Remarks
1	Adapter, Accessory Drive	1	
2	Bearing	1	
3	Shaft, Accessory Drive	1	
4	Gear, Accessory Drive	1	
5	Gasket, PTO Drive Cover	1	
6	Screw, Hex Hd Cap	2	
7	Gasket, PTO Drive Cover	1	
8	Plate, PTO Drive Cover	1	
9	Screw, Hex Hd Cap	2	

Drive Units - General Information

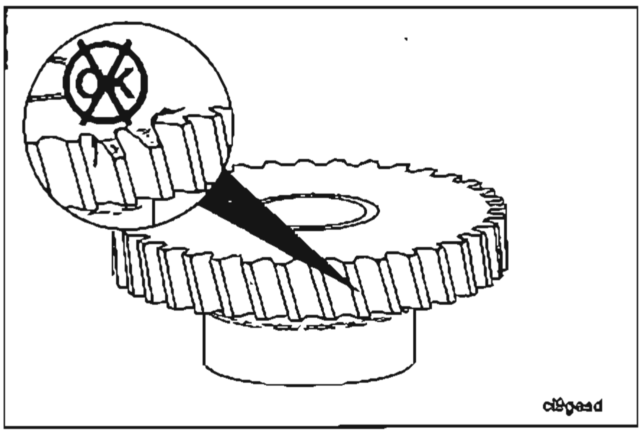
Accessory Drive Adapter

A gear driven adapter provides accessory drive capability of up to 142 N•m [105 ft. lb.] of torque. The accessory drive is equipped with either SAE A or B flange adapters.



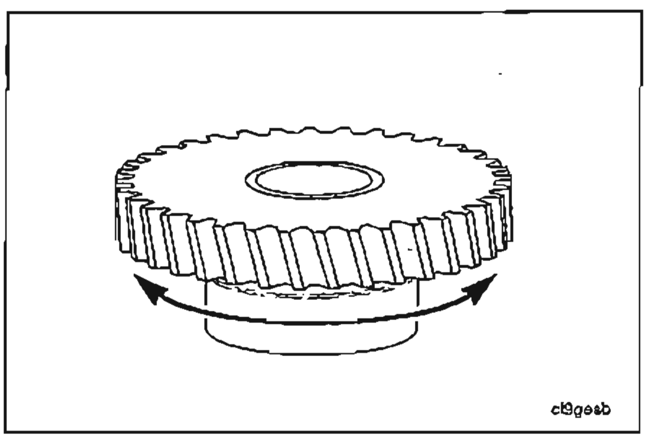
Accessory Drive - Cleaning (9-01)

Clean the Accessory Drive with clean solvent and blow dry with compressed air.

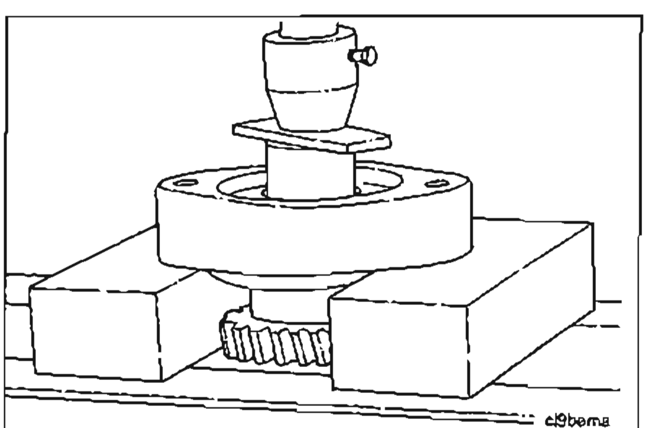


Accessory Drive - Inspection (9-02)

Visually inspect for obvious damage such as cracks, broken teeth and damaged threads.



Rotate the gear and inspect for rough spots in the bearing and excessive wear.



Accessory Drive Adaptor - Disassembly (9-03)

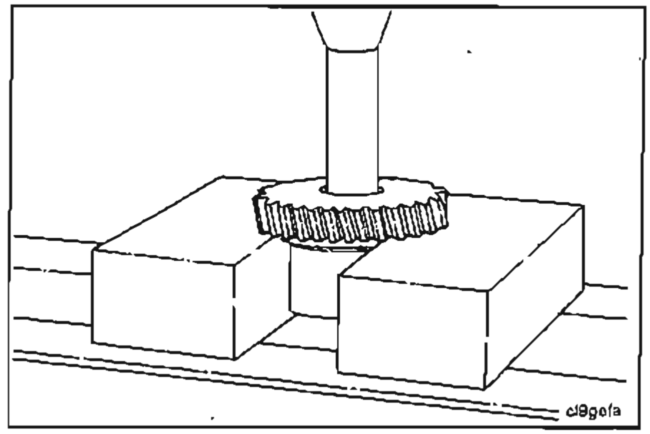
1.25 inch Pipe Coupling

Support the housing. Press the bearing, shaft, and gear assembly from the housing.

Approximately 4 tons of force is required.

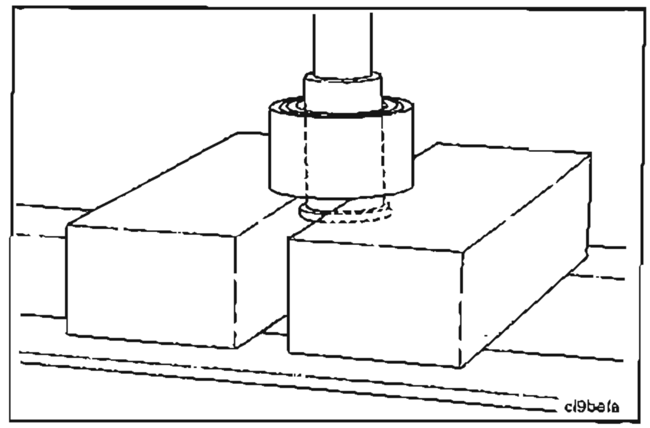
1 inch Drift

Press the shaft and bearing assembly out of the gear.



1 inch Drift

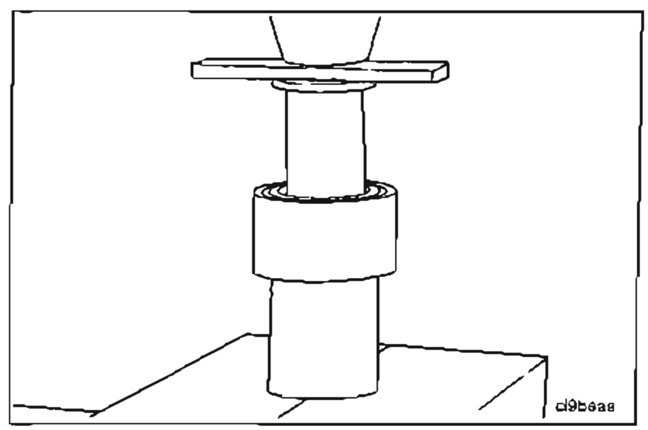
Support the bearing assembly and press the shaft from the bearing.



Accessory Drive Adaptor - Assembly (9-04)

1.25 inch Pipe Coupling

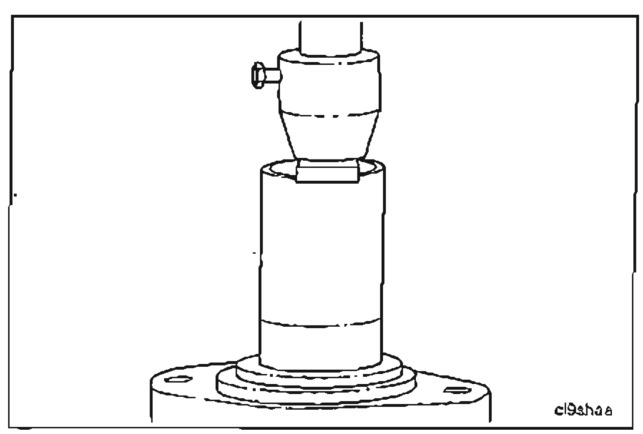
Support the inner race of the new bearing and press the shaft into the bearing until the shaft bottoms on the inner race.

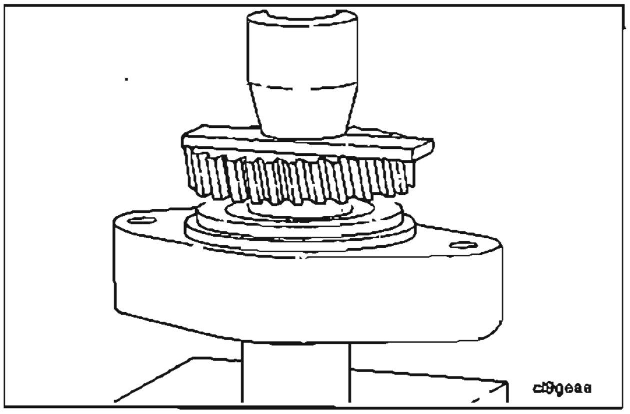


2 inch Pipe

Caution: Press on the outer race of the bearing assembly. Pressing on the inner race will damage the bearing.

Support the housing and press the bearing and shaft assembly in until it bottoms.





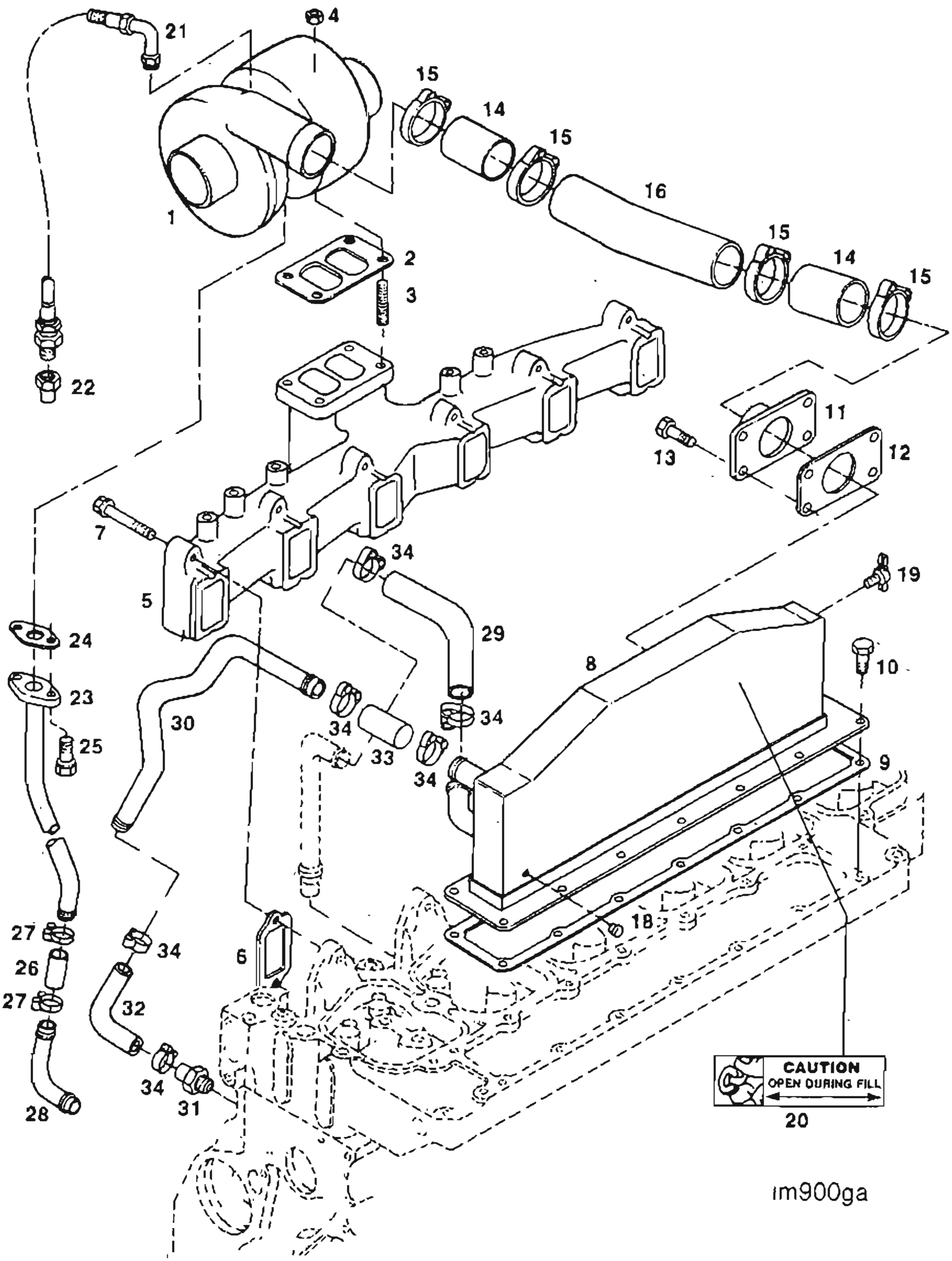
1.25 inch Pipe Coupling

Support the bottom of the shaft with a 1.25 inch pipe coupling and press the gear on until it bottoms against the inner-bearing race.

Section 10 - Air Intake System - Group 10

Section Contents

Air Intake System - Exploded View



Ref. No.	Part Name	Req.	Remarks
1	Turbocharger	1	
2	Gasket, Turbocharger	1	
3	Stud	4	
4	Nut, Hexagon Flange	4	
5	Manifold, Exhaust	1	
6	Gasket, Exhaust Manifold	6	
7	Screw, Hexagon Head Cap	12	M10 1.5 x 70mm
8	Aftercooler	1	
9	Gasket, Int Manifold Cover	1	
10	Screw, Hexagon Head Cap	14	M8 1.25 x 26mm
11	Connection, Air Crossover	1	
12	Gasket, Connection	1	
13	Screw, Hexagon Head Cap	4	M8 1.25 x 25mm
14	Hose, Plain	2	
15	Clamp, Hose	4	
16	Tube, Air	1	
18	Plug, Pipe	1	
19	Draincock	1	
20	Decal	1	
21	Hose, Flexible	1	
22	Connector Female	1	
23	Connection, Tur Oil Drain	1	
24	Gasket, Oil Drain	1	
25	Screw, Hexagon Head Cap	2	M8 1.25 x 20mm
26	Hose, Plain	1	
27	Clamp, Hose	2	
28	Tube, Tur Oil Drain	1	
29	Hose, Elbow	1	
30	Tube, Aftercooler	1	
31	Coupling, Plain Hose	1	
32	Hose, Molded	1	
33	Hose, Plain	1	
34	Clamp, Hose	6	

Air Intake System - General Information

The air intake system for the B Series turbocharged and aftercooled engines, Models 4BTA3.9 and 6BTA5.9, consists of the aftercooler and connections, air crossover hardware, turbocharger, and associated hardware.

The turbocharged engines, Models 4BT3.9 and 6BT5.9 use a manifold cover in place of the aftercooler.

The air intake system for the naturally aspirated engines, Models 4B3.9 and 6B5.9 consists of the manifold cover mounted to the intake manifold in the cylinder head.

The air intake system for the B Series automotive engines, Models B3.9 and B5.9, consists of the turbocharger, the charge air cooler, turbocharger-to-charge air cooler hardware, charge air cooler-to-intake manifold cover hardware, intake manifold cover, and associated hardware. On the higher horsepower ratings of the B5.9 engine, the turbocharger is equipped with a wastegate which limits the amount of boost pressure.

The turbocharger is cooled and lubricated with engine oil from the engine lubricating system.

The instructions for rebuilding the turbocharger are printed in Turbocharger Shop Manual Bulletin No. 3810321

Caution: If the engine experiences a turbocharger failure or any other occasion where oil or debris can enter the charge air cooler (CAC), the CAC must be cleaned (refer to Procedure 10-06).

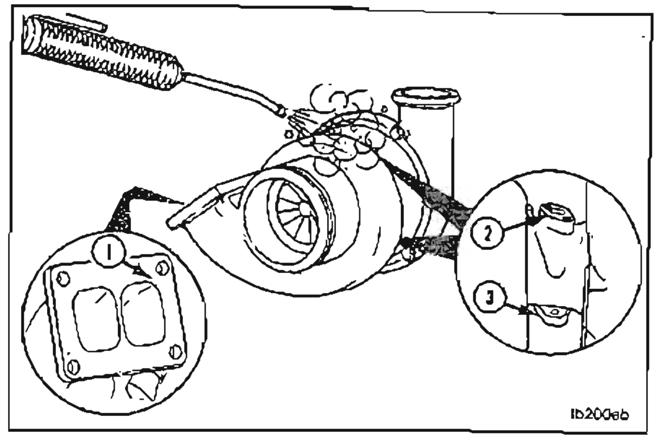
Turbocharger - Cleaning and Inspection for Reuse (10-01)

Remove all carbon deposits and gasket material from surfaces (1), (2), and (3).

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

Caution: Tape or plug all openings to prevent solvent or steam from damaging the oil cavities in the turbocharger.

Use solvent or steam to clean the exterior of the turbocharger. Dry with compressed air.



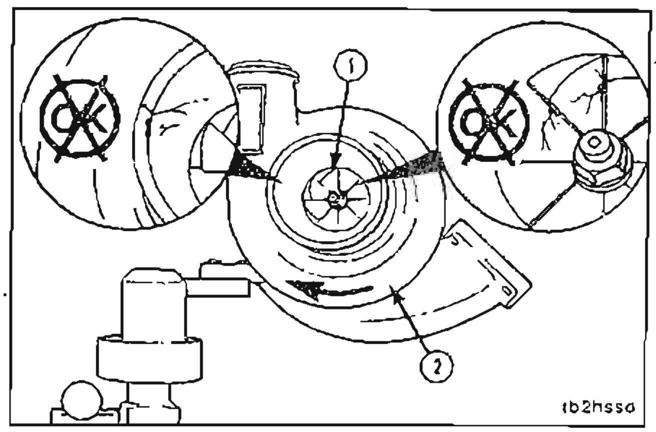
Inspection

Visually inspect the housings for damage.

Visually inspect the turbine wheel and compressor impeller (1) for fretting, cracked or broken vanes.

Turn the impeller in the direction shown with arrow (2), to inspect the turbine shaft for freedom of rotation. The shaft **must** rotate freely.

Replace damaged parts.

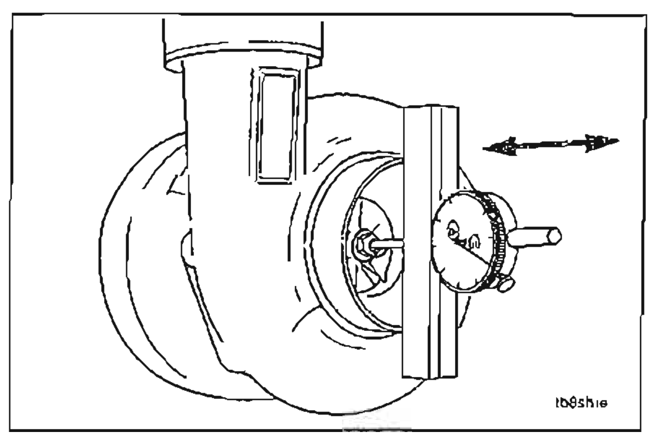


Measure the turbocharger shaft end clearance with the Part No. ST-537 Dial Depth Gauge.

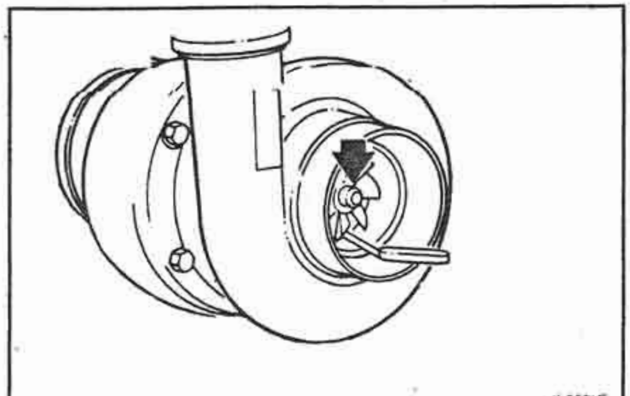
Push the rotor assembly away from the gauge.

Set the gauge on zero.

Push the rotor assembly toward the gauge and record the data.



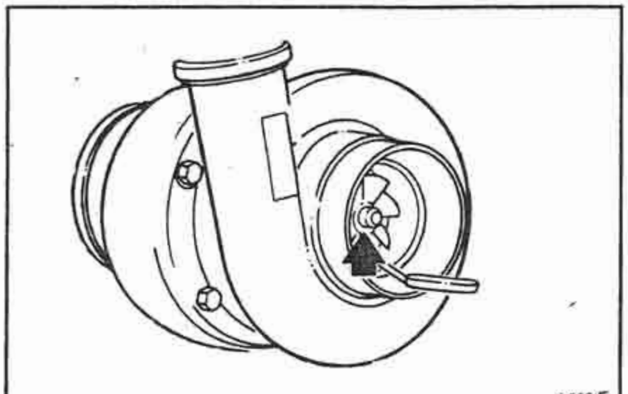
End Play		
mm		in
0.03	MIN	[0.001]
0.08	MAX	[0.003]


tb2001E

Push the compressor impeller by hand toward the compressor housing.

Install a wire feeler gauge, at the minimum clearance point, between the impeller and the housing to measure the clearance.

Record this clearance.


tb2001F

With the feeler gauge in the same location, push the turbine wheel by hand away from the compressor housing.

Install a wire feeler gauge, at the same point.

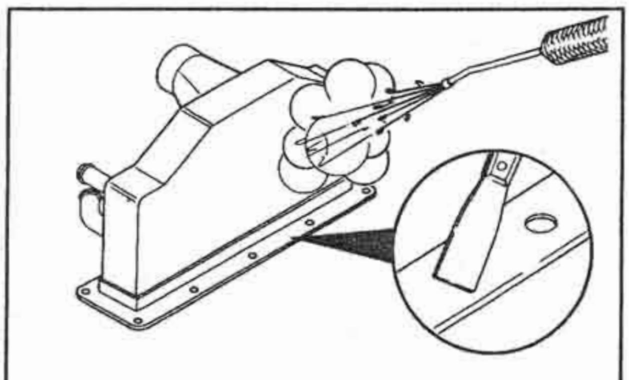
Record this clearance.

Subtract the smaller from the larger clearance.

Radial Clearance		
mm		in
0.30	MIN	[0.012]
0.46	MAX	[0.018]

If the radial clearance does **not** meet the above specifications, the turbocharger **must** be rebuilt. Refer to Turbocharger Components Shop Manual, Bulletin No. 3810321 for rebuild instructions.

Aftercooler Assembly - Cleaning and Inspection for Reuse (10-02)

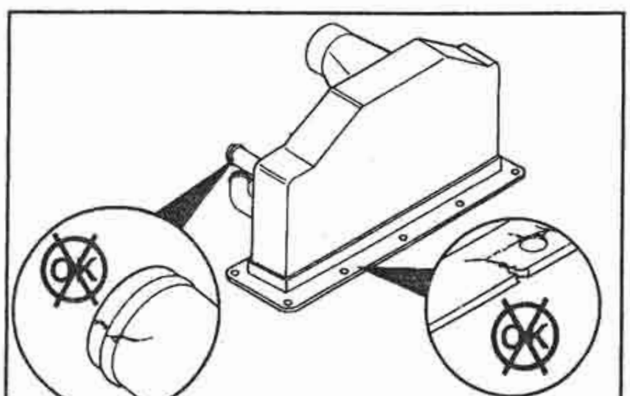

at900eb

Remove all gasket material from the mounting surfaces.

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

Use solvent or steam to clean the aftercooler assembly. Dry with compressed air.

Inspection



at900sb

Visually inspect the aftercooler assembly for cracks or damage. Replace if damaged.

Pressure Test the Aftercooler Core

Install the hose, hose clamps, and solid pipe plug (1) onto the inlet tube.

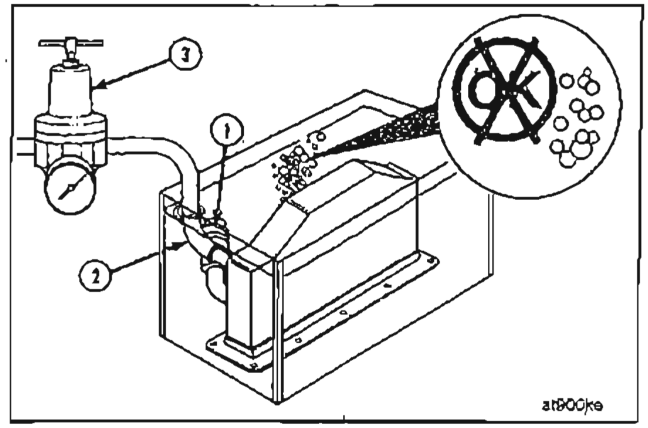
Install the hose and hose clamps (2), and air pressure gauge (3) onto the outlet tube.

Connect the air pressure gauge to a regulated air supply.

Air Pressure: 552 kPa [50 psi]

Submerge the aftercooler in a tank of water.

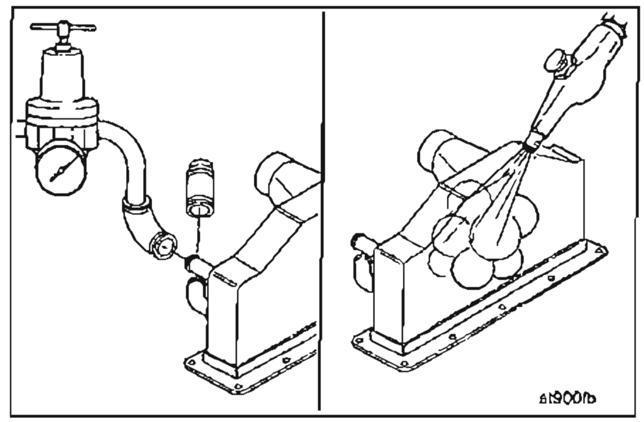
If air bubbles appear, the core is damaged and the aftercooler **must** be replaced.



Remove the aftercooler from the water tank.

Remove the test equipment.

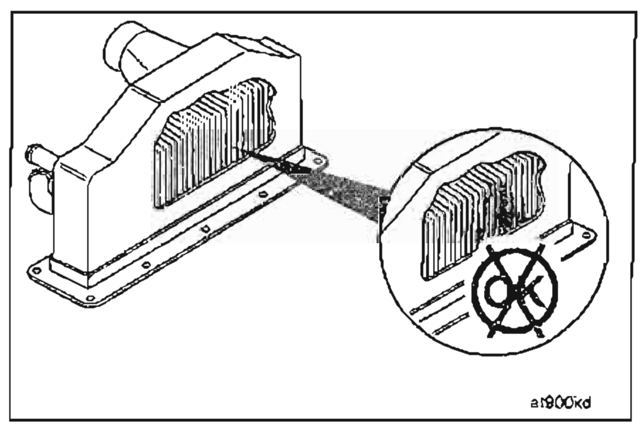
Use compressed air and dry the aftercooler.



Aftercooler Assembly - Rebuild (10-03)

Caution: The aftercooler is a unitized assembly and cannot be rebuilt. Any attempt to repair the aftercooler core will reduce the coolant flow and cause future engine damage.

Refer to Aftercooler Assembly Cleaning and Inspection for Reuse (10-02).

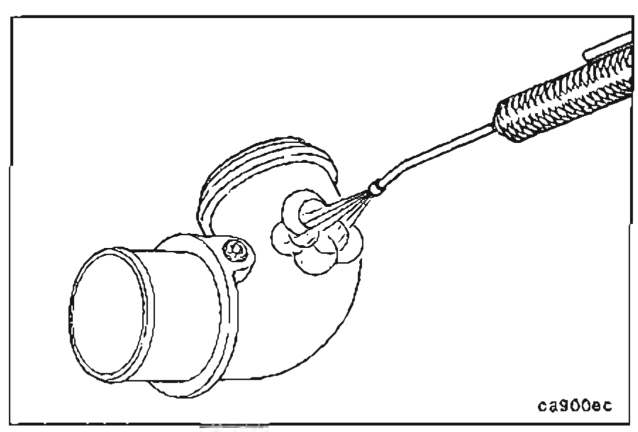


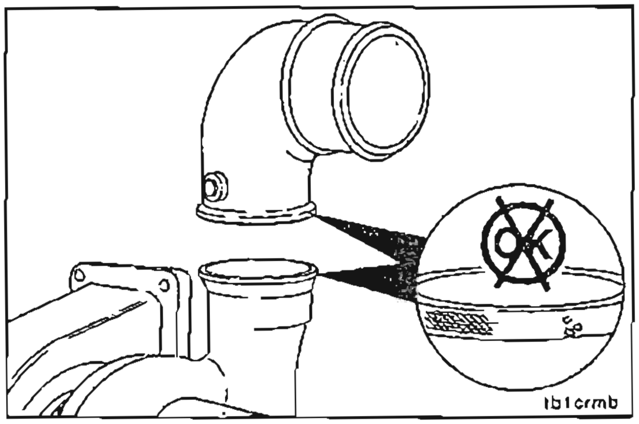
Air Transfer Pipe - Cleaning and Inspection for Reuse (10-04)

Cleaning

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

Use solvent or steam to clean the air transfer pipe. Dry with compressed air.

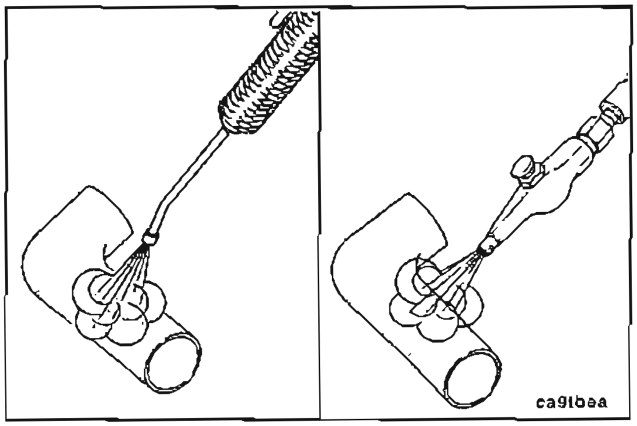




Inspection

Visually inspect the turbocharger compressor V-band outlet and the air transfer pipe connection for dents or fretting.

Replace the turbocharger compressor housing or air transfer pipe, if damaged.

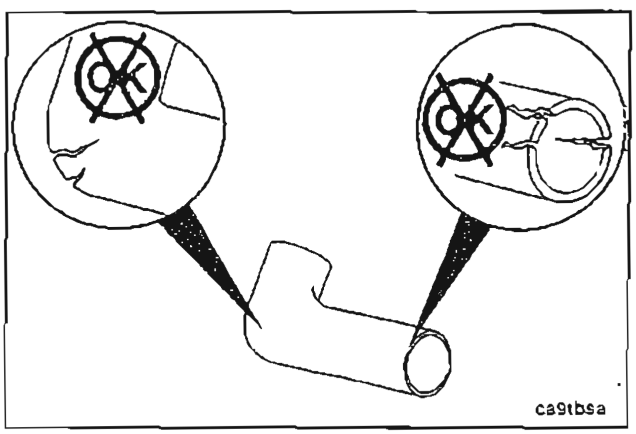


Air Crossover Tube - Cleaning and Inspection for Reuse (10-05)

Cleaning

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

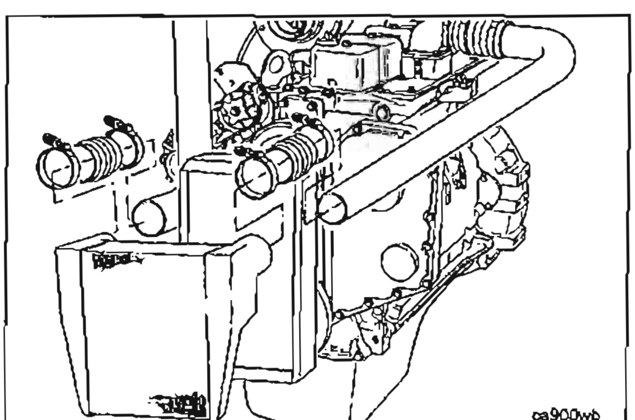
Use solvent or steam to clean the air crossover tube. Dry with compressed air.



Inspection

Visually inspect the air crossover tube for cracks or damage.

Visually inspect the hose sealing surfaces for pitting or damage. Replace damaged parts.



Charge Air Cooler (CAC) - Cleaning and Inspection for Reuse (10-06)

Cleaning

Caution: If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the CAC, the CAC must be cleaned.

Remove the CAC from the vehicle. Refer to the vehicle manufacturer for instructions.

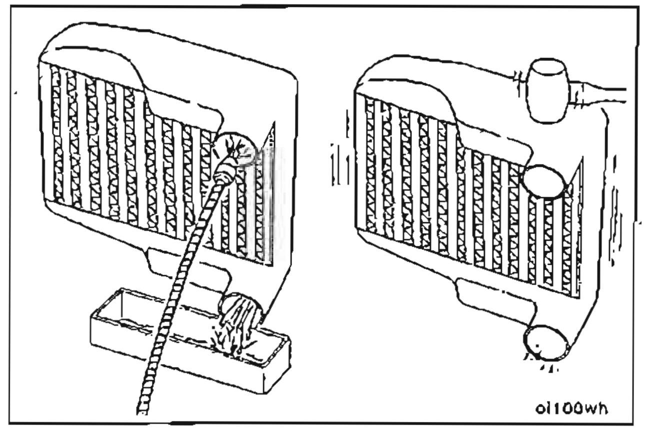
Caution: Do not use caustic cleaners to clean the CAC. Damage to the CAC will result.

NOTE: Make sure that the tubes are in the vertical direction when flushing.

Flush the CAC internally with solvent in the opposite direction of normal air flow. Shake the CAC and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed.

NOTE: If internal debris cannot be removed, scrap the CAC.

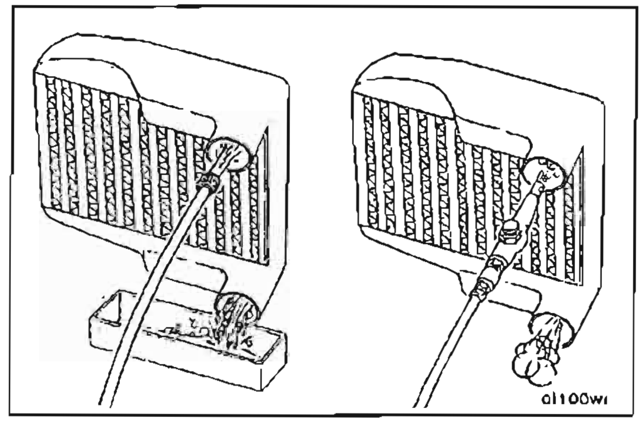
Use a flashlight and mirror to visually inspect the CAC for internal debris.



After the CAC has been thoroughly cleaned of all oil and debris with solvent, wash the CAC internally with hot soapy water to remove the remaining solvent. Rinse thoroughly with clean water.

Blow compressed air into the CAC in the opposite direction of normal air flow until the CAC is dry internally.

Caution: The CAC must be rinsed, dried, and free of solvent, oil, and debris or engine damage will result.

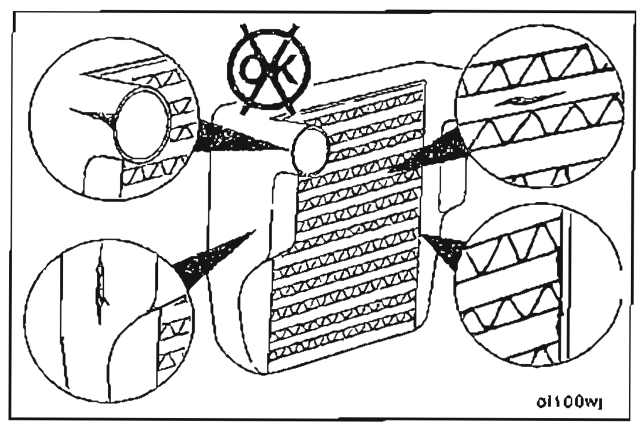


Inspection

Visually inspect the CAC for cracks, holes or damage.

Inspect the tubes, fins and welds for tears, breaks or other damage. If any damage causes the CAC to fail the air leak check mentioned in Procedure (10-07), the CAC must be replaced.

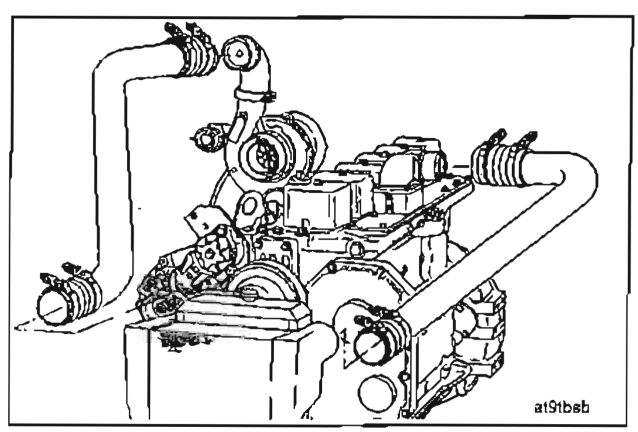
Install the CAC on the vehicle. Refer to the vehicle manufacturer for instructions.

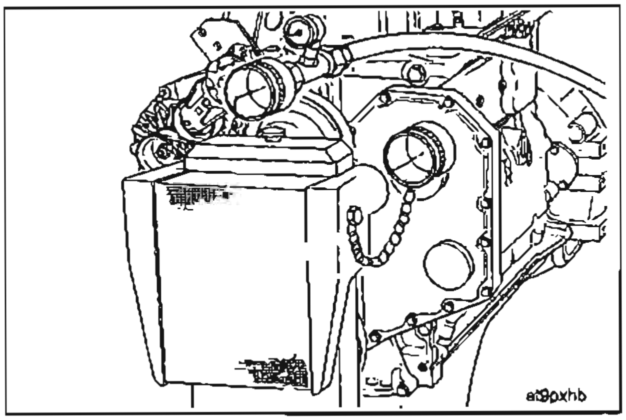


Charge Air Cooler (CAC) - Pressure Testing (10-07)

To check the charge air cooler for cracked tubes or header, remove the inlet and outlet hoses from the CAC.

Remove the charge air cooler. Refer to the vehicle manufacturer for instructions.

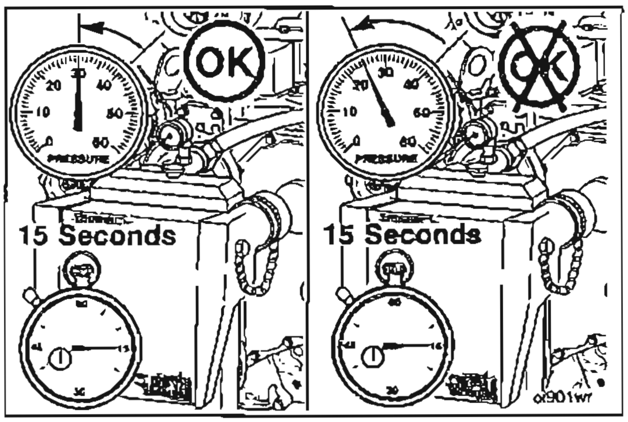




3824556 Test Kit

Install a cap over the outlet side of the CAC. Install a pressure gauge, air supply, and air pressure regulator to the inlet side of the cooler.

Warning: To prevent possible injury if either plug blows off during the test, secure safety chains on the test plugs to any convenient capscrew on the radiator assembly. This test must be performed with securely fastened safety chains.

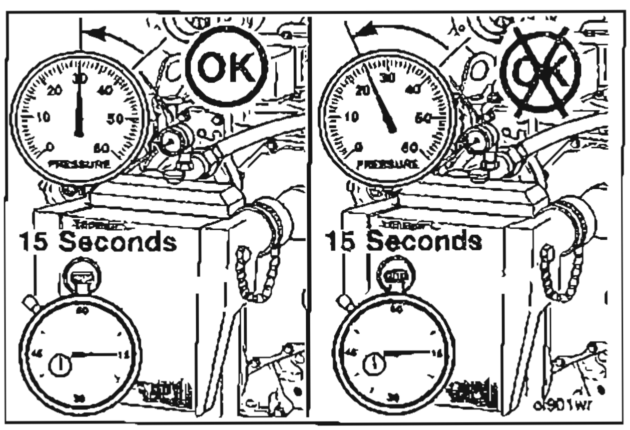


Apply 207 kPa [30 psi] of air pressure to the cooler. Close the air pressure regulator.

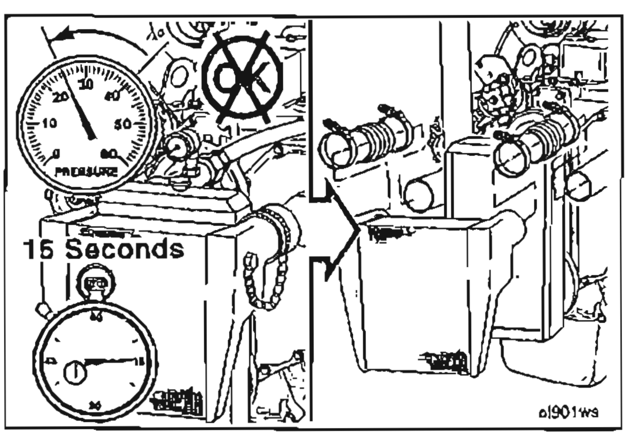
Monitor the pressure gauge and determine the rate of pressure decay with a stop watch.

If the pressure decay is 49 kPa [7 psi] or less in 15 seconds, the cooler is okay. If the pressure drop is greater than 49 kPa [7 psi] in 15 seconds, check all connections again.

Determine if pressure decay is caused by a leak in the CAC or from a leaky connection. Use a spray bottle filled with soapy water applied to all hose connections, and watch for bubbles to appear at the location of the leak.



If the pressure decay is caused by a leaky connection, repair the connection and repeat the test. If the leak is within the CAC, repeat the test to verify the accuracy of the pressure decay measurement. Similar pressure decay readings **must** be obtained at least three consecutive tests before the reading can be considered accurate.



If the pressure drop is greater than 49 kPa [7 psi] in 15 seconds, the CAC **must** be replaced.

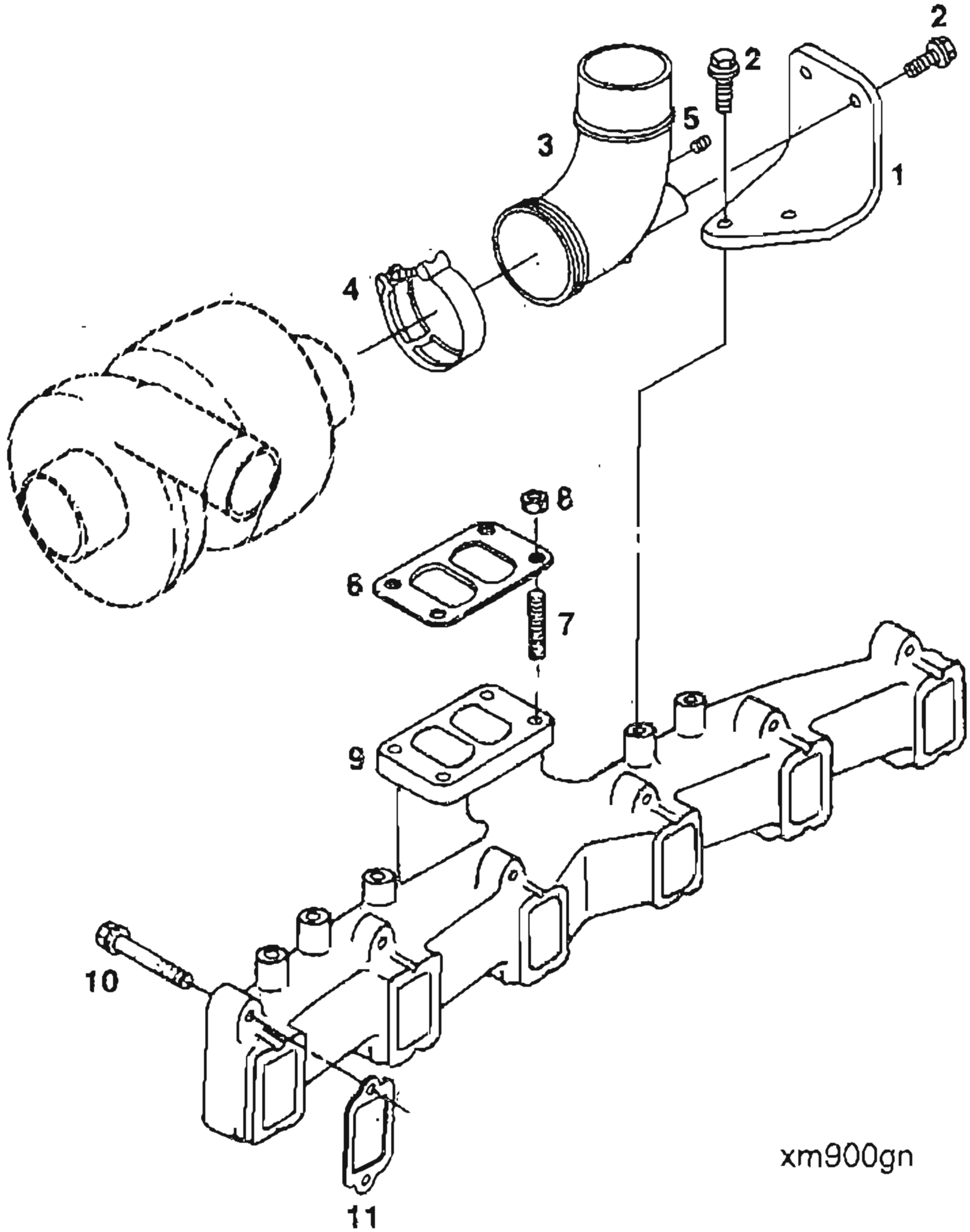
Refer to the manufacturer's repair manual for repalcement instructions.

NOTE: Charge air coolers are not designed to be 100% leak free. If the pressure decay is less than 49 kPa [7 psi] in 15 seconds, then the CAC does not need to be replaced.

Section 11 - Exhaust System - Group 11

Section Contents

Exhaust Manifold - Exploded View



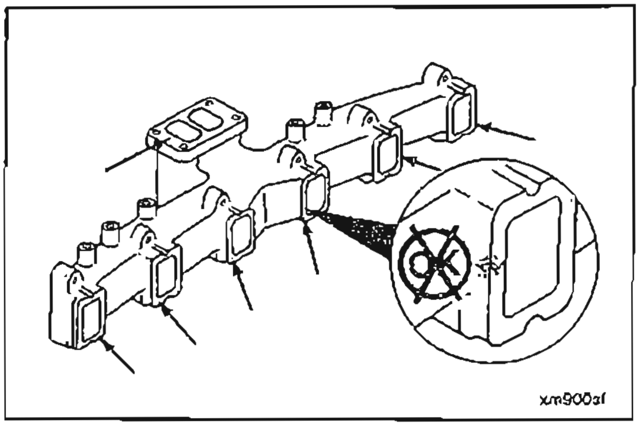
Ref. No.	Part Name	Qty	Remarks
1	Brace, Exh. Out Conn.	1	
2	Screw, Hex Hd Cap	4	
3	Connection, Exh. Out	1	90 degree turbo exhaust elbow
4	Clamp, V Band	1	
5	Pipe, plug	1	
6	Gasket, turbocharger	1	
7	Stud	4	
8	Nut	4	
9	Manifold, exhaust	1	
10	Screw, Hex Hd Cap	12	
11	Gasket, manifold	6	

General Information

Exhaust Manifold

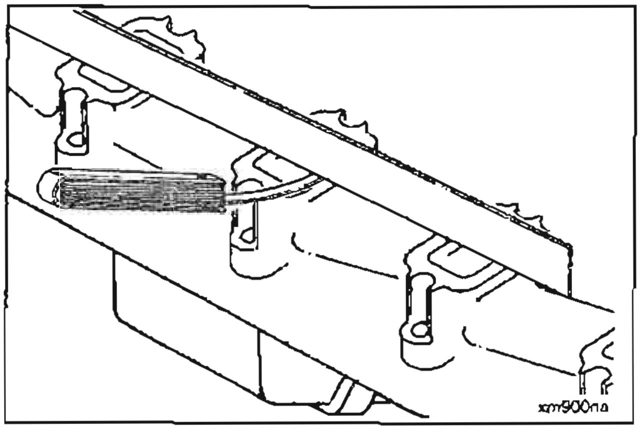
The B series engine uses a pulse-type manifold with a divided turbocharger entry passage (exhaust manifold outlet). Multiple turbocharger locations are available to suit space constraints of various installations. Center front, rear and high, low turbo mounting locations are offered.

Warping can be corrected by machining or grinding the sealing surfaces to the flatness specification.

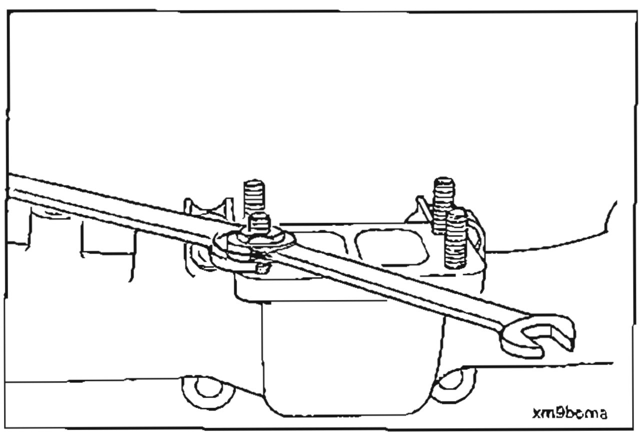


Exhaust Manifold Inspection (11-01)

Inspect the Exhaust Manifold for cracks, burn-out, or damaged threads.



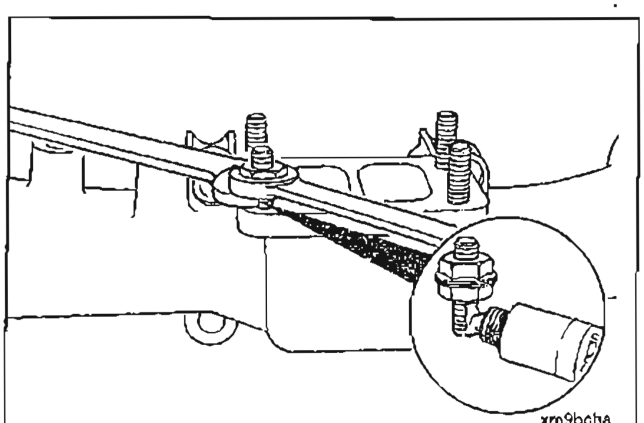
Place straight edge across the exhaust ports. The maximum allowable clearance between the manifold and straight edge is 0.10 mm [0.004 inch].



Turbocharger Mounting Stud Replacement (11-02)

Inspect the turbocharger studs for damaged threads.

To replace the studs, use two nuts jam locked on to the stud.



Before installing the studs, coat the threads with anti-sieze compound.

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. Two cylinder air compressors used on B & C engines are normally manufactured by Bendix & Midland.

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 air compressor support.

The air compressor is cooled by the engine coolant. Only the cylinder head is cooled on most single cylinder air compressors. Both the cylinder head and cylinders are normally cooled on the two cylinder air compressor

Service information, specifications, and repair of Cummins air compressors are contained in the following publications:

Holset SS191 8.5 CFM	Single Cylinder Air Compressor Rebuild Manual Bulletin # 3810433
Holset SS296 13.2 C.F.M.	Single Cylinder Air Compressor Bulletin # 3810242
Holset SS338 15.0 CFM	Single Cylinder Air Compressor Bulletin # 3810457

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

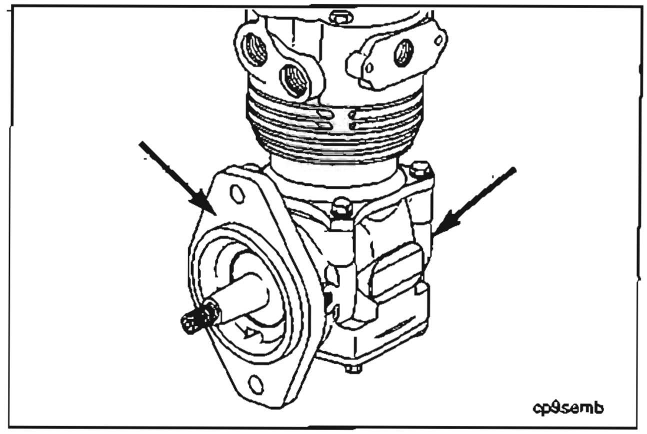
Bendix H.V.S.G.
P.O. Box 5712
1005 Wilton Grove Rd.
London Ontario, Canada N6A4S8
Attention: Technical Services Dept.

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)

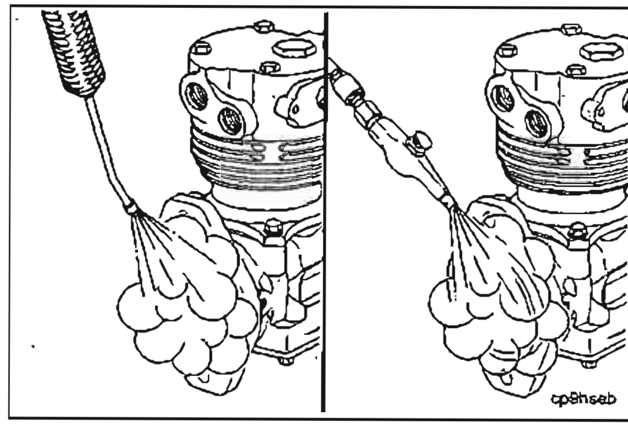
Remove all gasket material from the sealing surfaces.



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 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.

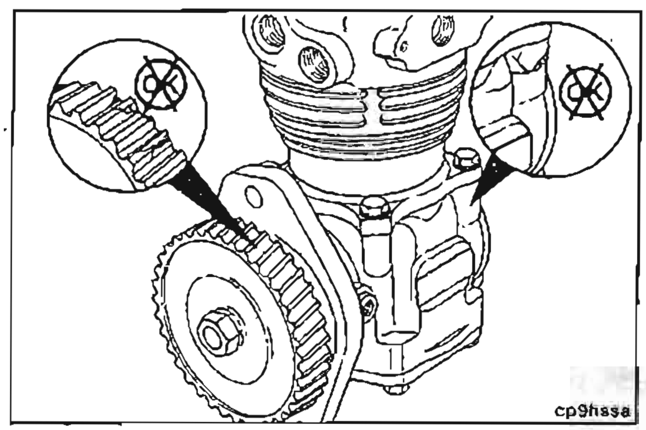


Inspection

Visually inspect the compressor housing for cracks or damage.

Visually inspect the compressor gear drive for cracks or broken teeth.

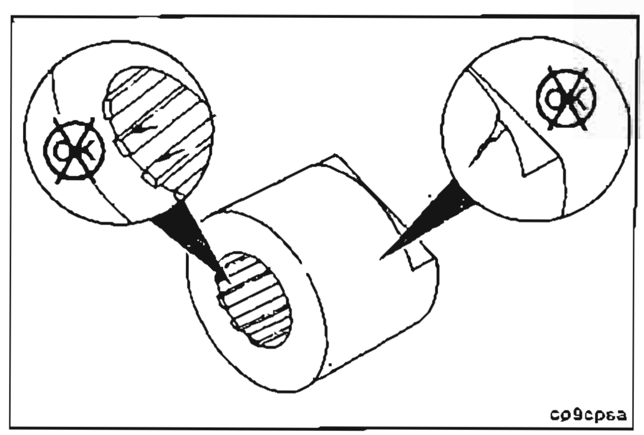
Visually inspect the fuel pump drive hub or spider coupling for wear or damage.

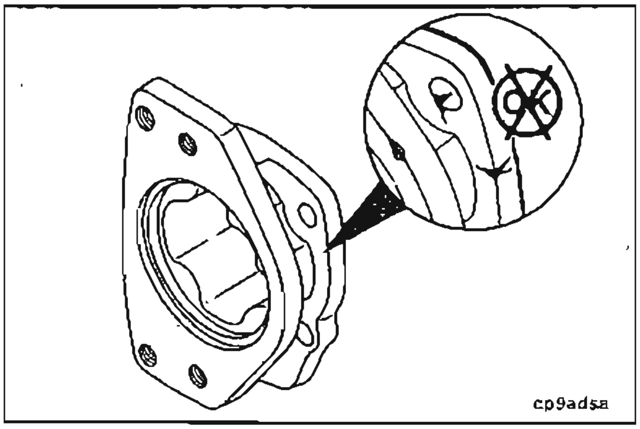


Power Steering Coupling (if Applicable)

Inspect the coupling for wear or cracks.

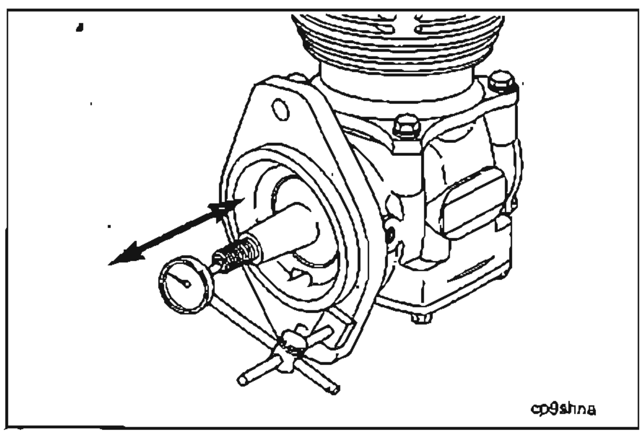
Replace the coupling if damaged.





Power Steering Adapter

Inspect and replace the adapter if any damage is found.



Measure the single cylinder air compressor crankshaft end clearance.

Crankshaft End Clearance		
mm		in.
0.05	MIN	0.002
0.15	MAX	0.006

Section 13 - Electrical Equipment - Group 13

Section Contents

Electrical Equipment - General Information

The electrical equipment used on the B series 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 166
Rhodes Way
Watford
WD2 41B
England
Telephone: 0923-44233

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

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

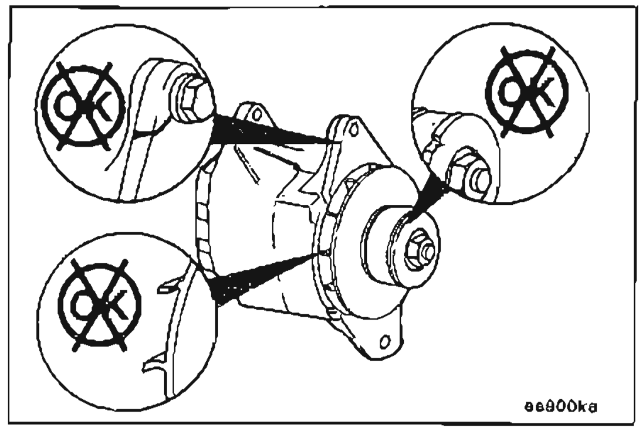
Delco-Remy
P.O. Box 2439
Anderson, IN 46018
U.S.A.
Telephone: (317) 646-7838

Nippendenso of Los Angeles
3900 Via Oro Avenue
Long Beach, CA 90810
Telephone: (800) 222-6352

* Non Electrical Equipment Suppliers

Alternator Inspection (13-01)

Visually inspect the alternator for obvious damage such as a broken or cracked housing. Damaged fan blades or pulleys and worn mounting holes in the alternator end frames.



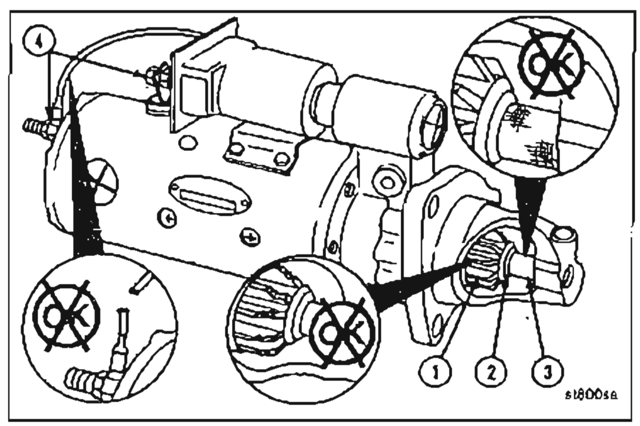
Starter Inspection (13-02)

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 electircal equipment manufacturers specifications to rebuild the starting motor.

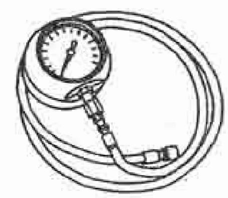
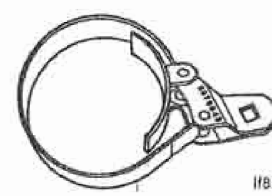
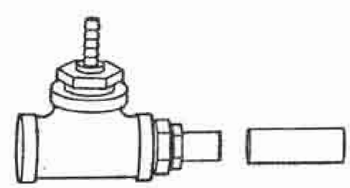
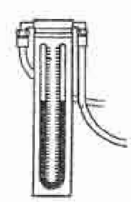
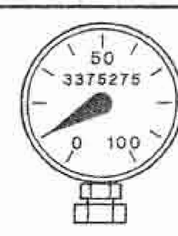


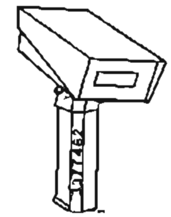
Section 14 - Engine Testing - Group 14

Section Contents

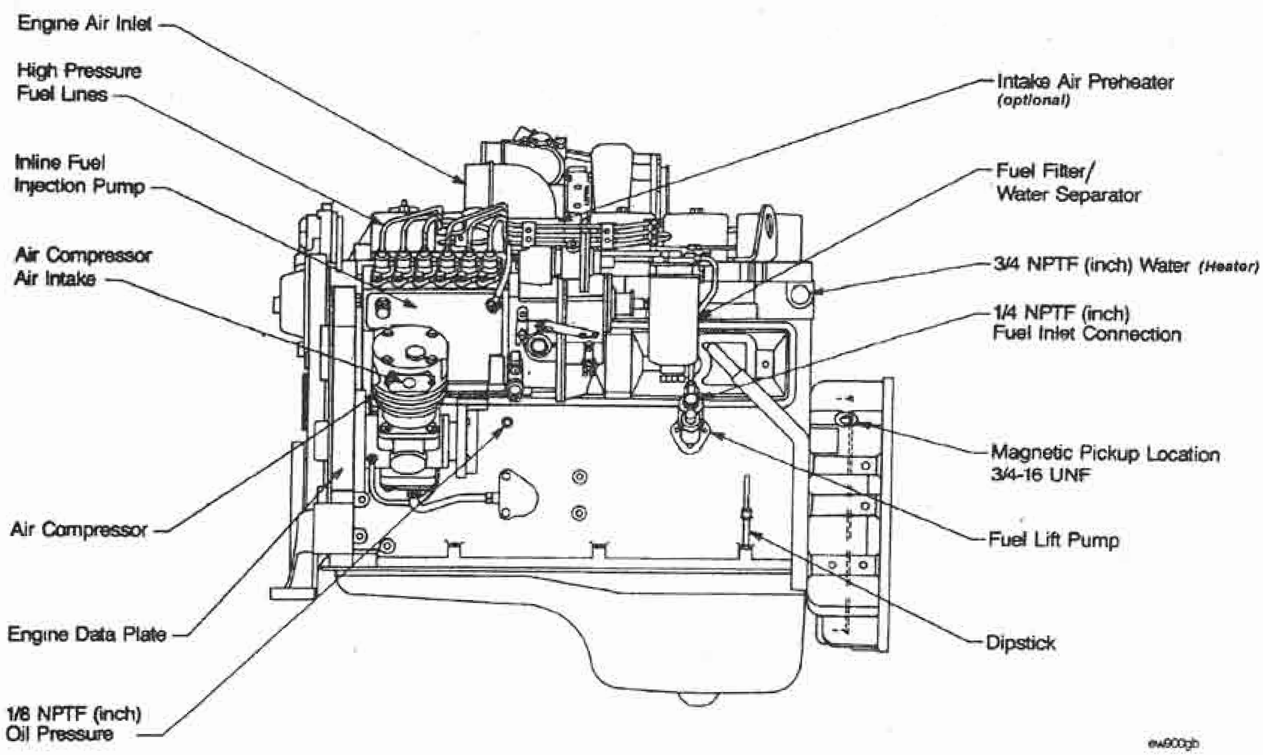
Engine Testing - Service Tools

The following special tools are recommended to perform procedures in Group 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** Check the fuel filter restriction during the engine performance test. Hose Adapter, Part No.ST-434-2, and vacuum gauge, Part No.ST-424-12, are used to perform the test.	 eg8togc
ST-1273	**Pressure Gauge** Use to measure the engine intake manifold pressure.	 eg8togr
3375049	**Oil Filter Wrench** Use to remove or tighten spin-on lubricating oil or fuel filters.	 lf8togb
3822476	**Blowby Checking Tool** Use to check engine crankcase blowby.	 eg8toge
ST-1111-3	**Water Manometer** Used with the blowby check tool to measure engine crankcase pressure.	
3375275	**Pressure Gauge (0-160 psi)** Used to measure lubricating oil pressure.	

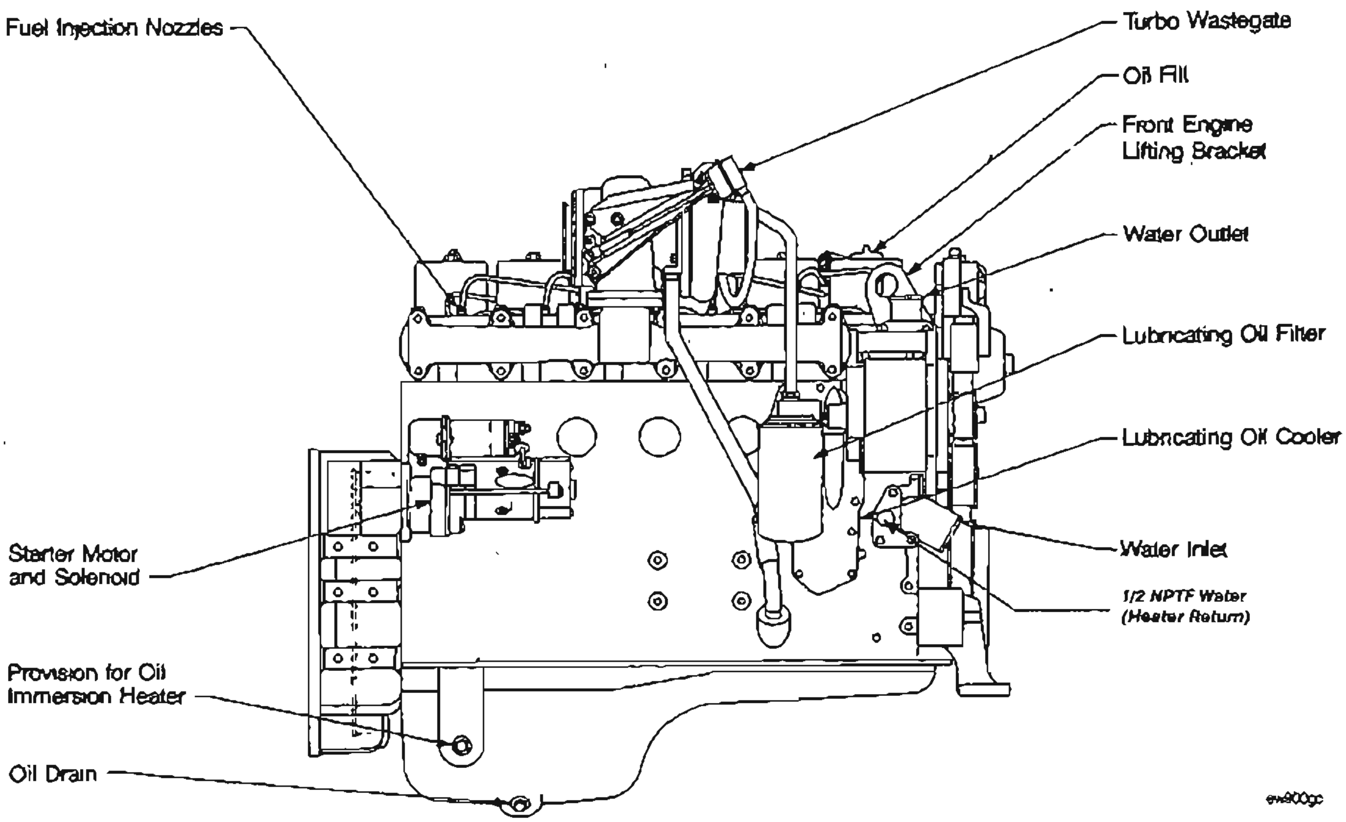
Tool No.	Tool Description	Tool Illustration
3377462	**Digital Optical Tachometer** Used to measure engine speed (RPM).	 3377462

Engine Testing - Engine Side Views



Fuel Pump Side

Engine Testing - Engine Side Views



Engine Testing - General Information

The engine test is a combination of an engine run-in and a performance check. The engine run-in procedure provides an operating period that allows the engine parts to achieve a final finish and fit. The performance check provides an opportunity to perform final adjustments needed to optimize the engine performance.

An engine test can be performed using **either** an engine dynamometer **or** a chassis dynamometer. If a dynamometer is **not** available, an engine test **must** be performed in a manner that simulates a dynamometer test.

Check the dynamometer before beginning the test. The dynamometer **must** have the capability to test the performance of the engine when the engine is operating at the maximum RPM and horsepower range (full power).

The engine crankcase pressure, often referred to as engine blowby, is an important factor that indicates when the piston rings have achieved the correct finish and fit. Rapid changes of blowby or values that exceed specifications more than 50 percent indicate that something is wrong. The engine test **must** be discontinued until the cause has been determined and corrected.

General Engine Test Specifications

Maintain the following limits during a chassis dynamometer test:

Intake Restriction (Maximum)
- Clean Filter (light duty).......254 mm H_20 [10 in. H_20]
  (medium duty).......305 mm H_20 [12 in. H_20]
  (heavy duty).......381 mm H_20 [15 in. H_20]
- Dirty Filter (light duty).......635 mm [25 in.]
  (medium duty).......635 mm [25 in.]
  (heavy duty).......635 mm [25 in.]

Exhaust Back Pressure (maximum)
- Industrial .... 76 mm Hg [3.0 in.Hg]
- EPA Certified.......114 mm Hg [4.5 in. Hg]
- Oxidation Catalyst.......152 mm Hg [6.0 in Hg]

Blowby** (at Given Speed, 100% Load)

	New (L/Min)	Worn (L/Min)
4B @ 2200	18	36
4B @ 2500	20	40
4B @ 2800	23	46
4BT/4BTA/B3.9 @ 2200	45	90
4BT/4BTA/B3.9 @ 2500	51	102
4BT/4BTA/B3.9 @ 2800	57	114
6B @ 2200	26	52
6B @ 2500	30	60
6B @ 2800	34	68
6BT/6BTA/B5.9 @ 2200	63	126
6BT/6BTA/B5.9 @ 2500	76	152
6BT/6BTA/B5.9 @ 2800	85	170

*Blowby checking tool, Part No. 3822476, has a special 5.613 mm [0.221 in.] orifice that **must** be used to get an accurate reading.

Oil Pressure
- Low Idle (minimum allowable) .... 69 kPa [10 psi]
- Rated Speed (minimum allowable) .... 207 kPa [30 psi]

Fuel Filter Restriction (Maximum pressure drop across filter)
- Dirty Filter .... 35 kpa [5 psi]

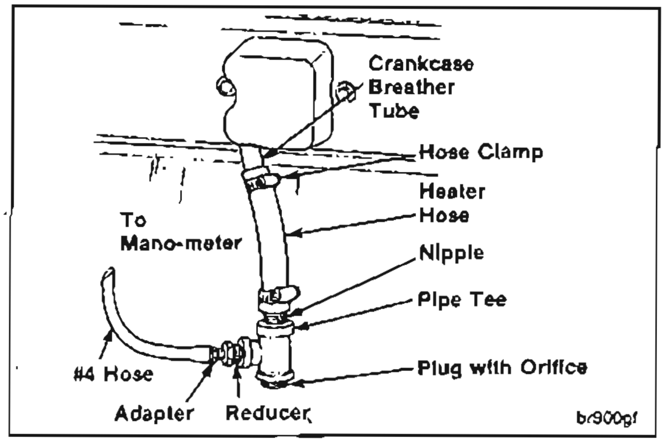
Fuel Return Restriction (Maximum) .... 518 mm Hg [20.4 in hg]

NOTE: Due to variations in ratings of different engine models, refer to the specific engine data sheet for the particular engine model being tested.

Blowby Measurement

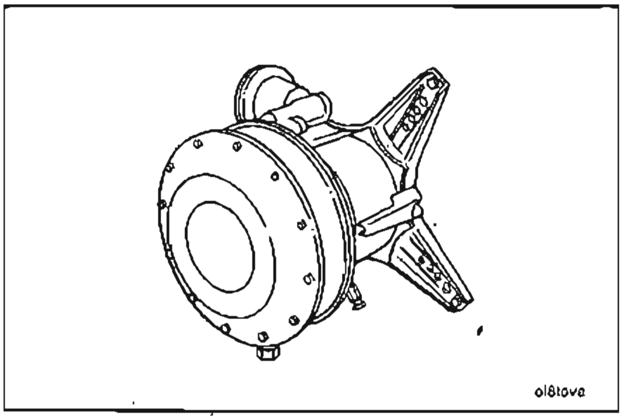
Blowby is generally recorded in liters/minute, but a water manometer may be used to measure blowby from the breather tube after fabricating the following adaptation:

1. Plug the end of the straight portion of a pipe tee.
2. Drill an orifice in the plug (refer to the Blowby Conversion Chart below for the appropriate orifice size).
3. Connect the open straight portion of the pipe tee to the breather tube.
4. Connect a water manometer to the 90 degree outlet.
5. Use the Blowby Conversion Chart to convert the manometer reading to liters/minute.



Blowby Conversion Chart (5.613 mm [0.221 in] Orifice)

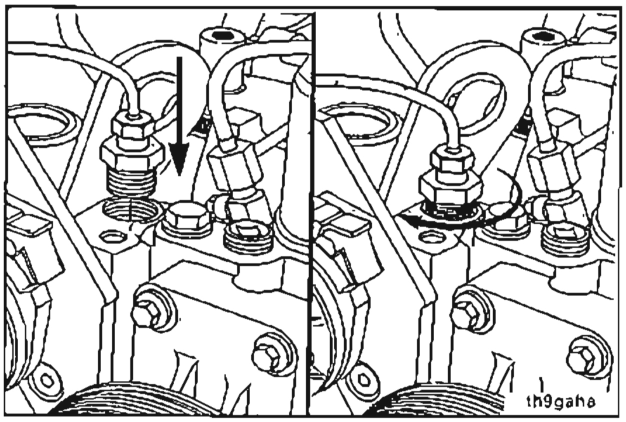
Inches of Water	Liters/Minute	Inches of Water	Liters/Minute
1	27	19	121
2	40	20	124
3	49	21	128
4	58	22	131
5	64	23	135
6	71	24	137
7	76	25	140
8	81	26	144
9	86	27	147
10	90	28	150
11	94	29	154
12	98	30	157
13	102	31	160
14	105	32	163
15	109	33	166
16	112	34	169
17	115	35	172
18	118		



Engine Dynamometer Test - Installation of the Engine (14-01)

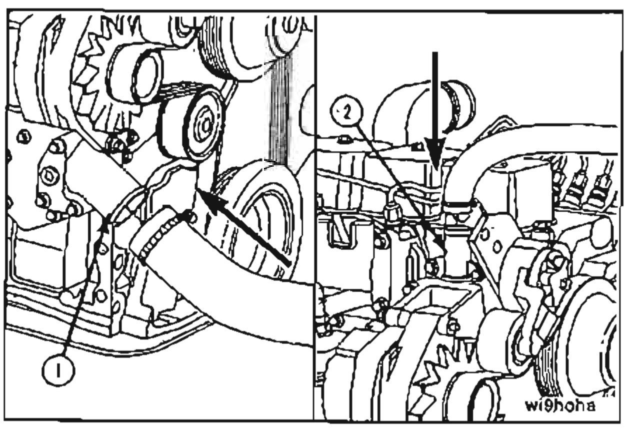
Use engine lifting fixture, Part No. ST 125, to install the engine to the test stand. Align and connect the dynamometer. Refer to the manufacturer's instructions for aligning and testing the engine.

NOTE: Make 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 match the restrictions of the dynamometer.



Install the coolant temperature sensor.

Minimum Gauge Capacity: 107°C [225°F]

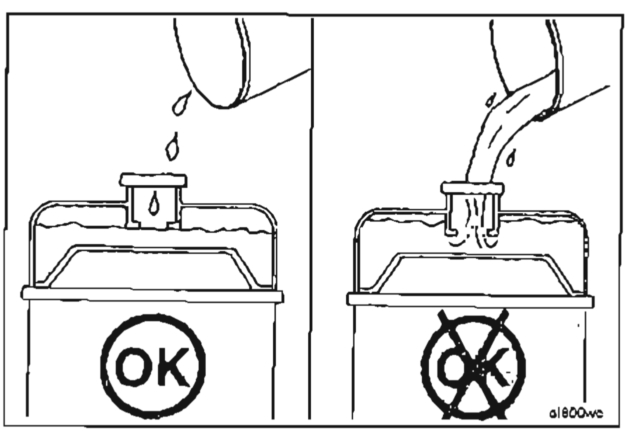


Connect the coolant supply to the water inlet connection (1).

Connect the coolant return to the water outlet connection (2).

Install the drain plugs, close all the water drain cocks, and make sure all the clamps and fittings are tight.

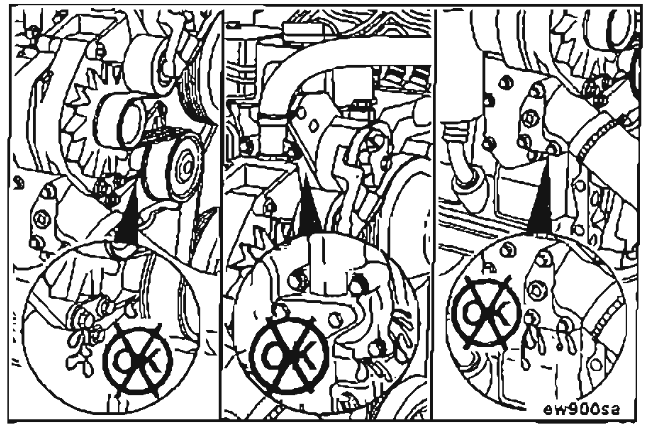
Connect the vent tube to the vent connection on the thermostat housing.



Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill (or expansion) tank.

NOTE: Maximum Fill Rate is 14 Liters/min [3.5 U.S. gallons/min]

Inspect the engine for coolant leaks at connections, fittings, plates, and plugs. Repair as necessary.

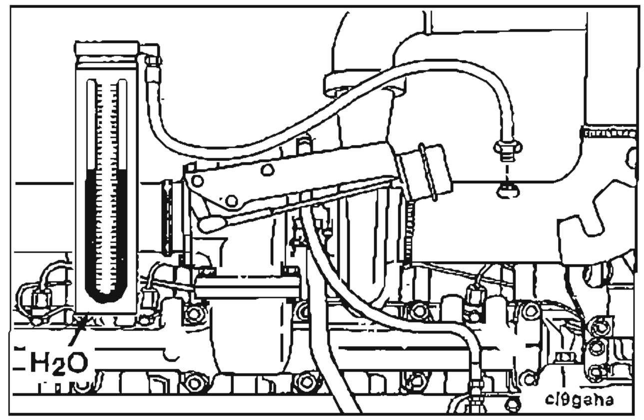


Connect a water manometer to the turbocharger air inlet pipe to test air restriction.

NOTE: The manometer connection **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 in place of the water manometer.

Minimum Gauge Capacity: 760 mm H_2O [30 in. H_2O]

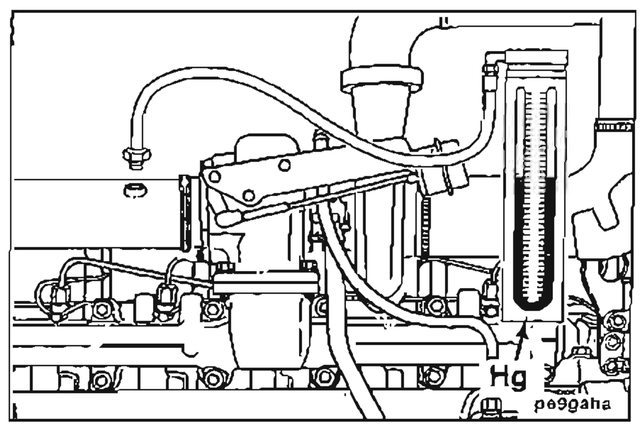


Connect a mercury manometer to a straight section of the exhaust piping near the turbocharger outlet to check exhaust restriction.

NOTE: A pressure gauge can be used in place of the mercury manometer.

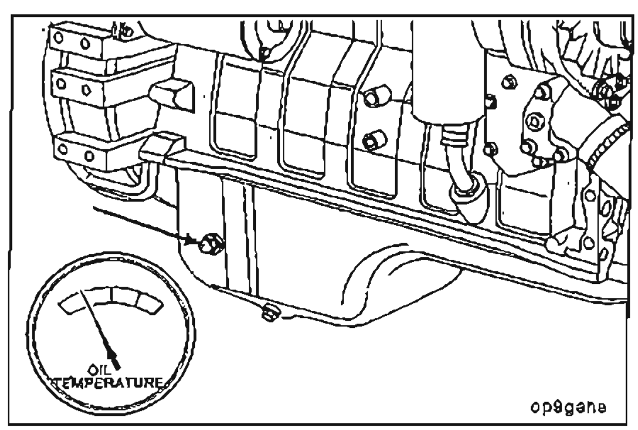
NOTE: For automotive applications, a tapped hole is provided on the inlet side of the catalyst to check exhaust restriction.

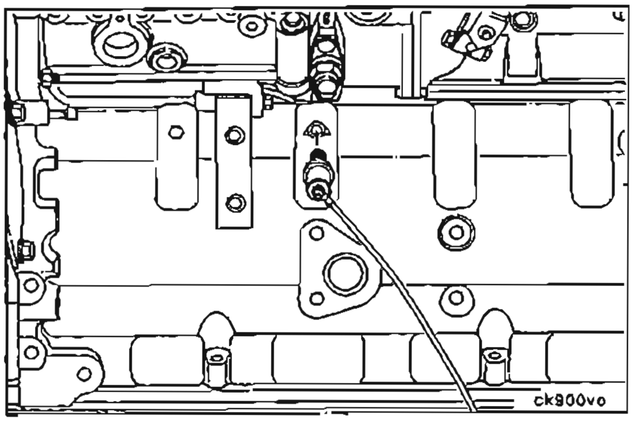
Minimum Gauge Capacity: 254 mm Hg. [10 in. Hg.]



Attach the lubricating oil temperature sensor in one of the locations on the side of the engine as shown.

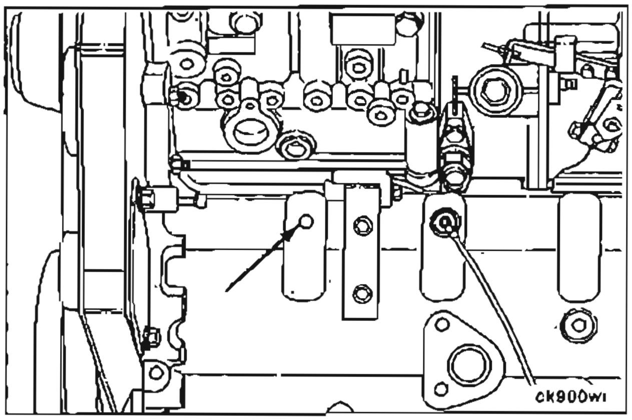
Minimum Gauge Capacity: 150°C [300°F]





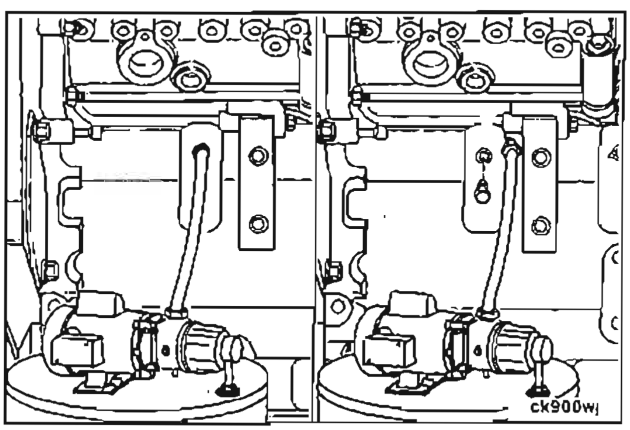
Attach the lubricating oil pressure sensor to the main oil rifle drilling in the cylinder block.

Minimum Gauge Capacity: 1034 kPa [150 psi]



Caution: The lubricating oil system must be primed before operating the engine after it has been rebuilt to avoid internal damage. Do not prime the system from the bypass filter head if an external pressure pump is used. Damage to the bypass filter will result.

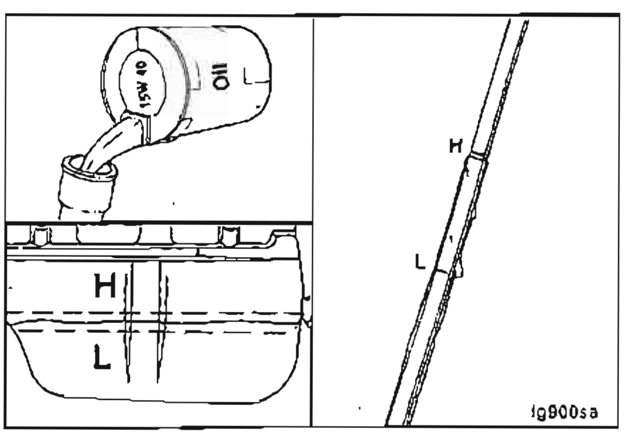
To prime the system using external pressure, connect the supply to the tapped hole in the main oil rifle.



Use a pump capable of supplying 210 kPa [30 psi] continuous pressure. Connect the pump to the port on the main oil rifle as shown.

Use clean 15W-40 oil to prime the system until the oil pressure registers on the gauge.

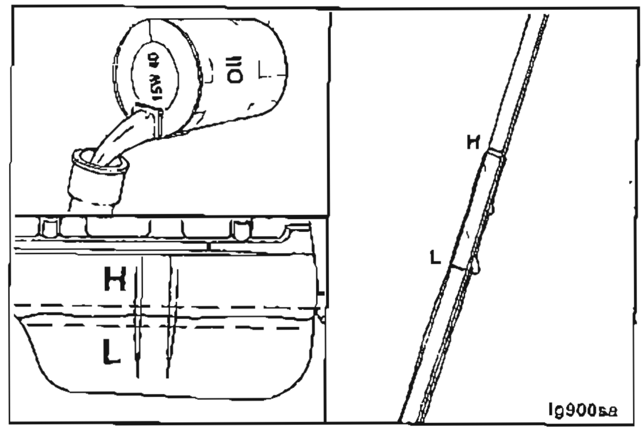
Remove the oil supply tube, and install the plug.



Make sure the lubricating oil has had time to drain to the pan, and fill the engine to the high mark as measured on the dipstick.

If an external pressure pump is **not** available, prime the lubricating system according to the following procedure.

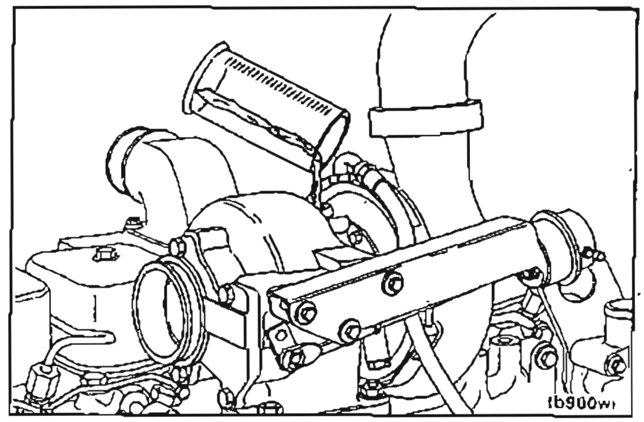
Fill the engine with oil to the high level mark on the dipstick.



Disconnect the turbocharger lubricating oil supply tube.

Pour 50 cc to 60 cc [2.0 fl.oz. to 3.0 fl.oz.] of clean 15W-40 oil into the turbocharger oil supply hole..

Connect the oil supply tube to the turbocharger.

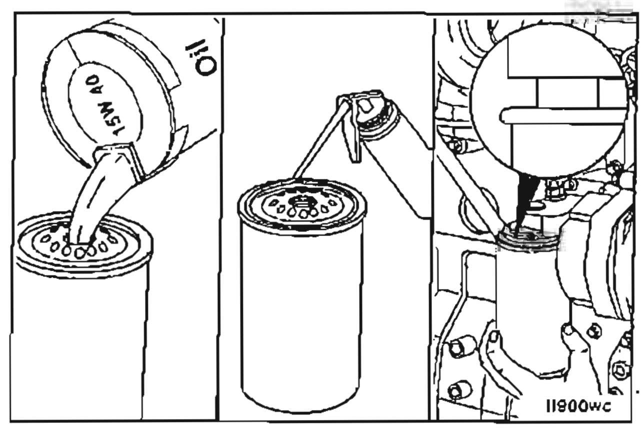


Caution: Mechanical over-tightening can distort the threads or damage the filter element seal.

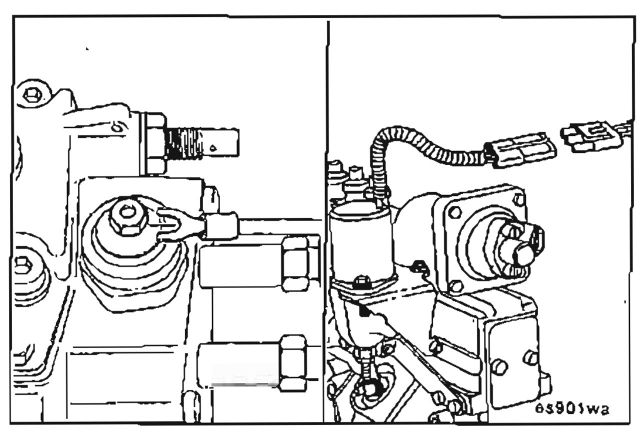
Fill the lubricating oil filter with clean 15W-40 oil.

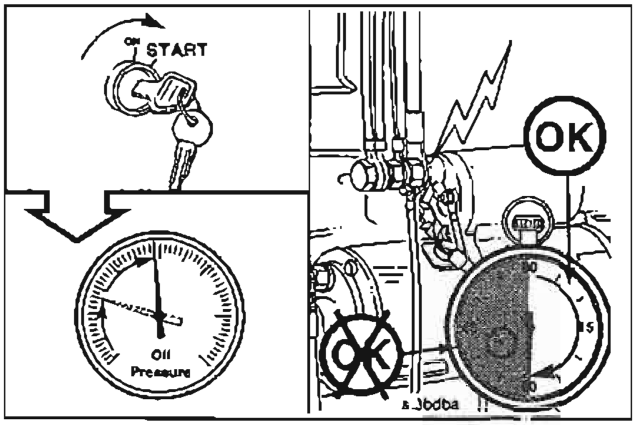
Screw the filter onto the filter head fitting until the gasket contacts the filter head surface.

Tighten the filter according to the manufacturer's specifications.



To make sure the lubricating oil pump is providing adequate oil to the engine, first disconnect any wires leading to the fuel pump solenoid.



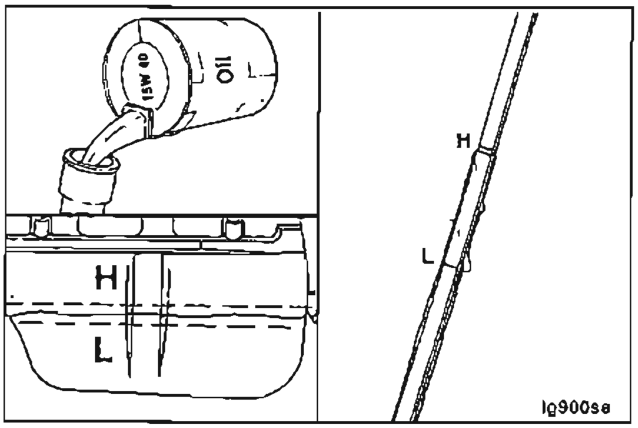


Caution: Do not crank the starting motor for periods longer than 30 seconds. Excessive heat will damage the starting motor.

Crank the engine until the oil pressure gauge indicates system pressure.

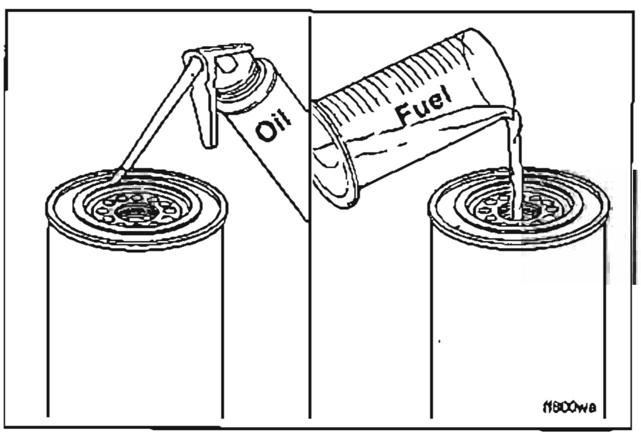
NOTE: Allow 2 minutes between the 30-second cranking periods so the starting motor can cool.

NOTE: If pressure is **not** indicated, find and correct the problem before continuing.



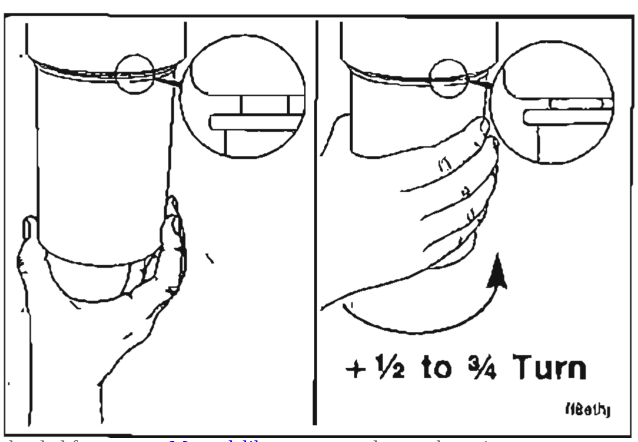
Allow the lubricating oil to drain into the oil pan, and measure the oil level with the dipstick.

Add oil as necessary to bring the level to the high level mark.



Lubricate the gasket on the fuel filter with clean 15W-40 oil.

Fill the fuel filter with clean fuel.

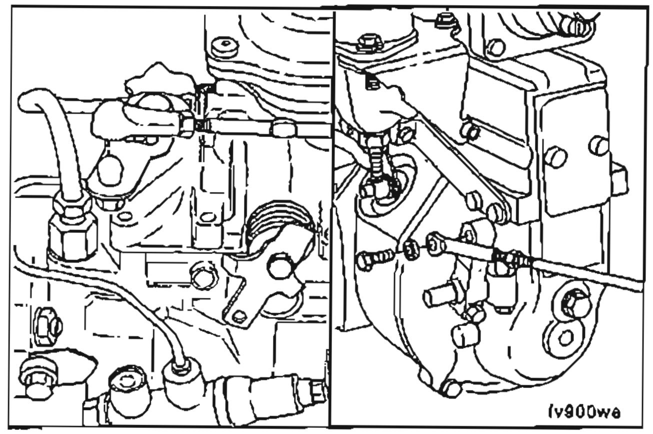


Screw the fuel filter onto the filter head until the gasket contacts the filter head surface.

Tighten the filter an additional 1/2 to 3/4 turn.

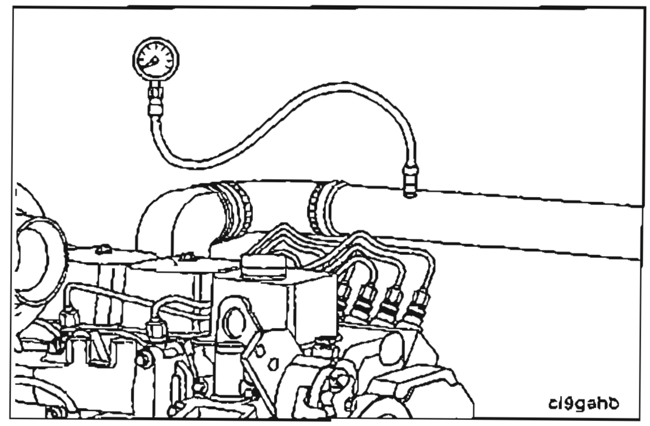
Make sure the voltage supply matches that of the fuel pump solenoid before connecting the electrical wires to it.

Attach the throttle control rod onto the fuel pump throttle lever.



ST-1273

To determine the amount of turbocharger boost and aftercooler/charge air cooler restriction install intake manifold pressure gauges, Part No. ST 1273 in the turbocharger outlet and the intake manifold.

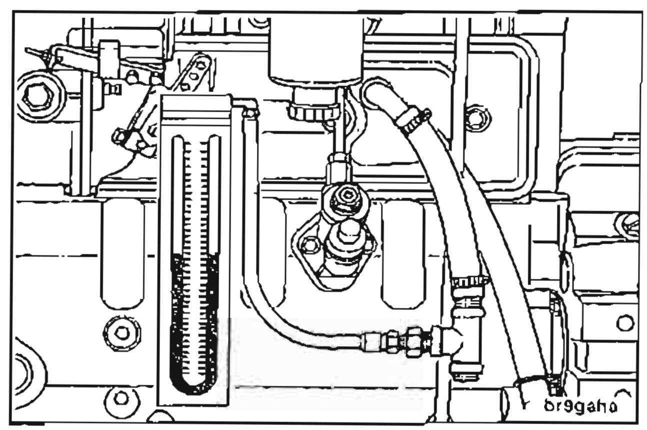


Part No. 3822676

For accurate engine crankcase blowby measurement, insert a blowby checking tool in the crankcase breather vent.

Connect a water manometer to the blowby tool Part No. 3822676. A pressure gauge can be used in place of the manometer.

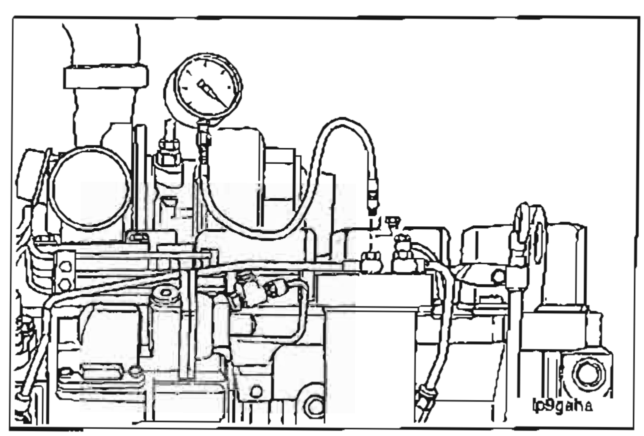
Minimum Gauge Capacity: 1270 mm H_2O [50 in. H_2O]

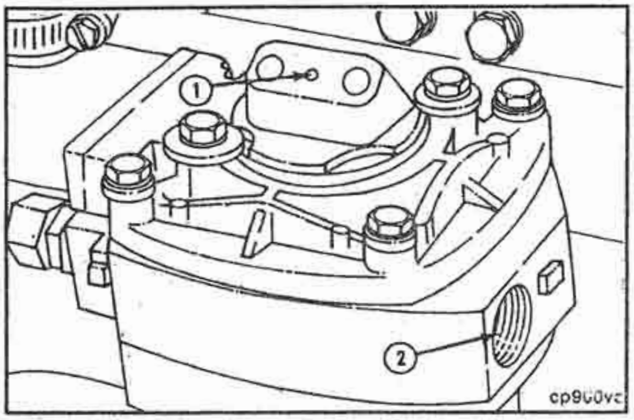


Part No. ST-434

To measure fuel filter restriction, connect vacuum gauge, Part No. ST-434, to the injection pump inlet line.

Minimum Gauge Capacity: 760 mm Hg [30 in. Hg]

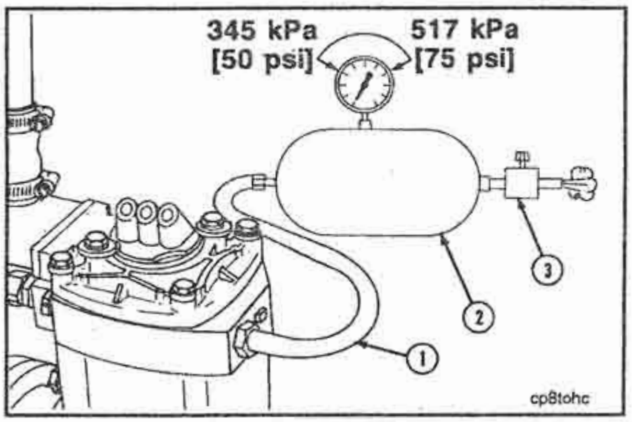




To be able to unload the compressor, connect a source of compressed air to the unloader (1). This air line **must** contain a valve between the source and the unloader.

NOTE: All air compressors manufactured by Cummins Engine Company, Inc. **must** be **loaded** during engine run-in. All air compressors **must** be **unloaded** during the engine performance check.

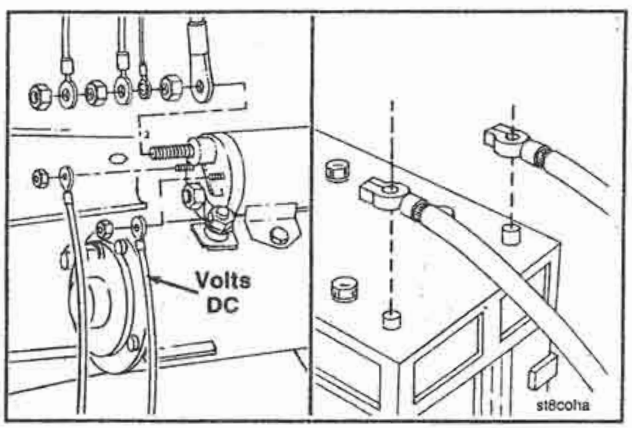
NOTE: The compressed air load in the accompanying illustration **must** be attached to the air compressor outlet (2).



To provide a load on the air compressor, connect an air tank to the compressor outlet (2), using steel tubing or a high temperature hose (1).

Install an air regulator (3) that can maintain tank air pressure of 345 kPa to 517 kPa [50 psi to 75 psi] at both the minimum and the maximum engine RPM.

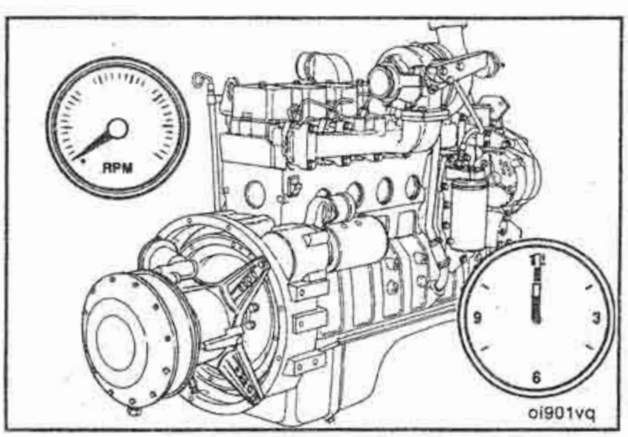
Hose Temperature (Minimum): 260°C [500°F]



Inspect the voltage rating on the starting motor before installing the electrical wiring.

Attach electrical wires to the starting motor and the batteries, if used.

NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.

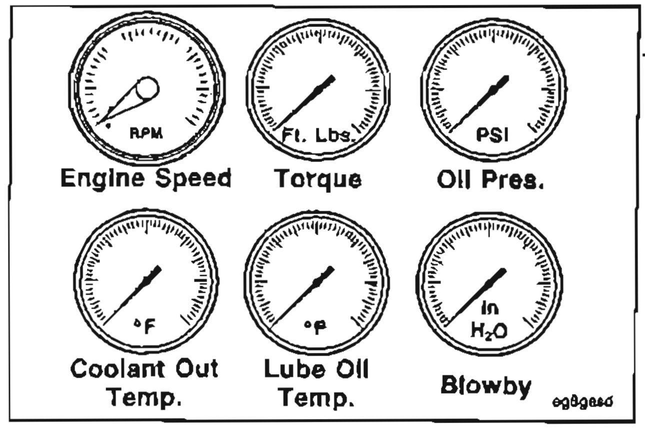


Engine Dynamometer Test - Engine Run-In (14-02)

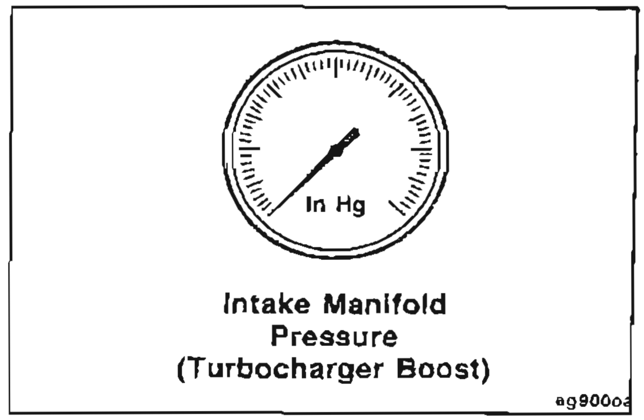
The engine run-in period allows the tester to detect assembly errors and to make final adjustments needed for performance that meets specifications.

NOTE: The amount of time specified for the following engine run-in phases are minimums. Additional time can be used at each phase **except** engine idle periods, if so desired.

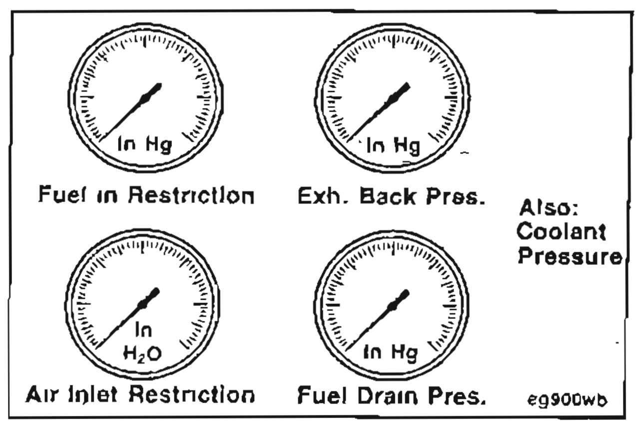
Measurements from these indicators and gauges **must** be observed closely during all phases of the engine run-in period. Refer to page 14-6 for specifications and acceptable readings.



To correctly evaluate the engine performance, this additional measurement **must** be observed during engine run-in phases.

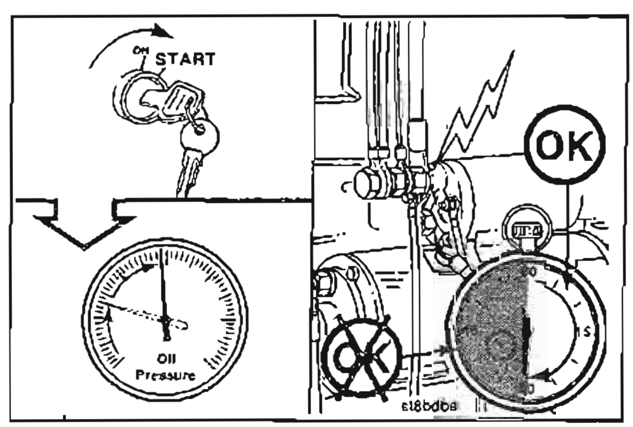


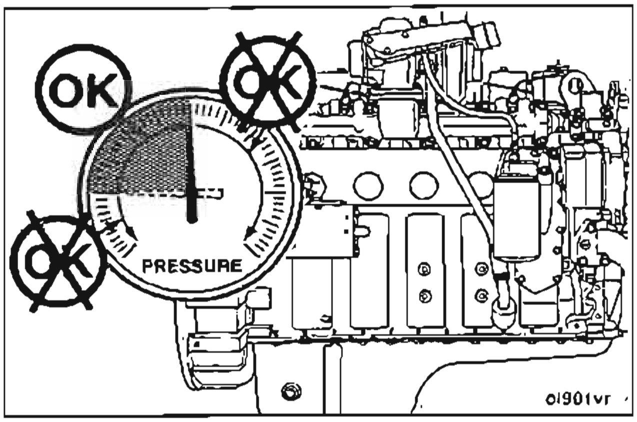
It is good practice to observe these measurements even if engine performance meets specifications. If engine performance does not meet specifications, these measurements can indicate possible reasons for under-performance.



Caution: Do not crank the engine for more than 30 seconds. Excessive heat will damage the starting motor.

Crank the engine and observe the oil pressure when the engine starts. If the engine fails to start within 30 seconds, allow the starting motor to cool for 2 minutes before cranking the engine again.

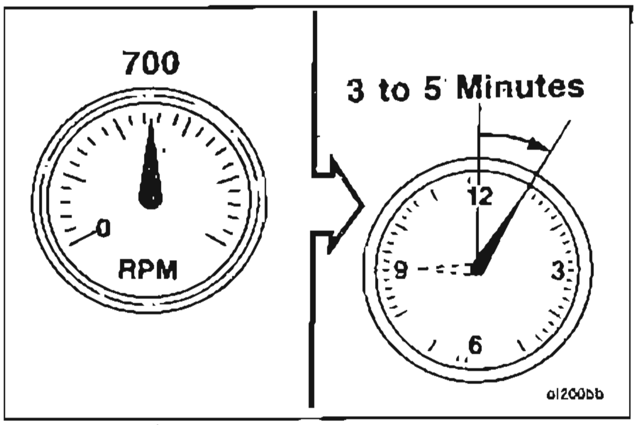




Caution: If the lubricating oil pressure is not within specifications, shut off the engine immediately. Either excessively low or excessively high oil pressure will cause engine damage.

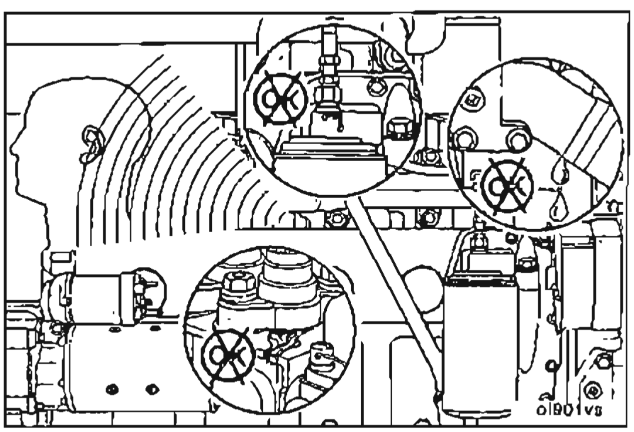
Engine oil pressure must be at least 69 kPa [10 psi] at 700 RPM.

Correct the problem if the oil pressure is not within specifications.



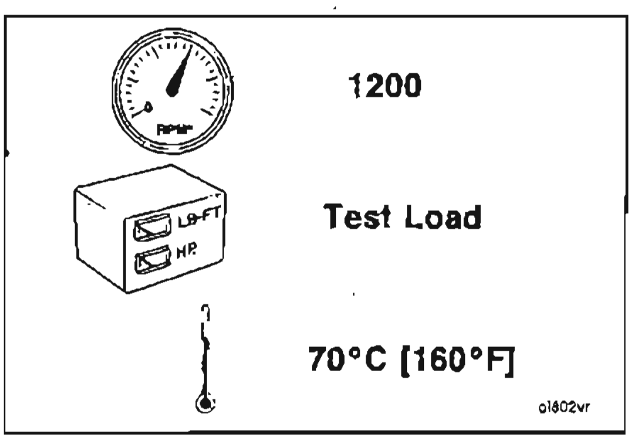
Caution: Do not operate the engine at idle speed longer than specified during engine run-in. Excessive carbon formation will cause damage to the engine.

Operate the engine at approximately 700 RPM for 3 to 5 minutes.



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.



Move the throttle to obtain 1,200 RPM engine speed, and set the test load to 25 percent of the torque peak load.

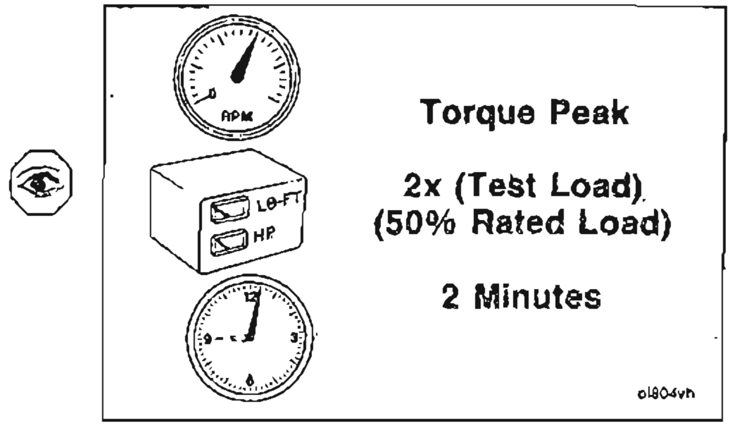
Operate the engine at this speed and load level until the coolant temperature is 70°C [160°F]. Check all gauges and record the data.

NOTE: Do not proceed to the next step until a steady blowby reading is obtained.

Operate the engine at this speed and load level for 2 minutes.

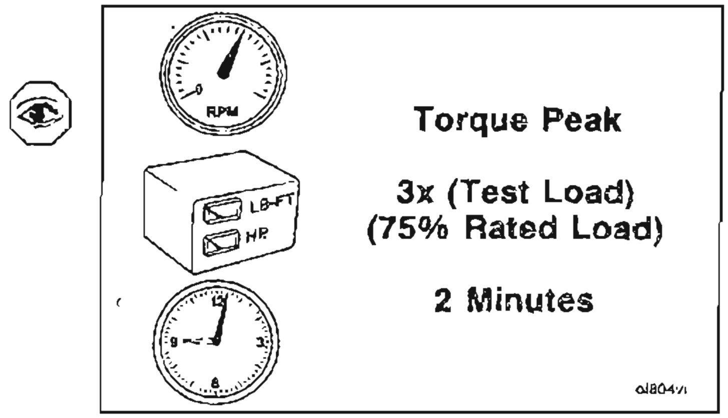
Check all gauges and record the data.

NOTE: Do **not** proceed to the next step until blowby is stable and within specifications.



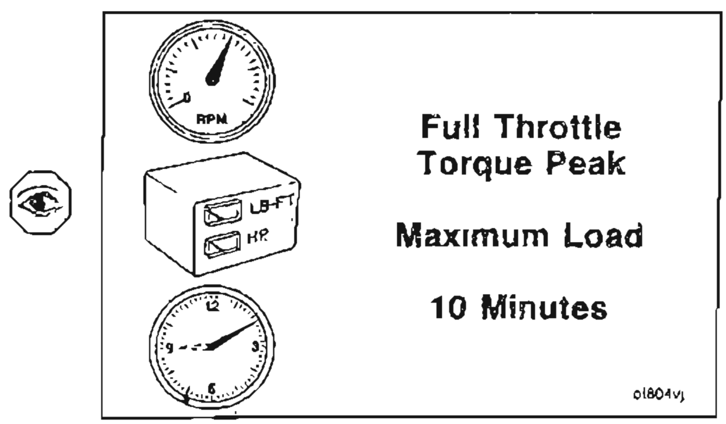
Maintain the engine speed at torque peak RPM, increase the dynamometer load to 75 percent of torque peak load. Operate the engine at this speed and load level for 2 minutes. Check all gauges and record the data.

NOTE: Do **not** proceed to the next step until blowby is stable and within specifications.



Move the throttle lever to its fully opened position, and increase the dynamometer load until the engine speed is at torque peak RPM. Operate the engine at this speed and load level for 10 minutes or until the blowby becomes stable and within specifications.

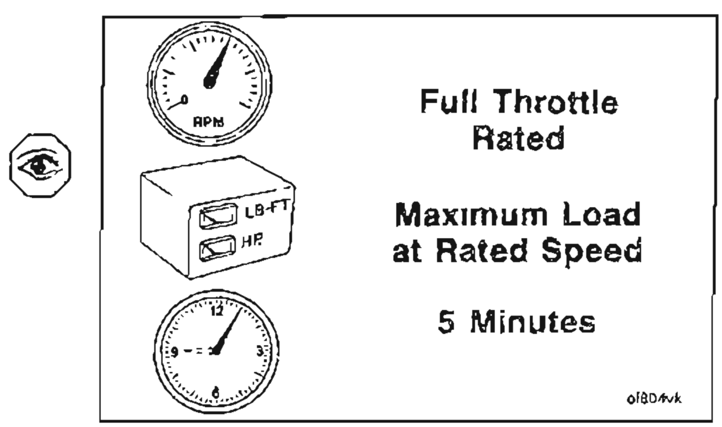
Check all gauges and record the data.

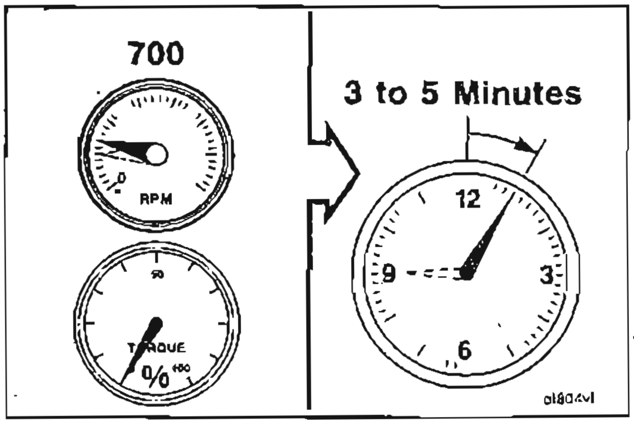


Reduce the dynamometer load until the engine speed increases to the engine's rated RPM.

Operate the engine at rated RPM for 5 minutes.

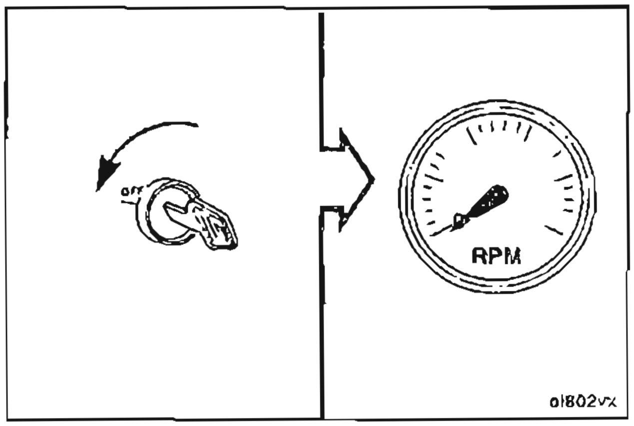
Check all gauges and record the data.



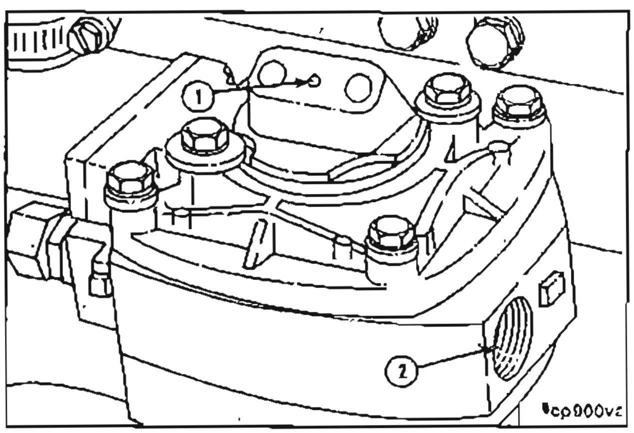


Caution: Shutting off the engine immediately after operating at full load will damage the turbocharger and internal components. Always allow the engine to cool before shutting it off.

Remove the dynamometer load completely, and operate the engine at 700 RPM for 3 to 5 minutes. This period will allow the turbocharger and other components to cool.



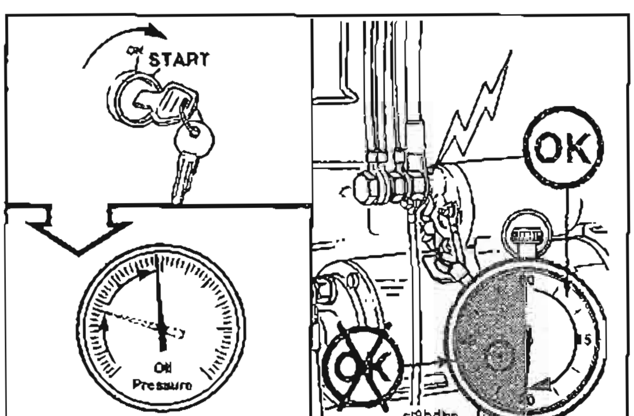
Shut off the engine.



Engine Dynamometer Test - Performance Checking (14-03)

Make sure the air compressor will be unloaded during the performance check.

Apply regulated air pressure of 655 kPa [95 psi] to the air compressor unloader (1).

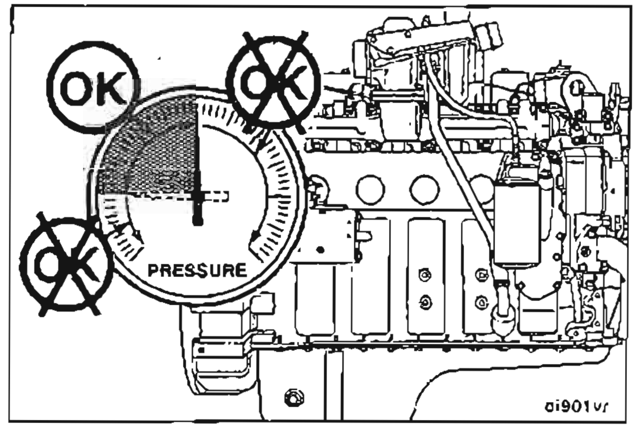


Caution: Do not crank the engine for more than 30 seconds. Excessive heat will damage the starting motor.

Crank the engine and observe the oil pressure when the engine starts. If the engine fails to start within 30 seconds, allow the starting motor to cool for 2 minutes before cranking the engine again.

Caution: If the lubricating oil pressure is not within specifications, shut off the engine immediately. Either excessively low or excessively high oil pressure will cause engine damage. Correct the problem if oil pressure is not within specifications.

Engine oil pressure **must** be a minimum of 69 kPa [10 psi] at approximately 700 RPM.



Make sure the engine is at operating temperature.

Move the throttle lever to the "FULL OPEN" position. Adjust the dynamometer load until the engine maintains the rated RPM.

Allow the readings to stabilize. Read the horsepower.

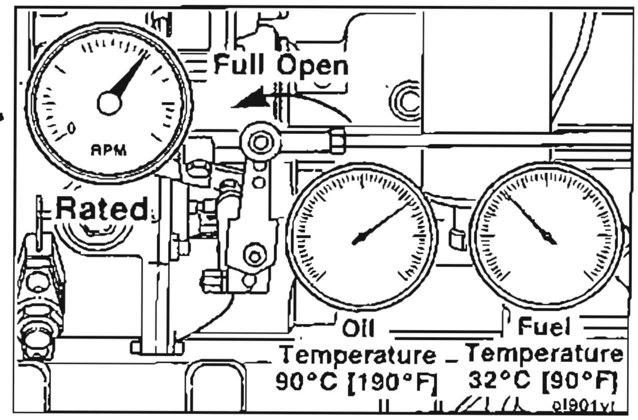
Check all the gauges, and record the readings.

NOTE: The horsepower reading will **not** be accurate if the lubricating oil temperature and fuel temperature are **not** within specifications.

Lubricating Oil Temperature: MIN 90°C [190°F]

Fuel Temperature: MAX 42°C [108°F]

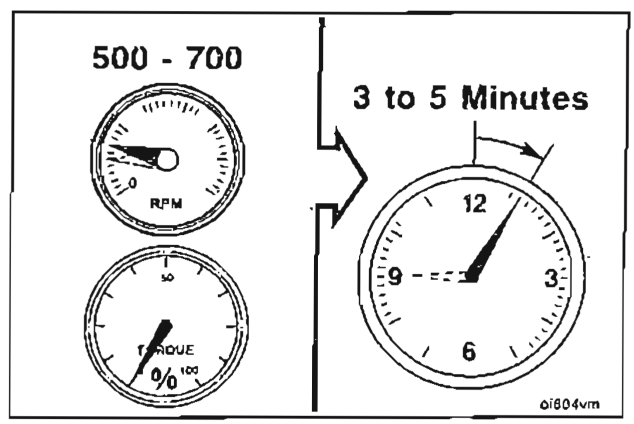
Check all gauges and record the data.



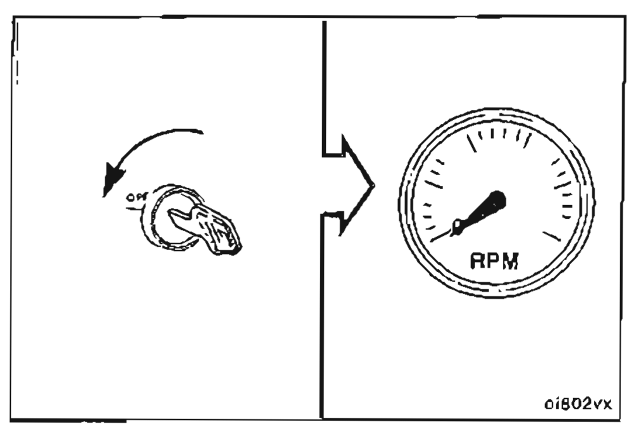
Caution: Do not shut off the engine immediately after it has been loaded. It must be allowed to sufficiently cool.

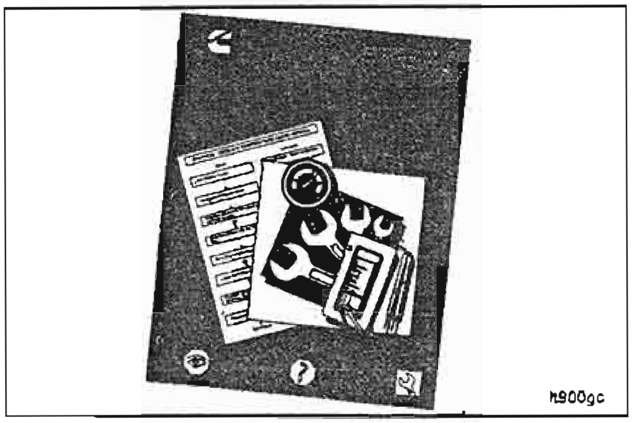
Remove the dynamometer load completely, and operate the engine at idle speed for 3 to 5 minutes. This will allow the turbocharger and other components to cool.

NOTE: Idle periods longer than 5 minutes are to be avoided.

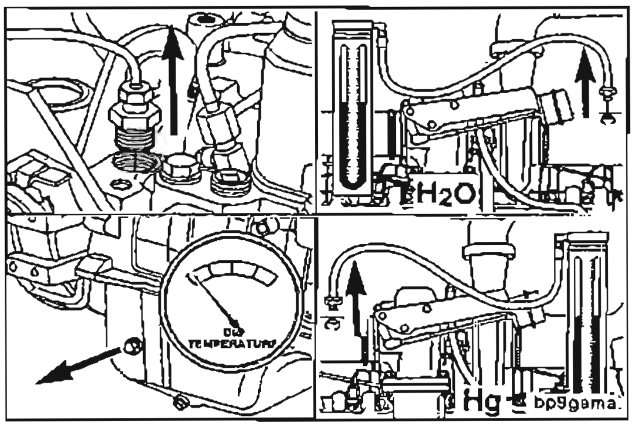


Shut off the engine after the cool-down period.




h900gc

If power specifications are not met, refer to B Series Troubleshooting and Repair Manual, Bulletin No. 3810486.

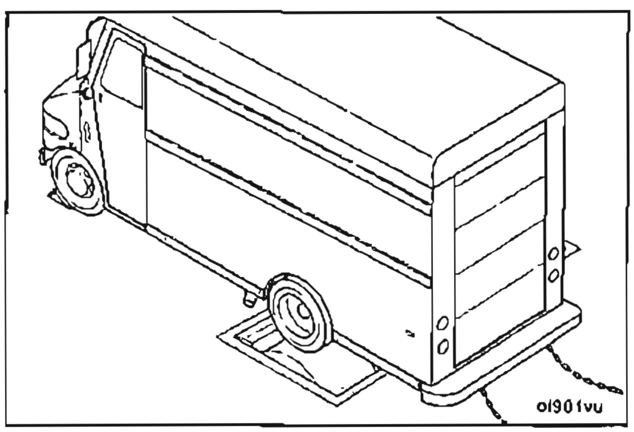


bp9gema

Remove all test instrumentation. Remove the engine from the dynamometer.

NOTE: If the engine is to be stored temporarily and does not have permanent-type antifreeze, it is necessary to drain all coolant. Drain locations are identified on the engine side views, pages 14-4 and 14-5.

Prepare the engine for Engine Painting (14-08) or Engine Storage (14-09) or (14-10).


ol901vu

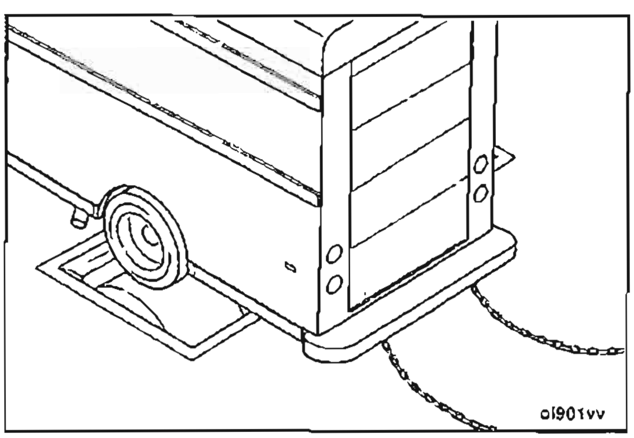
Chassis Dynamometer - Operation (14-04)

The performance of an engine installed in on-highway vehicles can be tested on a chassis dynamometer.

NOTE: Due to driveline efficiency and engine-driven accessories, the engine horsepower when measured at the rear wheels will be reduced by approximately

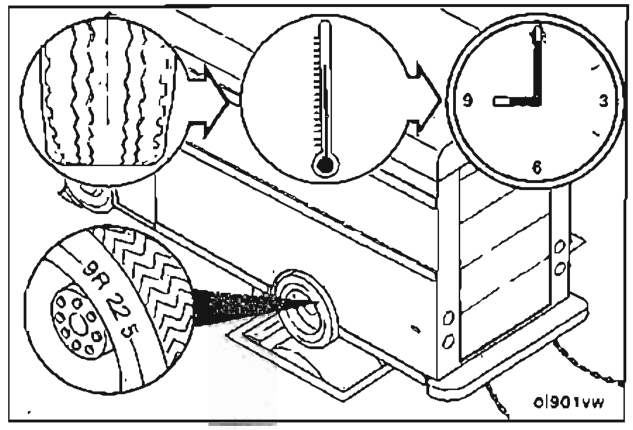
- 20 percent for single axle vehicles
- 25 percent for tandem axle vehicles

NOTE: These percentages are used for engine run-in only and are not to be used as absolute figures.


ol901vv

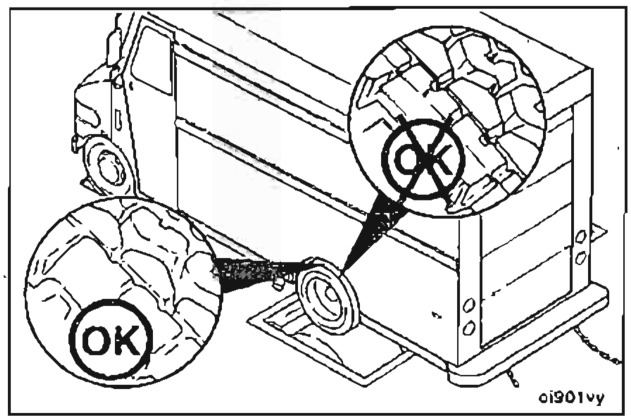
Caution: Follow all the vehicle manufacturer's safety precautions before installing or operating a vehicle on a chassis dynamometer.

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.

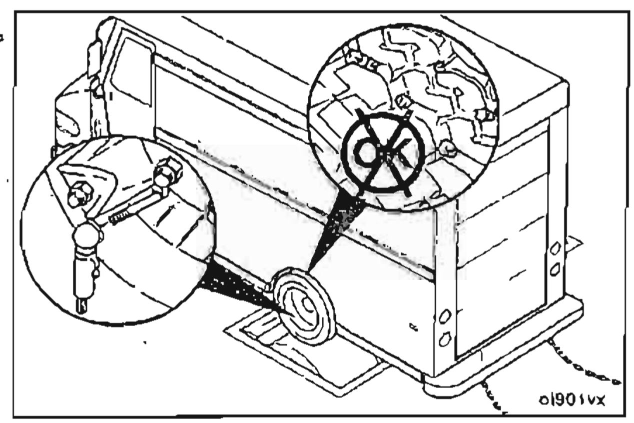


Follow the general safety precautions listed below while operating the chassis dynamometer:

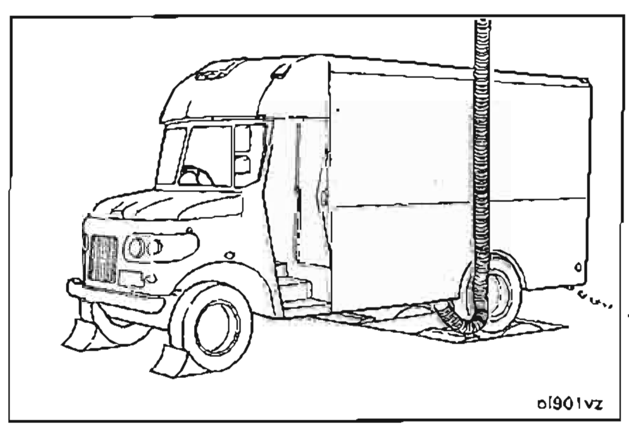
- Use tires that have more than 160 kilometers [100 miles] on them. Do **not** use new tires.
- Do **not** use recapped tires or tires of different sizes or designs.

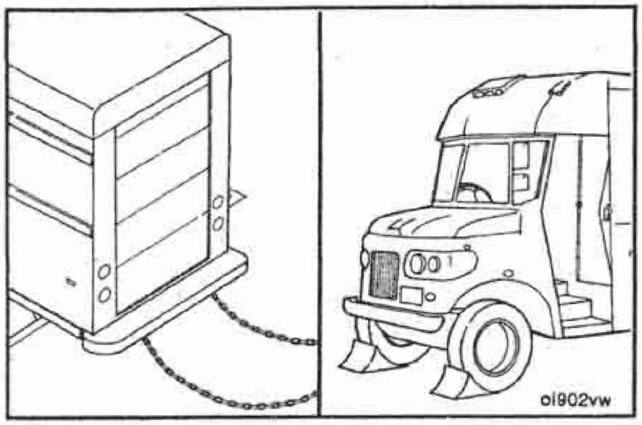


- Make sure the tires are inflated to the manufacturer's specifications.
- Remove all rocks or other material from the tread of all tires that will be rotating on the dynamometer rollers.



- Make sure there is correct overhead clearance for exhaust stacks, air deflectors, or other attachments above the cab.

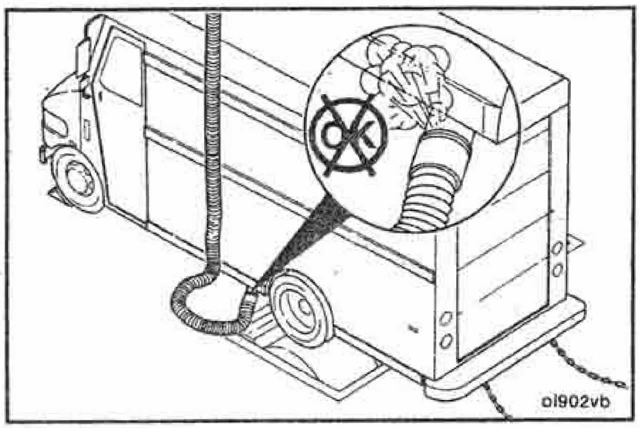




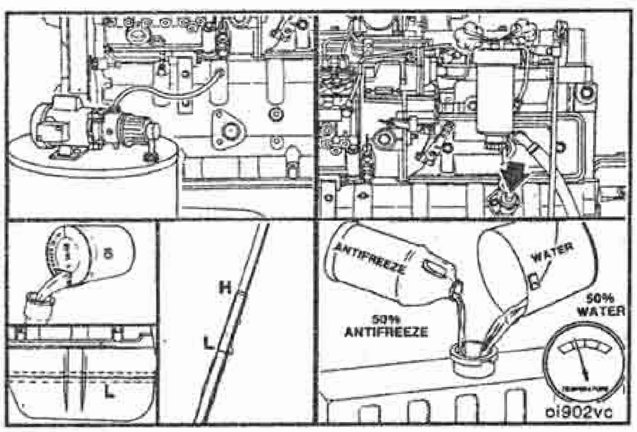
- Carefully position the vehicle on the rollers.

Caution: To prevent damage to the chassis dynamometer, there must be some slack in the tension of the tie-down chains.

- Attach the tie-down chains to the rear of the vehicle, and put wheel chocks in front of the front wheels.

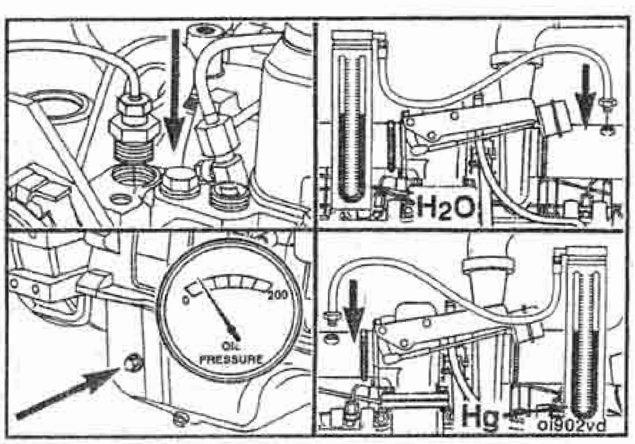


- Adjust the vehicle and dynamometer room exhaust system to make sure all exhaust gases are removed from the room.
- Refer to the chassis dynamometer and vehicle manufacturer's recommendations and specifications for testing procedures.



General Engine Test Procedures - (Chassis Dynamometer) (14-05)

The following procedure assumes that the lubricating oil and fuel systems were correctly primed, the dipstick calibrated, and the engine filled to the correct levels with oil and coolant during installation of the engine into the chassis. If these sytems were **not** serviced during installation of the engine, refer to Engine Dynamometer Test Installation of the Engine (14-01) for instructions on priming the lubricating oil and the fuel systems and calibrating the dipstick. Refer to the latest B Series Operation and Maintenance Manual, Bulletin No. 3810205, for instructions on filling the lubricating oil and the cooling systems.

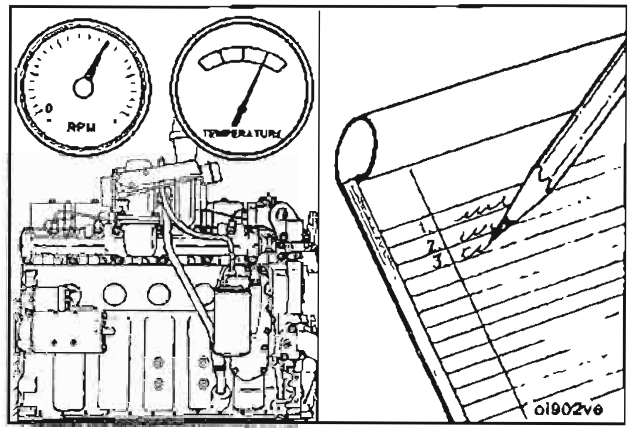


The number of instruments and gauges required to perform a chassis dynamometer test will vary according to the type and the capability of the test equipment used.

Refer to pages 14-4 and 14-5 for the correct system pressure and temperature gauge connecting locations.

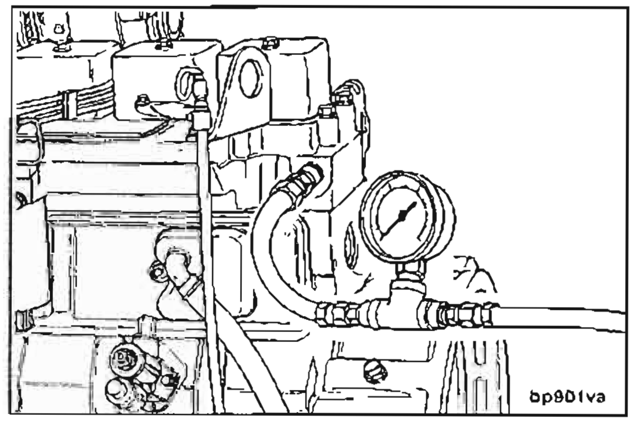
To correctly monitor an engine's performance, record the following parameters:

- Lubricating oil pressure (vehicle instrument panel)
- Coolant temperature (vehicle instrument panel)
- Coolant pressure
- Turbocharger outlet pressure
- Exhaust restriction
- Intake manifold pressure
- Inlet air restriction
- Blowby
- Engine speed (RPM) (vehicle instrument panel)
- Wheel horsepower (WHP) (dynamometer controls)

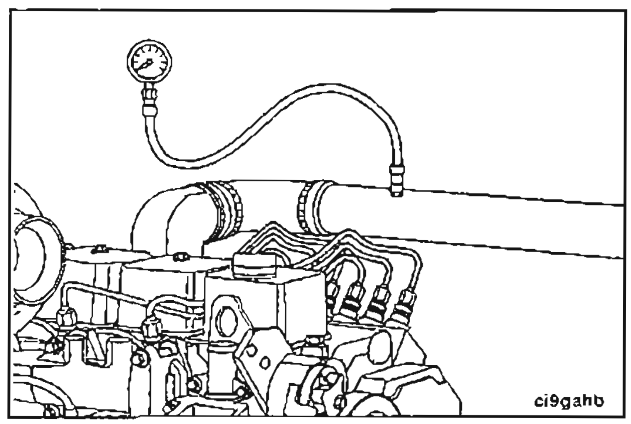


Measure the coolant pressure at the cylinder head, rear fuel pump side.

Minimum Gauge Capacity: 415 kPa [60 psi]



Measure turbocharger outlet pressure and intake manifold pressure. The drop in pressure accross the aftercooler/charge air cooler must not exceed 21 kPa [3 psi].

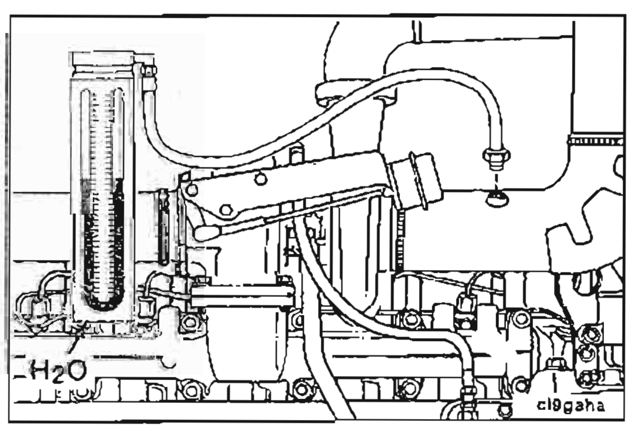


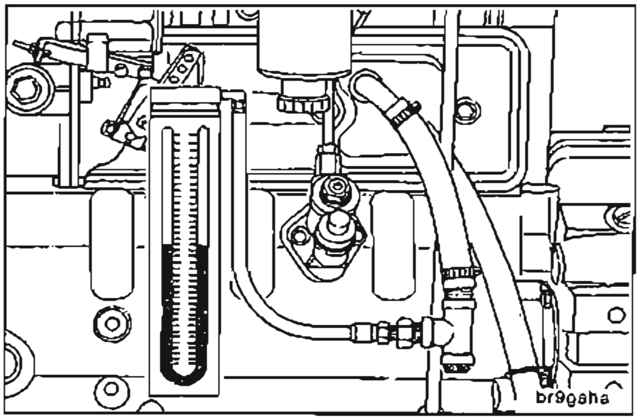
Connect a water manometer to the turbocharger air inlet pipe to test air restriction.

NOTE: The manometer connection 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 in place of the water manometer.

Minimum Gauge Capacity: 760 mm H_2O [30 in. H_2O]

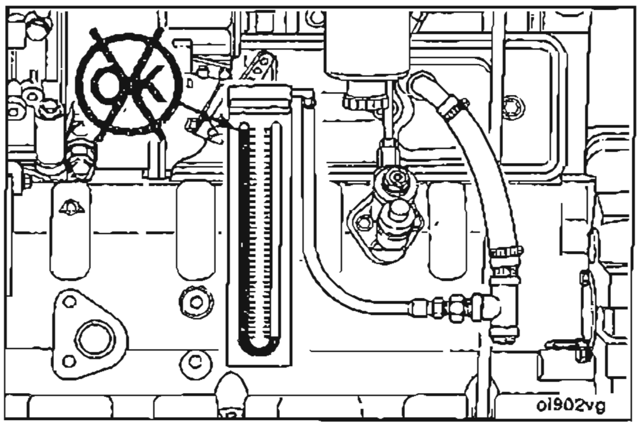




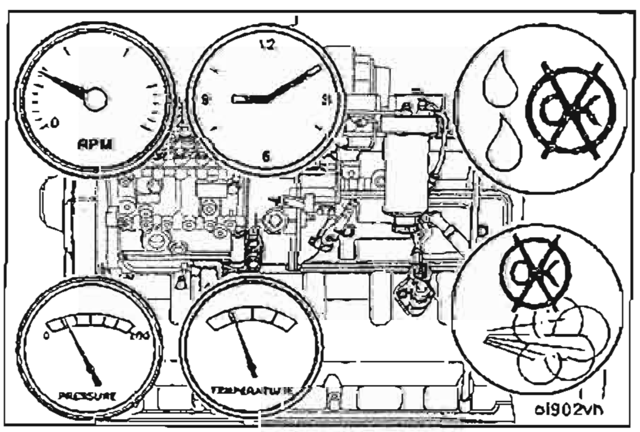
Measure the blowby by installing blowby checking tool in the crankcase breather vent. Connect the blowby tool to a water manometer.

NOTE: Excessive blowby indicates a turbocharger malfunction or an engine internal components malfunction, allowing combustion gases to enter the crankcase.

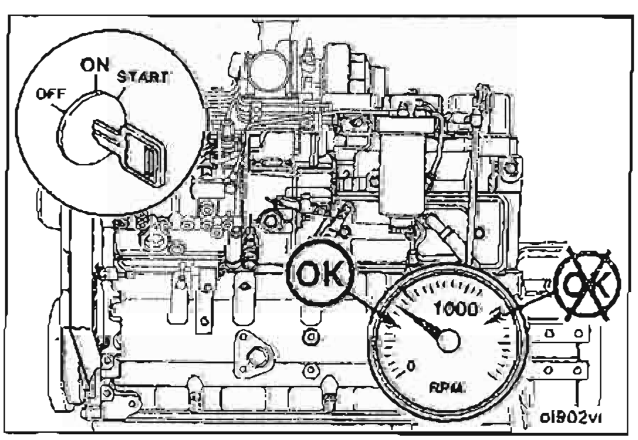
Minimum Gauge Capacity: 1270 mm H_2O [50 in. H_2O].



NOTE: 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, discontinue the run-in and determine the cause.

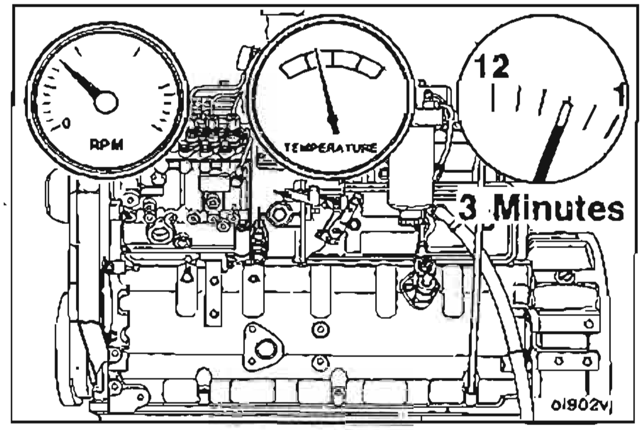


NOTE: Avoid long idle periods. Operate the engine at low idle only long enough (3 to 5 minutes) to check for correct oil pressure and any fuel, oil, water, or air leaks.



Caution: Do not allow the engine speed to exceed 1,000 RPM before run-in. The internal components can be damaged.

Caution: Do not shut off the engine immediately after the last step of 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.

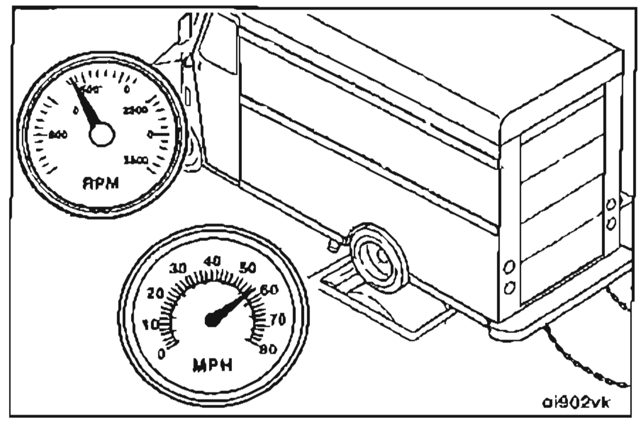


Engine Run-In Procedure - (Chassis Dynamometer) (14-06)

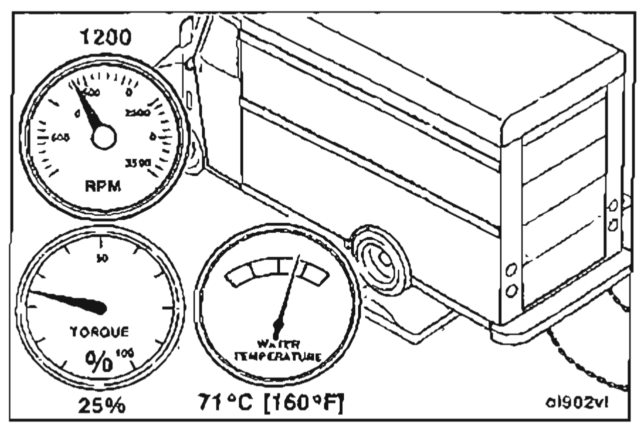
Caution: Refer to General Engine Test Procedures (Chassis Dynamometer) (14-05) before operating the engine to avoid internal component damage.

NOTE: Refer to Chassis Dynamometer Operation on page 14-19 for general operating procedures and safety precautions.

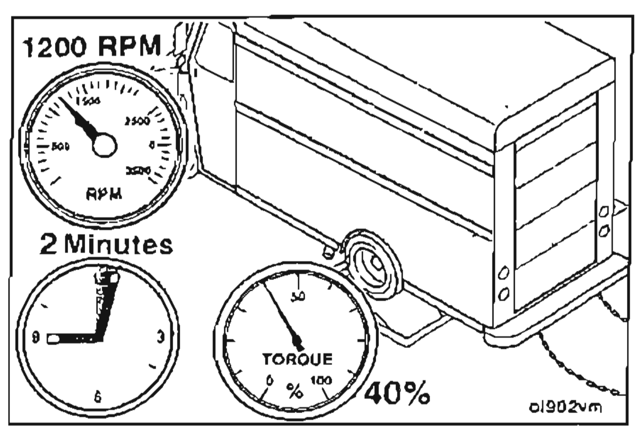
NOTE: Operate the vehicle in a gear that produces a road speed of 90 to 95 km/h [55 to 60 mph].

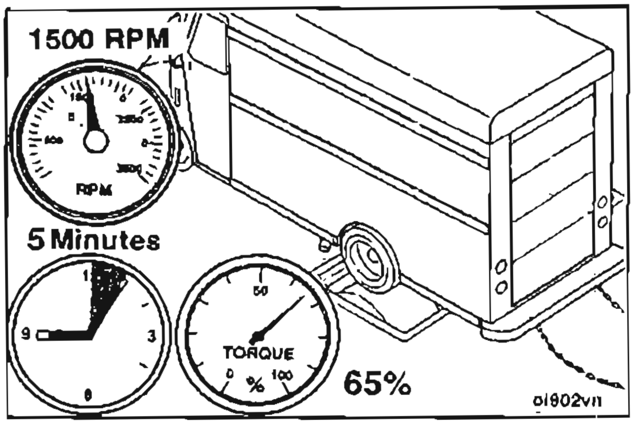


Operate the engine at 1,200 RPM and 25 percent of torque peak load until the water temperature reaches 70°C [160°F].

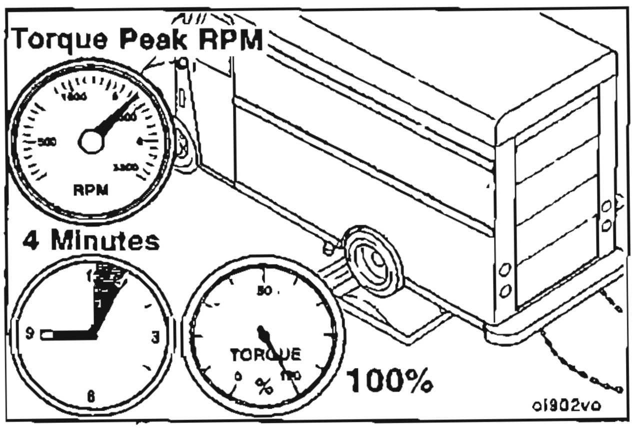


Operate the engine at 1,200 RPM and 40 percent of torque peak load for 2 minutes. Check the gauges, and record the readings.



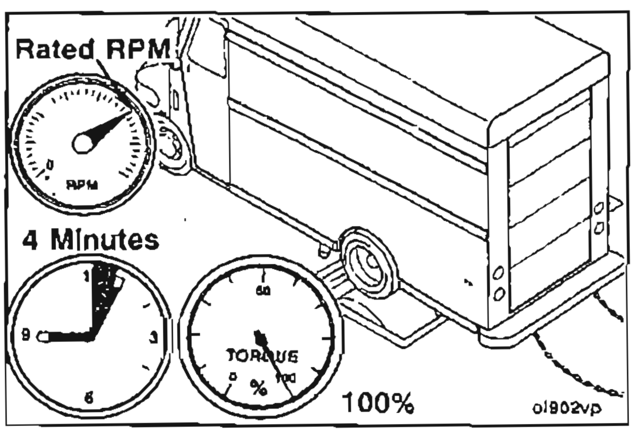


Operate the engine at 1,500 RPM and 65 percent of torque peak load for 5 minutes. Check the gauges, and record the readings.



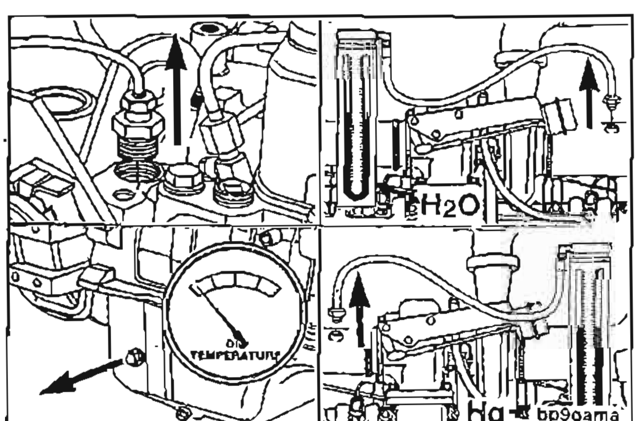
Operate the engine at torque peak RPM and full load for 4 minutes. Check the gauges, and record the readings.

NOTE: Refer to the engine data sheet for the torque peak RPM of the engine model being tested.



Operate the engine at rated speed (RPM) and full load for 4 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 low idle for a minimum of 3 minutes to avoid internal component damage.



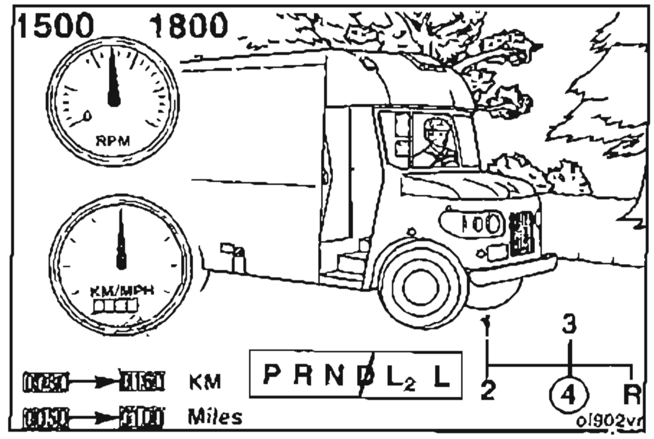
Make sure all instrumentation is removed before removing the vehicle from the dynamometer.

Engine Run-In Procedure "In Chassis" - (On- and Off-Highway Vehicles) (14-07)

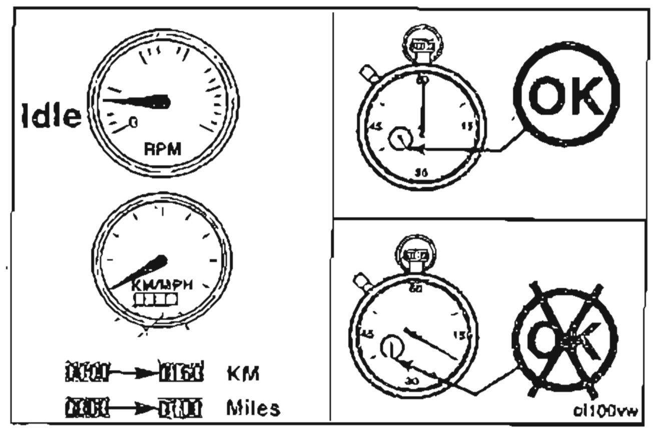
On-Highway

Caution: Refer to General Engine Test Procedures (Chassis Dynamometer) (14-05) before operating the engine to avoid internal component damage.

Operate the engine at 1,500 to 1,800 RPM in high gear for the first 80 to 160 kilometers [50 to 100 miles] after rebuild.



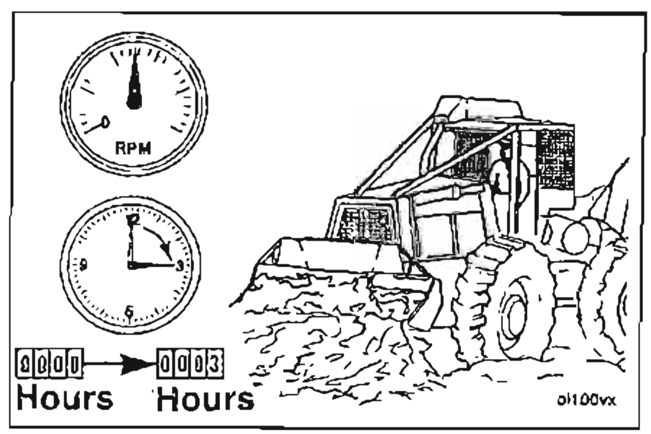
NOTE: Do **not** idle the engine for more than 5 minutes at any one time during the first 160 kilometers [100 miles] of operation.



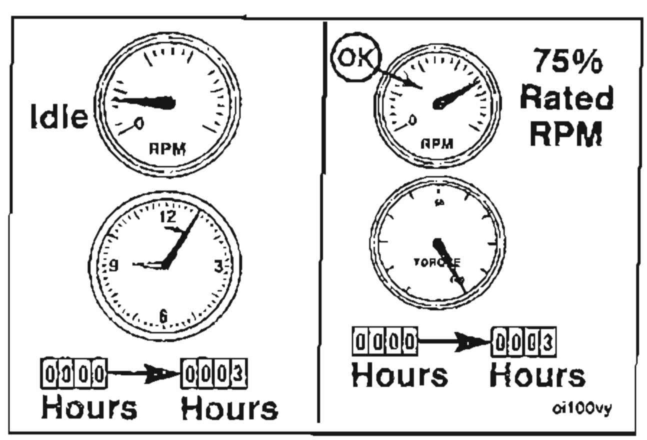
Off-Highway

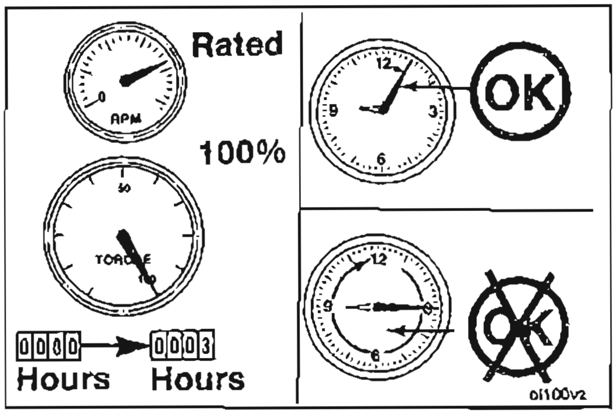
Caution: Refer to General Engine Test Procedures (Chassis Dynamometer) (14-05) before operating the engine to avoid internal component damage.

Operate the engine as follows during the first 3 hours after rebuild:

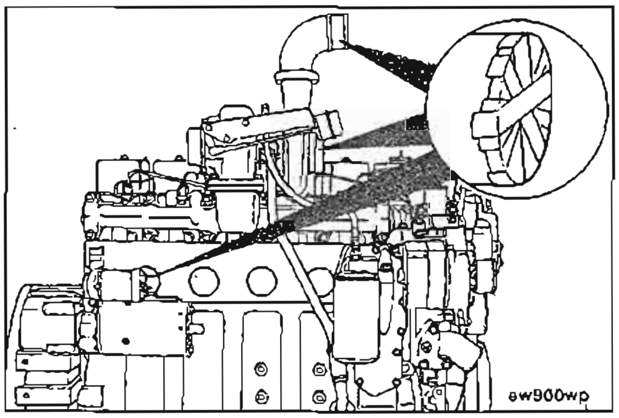


1. Do **not** idle the engine for more than 5 minutes at any one time.
2. Operate the engine at 75 percent throttle while loaded.





3. Do **not** operate the engine at rated speed (RPM) and full load for more than 5 minutes at any one time.

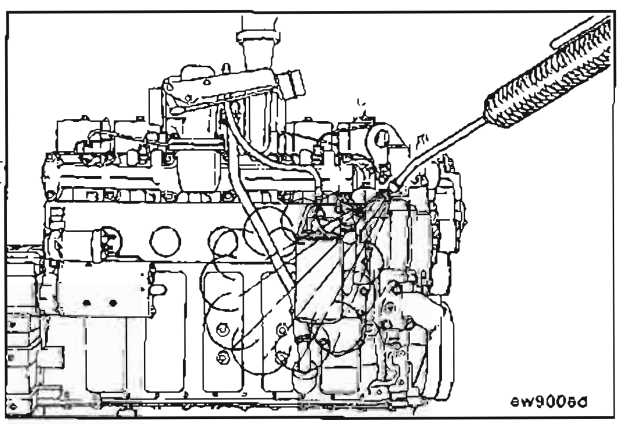


Engine - Painting (14-08)

Remove all belts from the engine.

Cover the following parts of the engine:

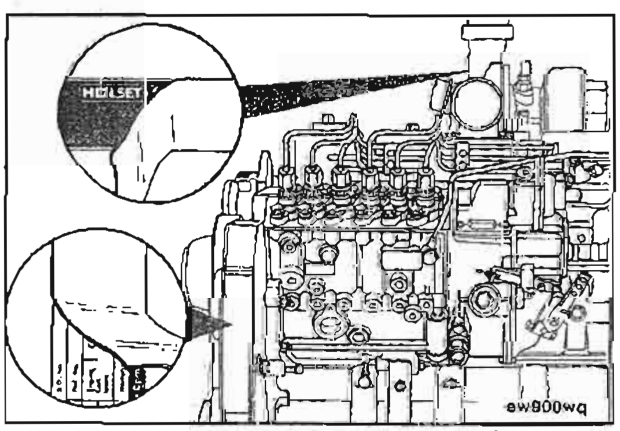
- Exhaust and intake openings
- Electrical components
- Fuel inlet and drain connections
- Any exposed fittings, threads, and electrical wire terminals



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

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

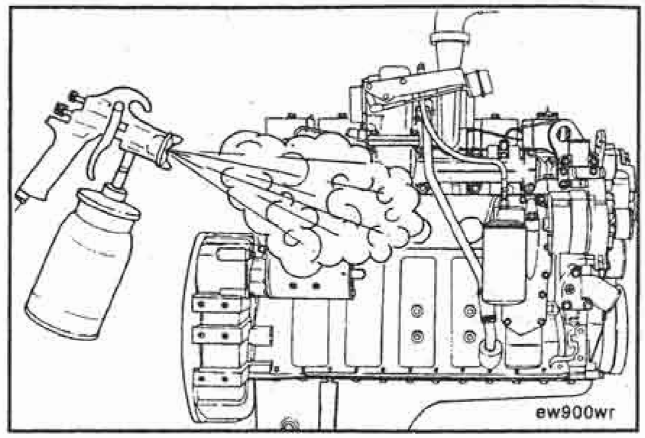
NOTE: Make sure all engine surfaces are clean and dry before painting the engine.



Protect the following components from the paint:

- All dataplates
- Valve and injector set marks.
- Exhaust manifold
- Turbocharger turbine housing
- Flywheel
- Flywheel housing transmission mounting surface

Paint the engine.

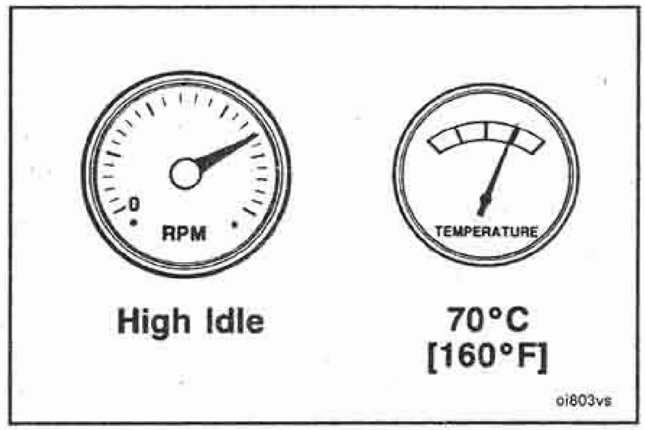


Engine Storage - Short Term (14-09)

NOTE: This procedure describes the correct method of preparing an engine for short-term (1 to 6 months) storage.

Operate the engine at high idle until the coolant temperature reaches 70°C [160°F].

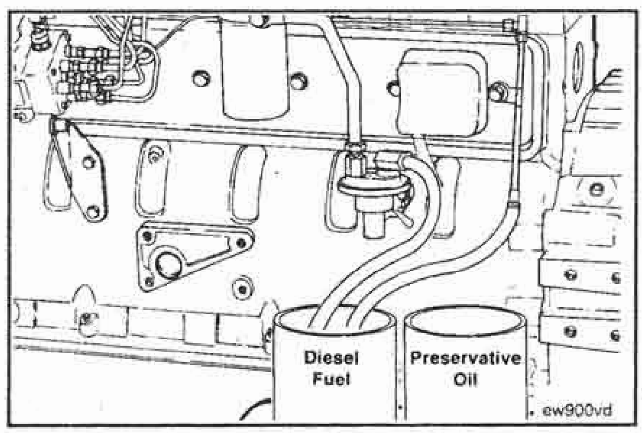
Shut off the engine.



Remove the fuel tube to the engine fuel filter and the injector return tube.

NOTE: Fuel system preservative oil **must** meet Federal Specification VV-L-800C. (Example: Daubert Chemical NoxRust No. 518.)

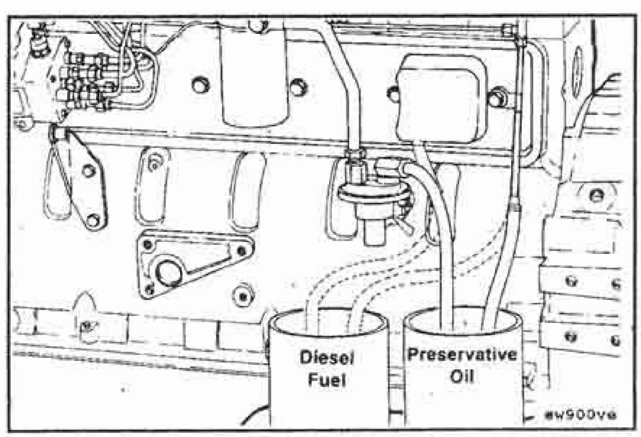
Fill two containers, one with diesel fuel and the other with the preservative oil. Put both fuel tubes into the container of diesel fuel.

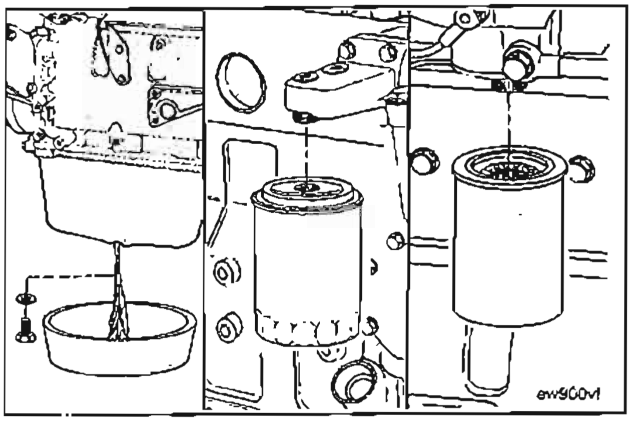


Start the engine. When it is operating smoothly, put the fuel supply tube into the container of preservative oil.

Remove the injector return tube from the diesel fuel container. When preservative oil flows from the tube, shut off the engine.

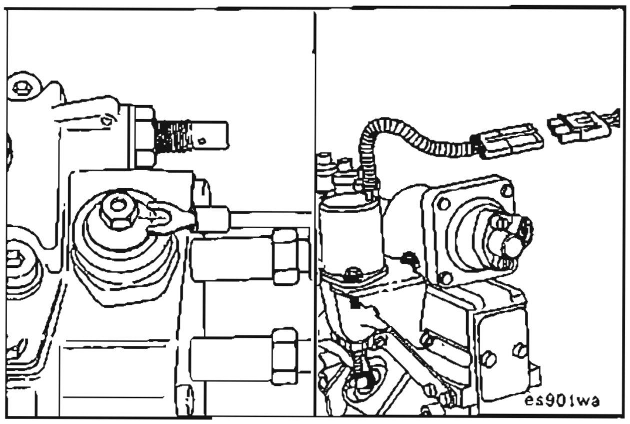
Install the fuel supply tube to the fuel filter, and put a cap on all other fuel tubes.



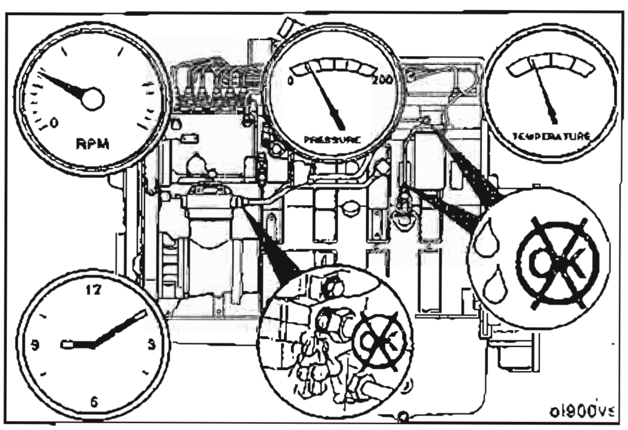


Drain the lubricating oil pan, the oil filters, and the fuel filter.

Install the drain plug into the oil pan, and install the filter cans. Tighten according to specifications.

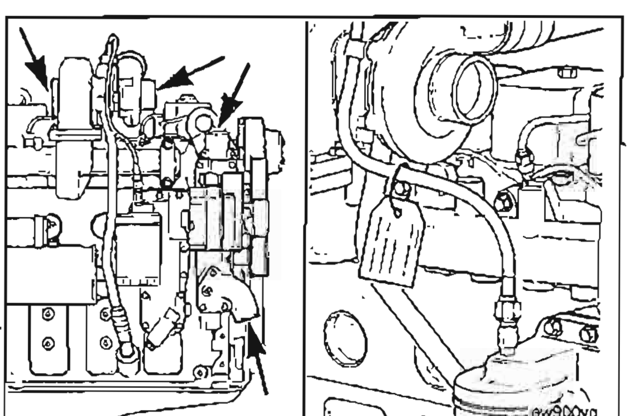


Disconnect the electrical wires from the fuel pump solenoid.



Drain the coolant passages and jackets.

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.

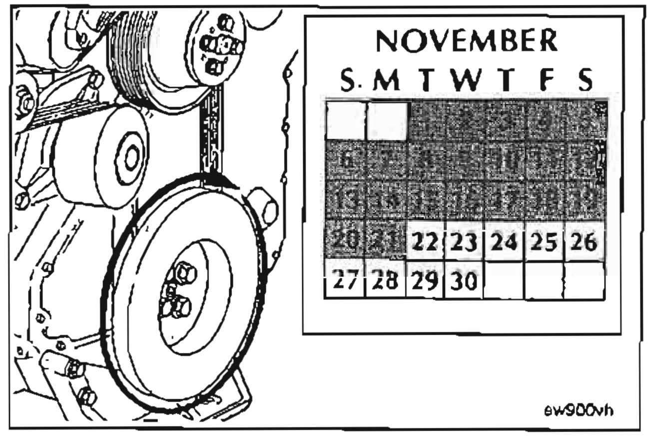


Look the engine over closely, and cover all openings with tape to prevent dirt and moisture from entering.

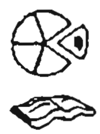
Install a warning tag which alerts others of no oil in the engine and that it **must not** be started.

Store the engine in a dry area of even temperature.

Rotate the crankshaft two to three revolutions every 3 to 4 weeks use the barring gear, Part No. 3904682 to rotate the crankshaft.



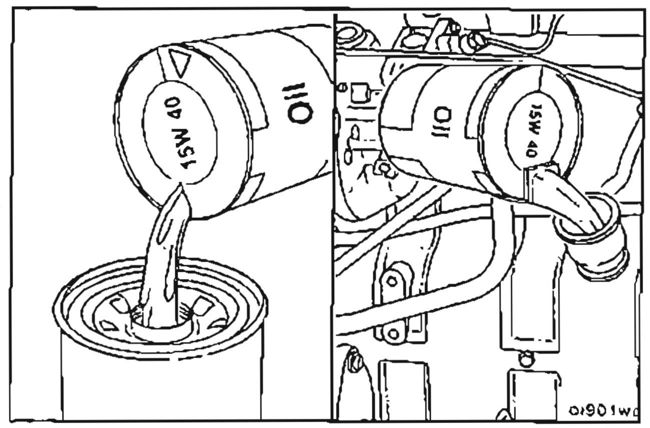
Removing the Engine from Short-Term Storage



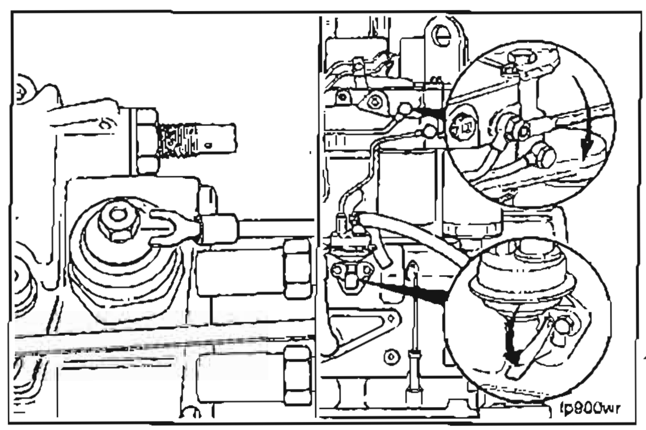
Remove the tape from all openings, and remove the warning tag.

Refill the oil filters with clean 15W-40 oil, and prime the lubrication system. Refer to Engine Dynamometer Test Engine Run-in.

Use clean diesel fuel to flush the preservative oil from the fuel system, and fill the fuel filter again.



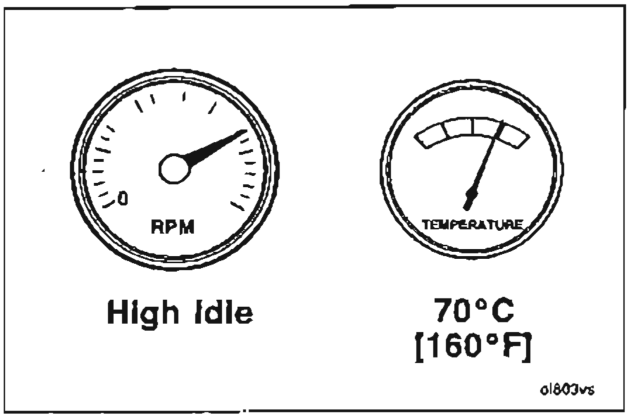
Connect the electrical wiring to the fuel pump solenoid. Prime and vent the fuel system.



Engine Storage - Long Term (14-10)

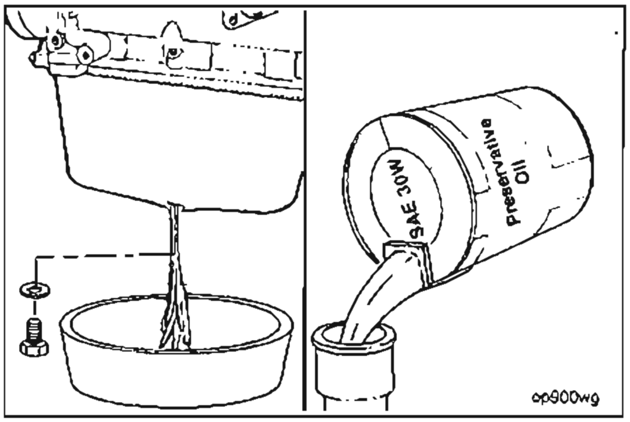
This procedure describes the correct method of preparing an engine for long-term (6 to 24 months) storage.

NOTE: If the engine has been stored for 24 months, the cooling system **must** be flushed with a solvent. Repeat the flushing procedure a second time.



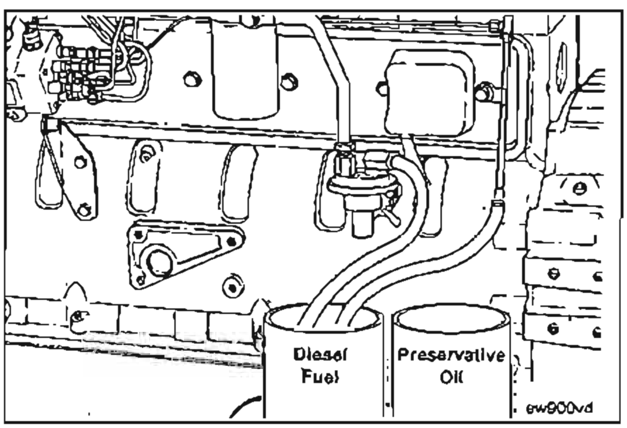
Operate the engine at the high idle throttle position until the coolant temperature is 70°C [160°F].

Shut off the engine.



Drain the lubricating oil pan. Install the drain plug, and fill the oil pan to the high level mark on the dipstick with preservative oil.

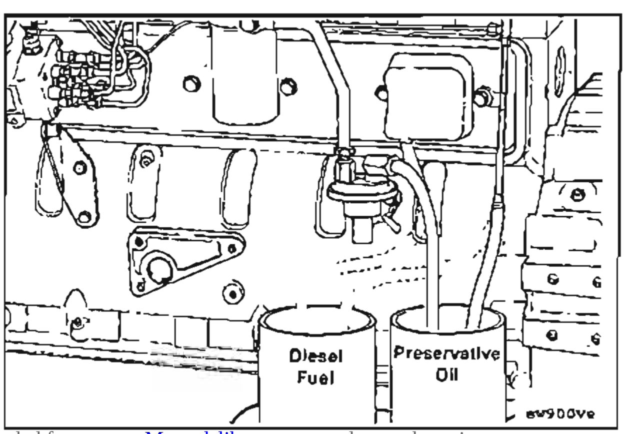
NOTE: Lubricating system preservative oil **must** meet Military Specification MIL-L-21260 Type PE30-1 SAE 30. (Example: Shell 66202.)



Disconnect the fuel supply tube at the fuel filter and the injector return tube at a convenient place.

NOTE: Fuel system preservative oil **must** meet Federal Specification VV-L-800C. (Example: Daubert Chemical NoxRust No. 518.)

Fill two containers, one with diesel fuel and the other with preservative oil. Put both fuel tubes into the container of diesel fuel.



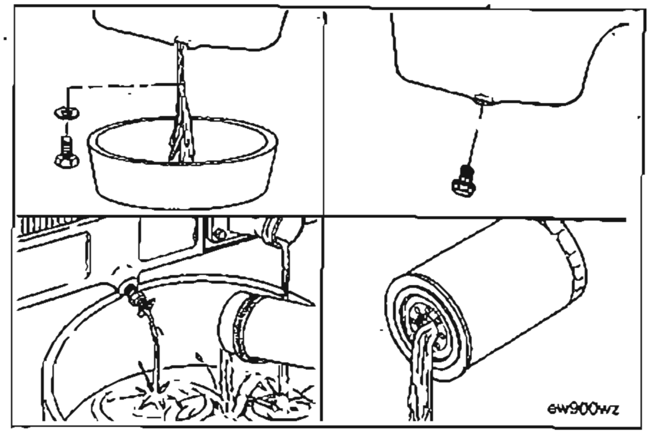
Start the engine and, when operating smoothly, put the fuel supply tube into the container of preservative oil.

Remove the injector return tube from the diesel fuel container. When the preservative oil flows from the tube, shut off the engine.

Connect the fuel supply tube to the fuel filter, and put a cap on the ends of all the other fuel tubes.

Drain the preservative oil from the lubricating oil pan and the oil filters. Install the drain plug.

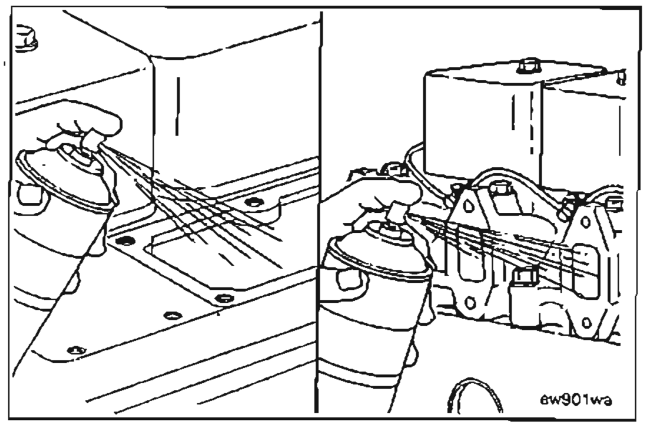
Drain and flush the cooling system, using a water-soluble rust inhibitor.



Remove the aftercooler assembly and the exhaust manifold. Refer to Engine Disassembly (00-01).

Spray preservative oil into the intake and the exhaust ports of the cylinder head and into the aftercooler housing and the exhaust manifold.

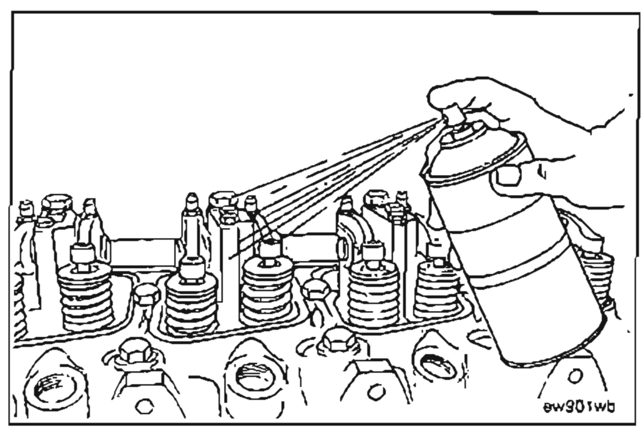
Install the aftercooler assembly and the exhaust manifold. Refer to Engine Assembly.



Remove the rocker housing covers, and spray the rocker levers, valve springs, valve stems, valve guides, and the push rods with preservative oil. Install the rocker housing cover.

Spray preservative oil into the intake port of the air compressor and on all exposed metal surfaces that are **not** painted.

NOTE: Use a preservative compound that meets Military Specification MIL-C-16137C Type P-2 Grade 1 or 2.

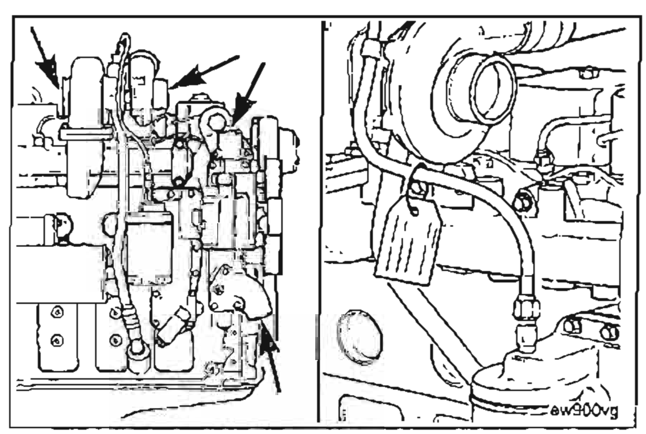


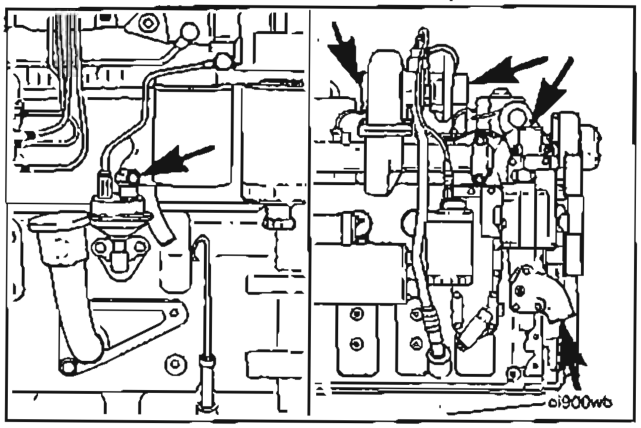
Cover all openings with heavy paper and tape to prevent entrance of dirt and moisture.

Put a warning tag on the engine which contains the following information:

- Date the engine was prepared for storage.
- Crankshaft **must not** be rotated.
- Coolant has been drained.
- Engine **must not** be operated.

Store the engine in a dry area of even temperature.

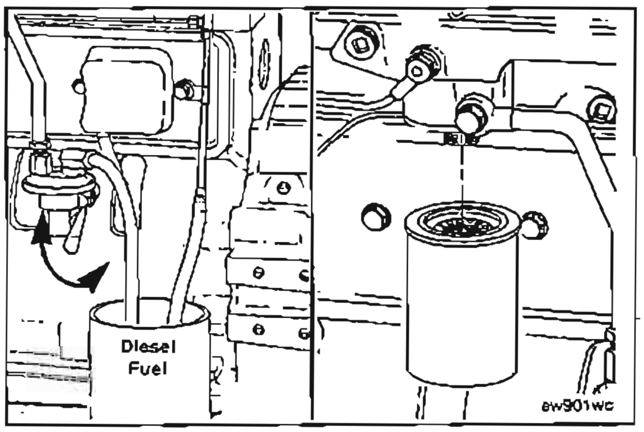




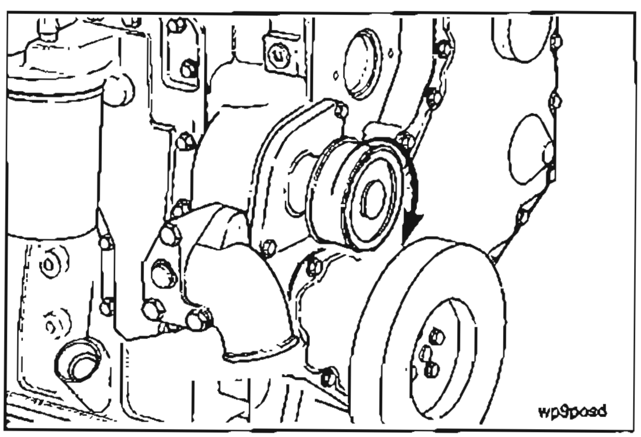
Removing the Engine from Long-Term Storage

Remove the paper and the tape from all openings.

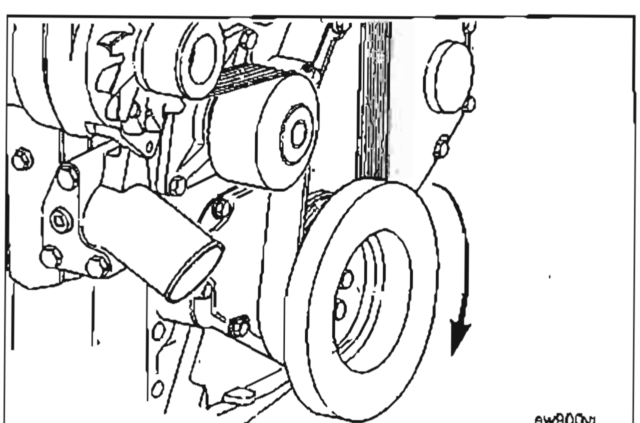
Remove the warning tag.



Flush the fuel system with clean diesel fuel to remove preservative oil.

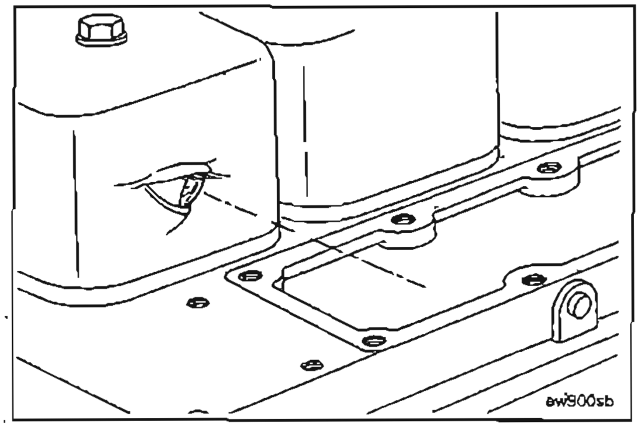


Rotate the water pump to make sure it hasn't rusted in place.

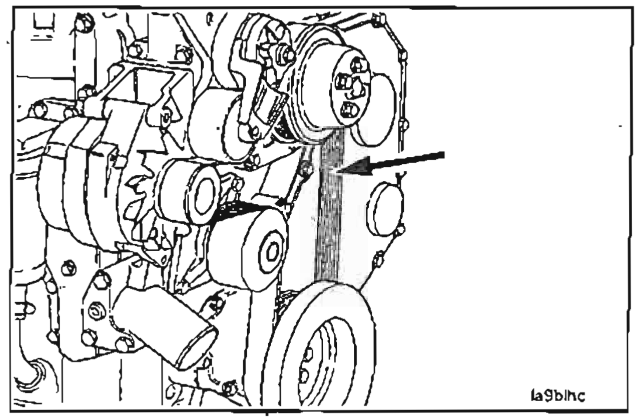


Rotate the crankshaft two complete revolutions to make sure the piston rings are free and no foreign objects are in the engine.

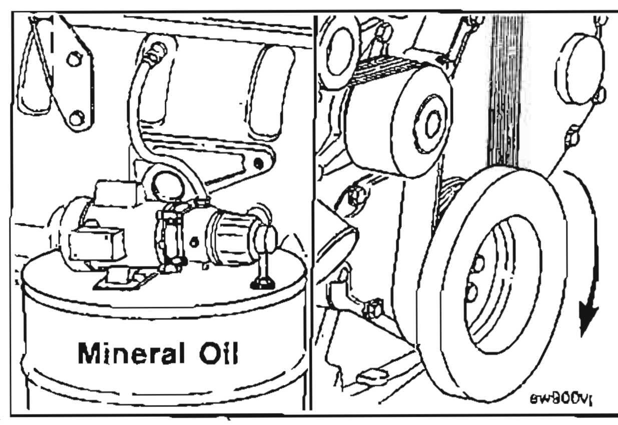
Remove the intake manifold cover or aftercooler and visually inspect the lower valve stem area for presence of rust. An accumulation of rust requires disassembly and rebuild of the cylinder head.



Install the drive belt or belts.

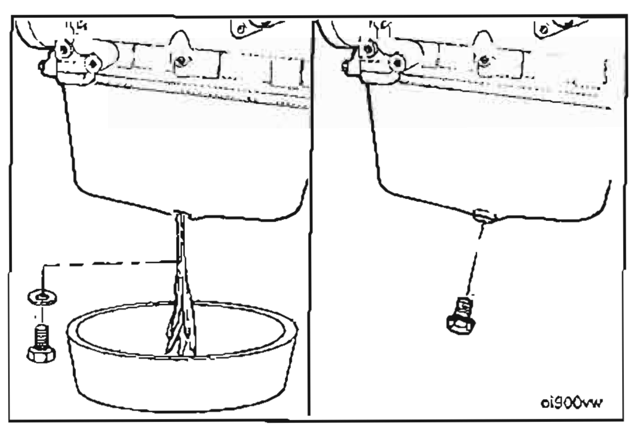


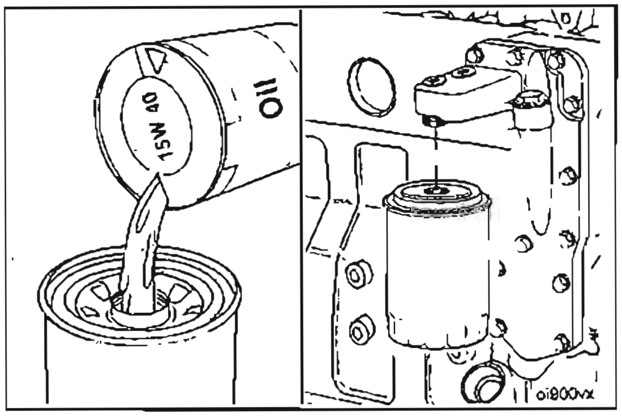
Remove a plug from the main oil rifle drilling and flush the preservative oil from the engine by pumping 4 liters of light mineral oil into the oil rifle. Rotate the crankshaft three or four revolutions as the engine is flushed. Install the plug.



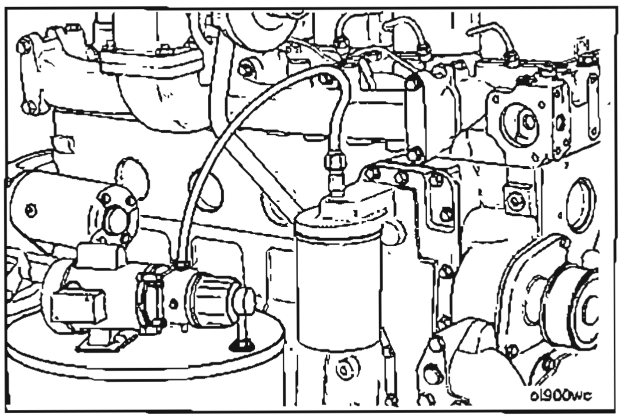
Remove the oil drain plug and allow the mineral oil to drain from the engine.

Install drain plug.

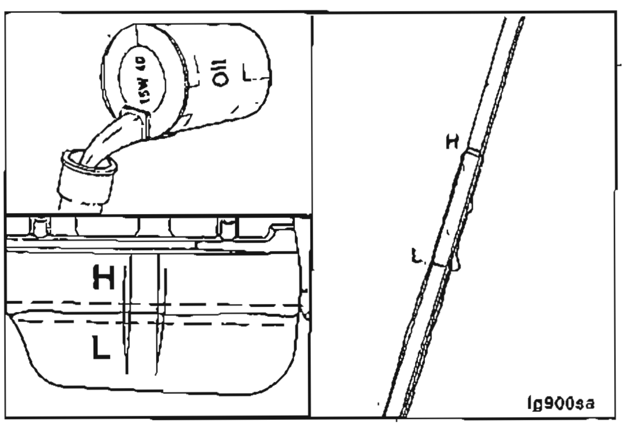




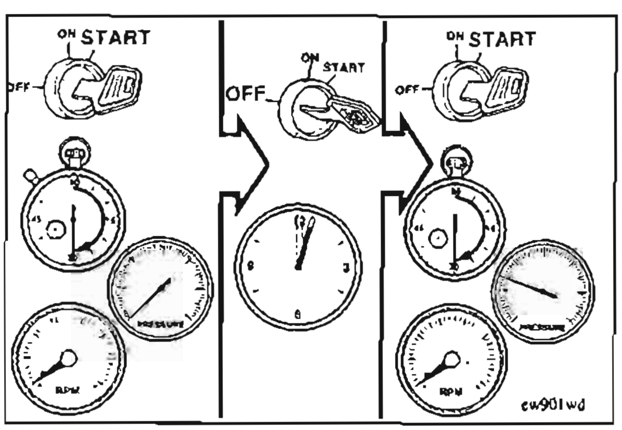
Remove the lubricating oil filter. Install a new filter according to the manufacturer's specifications.



Pressure fill the engine with 15W40 lubricating oil through the 1.8 inch pipe tap on the side of the oil filter housing directly below the turbocharger oil supply connection. Use 207 kPa (30 psi) to pressure fill the system with a minimum of 3.6 L (1 U.S. gal).



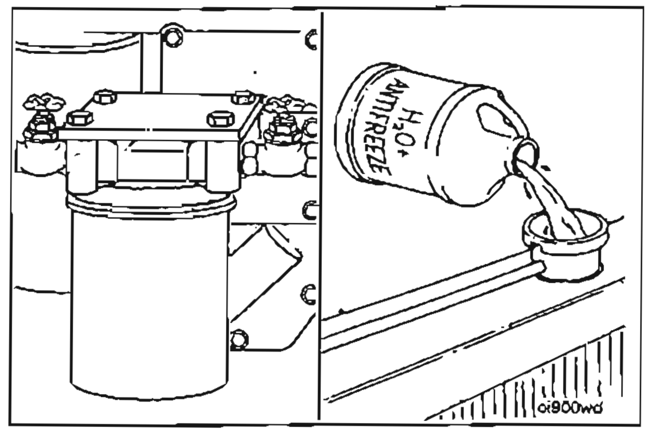
Reinstall the drain plug and fill the oil pan to the high mark on the dipstick.



Caution: Make sure the engine does not start when you crank the engine by disconnecting the fuel solenoid or positioning the shut down lever in the stop position.

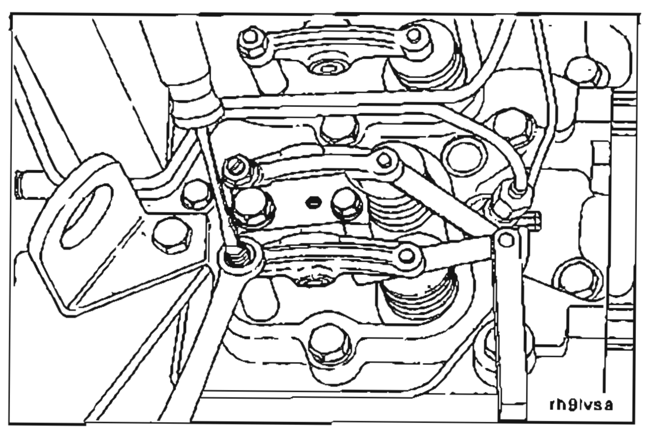
Use the starter to crank the engine for a maximum of 30 seconds, with two minute intervals, until oil pressure registers on the lubricating oil pressure gauge.

Install a new coolant filter if so equipped. Fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze.



Adjust the valve clearance according to the procedure in the applicable service manual.

Tighten all capscrews, plugs and fittings as necessary.



Section 16 - Mounting Adaptations - Group 16

Section Contents

General Information

Flywheel Housing

The flywheel housings are available in different sizes and styles for the various applications. Ring dowels are used to locate the housing within 0.20 mm [0.008 in] total indicated runout. Service housings are drilled for the dowels and re-dowelling is not required. Check the appropriate parts book and the engine parts listing for the correct part number for the engine application being serviced.

Flywheel and Ring Gear

The flywheel is available only as an assembly The assembly includes the flywheel and the ring gear The ring gear is available for service.

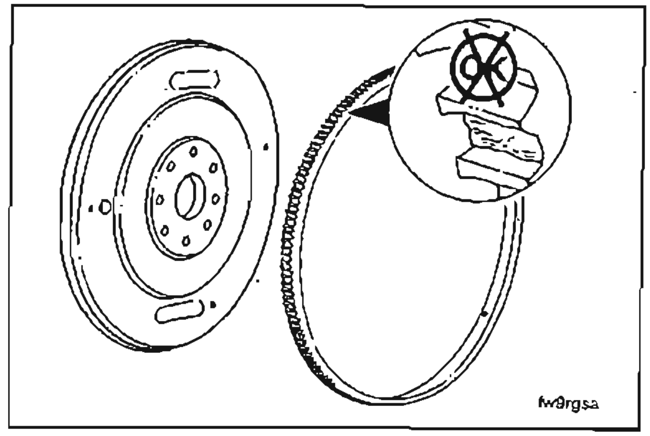
Front Support

Several different types of front engine mounts are available, depending upon specific applications.

Flywheel and Ring Gear Inspection (16-01)

Check the ring gear teeth for wear or damage. Use the dye penetrant method to check the mounting holes for cracks. Check the clutch face surface for cracks or damage. If equipped with a flexplate, check the flexplate for cracks or damage.

NOTE: If the ring gear teeth are worn or damged, the ring gear must be replaced.



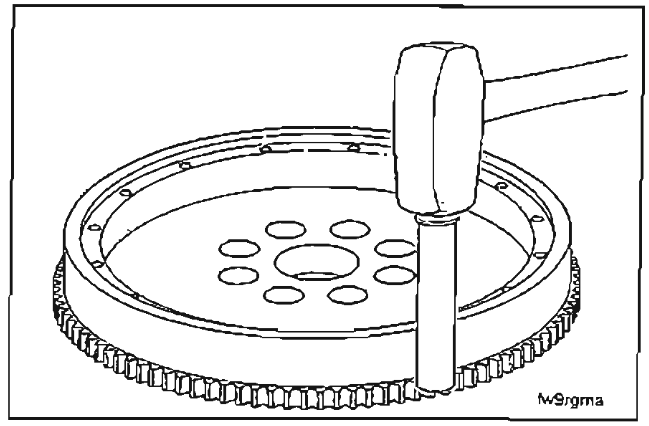
Ring Gear Replacement (16-02)

Brass Drift Pin

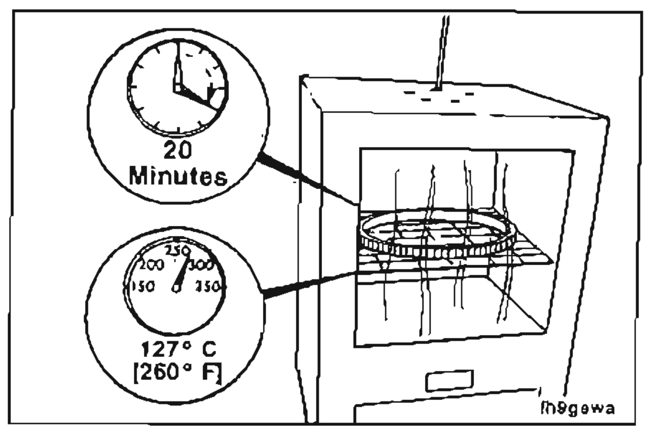
Warning: Wear eye protection when you drive the gear from the flywheel. Do not use a steel drift pin.

Use the drift pin to drive the ring gear from the flywheel.

NOTE: The ring gear on flexplate applications cannot be replaced as a separate unit. The entire flexplate assembly must be replaced.

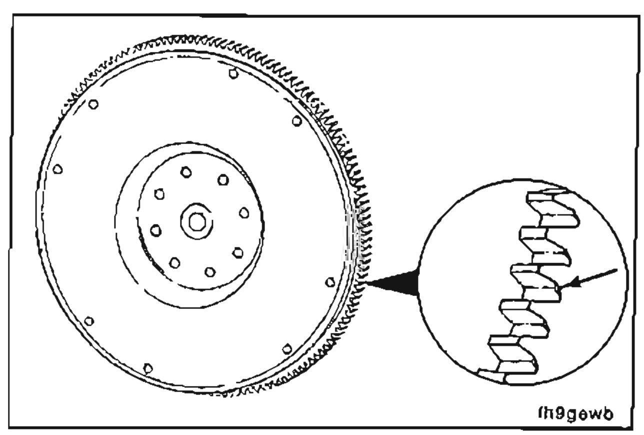


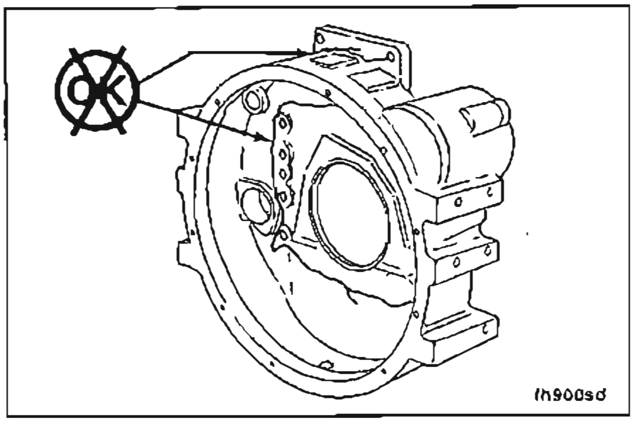
Heat the new ring gear for 20 minutes in an oven preheated to 127°C [260°F].



Warning: Wear protective gloves when you install the heated gear.

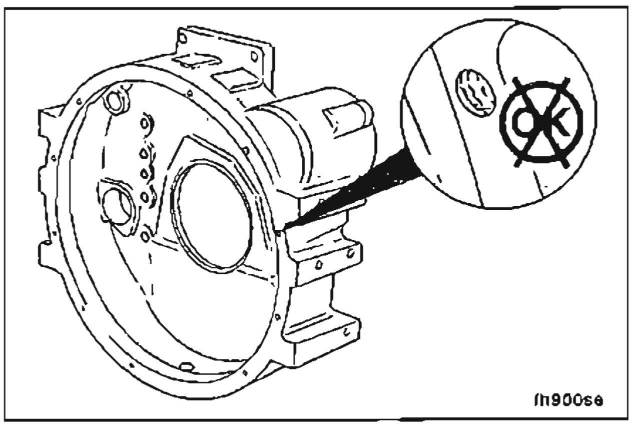
Install the gear. The gear must be installed so the bevel on the teeth is toward the crankshaft side of the flywheel.



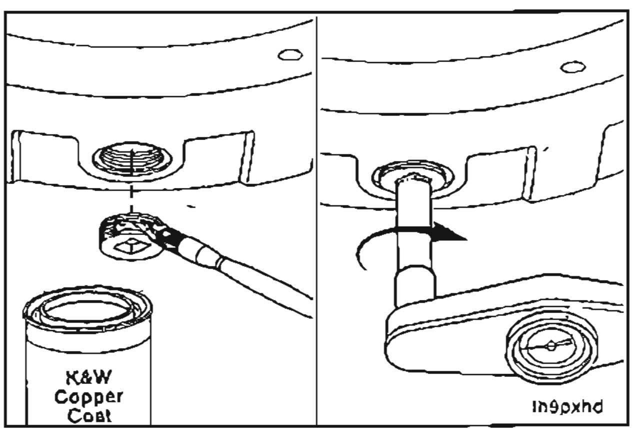


Flywheel Housing Inspection (16-03)

Inspect the flywheel housing for cracks, especially in the bolt pattern area.



Inspect for damaged threads commonly caused by cross threaded capscrews or installing an incorrect capscrew. Heli-coils are available to repair damaged threads.

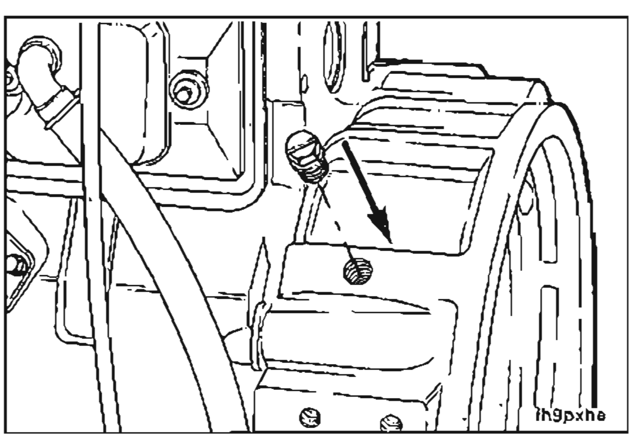


Flywheel Housing Assembly (16-04)

3/8 Inch Square Drive

Coat the drain plug with KW Copper Coat™ and install.

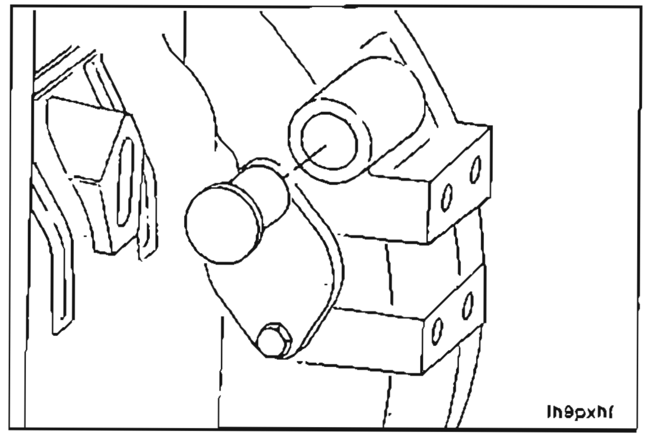
Torque Value		
Cast Iron	55 N•m	[42 ft-lb]
Aluminum	35 N•m	[26 ft-lb]



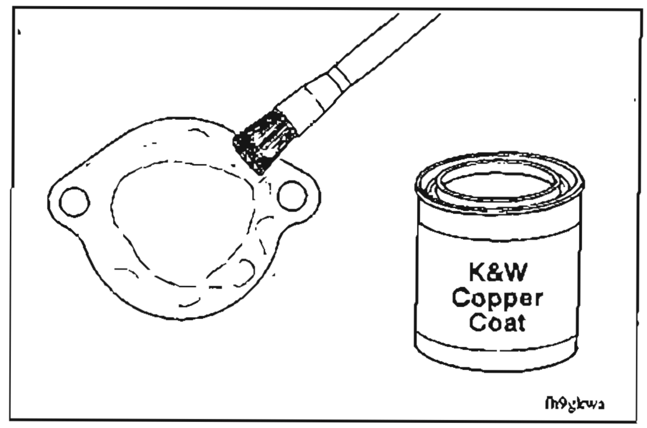
Screwdriver

Install the plastic plug in the tach probe hole.

Install the expanding plug in the barring tool hole.



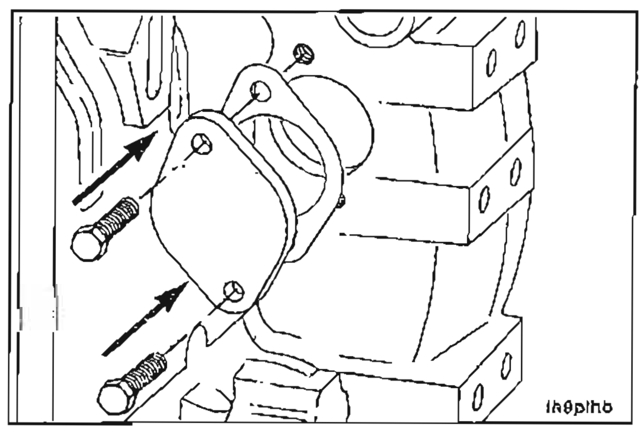
Coat both sides of the inspection plate gasket with KW Copper Coat®



13 mm

Install the inspection plate.

Tighten to 24 N•m [18 ft-lbs].



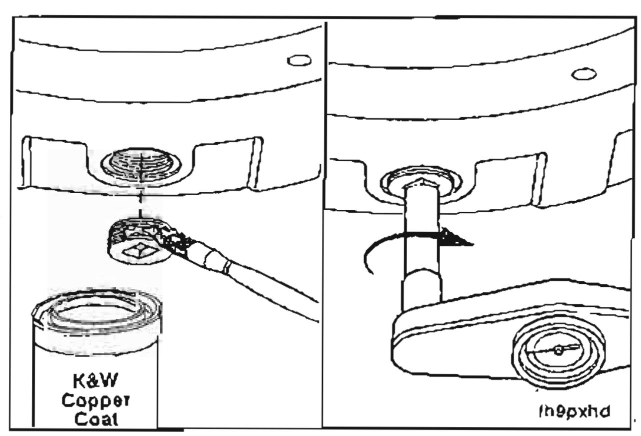
Wet Clutch Application

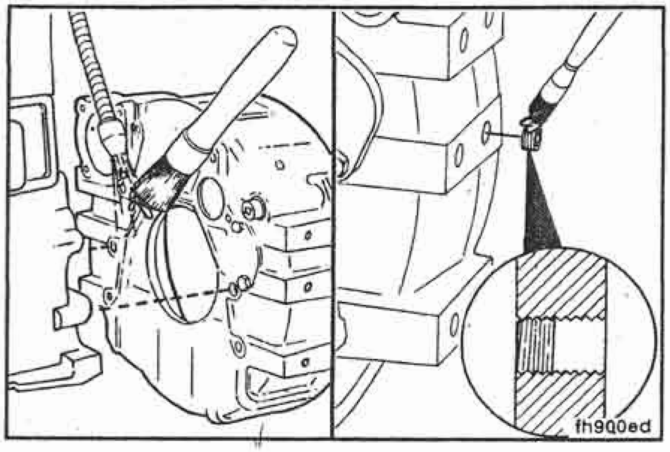
Perform all the steps in the procedure for dry clutch installation in addition to the following:

Coat the flywheel housing drain plug with pipe sealant and install in the hole in the bottom of the flywheel housing.

Tighten the plug.

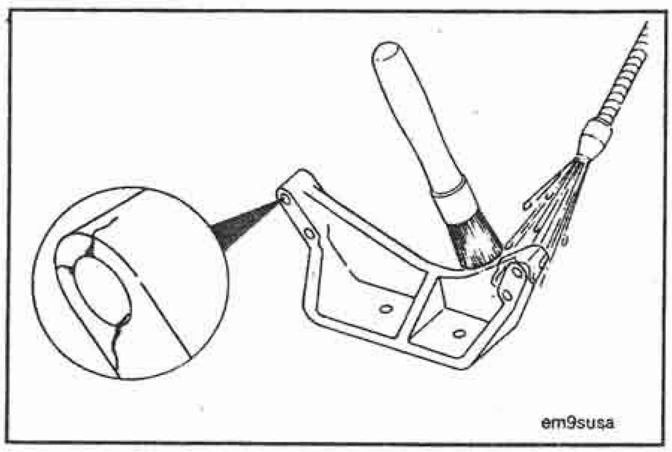
Refer to the pipe plug torque values in Section 10 for different plug sizes.





The capscrew holes on the mounting pads are drilled through. Coat set screws with Loctite™ 277 and install into holes.

Set Screw Installation Depth		
mm		in
0.00	MIN	0.000
3.00	MAX	0.118



Front Support - Cleaning and Inspection (16-05)

Use solvent. Clean the part.

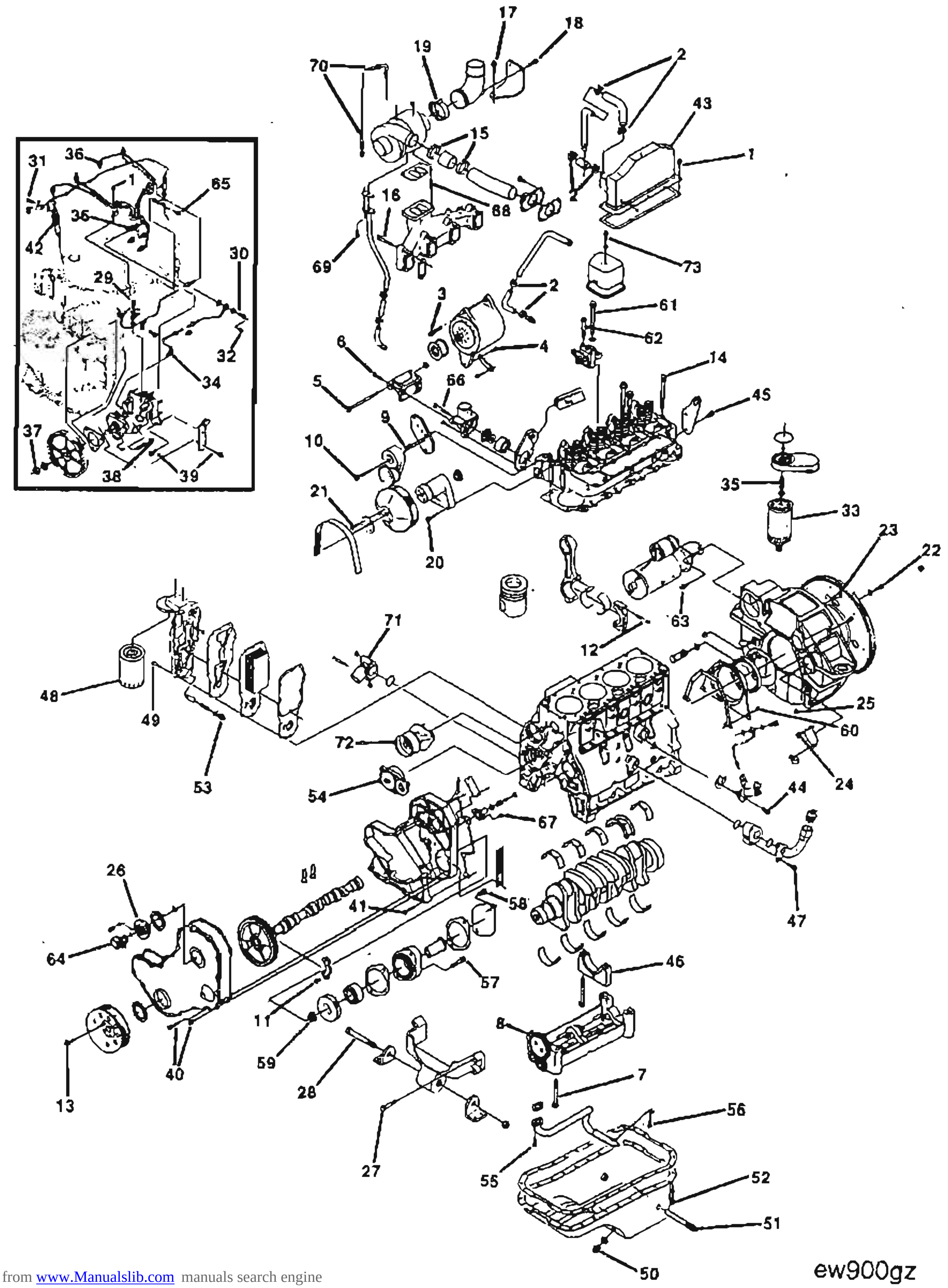
Check the part for cracks or damage.

Section V - Engine Component Specifications - Group 18

Section Contents

Specifications - General Information

This specification section contains the engine specifications for the B series engines. A detailed Engine Component Torque Value sheet is provided in addition to a summary listing with reduced line art of the key specifications from each section is included.



Engine Component Torque Values

Ref. No.	Socket or Wrench Size MM[Inch]		Torque N•m	[Ft-lb]
1	10	Aftercooler Mounting	24	[18]
2	[5/16]	Aftercooler Water Hose Clamp	5	[4]
3	[15/16]	Alternator Pulley	80	[59]
4	13 or [3/4]	Alternator Link (Delco 15-20-27 SI)	43	[32]
5	16	Alternator Mounting Bolt 15 SI	43	[32]
5	18	Altenator Mounting Bolt and Nut 20-27 SI	77	[57]
6	13	Alternator Support (Upper)	24	[18]
7	23	Balancer Mounting ... Step 1	50	[36]
		(Alternately Tighten ... Step 2	80	[58]
		in Three Steps) ... Step 3	175	[129]
8	Allen 8mm	Balancer Idler Gear	43	[32]
9	Allen 5mm	Belt Tensioner Flat Bracket	24	[18]
10	15	Belt Tensioner Mounting	43	[32]
		Camshaft Bolt ... Step 1	27	[20]
		... Step 2	Rotate 180 Degrees	
11	13	Cam Thrust Plate	24	[18]
	[3/8]	Coolant Heater	12	[9]
12	12	Connecting Rod Bolt ... Step 1	35	[26]
		(Alternately Tighten ... Step 2	70	[51]
		in Three Steps) ... Step 3	100	[73]
13	15	Crankshaft Damper & Pulley	125	[92]
14	18	Cylinder Head Mounting ... Step 1 (All)	90	[66]
		... Step 2 (All) Recheck to	90	[66]
		... Step 3 (Long Capscrews)	120	[90]
		... Step 4 Recheck (Long Capscrews Only)	120	[90]
		... Step 5 (All) Rotate 90°		
15	[5/16]	Crossover Clamp	5	[4]
16	13	Exhaust Manifold	43	[32]
17	13	Exhaust Outlet Pipe Brkt. Mounting	43	[32]
18	13	Exhaust Outlet Pipe, Flanged	24	[18]
19	[7/16]	Exhaust Outlet Pipe, V Band Clamp	8	[6]
20	10	Fan Bracket Mounting	24	[18]
21	13	Fan Pulley	24	[18]
22	19	Flywheel	137	[101]
23	15	Flywheel Housing	77	[57]
24	13	Flywheel Housing Access Cover	24	[18]
15	[1/2]	Flywheel Housing Plug	36	[25]
26	–	Front Cover Cap	—Hand Tighten—	
27	18	Front Engine Support Mounting	77	[57]
28	[1 1/8]	Front Engine Support (Barrel)	350	[257]
29	17	Fuel Banjo Screw (In Fuel Pump)	32	[24]
30	17	Fuel Banjo Screw (In Head)	24	[18]
31	10	Fuel Banjo Screw (In Injector)	9	[7]
32	10	Fuel Vent Screw (In Banjo)	9	[7]
33	80-95	Fuel Filter	3/4 Turn After Contact	
34	14	Fuel Low Pressure Supply (Lift Pump Outlet)	24	[18]
35	24	Fuel Filter Adapter Nut	32	[24]
36	17	Fuel Line Fitting (High Press)	24	[18]

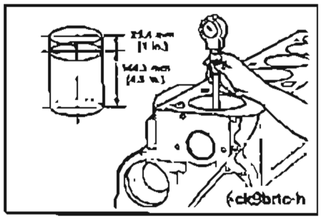
Engine Component Torque Values

Ref. No.	Socket or Wrench Size MM[Inch]		Torque N•m	[Ft-lb]
37	22	Fuel Pump Drive Gear (With Pump Unlocked)		
		Bosch (Rotary), Lucas CAV, Stanadyne DB4	65	[48]
		Nippondenso	123	[92]
		Bosch (P3000, P7100)	165	[122]
	10	Fuel Pump Lock (Bosch)	30	[22]
		Fuel Pump Unlock (Bosch	13	[10]
	[9/16]	Fuel Pump Lock (CAV) (Stanadyne DB4)	12	[9]
		Fuel Pump Unlock (CAV) (Stanadyne DB4)	12	[9]
38	13	Fuel Pump Mounting Nut (Bosch Rotary) (Stanadyne DB4)	24	[18]
		Fuel Pump Mtg. Nut (Nippondenso)	43	[32]
		Fuel Pump Mtg. Nut (Lucas CAV)	30	[22]
		Fuel Pump Mtg. Nut (Bosch In-Line)	43	[32]
		Fuel Pump Solenoid		
	24	(Bosch VE)	43	[32]
	22	(CAV)	15	[11]
39	10	Fuel Pump Support Bracket	24	[18]
40	10	Gear Cover	24	[18]
41	10	Gear Housing-to-Block	24	[18]
42	24	Injector Retaining Nut	60	[44]
43	10	Intake Manifold Cover	24	[18]
	[5/8]	Intake Heater Plug	125	[90]
44	10	Lift Pump Mounting/Cover Plate	24	[18]
45	18	Lifting Bracket (Rear)	77	[57]
46	23	Main Bearing Cap ... Step 1	60	[44]
		Step 2	119	[88]
		Step 3	176	[129]
47	15	Oil Fill Tube Mounting	43	[32]
48	75-85	Oil Filter	3/4 Turn After Contact	
49	10	Oil Cooler Assembly	24	[18]
50	17	Oil Pan Drain Plug	80	[60]
51	17	Oil Pan Heater Plug	80	[60]
52	10	Oil Pan Mounting	24	[18]
53	19	Oil Pressure Regulator Plug	80	[60]
54	13	Oil Pump Mounting	24	[18]
55	13	Oil Suction Tube (Flange)	24	[18]
56	10	Oil Suction Tube Brace	24	[18]
57	15	PTO Adapter	77	[57]
58	13	PTO Adapter Cover Plate (A Drive)	43	[32]
	15	PTO Adapter Cover Plate (B Drive)	77	[57]
59	[3/4]	PTO Gear Nut A Drive	100	[74]
	[15/16]	PTO Gear Nut B Drive	134	[100]
60	8	Rear Seal Mounting	9	[7]
61	13	Rocker Support	24	[18]
62	[14]	Rocker Lever Nut	34	[25]
63	10	Starter Mounting	43	[32]
64	10	Tach Drive Retainer	3	[2]
65	10	Tappet Cover/Fuel Drain Line Supports	24	[18]
66	10	Thermostat Housing	24	[18]
67	T-25 Torx	Timing Pin Flange Mounting	5	[4]
	10	Turbocharger Compressor Housing V-Band	8.5	[6]
68	15	Turbocharger Mounting Nut	43	[32]

Engine Component Torque Values

Ref. No.	Socket or Wrench Size MM[Inch]		Torque N•m	[Ft-lb]
69	13	Turbocharger Oil Drain Tube	24	[18]
70	[5/8]	Turbocharger Oil Supply (Both Ends)	35	[26]
	13	Turbocharger Turbine Housing	20	[15]
		Water Hose Clamps	4-5	[4]
71	13	Water Inlet Connection..	43	[32]
	[3/8]	Water Inlet Plugs	24	[18]
72	13	Water Pump Mounting	24	[18]
73	15	Valve Cover...	24	[18]
	–	Valve Cover Oil Fill	Hand Tighten	

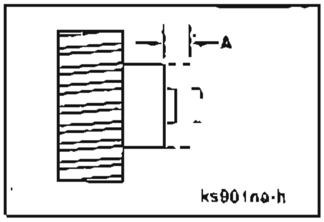
Component or Assembly (Procedure) | Ref.No./Steps | Metric | U.S.



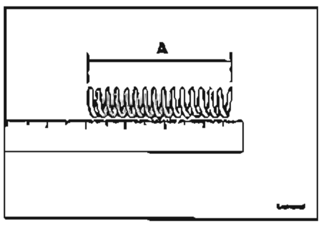
Component Specifications and Torque Values

Engine Assembly - Specifications

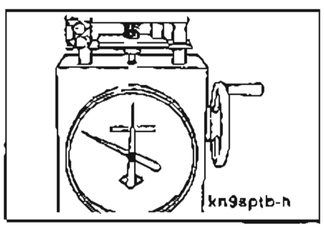
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Cylinder Bores				
Cylinder Bore I.D.		102.000 mm	MIN	4.0157 in
		102.116 mm	MAX	4.0203 in
Cylinder Bore Out of Round		0.035 mm	MAX	0.0014 in
Cylinder Bore Taper		0.076 mm	MAX	0.003 in



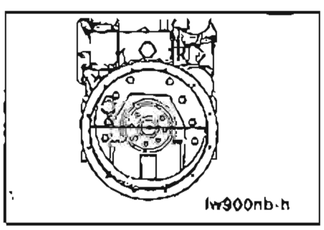
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Crankshaft End Clearance	A	0.102 mm	MIN	0.004 in
		0.432 mm	MAX	0.017 in



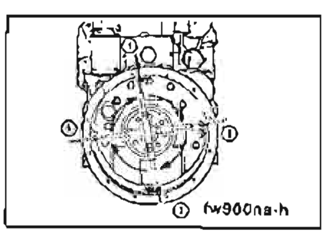
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Oil Pressure Regulating Spring				
• Spring Free Length				
1991 Engines	A	60.6 mm	MIN	2.385 in
1994 Engines		66.0 mm	MIN	2.598 in



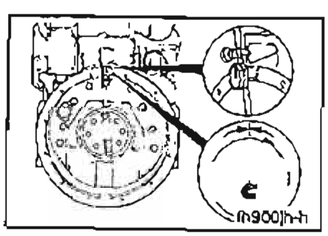
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
• Spring Tension at 38.50 mm [1.516 in] Height				
(A) 1991 Engines		(A) 109.0 N	MIN	24.5 lb
(B) 1994 Engines		(B) 141.2 N	MIN	31.7 lb



Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Flywheel Housing Bore I.D.	SAE No.			
	2	447.8 mm	MAX	17.63 in
	3	409.7 mm	MAX	16.13 in



Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Flywheel Housing Bore Alignment TIR		0.20 mm	MAX	0.008 in

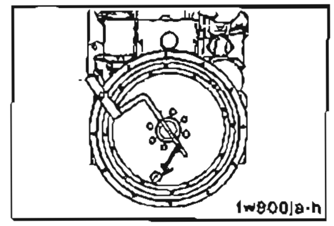


Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Flywheel Housing Face Alignment TIR	SAE No.			
	2	0.20 mm	MAX	0.008 in
	3	0.20 mm	MAX	0.008 in

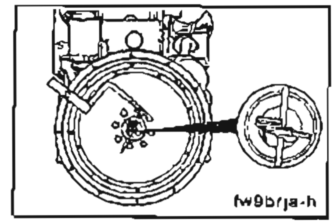
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

Flywheel Face Runout TIR

Radius mm	Radius in	Metric		U.S.
254	10	0.254	MAX	0.010
205	8	0.203	MAX	0.008
181	7	0.152	MAX	0.006
157	6	0.152	MAX	0.006
133	5	0.152	MAX	0.006

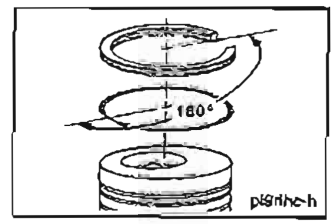


Flywheel Bore Runout TIR — 0.127 MAX 0.0050



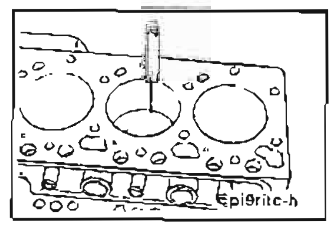
Oil Control Ring End Gap

The two-piece oil ring must be installed with the expander gap 180 degrees from the oil ring gap.



Ring Gap (Feeler Gauge)

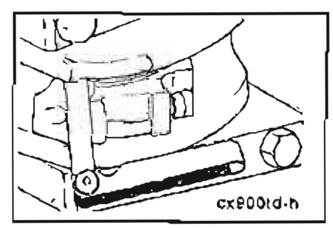
	Metric		U.S.
• Top Ring Gap Naturally Aspirated	0.25 mm	MIN	0.010 in
	0.55 mm	MAX	0.022 in
• Top Ring Gap Turbocharged	0.40 mm	MIN	0.016 in
	0.70 mm	MAX	0.028 in
• Intermediate Ring Gap	0.25 mm	MIN	0.010 in
	0.55 mm	MAX	0.022 in
• Oil Control Ring Gap	0.25 mm	MIN	0.010 in
	0.55 mm	MAX	0.022 in



Connecting Rod Side Clearance

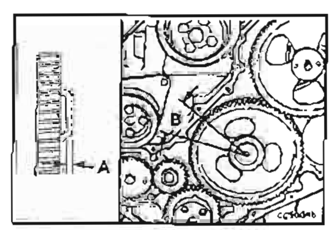
Metric		U.S.
0.100 mm	MIN	0.004 in
0.330 mm	MAX	0.013 in

Note: The rod must move freely from side-to-side.



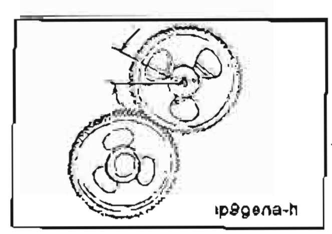
Camshaft End Clearance

Metric		U.S.
0.08 mm	MIN	0.003 in
0.47 mm	MAX	0.0185 in

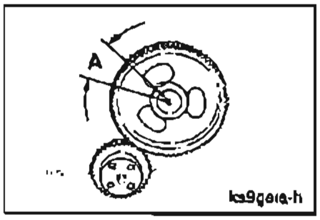


Injection Pump Drive Gear Backlash

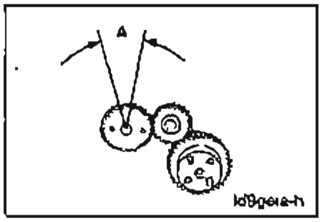
Ref.No./Steps	Metric		U.S.
A	0.076 mm	MIN	0.003 in
	0.330 mm	MAX	0.013 in



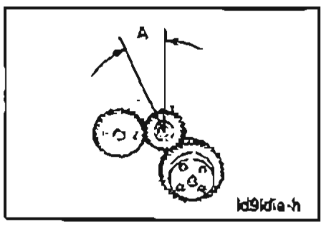
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



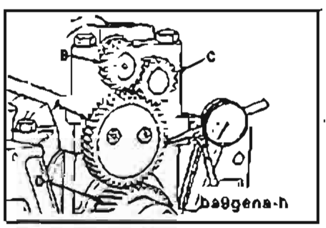
Camshaft Gear Backlash	A	0.076 mm	MIN	0.003 in
		0.330 mm	MAX	0.013 in



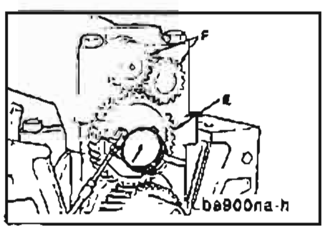
Lubricating Oil Pump Gear Backlash	A	0.076 mm	MIN	0.003 in
		0.330 mm	MAX	0.013 in



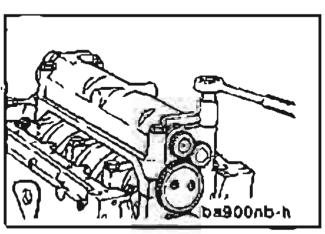
Lubricating Oil Pump Idler Gear Backlash	A	0.076 mm	MIN	0.003 in
		0.330 mm	MAX	0.013 in



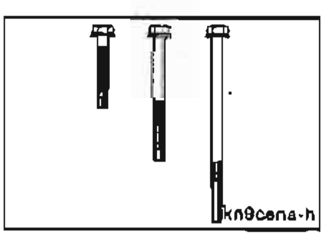
Balancer Gear Backlash	A to D	0.088 mm	MIN	0.003 in
		0.420 mm	MAX	0.017 in
	B to C	0.153 mm	MIN	0.006 in
		0.355 mm	MAX	0.014 in
	A to C	0.088 mm	MIN	0.003 in
		0.420 mm	MAX	0.017 in



Balancer End Clearance	E	0.13 mm	MIN	0.005 in
		0.63 mm	MAX	0.024 in
	F	0.075 mm	MIN	0.003 in
		0.175 mm	MAX	0.007 in

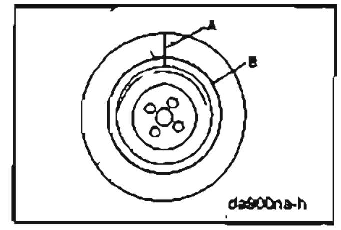


Balancer Torque Value and Sequence	1	50 N•m		36 ft-lb
	2	80 N•m		58 ft-lb
	3	176 N•m		129 ft-lb

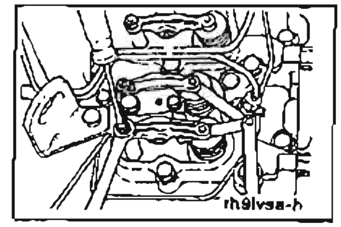


Cylinder Head Capscrew Free Length (Maximum)				
Short		71.5 mm	MAX	2.815 in
Medium		122.1 mm	MAX	4.807 in
Long		182.9 mm	MAX	7.201 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Vibration Damper				
Index line out of alignment	A	1.588 mm	MAX	0.0625 in
Missing rubber member chunks	B	3.175 mm	MAX	0.1250 in



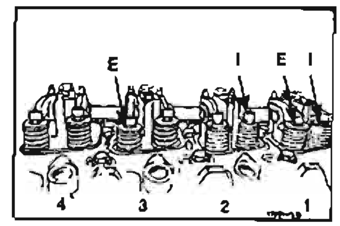
Valve Stem to Rocker Lever Clearances				
Intake		0.25 mm		0.010 in
Exhaust		0.51 mm		0.020 in
Locknut		34 N•m		25 ft-lb



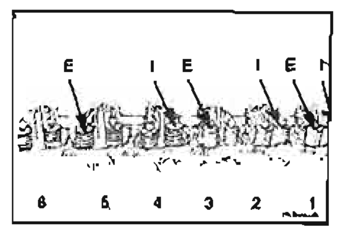
Valve Adjustment Procedure

Perform Step A of the valve set procedure with cylinder No. 1 at TDC compression stroke (timing pin will engage).

Step A Four Cylinder

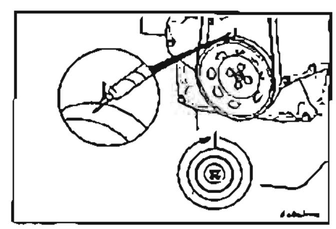


Step A Six Cylinder

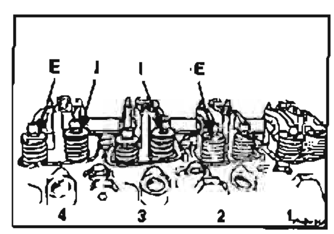


Perform Step B of the valve set procedure with cylinder No. 1 at TDC plus 360 degrees (timing pin will not engage).

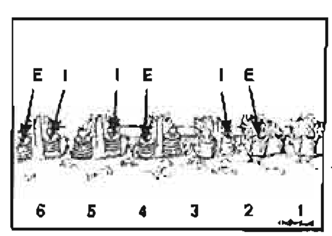
Mark the crankshaft and gear cover. Rotate the crankshaft one full turn in the direction of engine rotation.



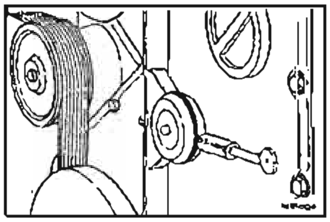
Step B Four Cylinder



Step B Six Cylinder

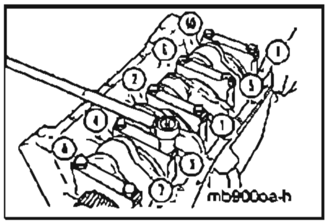


Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



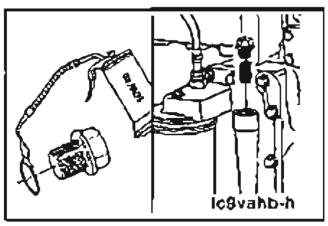
Belt Tension - Fan Drive

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Belt Tension		267 N	MIN	60 lbf
		578 N	MAX	130 lbf

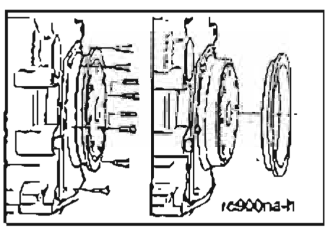


Engine Assembly - Capscrew Torque Values

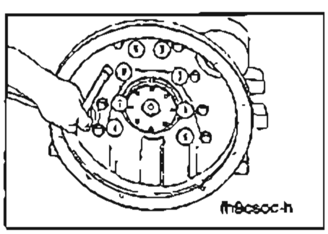
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Main Bearing Capscrew Torque Value and Sequence	1	60 N•m	44 ft-lb
	2	119 N•m	88 ft-lb
	3	176 N•m	129 ft-lb



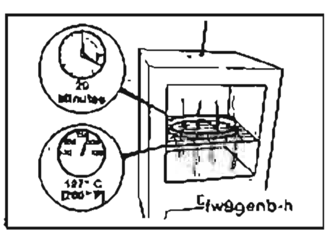
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Oil Pressure Regulator Retainer Plug		80 N•m	60 ft-lb



Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Rear Seal Cover Mounting		9 N•m	84 in-lb

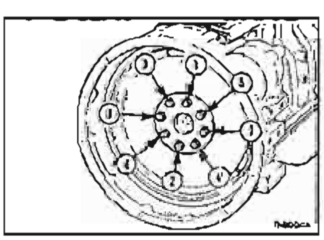


Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Flywheel Housing Capscrews Note: Tighten the capscrews in the sequence shown.		77 N•m	57 ft-lb

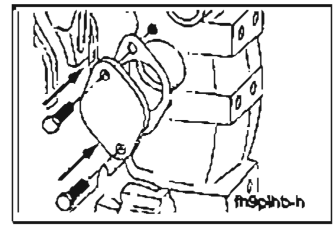
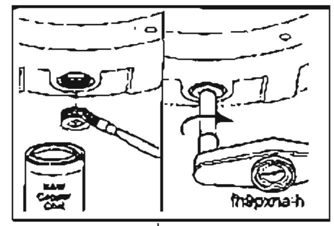
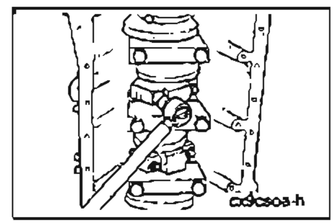
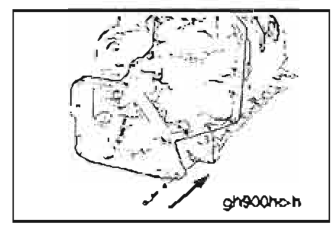
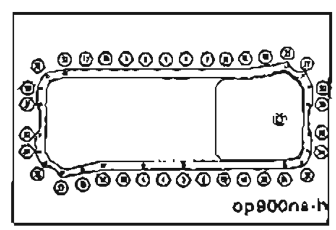
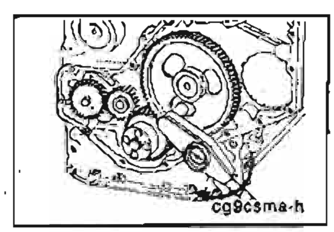
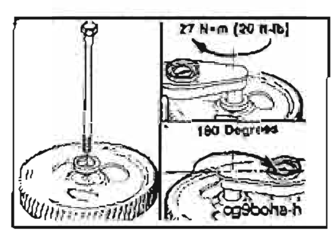


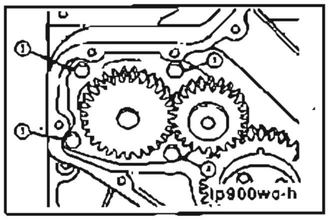
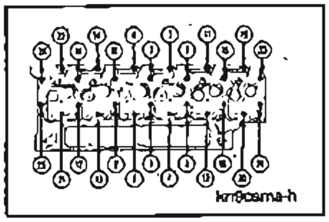
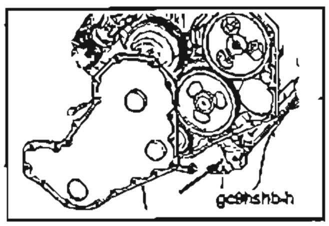
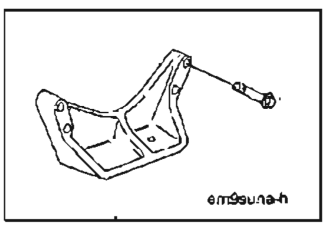
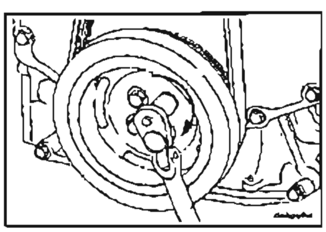
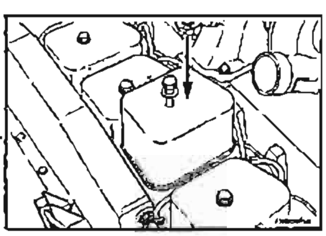
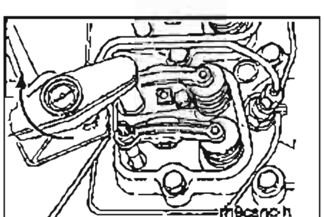
Ring Gear Replacement

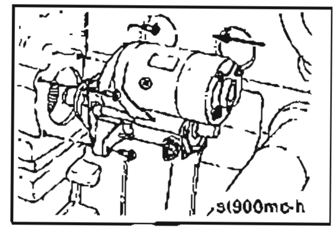
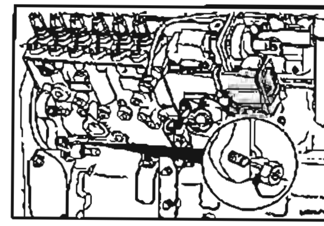
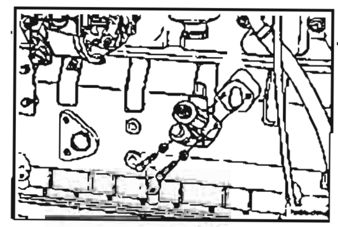
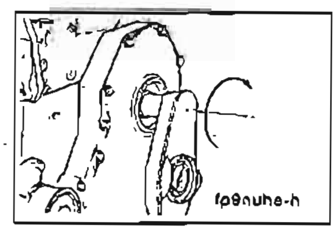
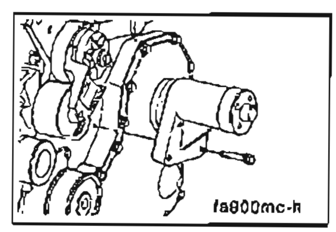
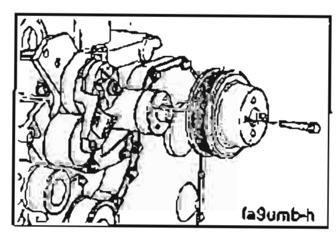
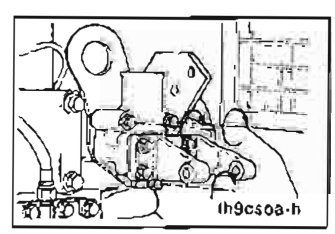
Heat the new ring gear for 20 minutes in an oven preheated to 127°C [260°F].

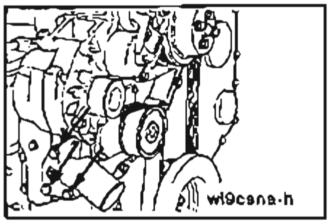
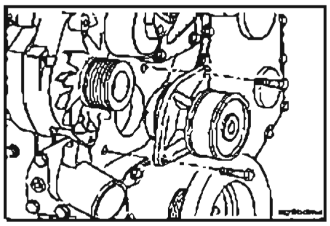
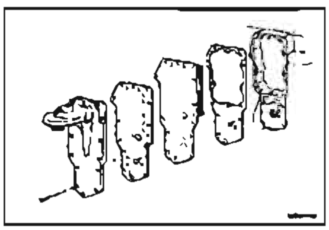
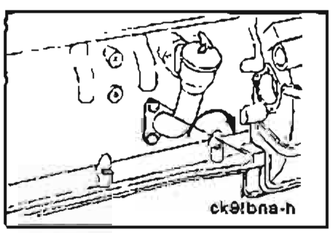
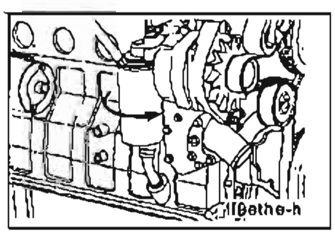
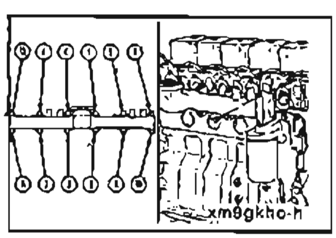
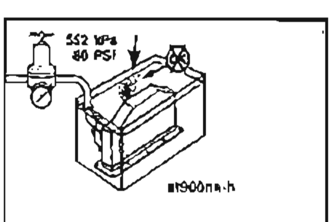


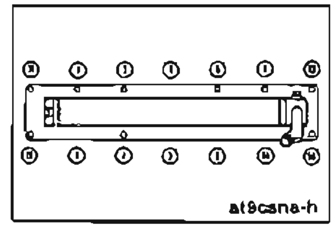
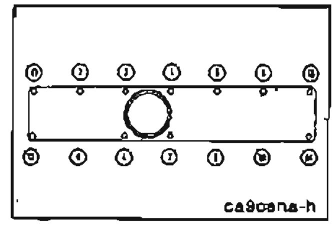
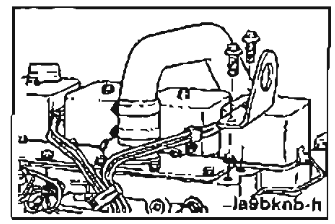
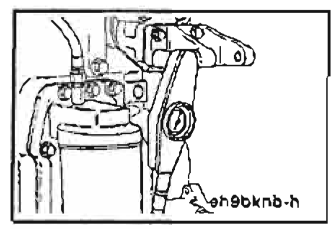
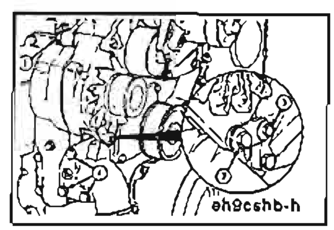
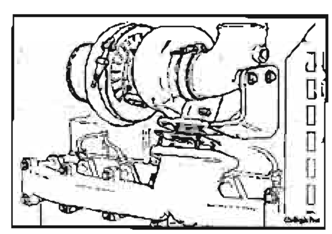
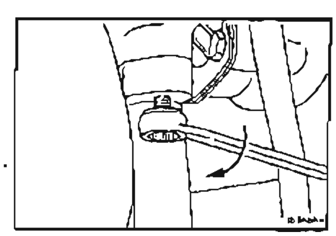
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Flywheel Mounting Capscrews Tighten in the sequence shown		137 N•m	101 ft-lb

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
Flywheel Housing Access Cover		24 N•m	18 ft-lb	
Flywheel Housing Plug		36 N•m	27 ft-lb	
Connecting Rod Bolt	1 2 3	35 N•m 70 N•m 100 N•m	26 ft-lb 52 ft-lb 74 ft-lb	
Gear Housing Mounting Capscrews		24 N•m	18 ft-lb	
Lubricating Oil Pan **Note:** Tighten the capscrews in the sequence shown. Start at the center of the oil pan and alternate toward both ends.		24 N•m	18 ft-lb	
Camshaft Thrust Plate Capscrew		24 N•m	18 ft-lb	
Camshaft Bolt Step 1 Step 2		 27 N•m Rotate 180 Degrees	 20 ft-lb	

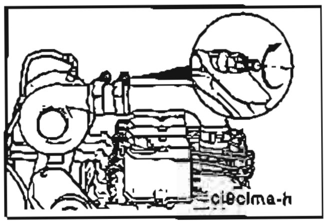
	Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
	**Oil Pump Mounting Capscrews** Tighten in the sequence shown		24 N•m	18 ft-lb
	**Cylinder Head Mounting Capscrew (Tighten Capscrews in the Sequence Shown)**			
	Step 1		90 N•m	66 ft-lb
	Step 2 Recheck to		90 N•m	66 ft-lb
	Step 3 (Long capscrews only)		120 N•m	90 ft-lb
	Step 4 (Long capscrews only) Recheck to		120 N•m	90 ft-lb
	Step 5 Rotate 90 degrees			
	**Gear Cover Capscrews**		24 N•m	18 ft-lb
	**Front Engine Support Mounting**		77 N•m	57 ft-lb
	**Crankshaft Pulley Capscrew**		125 N•m	92 ft-lb
	**Rocker Cover Capscrews**		24 N•m	18 ft-lb
	**Rocker Pedestal Capcrews (8 mm)**		24 N•m	18 ft-lb

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
Starting Motor Mounting Capscrews		43 N•m	32 ft-lb	
Injection Pump Mounting Nuts				
Nippondenso		43 N•m	32 ft-lb	
Lucas CAV, Bosch (Rotary), Stanadyne DB4		30 N•m	22 ft-lb	
Bosch (In-Line)		43 N•m	32 ft-lb	
Fuel Transfer Pump Mounting Capscrews		24 N•m	18 ft-lb	
Injection Pump Drive Gear Nut				
Bosch (Rotary), Lucas CAV, Stanadyne DB4		65 N•m	48 ft-lb	
Nippondenso		123 N•m	92 ft-lb	
Bosch (P3000, P7100)		165 N•m	122 ft-lb	
Fan Hub Mounting Capscrews		24 N•m	18 ft-lb	
Fan Hub Pulley Mounting Capscrews	8 mm	24 N•m	18 ft-lb	
	10 mm	43 N•m	32 ft-lb	
Thermostat Housing Mounting Capscrews		24 N•m	18 ft-lb	

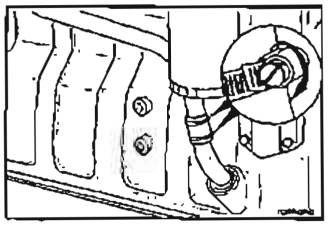
	Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
	**Coolant Inlet Connection**		43 N•m	32 ft-lb
	**Water Pump Mounting Capscrews**		24 N•m	18 ft-lb
	**Oil Cooler Mounting Capscrews**		24 N•m	18 ft-lb
	**Oil Fill Tube Capscrews**		43 N•m	32 ft-lb
	**Oil Filter**		3/4 Turn after contact	
	**Exhaust Manifold Capscrews** **Note:** Tighten the capscrews in the sequence shown.		43 N•m	32 ft-lb
	**Aftercooler Inspection** Inspect the housing and core for damage. Check the core for leaks: • Plug the bottom inlet tube • Pressurize the core to 483 kPa [70 psi] and submerge in a container of water. • Water temperature at 60°C [140°F].			

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
Aftercooler Capscrews **Note:** Tighten the capscrews in the sequence shown.		24 N•m	18 ft-lb	
Air Intake Manifold Capscrews **Note:** Tighten the capscrews in the sequence shown.		24 N•m	18 ft-lb	
Lifting Bracket (Rear)		77 N•m	57 ft-lb	
Alternator Mounting Bracket Capscrews		24 N•m	18 ft-lb	
Alternator Assembly Torque Sequence **Note:** Tighten the capscrews in the sequence shown.				
Turbocharger Mounting Nuts		43 N•m	32 ft-lb	
Turbocharger Oil Drain Tube Mounting Capscrew		24 N•m	18 ft-lb	

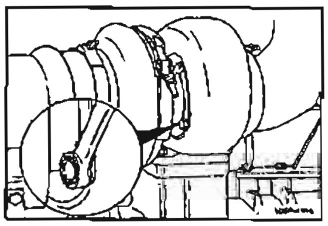
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



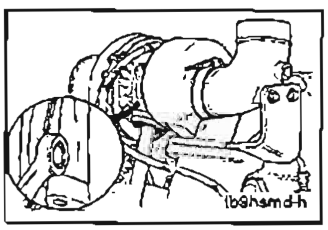
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Turbocharger Air Crossover Hose Clamps		5 N•m		44 in-lb



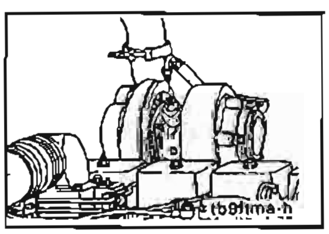
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Turbocharger Oil Drain Line Hose Clamps		6 N•m		53 in-lb



Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Turbocharger Turbine Housing Capscrews		20 N•m		15 ft-lb

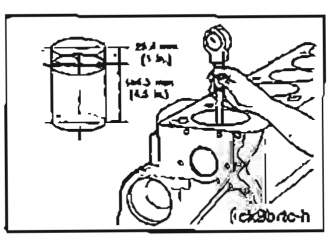


Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Turbocharger Compressor Housing				
• Diffuser Plate Capscrews		8.5 N•m		75 in-lb
• V Band Clamp (Silver Plated Nut)		8.5 N•m		75 in-lb

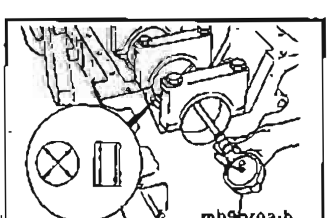


Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Turbocharger Oil Supply Line Connection		35 N•m		26 ft-lb

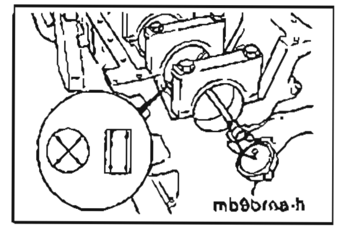
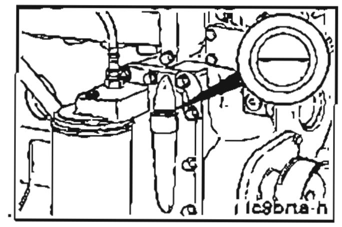
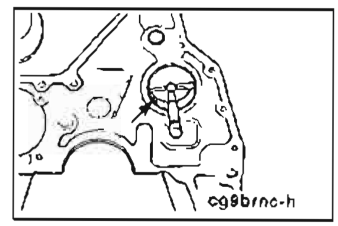
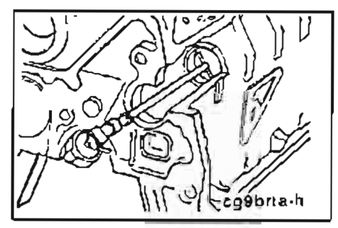
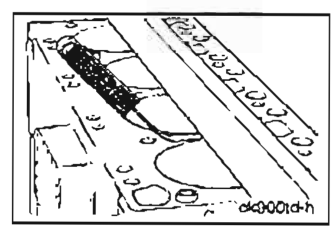
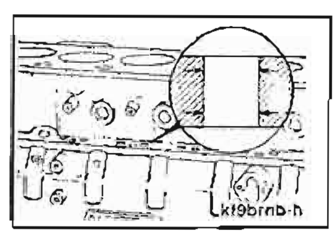
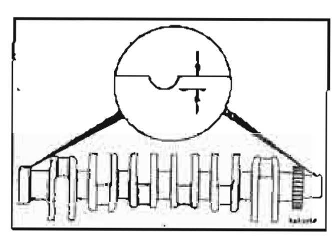
Cylinder Block - Rebuild Specifications



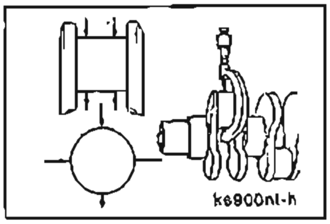
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Cylinder Bore Diameter		102.000 mm	MIN	4.0157 in
		102.116 mm	MAX	4.0203 in
Out-of-Roundness		0.035 mm	MAX	0.0014 in
Taper		0.076 mm	MAX	0.003 in



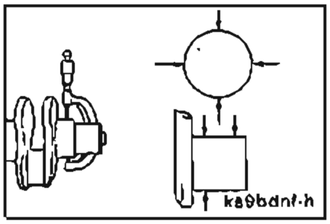
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Main Bearing Diameter (Bearings Installed) With Capscrews Tightened to 176 N•m [130 ft-lb]		83.106 mm	MAX	3.27720 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.	
Main Bearing Bore I.D. (Without Bearings) With Capscrews Tightened to 176 N•m [130 ft-lb]		87.982 mm 88.018 mm	MIN MAX	3.4639 in 3.4653 in	
Main Oil Pressure Regulator Valve Bore I.D.		18.30 mm 18.35 mm	MIN MAX	0.7205 in 0.7224 in	
Camshaft Bore Diameter (Number 1 bore without bushing) (Number 1 bore with bushing installed)		57.222 mm 57.258 mm 54.107 mm 54.146 mm	MIN MAX MIN MAX	2.2528 in 2.2543 in 2.1302 in 2.1317 in	
Camshaft Bore Diameter All Journals Except No. 1		54.089 mm 54.164 mm	MIN MAX	2.1295 in 2.1324 in	
Cylinder Block Overall Flatness • End-to-end • Side-to-side		 0.076 mm 0.051 mm	 MAX MAX	 0.003 in 0.002 in	
Valve Tappet Bore Diameter		16.000 mm 16.055 mm	MIN MAX	0.630 in 0.632 in	
Crankshaft Front and Rear Oil Seal Wear Groove		0.25 mm	MAX	0.010 in	

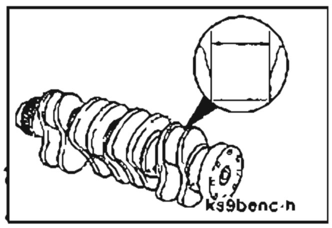
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



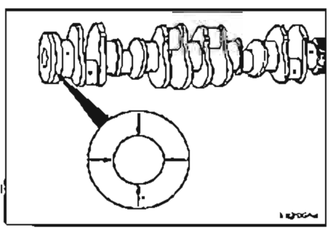
Crankshaft Connecting Rod Journal O.D.		68.962 mm	MIN	2.7150 in
		69.013 mm	MAX	2.7170 in
Out of roundness		0.050 mm	MAX	0.002 in
Taper		0.013 mm	MAX	0.005 in
Bearing clearance		0.114 mm	MAX	0.0045 in



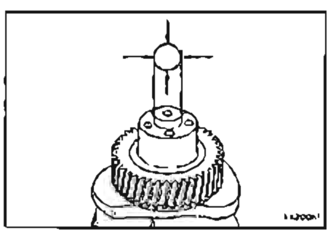
Crankshaft Main Bearing Journal Diameter		82.962 mm	MIN	3.2662 in
		83.013 mm	MAX	3.2682 in
Out of roundess		0.050 mm	MAX	0.002 in
Taper		0.013 mm	MAX	0.005 in
Bearing clearance		0.119 mm	MAX	0.0047 in



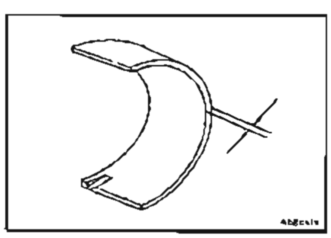
Crankshaft Thrust Face Width		37 475 mm	MIN	1.4754 in
		37.602 mm	MAX	1 4804 in



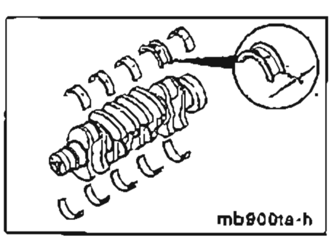
Crankshaft Rear Oil Seal Flange O.D.		129.975 mm	MIN	5.1171 in
		130.025 mm	MAX	5.1191 in



Crankshaft Damper Pilot O.D.		18.924 mm	MIN	0.7450 in
		19.000 mm	MAX	0.7480 in

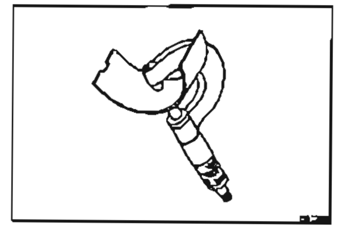


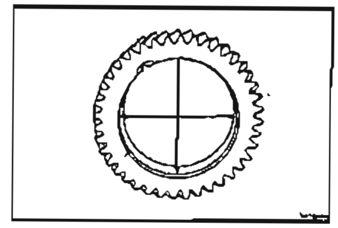
Main Bearing Shell Thickness (Standard)		2.438 mm	MIN	0.0960 in
		2.464 mm	MAX	0.0970 in

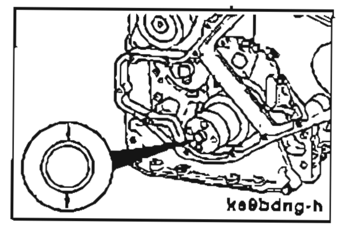


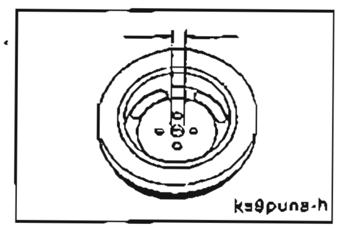
Crankshaft Thrust Bearing Flange Thickness		2.45 mm	MIN	0.096 in
		2.55 mm	MAX	0.100 in

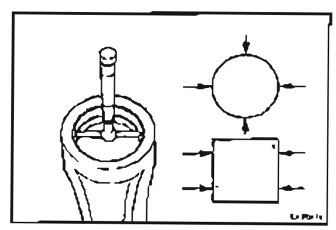
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Connecting Rod Bearing Thickness (Standard)		1.955 mm	MIN	0.0769 in
		1.968 mm	MAX	0.0775 in
Crankshaft Gear Bore I.D.		63.910 mm	MIN	2.5161 in
		63.934 mm	MAX	2.5171 in
Crankshaft Gear Journal O.D.		63.987 mm	MIN	2.5192 in
		64.006 mm	MAX	2.5199 in
Crankshaft Pulley Crankshaft Pilot Bore I.D.		19.05 mm	MIN	0.7500 in
		19.15 mm	MAX	0.7539 in
Connecting Rod Piston Pin Bore I.D. Bushing Removed		42.987 mm	MIN	1.6924 in
		43.013 mm	MAX	1.6934 in
Bushing Installed (1991 Engines)		40.053 mm	MIN	1.5769 in
		40.076 mm	MAX	1.5778 in
Bushing Installed (1994 Engines)		40.019 mm	MIN	1.5756 in
		40.042 mm	MAX	1.5765 in
Connecting Rod Crankshaft Bore I.D. (Bearings Installed)		69.051 mm	MIN	2.7185 in
		69.103 mm	MAX	2.7205 in
(Bearings Removed)		72.987 mm	MIN	2.8735 in
		73.013 mm	MAX	2.8745 in
Connecting Rod Length		191.975 mm	MIN	7.5581 in
		192.025 mm	MAX	7.5600 in
Connecting Rod Alignment: • (With Bushing)		0.15 mm	MAX	0.006 in

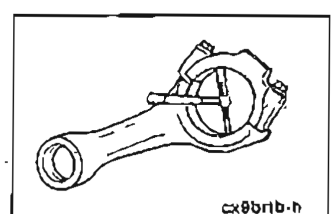


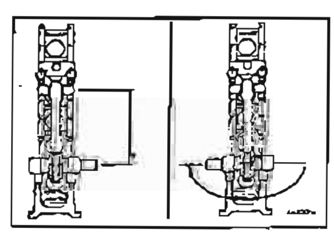




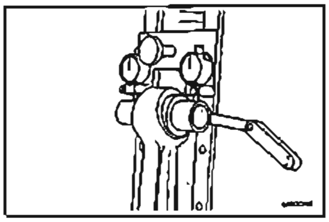




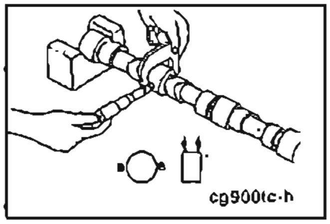




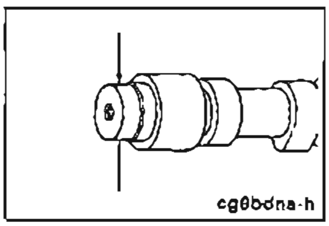
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



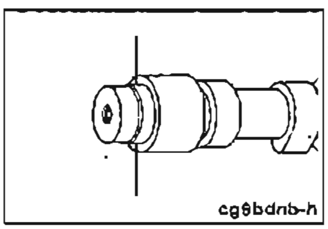
Connectind Rod Twist:				
• (With Bushing)		0.15 mm	MAX	0.006 in



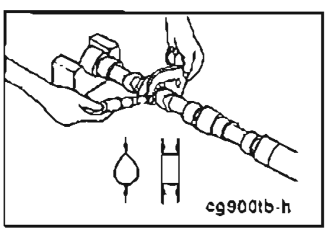
Camshaft Bearing Journal Diameter		53.962 mm	MIN	2.1245 in
		54.013 mm	MAX	2.1265 in



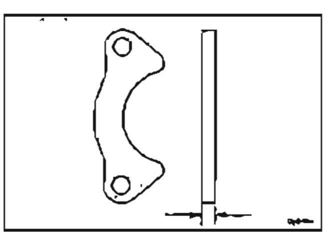
Camshaft Gear Mounting Surface O.D.		41.575 mm	MIN	1.6368 in
		41.593 mm	MAX	1.6375 in



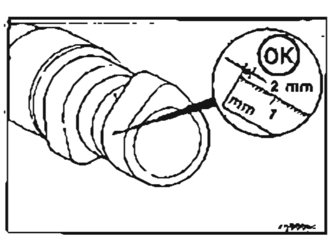
Camshaft Thrust Bearing Journal O.D.		45.550 mm	MIN	1.7933 in
		45.750 mm	MAX	1.8012 in



Camshaft Diameter at Peak of the Lobe	Intake	47.040 mm	MIN	1.852 in
		47 492 mm	MAX	1.870 in
	Exhaust	46.770 mm	MIN	1.841 in
		47.222 mm	MAX	1.859 in
	Fuel Transfer	35.50 mm	MIN	1.398 in
	Pump	36.26 mm	MAX	1 428 in



Camshaft Thrust Plate Thickness		9.4 mm	MIN	0.370 in
		9.6 mm	MAX	0.378 in

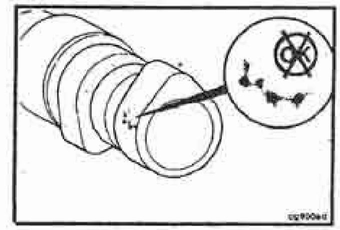


Camshaft Pitting Reuse Guidelines

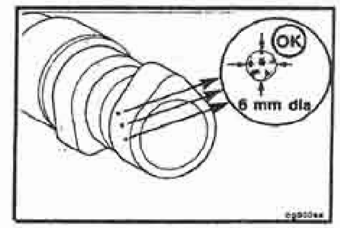
A single pit should not be greater than the area of a 2mm [0.079 in] diameter circle.

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

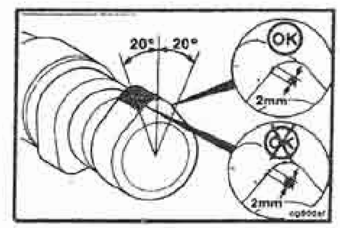
Interconnection of pits is not allowable and is treated as one pit.



The total pits, when added together, should not exceed a circle of 6 mm [0.236 in].

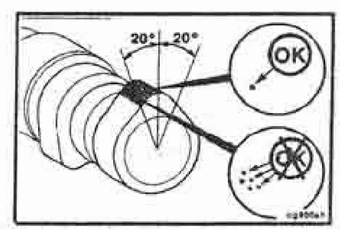


Only one pit is allowed within + or 20 degrees of the nose of the camshaft lobe.

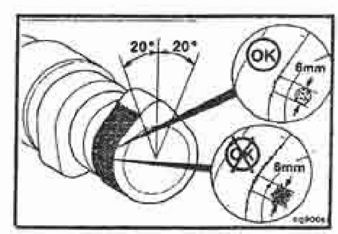


Edge Deterioration (Breakdown):

The area of edge deterioration should not be greater than the equivalent area of a 2 mm [0.079 in] circle within + or 20 degrees of the nose of the camshaft lobe.



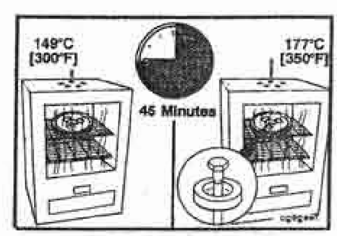
Outside of the + or 20 degrees of the nose of the camshaft lobe, the areas of edge deterioration should not be greater than the quivalent area of a 6 mm [0.236 in] circle.



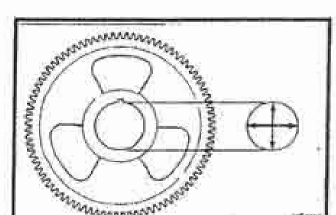
Caution: The camshaft gear will be permanently distorted if overheated. The oven temperature should never exceed 177°C [350°F].

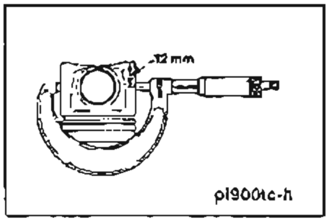
Heat the camshaft gear for **non-bolted** 1991 and non-automotive 1994 camshafts in an oven at 149°C [300°F] for 45 minutes.

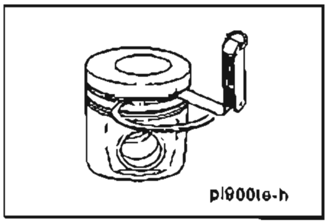
Heat the camshaft gear for **bolted** 1991 camshafts (steel gear) and **all** 1994 automotive to 177°C [350°F].

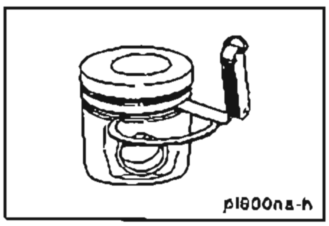


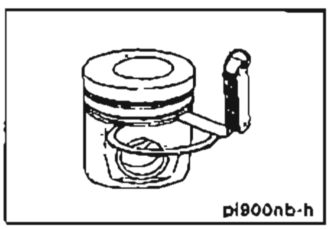
Camshaft Gear Bore I.D.		41.500 mm	MIN	1.6339 in
		41.525 mm	MAX	1.6348 in

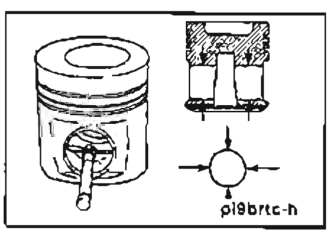


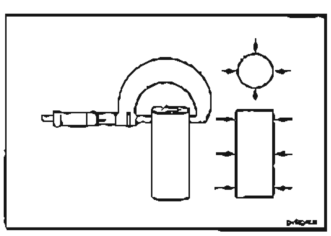




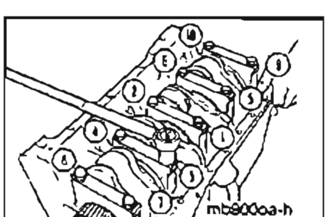








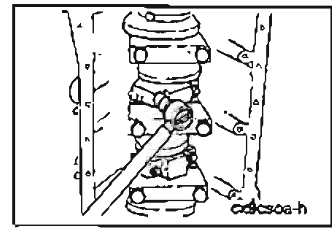
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Piston Skirt O.D. (Worn Limit)		101.823 mm	MIN	4.0088 in
		101.887 mm	MAX	4.0113 in
Top Ring Side Clearance • (Naturally Aspirated Only)		0.15 mm	MAX	0.006 in
Intermediate Ring Side Clearance		0.15 mm	MAX	0.006 in
Oil Control Ring Side Clearance		0.13 mm	MAX	0.005 in
Piston Pin Bore I.D.		40.006 mm	MIN	1.5750 in
		40.025 mm	MAX	1.5758 in
Piston Pin O.D.		39.990 mm	MIN	1.5744 in
		40.003 mm	MAX	1.5749 in



Cylinder Block - Torque Values

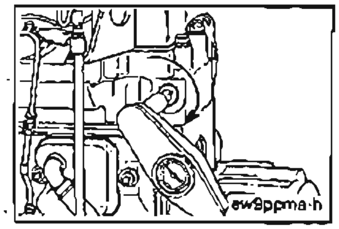
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
Main Bearing Capscrew	1	60 N•m	44 ft-lb
	2	119 N•m	88 ft-lb
	3	176 N•m	129 ft-lb

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Connecting Rod Capscrews	1	35 N•m		26 ft-lb
	2	70 N•m		52 ft-lb
	3	100 N•m		74 ft-lb



Cylinder Block Pipe Plugs

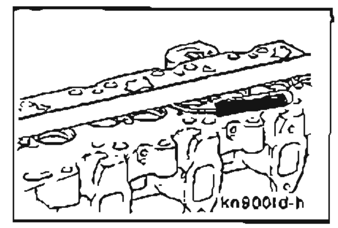
Refer to "Pipe Plug Torque Value Table" at the rear of this section for torque value of various plug sizes.



Cylinder Head - Rebuild Specifications

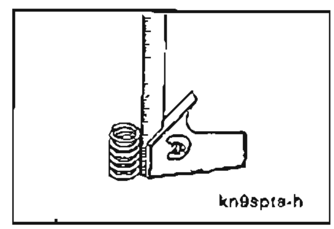
Cylinder Head Flatness

• End-to-End	4 Cylinder	0.203 mm	MAX	0.008 in
	6 Cylinder	0.305 mm	MAX	0.012 in
• Side-to-Side		0.076 mm	MAX	0.003 in



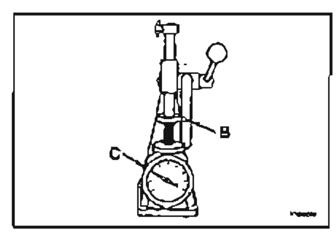
Valve Spring Free Height:

1991	55.63 mm	Nominal	2.190 in
Exhaust Brake	70.64 mm	Nominal	2.781 in
Marine/Rotator	56.00 mm	Nominal	2.208 in
1994	60.00 mm	Nominal	2.362 in

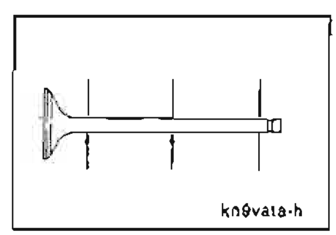


Valve Spring Working Height and Load

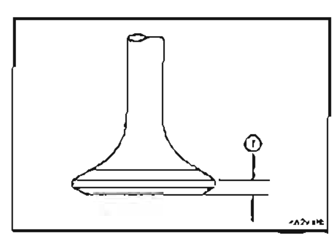
	Working Height (B)	Load For Working Height (C)		
HD Exhaust Brake	48.97 mm	643.2 N	MIN	144.6 lbf
	1.927 in	691.2 N	MAX	155.4 lbf
Marine With Rotator	47.24 mm	282.7 N	MIN	63.5 lbf
	1.859 in	323.1 N	MAX	72.6 lbf
1994	49.25 mm	359 N	MIN	80.7 lbf
	1.94 in	397 N	MAX	89.2 lbf
All Others	49.25 mm	285 N	MIN	64.0 lbf
	1.94 in	321 N	MAX	72.1 lbf



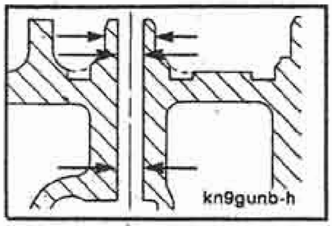
Valve Stem O.D.		7.98 mm	MAX	0.3142 in



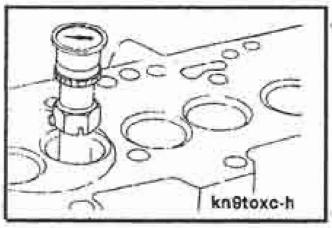
Valve Head Thickness at O.D.	T	0.79 mm	MIN	0.031 in



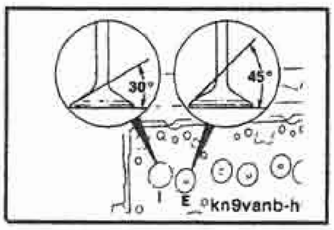
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.



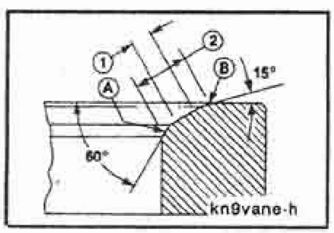
Valve Guide Bore Diameter		8.019 mm 8.090 mm	MIN MAX	0.3157 in 0.3185 in



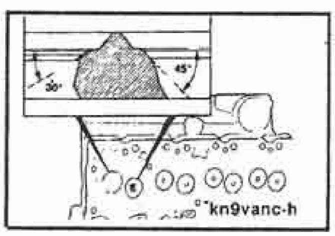
Valve Seat-to-Valve Guide Runout 360 Degrees		0.10 mm	MAX	0.004 in



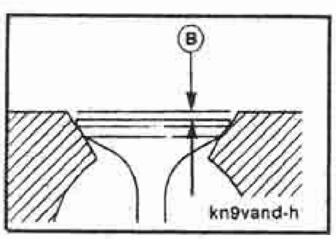
Valve Face Grinding Angle Intake: Exhaust:		 30 degrees 45 degrees		



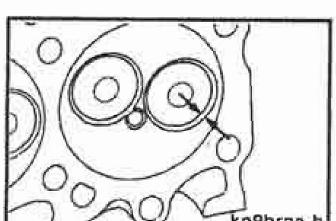
Valve Seat Width Limit Grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face and obtain the valve seat width limits.	 1 2	 1.5 mm 2.0 mm	 MIN MAX	 0.060 in 0.080 in



Valve Seat Grinding Angle Intake: Exhaust:		 30 degrees 45 degrees		



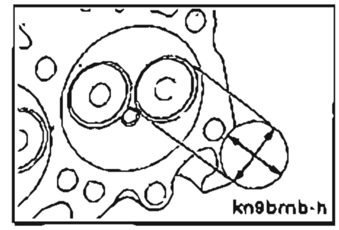
Valve Recess in Cylinder Head	B	0.99 mm 1.52 mm	MIN MAX	0.039 in 0.060 in



Valve Insert Bore Depth (Standard Insert)		10.30 mm 10.50 mm	MIN MAX	0.4055 in 0.4139 in

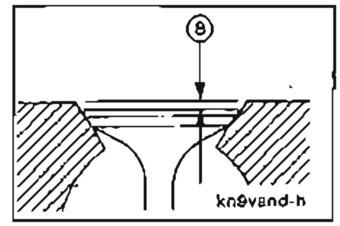
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Valve Insert Bore I.D. (Standard Insert)		46.987 mm 47.013 mm	MIN MAX	1.8499 in 1.8509 in

Note: Refer to Cylinder Head Oversize Valve Seat Installation for oversize valve insert dimensions.



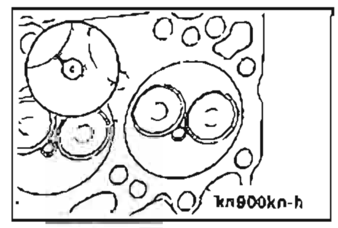
Valve Seat Grinding Depth	B	0.254 mm	MAX	0.010 in

Seat grinding depth is the difference in dimension 'B' before and after grinding.



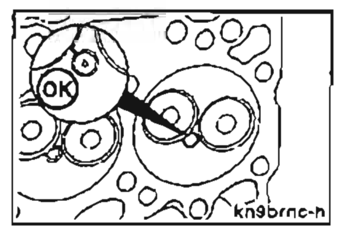
Cylinder Head Cracks Reuse Guidelines

These guidelines apply only to cracks extending from the injector bore to the intake valve seats. Replace cylinder heads which exhibit valve bridge cracks in any other location.

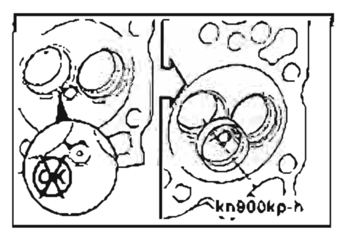


The reuse guidelines for a cylinder head with a crack extending from the injector bore to the intake valve seat are as follows:

If the crack does not extend into the valve seat, the head is reusable.



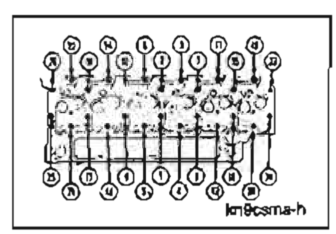
If the crack extends into or through the valve seat, the head must be repaired by installing a valve seat insert as described in the Alternative Repair Manual, Bulletin No. 3810234.



Cylinder Head - Torque Values

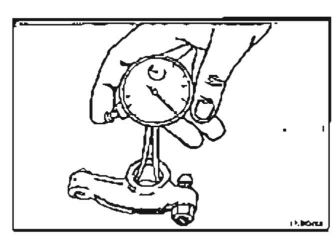
Cylinder Head Mounting Capscrew (Tighten in the Sequence Shown)

Step 1 All	90 N•m	66 ft-lb
Step 2 Recheck to	90 N•m	66 ft-lb
Step 3 (Long Capscrews Only)	120 N•m	90 ft-lb
Step 4 (Long Capscrews Only) - Recheck to	120 N•m	90 ft-lb
Step 5 Rotate 90 degrees All		

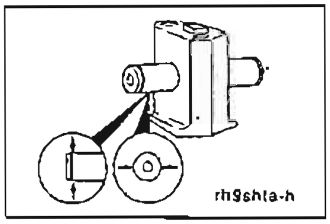


Rocker Levers and Pedestals

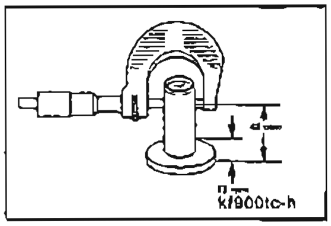
Rocker Lever Bore Diameter	19.000 19.051	MIN MAX	0.7480 in 0.7500 in



Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

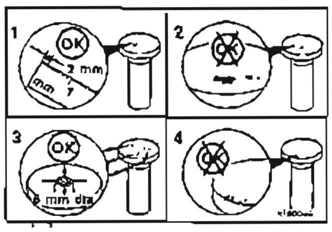


Pedestal Shaft Diameter		18.938 mm 18.975 mm	MIN MAX	0.7456 in 0.7470 in



Tappet and Push Rods

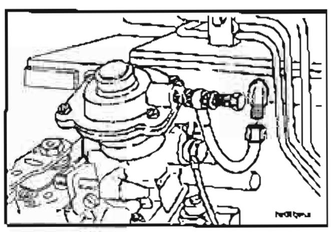
Valve Tappet Stem Diameter		15.936 mm 15.977 mm	MIN MAX	0.627 in 0.629 in



Pit marks on the tappet face are acceptable.

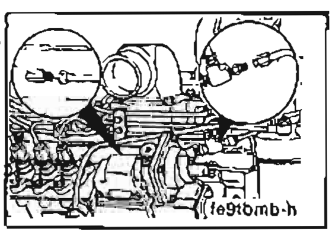
The following criteria defines the size of the pits allowed:

1. A single pit cannot be greater than 2mm [0.078 in] diameter.
2. Interconnection of pits is not allowed.
3. Total pits when added together should not exceed 6 mm [0.236 inch] diameter or a total of 4 percent of the tappet face.

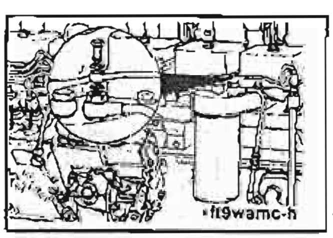


Fuel System

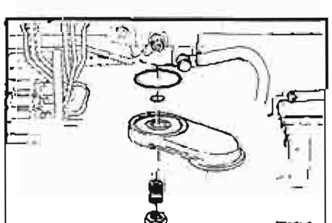
Air Fuel Control (AFC) Banjo Fitting (Rotary Pump)		12 N•m		106 in-lb



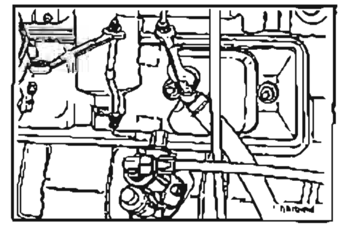
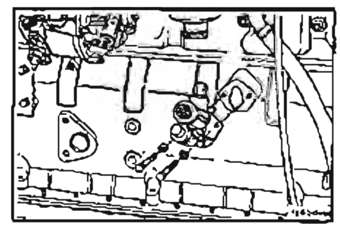
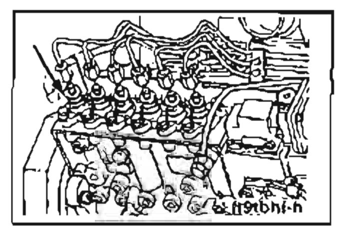
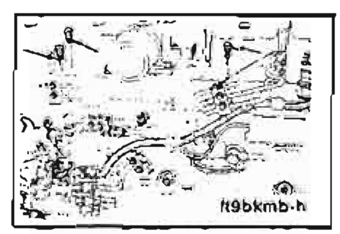
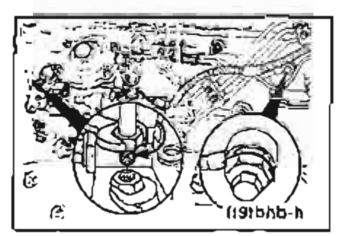
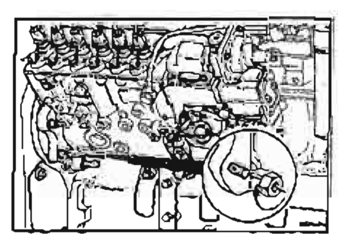
Air Fuel Control (AFC) Banjo Fitting (In-Line Pump)				
Pipe Adapter (in cylinder head)		24 n•m		18 ft-lb
Tube Fittings		9 N•m		7 ft-lb

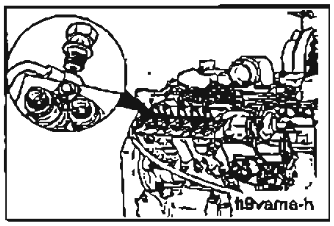
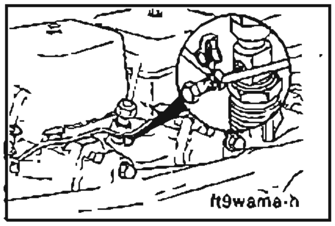
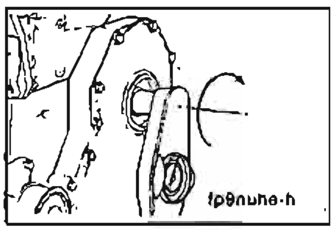
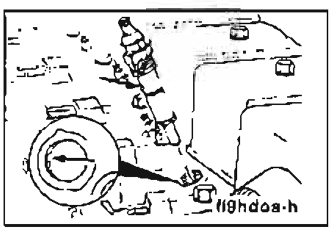
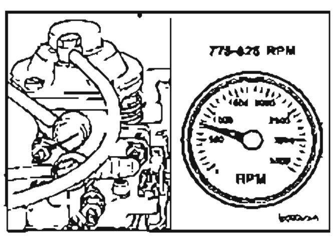
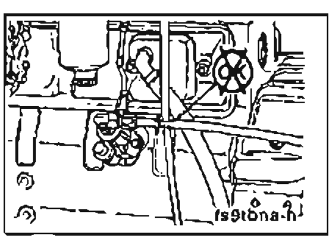
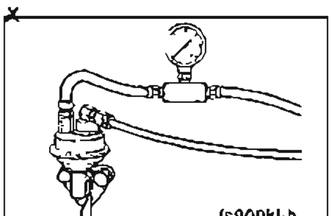


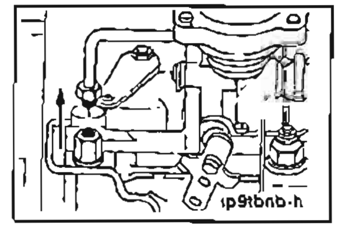
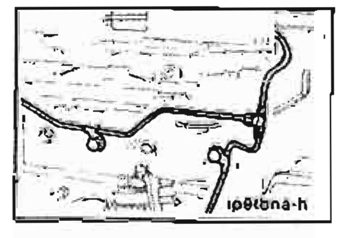
Fuel Filter Banjo Fittings				
Supply Line Fittings		24 N•m		18 ft-lb
Return Line Fitting		13 N•m		10 ft-lb
Vent Screw		9 N•m		7 ft-lb



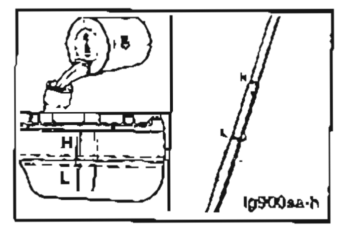
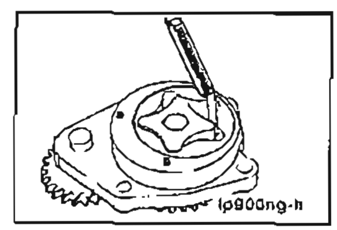
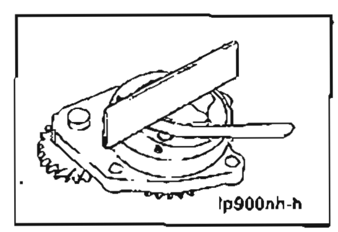
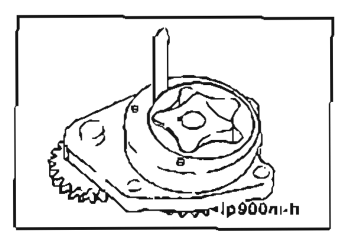
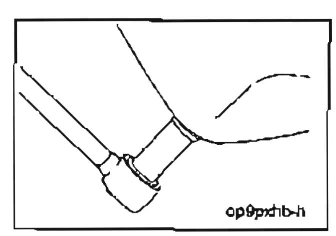
Fuel Filter Head Adapter		32 N•m		24 ft-lb

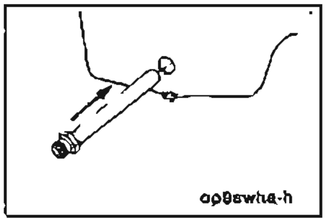
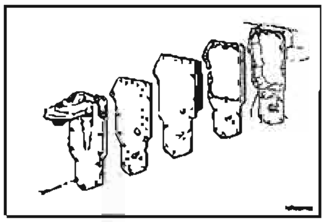
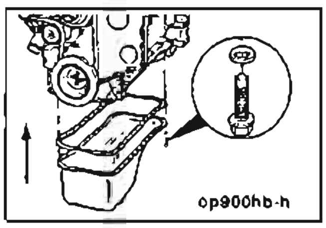
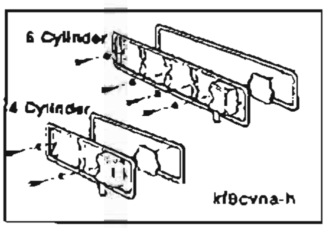
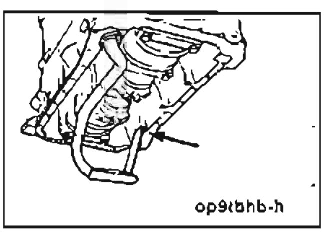
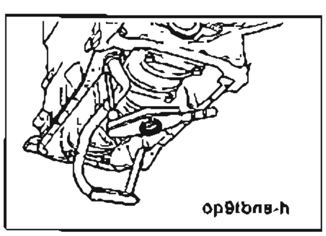
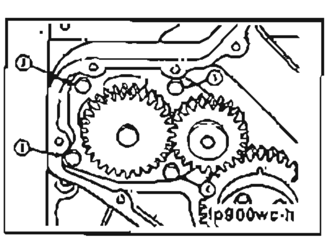
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
Fuel Pump Solenoid (Bosch VE) (CAV)		43 N•m 15 N•m	32 ft-lb 11 ft-lb	
Fuel Supply Line (Fuel Transfer Pump Outlet)		24 N•m	18 ft-lb	
Fuel Transfer Pump Mounting Capscrews		24 N•m	18 ft-lb	
High Pressure Fuel Line Fittings		24 N•m	18 ft-lb	
High Pressure Fuel Line Support Clamp Bracket		 6 N•m 24 N•m	 53 in-lb 18 ft-lb	
Injection Pump Supply Line Inlet		32 N•m	24 ft-lb	
Injection Pump Mounting Nuts Nippondenso Lucas, CAV, Bosch (Rotary), Stanadyne DB4 Bosch (In-Line)		 43 N•m 30 N•m 43 N•m	 32 ft-lb 22 ft-lb 32 ft-lb	

	Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
	**Injection Pump Fuel Return Banjo Fitting**		32 N•m		24 ft-lb
	**Injector Drain Manifold**				
	Injector Banjo		9 N•m		80 in-lb
	Filter Head Banjo		13 N•m		10 ft-lb
	Bracket		24 N•m		18 ft-lb
	**Injection Pump Drive Gear Nut**				
	Bosch (Rotary), Lucas CAV, Stanadyne DB4		65 N•m		48 ft-lb
	Nippondenso		123 N•m		92 ft-lb
	Bosch (P3000, P7100)		165 N•m		122 ft-lb
	**Injector**		60 N•m		44 ft-lb
	**Engine Low Idle Speed (Typical)**		700 RPM	MIN	
	(Refer to Engine Data Tag)		800 RPM	MAX	
	**Fuel Transfer Pump Inlet Restriction**		100 mm Hg	MAX	4 in Hg
	**Fuel Transfer Pump Outlet Pressure at Rated Speed**				
	In-Line Injection Pump (Minimum)		172 kPa		25 psi
	Rotary Injection Pump (Maximum)		70 kPa		10 psi

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.	
Fuel Injection Pump Inlet Pressure at Rated Speed					
Rotary		0 to 70 kPa		0 to 10 psi	
In-Line (minimum)		172 kPa		25 psi	
Fuel Injection Pump Return Line Restriction		518 mm Hg	MAX	20.4 in Hg	

Lubricating Oil System - Specifications

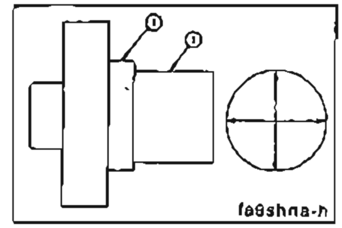
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.	
Oil Pan Capacity	4 Cylinder	8.6 liters	Low	9 qts.	
		9.5 liters	High	10 qts.	
	6 Cylinder	12.4 liters	Low	13 qts.	
		14.2 liters	High	15 qts.	
	6 Cylinder Optional	9.5 liters	Low	10 qts.	
		10.4 liters	High	11 qts.	
Oil Pump Tip Clearance		0.1778 mm	MAX	0.007 in	
Oil Pump Port Plate Clearance		0.127 mm	MAX	0.005 in	
Oil Pump Body Bore Clearance		0.381 mm	MAX	0.015 in	
Oil Pan Drain Plug		80 N•m		60 ft-lb	

	Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
	Oil Pan Heater Plug		80 N•m	60 ft-lb
	Oil Cooler Mounting Capscrews		24 N•m	18 ft-lb
	Oil Pan Mounting Capscrews		24 N•m	18 ft-lb
	Tappet Cover Mounting Capscrews		24 N•m	18 ft-lb
	Oil Pump Suction Tube Brace Capscrews		24 N•m	18 ft-lb
	Oil Pump Suction Tube Mounting Capscrews		24 N•m	18 ft-lb
	Oil Pump Mounting Capscrews		24 N•m	18 ft-lb

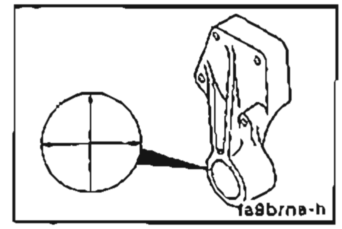
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

Fan Hub - Specifications

Fan Hub Shaft O.D.	1	41.75 mm	MIN	1.644 in
		42.25 mm	MAX	1.663 in
	2	35.004 mm	MIN	1.3781 in
		35.024 mm	MAX	1.3789 in

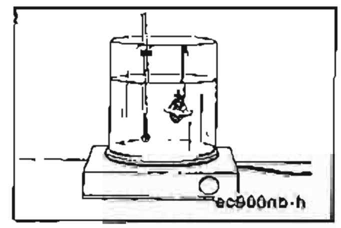


Hub Bearing Bore I.D.		63.938 mm	MIN	2.5172 in
		63.956 mm	MAX	2.5179 in



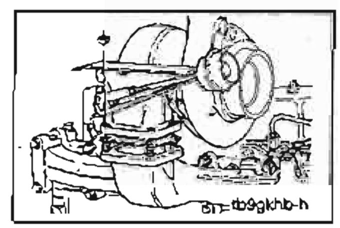
Thermostat, Coolant Operating Temperature

• Initial Opening Temperature		80°C	MIN	176°F
		83°C	MAX	182°F
• Fully Open Temprature		95°C	MAX	203°F
• Maximum Opening Distance		6.6 mm	MAX	0.260 in

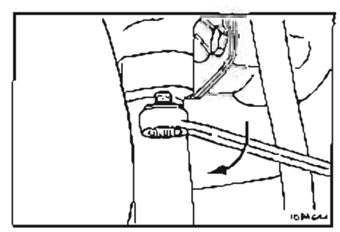


Combustion Air System

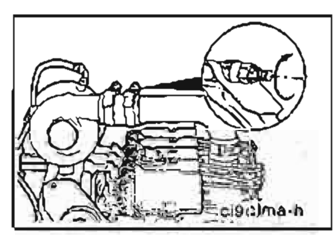
Turbocharger Mounting Nuts		43 N•m		32 ft-lb



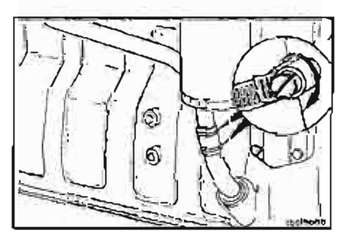
Turbocharger Oil Drain Tube Mounting Capscrew		24 N•m		18 ft-lb



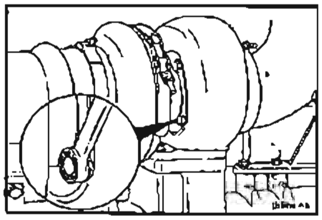
Turbocharger Air Crossover Hose Clamps		5 N•m		44 in-lb



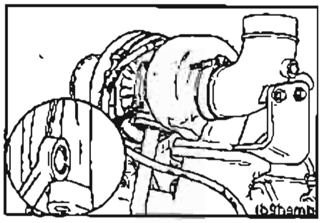
Turbocharger Oil Drain Line Hose Clamps		6 N•m		53 in-lb



Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

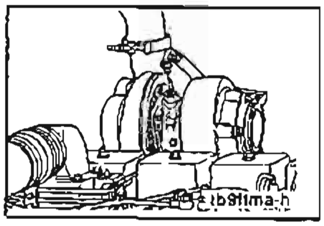


Turbocharger Turbine Housing Capscrews — 20 N•m — 15 ft-lb



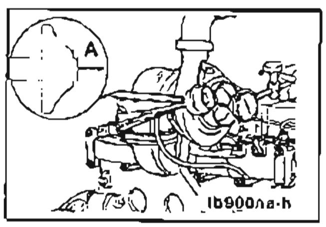
Turbocharger Compressor Housing Capscrews

	Metric	U.S.
• Diffuser Plate Capscrews	8.5 N•m	75 in-lb
• V Band Clamp (Silver Plated Nut)	8.5 N•m	75 in-lb



Turbocharger Oil Supply Line Connection — 35 N•m — 26 ft-lb

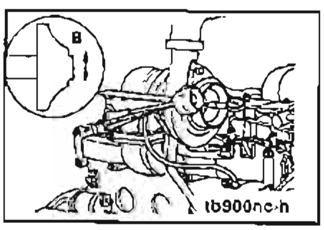
Air Intake System



Turbocharger Axial Clearance

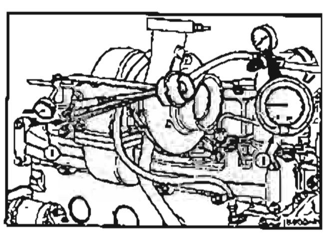
Metric		U.S.
*0.10 mm	MIN	0.004 in
0.16 mm	MAX	0.006 in
**0.03 mm	MIN	0.001 in
0.08 mm	MAX	0.003 in

* For turbochargers with a serial number before 840638.
** For turbochargers with a serial number after and including 840638.



Turbocharger Radial Clearance

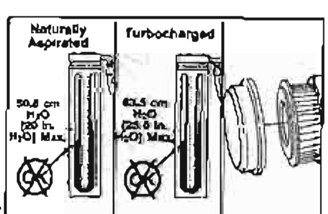
Metric		U.S.
0.30 mm	MIN	0.012 in
0.46 mm	MAX	0.018 in



Wastegate Rod Travel at the Following Wastegate Applied Pressure

Metric		U.S.
0.33 mm	Min	0.013 in
1.3 mm	Max	0.050 in

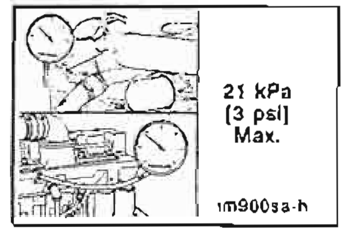
Engine Year	HP Rating	Application	Wastegate Applied Pressure
1991	110	Automotive (4B)	133 kPa [19.3 psi]
1991	190-230	Automotive	153 kPa [22.2 psi]
1994	160-175	Automotive	133 kPa [19.3 psi]
1994	190-230	Automotive	198 kPa [28.7 psi]
1994	All	Industrial	191 kPa [27.7 psi]



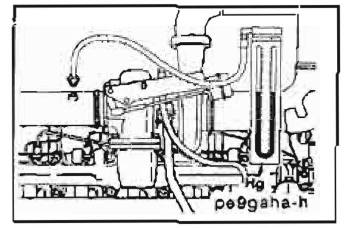
Intake Air Restriction (Rated Speed and Load)

	Metric		U.S.
• Naturally Aspirated Engine	508 mm H_2O	MAX	20 in H_2O
• Turbocharged Engine	635 mm H_2O	MAX	25 in H_2O

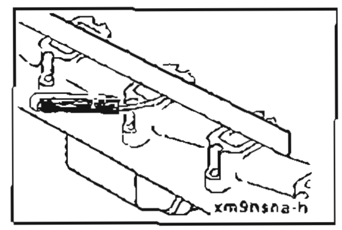
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
Charge Air Cooler				
Differential Pressure Across Cooler		21 kPa	Max	3 psi



Exhaust Air Restriction (Rated Speed and Load)		76.2 mm Hg	MAX	3 in Hg
(Naturally aspirated engines are checked at rated speed and no load).				
Automotive With Catalyst		114.3 mm Hg	MAX	4.5 in Hg
Automotive Without Catalyst		152.4 mm Hg	MAX	6.0 in Hg

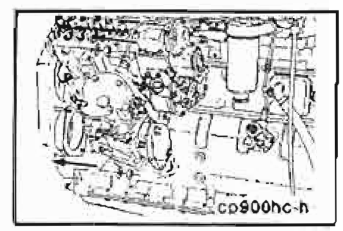


Exhaust Manifold Flatness		0.10 mm	MAX	0.004 in

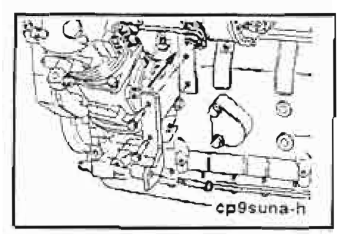


Compressed Air System Torque Values

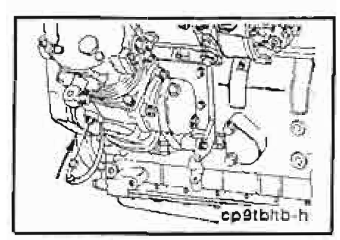
Air Compressor Mounting Nuts		77 N•m		57 ft-lb



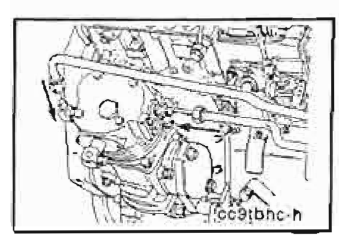
Air Compressor Support Capscrews		24 N•m		18 ft-lb



Air Compressor Oil Suppy Line		15 N•m		12 ft-lb

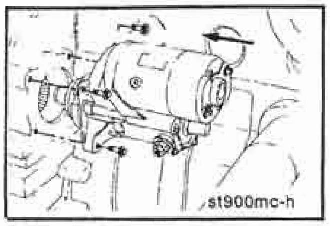


Air Compressor Coolant Lines		24 N•m		18 ft-lb

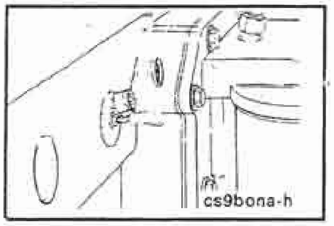


Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.

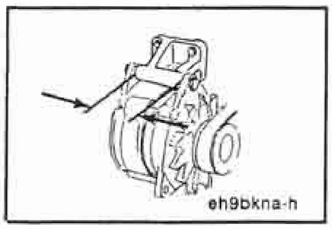
Electrical System



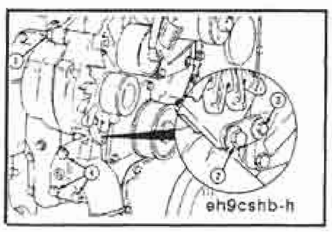
Starıng Motor Mounting Capscrews		43 N•m	32 ft-lb



Coolant Heater		12 N•m	108 ın-lb

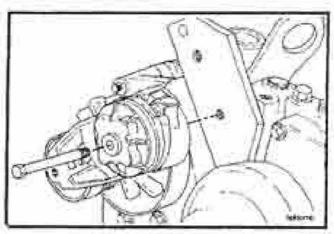


Alternator Mounting Bracket Dimensıon			
Delco 10/15SI		55.72 mm	2 3/16 ın
Motorola 100 Amp		81 mm	3 3/16 ın
Delco 20/27SI		98 mm	3 7/8 ın
Lucas		78 mm	3 ın

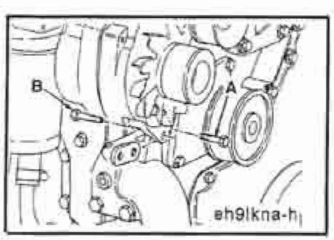


Alternator Assembly Torque Sequence

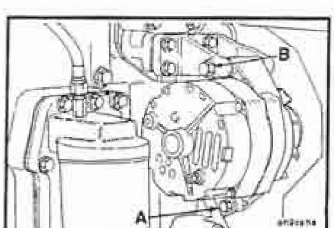
1 Alternator-to-alternator bracket capscrew.
2. Lower brace-to-alternator capscrew.
3. Alternator-to-water ınlet capscrew.
4. Water ınlet-to-block capscrews.



Belt Tensıoner Capscrew		43 N•m	32 ft-lb



Alternator Lınk			
8 mm Capscrew	A	24 N•m	18 ft-lb
10 mm Capscrew	B	43 N•m	32 ft-lb

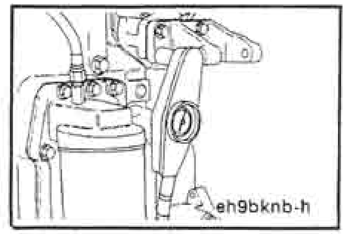


Alternator Mounting Bolt	B		
Delco 10 to 15SI, Lucas, Motorola and Bosch		43 N•m	32 ft-lb
Delco 20SI, 27SI, 29SI		80 N•m	59 ft-lb

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.

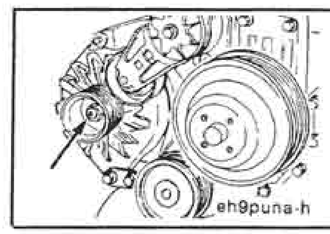
Alternator Bracket Mounting Capscrews
8 mm

24 N•m | 18 ft-lb



Alternator Pulley Nut

80 N•m | 59 ft-lb



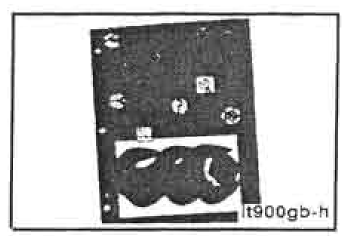
Batteries State of Charge

Specific Gravity at 27°C [80°F]	State of Charge
1.260 to 1.280	100%
1.230 to 1.250	75%
1.200 to 1.220	50%
1.170 to 1 190	25%
1 110 to 1 130	Discharged

Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260-1.280
75%	1.230-1.250
50%	1.200-1.220
25%	1.170-1.190
Discharged	1.110-1.130

Engine Testing - Test Specifications

Note: The specifications and instructions for testing the engine are provided in the Shop Manual, Bulletin No. 3810206. Refer to Engine Testing Group 14, Page 14-1



Drive Belt Tension

SAE Belt Size	Belt Tension Gauge Part No.		Belt Tension New		Belt Tension Range Used*	
	Click-type	Burroughs	N	lbf	N	lbf
.380 in.	3822524		620	140	270 to 490	60 to 110
440 in.	3822524		620	140	270 to 490	60 to 110
1/2 in.	3822524	ST 1138	620	140	270 to 490	60 to 110
11/16 in.	3822524	ST 1138	620	140	270 to 490	60 to 110
3/4 in.	3822524	ST 1138	620	140	270 to 490	60 to 110
7/8 in.	3822524	ST 1138	620	140	270 to 490	60 to 110
4 rib	3822524	ST 1138	620	140	270 to 490	60 to 110
5 rib	3822524	ST 1138	670	150	270 to 530	60 to 120
6 rib	3822525	ST 1293	710	160	290 to 580	65 to 130
8 rib	3822525	ST 1293	890	200	360 to 710	80 to 160
10 rib	3822525	3823138	1110	250	440 to 890	100 to 200
12 rib	3822525	3823138	1330	300	530 to 1070	120 to 240

* A belt is considered used if it has been in service for ten minutes or longer.

* If used belt tension is less than the minimum value, tighten the belt to the maximum used belt value.

FRACTION, DECIMAL, MILLIMETER CONVERSIONS

8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM	8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM
			1	0.0156	0.397				33	0.5156	13.097
		1		0.0313	0.794			17		0.5313	13.494
			3	0.0469	1 191				35	0.5469	13.891
	. 1			0.0625	1.588		9			0.5625	14.288
			5	0.0781	1.984				37	0.5781	14.684
		3		0.0938	2.381			19		0.5938	15.081
			7	0.1094	2.778				39	0.6094	15.478
1				0.1250	3.175	5				0.6250	15.875
			9	0.1406	3.572				41	0.6406	16.272
		5		0.1563	3.969			21		0.6563	16.669
			11	0.1719	4.366				43	0.6719	17.066
	3			0.1875	4.763		11			0.6875	17 463
			13	0.2031	5.159				45	0.7031	17.859
		7		0.2188	5.556			23		0.7188	18.256
			15	0.2344	5.953				47	0.7344	18.653
1/4				0.2500	6.350	3/4				0.7500	19.050
			17	0.2656	6.747				49	0.7656	19.447
		9		0.2813	7 144			25		0.7813	19.844
			19	0.2969	7.541				51	0.7969	20.241
	5			0.3125	7.938		13			0.8125	20.638
			21	0.3281	8.334				53	0.8281	21.034
		11		0.3438	8.731			27		0.8438	21 431
			23	0.3594	9.128				55	0.8594	21.828
3				0.3750	9.525	7				0.8750	22.225
			25	0.3906	9.922				57	0.8906	22.622
		13		0.4063	10.319			29		0.9063	23.019
			27	0.4219	10.716				59	0.9219	23.416
	7			0.4375	11 113		15			0.9375	23.813
			29	0.4531	11.509				61	0.9531	24.209
		15		0.4688	11.906			31		0.9688	24.606
			31	0.4844	12.303				63	0.9844	25.003
1/2				0.5000	12.700	1 IN.				1.0000	25.400

CONVERSION FACTOR: 1 INCH = 25.4MM

Weight and Measures - Conversion Factors

QUANTITY	U.S. CUSTOMARY		METRIC		FROM U.S. CUSTOMARY TO METRIC MULTIPLY BY	FROM METRIC TO U.S. CUSTOMARY MULTIPLY BY
	Unit Name	Abbr.	Unit Name	Abbr.		
Area	sq. inch	in^2	sq. millimeters	mm^2	645.16	0.001550
			sq. centimeters	cm^2	6.452	0.155
	sq. foot	ft^2	sq. meter	m^2	0.0929	10.764
Fuel Consumption	pounds per horsepower hour	lb/hp-hr	grams per kilowatt hour	g/kw-hr	608.277	0.001645
Fuel Performance	miles per gallon	mpg	kilometers per liter	km/l	0.4251	2.352
	gallons per mile	gpm	liters per kilometer	l/km	2.3527	0.4251
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
	foot	ft	millimeters	mm	304.801	0.00328
Power	horsepower	hp	kilowatt	kw	0.746	1.341
Pressure	pounds force per sq. in	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H2O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H2O	millimeters of water	mm H2O	25.40	0.039370
	bars	bars	kilopascals	kPa	100.001	0.00999
	bars	bars	millimeters of mercury	mm Hg	750.06	0.001333
Temperature	fahrenheit	°F	centigrade	°C	(°F-32) − 1.8	(1.8 x °C) +32
Torque	pound force per foot	ft lb	Newton-meter	N•m	1.35582	0.737562
	pound force per inch	in lb	Newton-meter	N•m	0.113	8.850756
Velocity	miles/hour	mph	kilometers/hour	kph	1.6093	0.6214
Volume: liquid displacement	gallon (U.S.)	gal.	liter	l	3.7853	0.264179
	gallon (Imp*)	gal.	liter	l	4.546	0.219976
	cubic inch	in^3	liter	l	0.01639	61.02545
	cubic inch	in^3	cubic centimeter	cm^3	16.387	0.06102
Weight (mass)	pounds (avoir.)	lb	kilograms	kg	0.4536	2.204623
Work	British Thermal Unit	BTU	joules	j	1054.5	0.000948
	British Thermal Unit	BTU	kilowatt-hour	kw-hr	0.000293	3414
	horsepower hours	hp-hr	kilowatt-hour	kw-hr	0.746	1.341

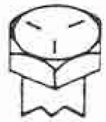
Newton-Meter to Foot-Pound Conversion Chart

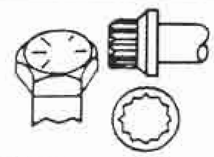
N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	8.850756 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
1	0.737562 ft-lb	90	66	190	140
12	9	95	70	195	144
14	10	100	74	200	148
15	11	105	77	205	151
16	12	110	81	210	155
18	13	115	85	215	159
20	15	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184

NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.

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 Body Size		Capscrew Torque Grade 5 Capscrew Cast Iron		Aluminum		Capscrew Torque Grade 8 Capscrew Cast Iron		Aluminum	
		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	8	6
	28	12	9	9	7	18	13	9	7
5/16	18	20	15	16	12	30	22	16	12
	24	23	17	19	14	33	24	19	14
3/8	16	40	30	25	20	55	40	25	20
	24	40	30	35	25	60	45	35	25
7/16	14	60	45	45	35	90	65	45	35
	20	65	50	55	40	95	70	55	40
1/2	13	95	70	75	55	130	95	75	55
	20	100	75	80	60	150	110	80	60
9/16	12	135	100	110	80	190	140	110	80
	18	150	110	115	85	210	155	115	85
5/8	11	180	135	150	110	255	190	150	110
	18	210	155	160	120	290	215	160	120
3/4	10	325	240	255	190	460	340	255	190
	16	365	270	285	210	515	380	285	210
7/8	9	490	360	380	280	745	550	380	280
	14	530	390	420	310	825	610	420	310
1	8	720	530	570	420	1100	820	570	420
	14	800	590	650	480	1200	890	650	480

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 the wrong capscrews can result in engine damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:

Metric M8-1.25 X 25

M8	1.25	25
Major Thread Diameter in Millimeters	Distance Between Threads in Millimeters	Length in Millimeters

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 tables 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.

3. The torque values in the table are based on the use of lubricated threads.

4. When the ft-lb value is less than 10, give consideration to converting the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

Pipe Plug Torque Values

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	in	N•m	ft-lb	N•m	ft-lb
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary & Metric

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

Tap Size 60%	Tap Size 75%	Drill Size
		48
		1.95mm
		5/64
	3-48	47
		2.00mm
	M2.5x.45	2.05mm
		46
3-48	3056	45
		2 10mm
M2.5x.45	M2.6x.45	2.15mm
3-56	4-36	44
		2 20mm
M2.6x.45		2.25mm
4-36	4-40	43
		2.30mm
		2.35mm
4-40	4-48	42
		3/32
	M3x.6	2.40mm
4-48		41
		2 45mm
		40
M3x.6	M3x.5	2.50mm
		39
	5-40	38
M3x.5		2.60mm
5-40	5-44	37
		2.70mm
5-44	6-32	36
		2.75mm
		7/64
		35
		2.80mm
		34
6-32	6-40	33
	M3.5x6	2.90mm
		32
M3.5x6		3.00mm
6-40		31
		3.10mm
		1/8
		3.20mm
	M4x 75	3.25mm
		30
	M4x.7	3.30mm
M4x.75		3.40mm
M4x.7	8-32	29
		3 50mm
	8-36	28
8-32		9/64
		3.60mm
8-36		27
		3 70mm
		26
	M4.5x.75	3.75mm
	10-24	25
		3.80mm
		24
M4.5x.75		3.90mm
		23
		5/32
10-24		22
	M5x1	4.00mm
	10-32	21
		20
	M5x.9	4.10mm
M5x1	M5x 8	4.20mm
10-32		19
M5x.9		4.25mm
M5x.8		4.30mm
		18
		11/64
		17

Tap Size 60%	Tap Size 75%	Drill Size
		4.40mm
	12-24	16
		4.50mm
		15
	M5.5x.9	4.60mm
12-24	12-28	14
		13
		4.70mm
M5.5x.9		4.75mm
12-28		3/16
		12
		4 80mm
		11
		4.90mm
		10
		9
	M6x1	5.00mm
		8
		5.10mm
	1/4-20	7
		13/64
		6
M6x1		5 20mm
		5
	M6x 75	5.25mm
		5.30mm
1/4-20		4
M6x.75		5.40mm
	1/4-28	3
		5.50mm
		7/32
		5.60mm
1/4-28		2
		5.70mm
		5.75mm
		1
		5.80mm
		5.90mm
		A
		15/64
	M7x1	6.00mm
		B
		6.10mm
		C
M7x1		6.20mm
		D
	M7x 75	6.25mm
		6.30mm
		E
		1/4
M7x.75		6 40mm
		6.50mm
	5/16-18	F
		6.60mm
		G
		6.70mm
		17/64
	M8x1.25	6.75mm
5/16-18		H
		6.80mm
		6.90mm
	5.16-24	I
M8x1 25	M8x1	7.00mm
		J
		7.10mm
5/16-24		K
		9/32
M8x1		7.20mm
		7.25mm
		7.30mm
		L
		7 40mm
		M

Tap Size 60%	Tap Size 75%	Drill Size
		7.50mm
		19/64
		7.60mm
		N
		7.70mm
	M9x1.25	7.75mm
		7.80mm
		7.90mm
	3/8-16	5/16
M9x1.25	M9x1	8.00mm
		O
		8.10mm
M9x1		8 20mm
		P
		8.25mm
		8.30mm
3/8-16	1/8-27NPT	21/64
		8.40mm
	3/8-24	Q
	M10x1.5	8.50mm
		8.60mm
		R
3/8-24		8.70mm
1/8-27NPT		11/32
	M10x1 25	8.75mm
M10x1.5		8.80mm
		S
		8.90mm
M10x1.25	M10x1	9.00mm
		T
		9 10mm
		23/64
M10x1		9.20mm
		9.30mm
	7/16-14	U
		9 40mm
	M11x1.5	9.50mm
		3/8
		V
		9.60mm
		9.70mm
		9.75mm
M11x1.5		9.80mm
7/16-14		W
		9.90mm
	7/16-20	25/64
		10.00mm
7/16-20		X
	M12x1.75	10.20mm
		Y
		13/32
		Z
M12x1.75	M12x1 5	10 50mm
	1/2-13	27/64
M12x1.5	M12x1.25	10.75mm
M12x1.25		11.00mm
1/2-13		7/16
1/4-18NPT		
		11.25mm
		11.50mm
		29/64
		11.75mm
		11.50mm
	1/2-20	29/64
	9/16-12	15/32
	M14x2	12.00m
		12.25mm
9/16-12		31/64
M14x2	M14x1.5	12.50mm
	9/16-18	1/2
M14x1.5	M14x1.25	12.75mm
M14x1.25		13.00mm
9/16-18		33/64

Tap Size 60%	Tap Size 75%	Drill Size
		13.25mm
	5/8-11	17/32
	M15x1.5	13.50mm
M15x1.5		13 75mm
5/8-11		35/64
	M16x2	14.00mm
		14 25mm
	5/8-18	9/16
M16x2	M16x1.5	14.50mm
5/8-18		37/64
		14.75mm
M16x1.5		15.00mm
		19.32
		15 25mm
		39/64
	M17x1.5	15.50mm
M17x1.5	M18x2.5	15.75mm
		5/8
M18x2 5	M18x2	16.00mm
M18x2		16.25mm
	3/4-10	41/64
	M18x1.5	16.50mm
3/4-10	M19x2.5	21/32
M18x1.5		16.75mm
M19x2.5		17.00mm
		43/64
		17.25mm
3/4-16	3/4-16	11/16
	M20x2.5	17.50mm
		17.75mm
		45/64
M20x2.5	M20x2	18 00mm
M20x2		18 25mm
		23/32
	M20x1.5	18.50mm
		47/64
M20x1.5		18.75mm
		19 00mm
		3/4
		19.25mm
	7/8-9	49/64
	M22x2.5	19.50mm
7/8-9		25/32
		19.75mm
M22x2.5	M22x2	20.00mm
	7/8-14	51/64
M22x2		20.25mm
	M22x1.5	20.50mm
7/8-14		13/16
		20.75mm
M22x1.5	M24x3	21.00mm
		53/64
		21/25mm
		27/32
M24x3		21.50mm
		21.75mm
		55/64
	M24x2	22.00mm
	1"-8	7/8
M24x2		22.25mm
	M24x1.5	22.50mm
1"-8		57/64
M24x1.5		22.75mm
	M25x2	23.00mm
	1"-12	29/32
M25x2		23.25mm
1"x12	1"-14	59/64
	M25x1.5	23 50mm
M20x1.5		23.75mm
1"-14		15/16

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
3666087	Troubleshooting and Repair Manual
3666017	B Series Engine Shop Manual
3810234	B Series Alternative Repair
3666029	4B Series Standard Repair Times
3666028	6B Series Standard Repair Times

Service Literature Ordering Location

Region	Ordering Location
United States and Canada	Cummins Distributors or Cummins Engine Co., Inc. Publishing Services CMC 40924 Box 3005 Columbus, IN 47202-3005
U.K., Europe, Mid-East, Africa, and Eastern European Countries	Cummins Engine Co., Ltd. Royal Oak Way South Daventry Northants, NN11 5NU, England
South and Central America (excluding Brazil and Mexico)	Cummins Americas, Inc. 16085 N.W. 52nd Avenue Hialeah, FL 33104
Brazil and Mexico	Cummins Engine Co., Inc. International Parts Order Dept., MC 40931 Box 3005 Columbus, IN 47202-3005
Far East (excluding Australia and New Zealand)	Cummins Diesel Sales Corp. Literature Center 8 Tanjong Penjuru Jurong Industrial Estate Singapore
Australia and New Zealand	Cummins Diesel Australia Maroondah Highway P.O.B. 139 Ringwood 3134 Victoria, Australia

Obtain current price information from your local Cummins Distributor or (for U.S.A.) by calling Cummins Toll Free Number 1-800-DIESELS (1-800-343-7357).

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2					
3					
4					
5					
6					

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Name: ____________________

Street Address: ____________________

City: ____________ State: ____________ Zip Code: ____________

Country: ____________

Section C - Component Manufacturers

Section Contents

United States and United Kingdom Offices

NOTE: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers may 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

Start Master
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

Advanced Drivetrain Corporation
938 South Marr Road
Columbus, IN 47201
Telephone: (812) 377-8894

Twin Disc International S.A.
Chaussee de Namur
Nivelles
Belgium
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

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

Brookside
McCordsville, IN 46055
Telephone: (317) 873-5093

Aerovent
8777 Purdue Rd.
Indianapolis, IN 46268
Telephone: (317) 872-0030

Kysor
1100 Wright Street
Cadillac, MI 49601
Telephone: (616) 775-4681

Schwitzer
1125 Brookside Avenue
P.O. Box 80-B
Indianapolis, IN 46206
Telephone: (317) 269-3100

Fan Clutches

Advanced Drivetrain Corporation
983 South Marr Road
Columbus, IN 47201
Telephone: (812) 377-8894

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 Power Train, Inc.
1200 Windsor Road
P.O. Box 2908
Rockford, IL 61132-2908
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

Fleetguard, Inc.
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

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

Governors

Woodward Governors Ltd.
P.O. Box 15
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

Hydraulic and Power Steering Pumps

Hobourn Eaton Ltd.
Priory Road
Strood
Rochester
Kent
ME2 2BD
Telephone: 0634-71773

Honeywell Control Systems Ltd.
Honeywell House
Charles Square
Bracknell
Berks RG12 1EB
Telephone: 0344-424555

Sundstrand Hydratec Ltd.
Cheney Manor Trading Estate
Swindon
Wiltshire
SN2 2PZ
England
Telephone: 0793-30101

Sperry Vickers
1401 Crooks Road
Troy, MI 48084
Telephone: (313) 280-3000

Z.F
P.O. Box 1340
Grafvonsoden Strasse
5-9 D7070
Schwaebisch Gmuend
West Germany
Telephone: 7070-7171-31510

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

Safety 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

Torque Converters

Twin Disc International S.A.
Chaussee de Namur
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
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Modine
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Racine, WI 53401
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