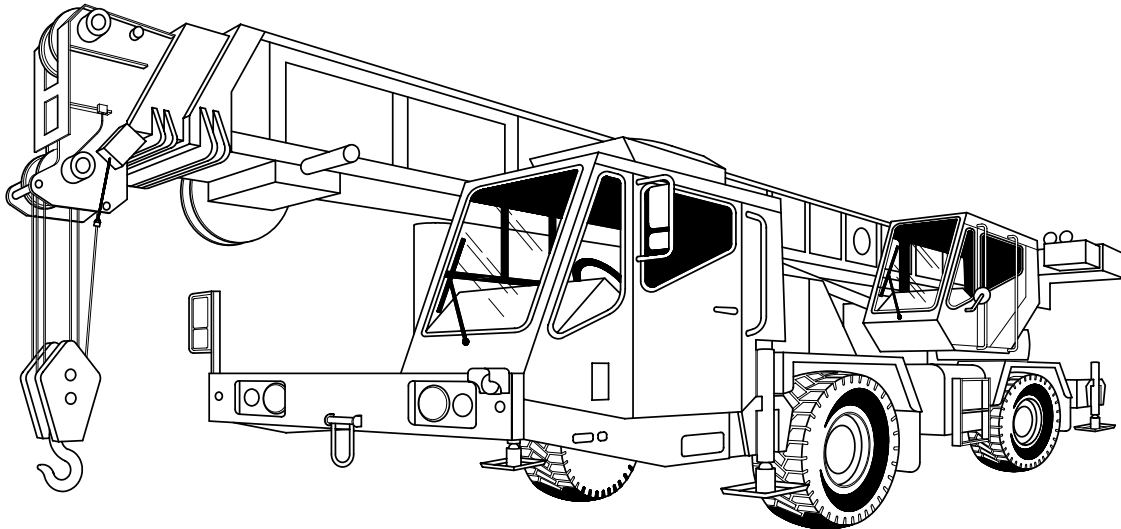


TM 5-3810-307-24-2-2

TECHNICAL MANUAL

**MAINTENANCE MANUAL FOR
DIESEL ENGINE
ALL-TERRAIN CRANE (ATEC) AT422T
DIESEL ENGINE DRIVEN, 22 TON CAPACITY
TRUCK MOUNTED WITH CAB**

NSN 3810-01-448-2619



DISTRIBUTION STATEMENT A - Approved for public release; distribution is unlimited.

HEADQUARTERS, DEPARTMENT OF THE ARMY

1 August 2000

WARNING

OPERATIONS ADJACENT TO OVERHEAD LINES ARE PROHIBITED UNLESS ONE OF THE FOLLOWING CONDITIONS ARE SATISFIED.

1	POWER HAS BEEN SHUT OFF AND POSITIVE MEANS TAKEN TO PREVENT LINES FROM BEING ENERGIZED.	
2	POSITION AND BLOCK EQUIPMENT INSURING NO PARTS, INCLUDING CABLE, CAN COME WITHIN THE FOLLOWING CLEARANCES:	<u>VOLTAGE REQD CLEARANCE</u> UNDER 50 KV - 10 FEET 69 KV - 12 FEET 115-161 KV - 15 FEET 230-285 KV - 20 FEET 345 KV - 25 FEET 500 KV - 35 FEET

CHECK WITH YOUR LOCAL POWER SUPPLIER FOR CORRECT LINE VOLTAGE

NOTE

READ AND UNDERSTAND ALL OF THE SAFETY WARNINGS AND CAUTIONS CONTAINED IN SECTION 2 OF THE OPERATOR'S MANUAL BEFORE OPERATING OR MAINTAINING THE CRANE, DIRECT ANY QUESTIONS THAT YOU MAY HAVE TO YOUR SUPERVISOR FOR CLARIFICATION.

TM 5-3810-307-24-2-2

CHANGE
NO. 1

HEADQUARTERS, DEPARTMENT OF THE ARMY
WASHINGTON D.C., 30 NOVEMBER 2006

TECHNICAL MANUAL

VOLUME 2 MAINTENANCE MANUAL FOR
DIESEL ENGINE

All-Terrain Crane (ATEC)
Diesel Engine Driven, 22 Ton Capacity
Truck Mounted With Cab
NSN 3810-01-448-2619

DISTRIBUTION STATEMENT A – Approved for public release; distribution is unlimited.

TM 5-3810-307-24-2-2, 1 August 2000, is updated as follows:

1. File this sheet in front of the manual for reference.
2. This change is a result of miscellaneous changes documented against the diesel engine configuration. The most significant change involves the replacement of Holset air compressor with a Cummins/Wabco air compressor.
3. New or updated test is indicated by a vertical bar in the outer margin of the page.
4. Added illustrations are indicated by a vertical bar adjacent to the figure number. Changed illustrations are indicated by change bars in the outside margin adjacent to the updated area and a change bar adjacent to the figure number.
5. Remove old pages and insert new pages as indicated below:

Remove Pages

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and Exploded Diagram
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O-1 thru O-4
O-7 and O-8
O-13 thru O-114
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V-1 and V-2
V-7 thru V-10
V-21 and V-22
V-25 thru V-28
V-33 thru V-42
Index 1 thru Index 4

By Order of the Secretary of the Army:

Official:

A handwritten signature in black ink, appearing to read "Joyce E. Morrow". The signature is fluid and cursive, with the first name "Joyce" being more prominent.

JOYCE E. MORROW
*Administrative Assistant to the
Secretary of the Army*
0632503

PETER J. SCHOOMAKER
*General, United States Army
Chief of Staff*

Distribution:

To be distributed in accordance with the initial distribution number (IDN) 256627,
requirements for TM 5-3810-307-24-2-2.

TM 5-3810-307-24-2-2

INSERT LATEST CHANGED PAGES. DESTROY SUPERCEDED DATA.

LIST OF EFFECTIVE PAGES

NOTE: The portion of text affected by the changes is indicated by a vertical line in the outer margins of the pages. Changes to illustrations are also indicated by vertical lines in the outer margins.

Dates of issue for original and changed pages are:

Original ..0..1 August 2000

Change ..1..30 November 2006

TOTAL NUMBER OF PAGES FOR THIS MANUAL IS 372 CONSISTING OF THE FOLLOWING:

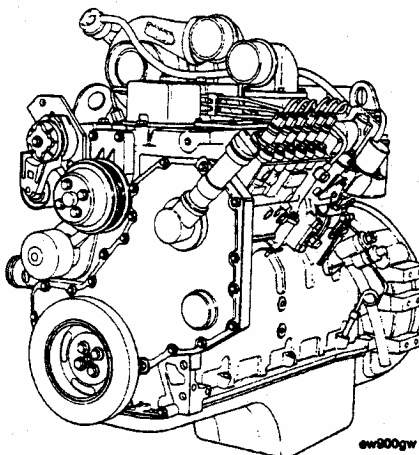
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4-1 – 4-6	0	V-23 – V-24	0		

* Zero in this column indicates an original page.

VOLUME 2 MAINTENANCE MANUAL FOR DIESEL ENGINE
ALL TERRAIN CRANE (ATEC) DIESEL ENGINE DRIVEN, 22 TO CAPACITY
TRUCK MOUNTED WITH CAB NSN 3810-01-448-2619

B Series
Shop Manual
1991 and 1994
Certification Levels

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.



Six Cylinder
B5.9-190

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.

The latest technology and the highest quality components are used to manufacture the engines. When replacement parts are needed, we recommend using only genuine original equipment exchange parts.

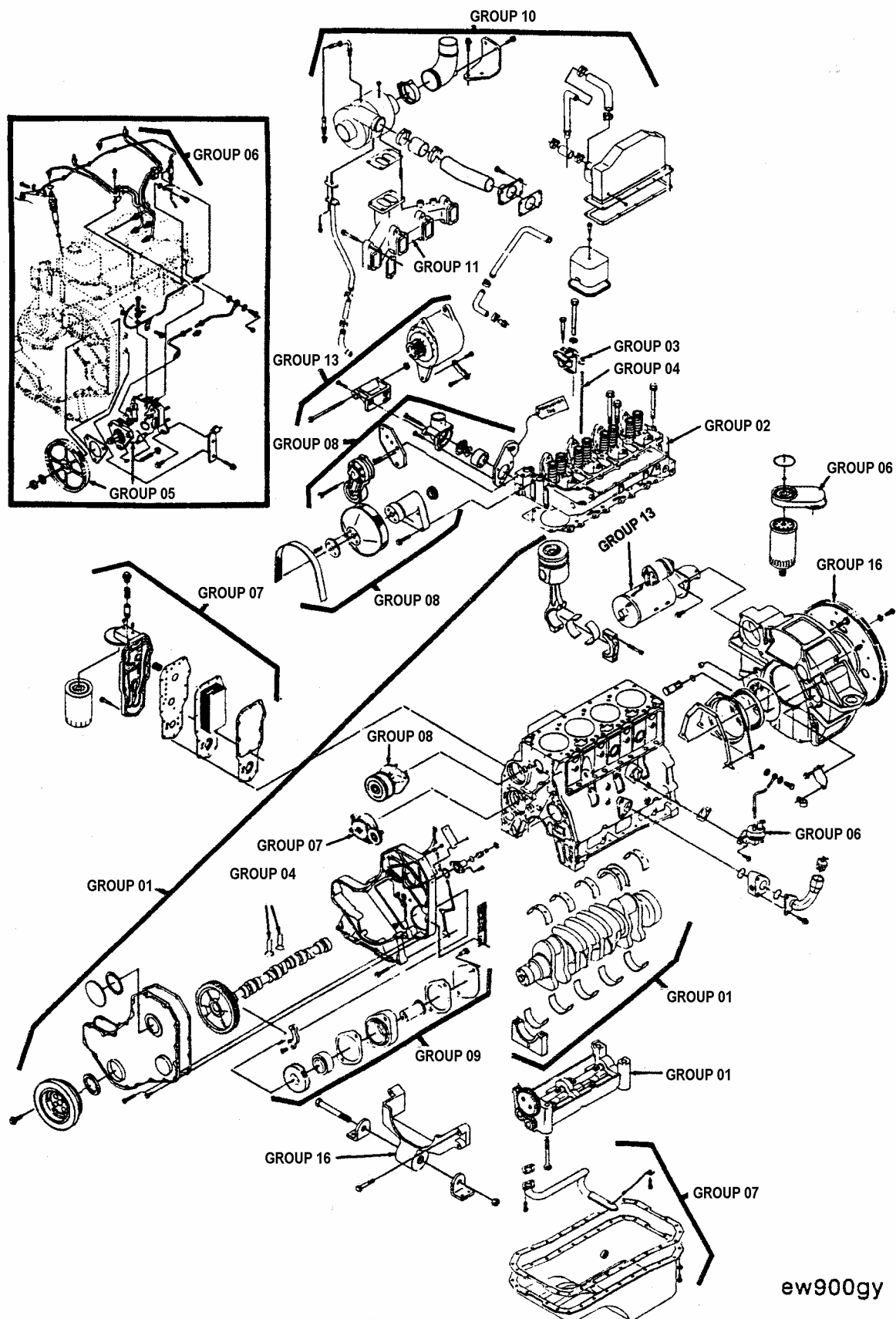
REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this publication. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Submit your DA Form 2028 (Recommended Changes to Equipment Technical Publications), through the Internet, on the Army Electronic Product Support (AEPS) website. The Internet address is <http://aeeps.ria.army.mil>. The DA Form 2028 is located under the Public Applications section in the AEPS Public Home Page. Fill out the form and click on SUBMIT. Using this form on the AEPS will enable us to respond quicker to your comments and better manage the DA Form 2028 program. You may also mail, fax or E-mail your letter or DA Form 2028 direct to: AMSTA-LC-LPIT / TECH PUBS, TACOM-RI, 1 Rock Island Arsenal, Rock Island, IL 61299-7630. The email address is TACOM-TECH-PUBS@ria.army.mil. The fax number is DSN 793-0726 or Commercial (309) 782-0726.

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Group System Exploded Diagram



ew900gy

Section i - Introduction

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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.

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 appear on page i-4.

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.



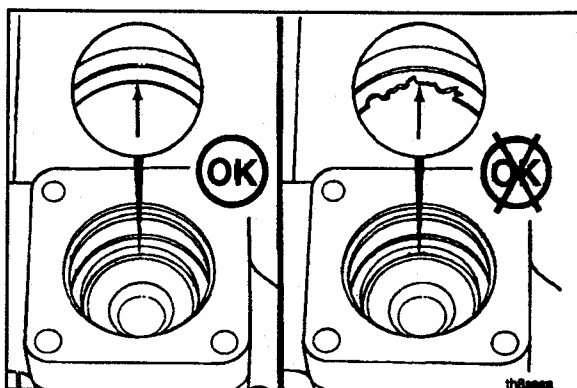
PERFORM an electrical **MEASUREMENT**.



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

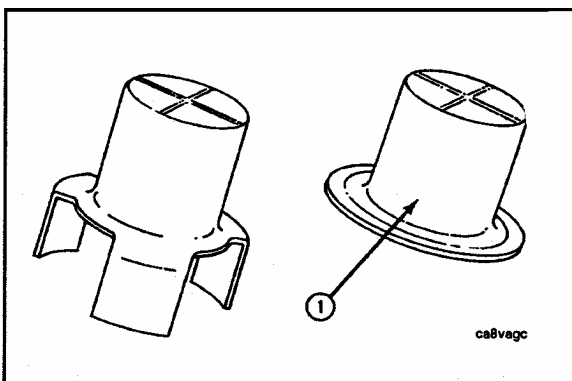


The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.



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.

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 lesser 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.

- The diesel engine manufacturer does not recommend or authorize any modifications or repairs to engines or components except for those detailed in this technical manual. In particular, unauthorized repair to safety-related components can cause personal injury. Below is a partial listing of components classified as safety-related:

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

- **Follow All Safety Instructions Noted in the Procedures.**
 - Follow the manufacturer's recommendations for cleaning solvents and other substances used during the repair of the engine. Some solvents and used engine oil have been identified by government agencies as toxic or carcinogenic. Avoid excessive breathing, ingestion 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 and 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, Service 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. The diesel engine manufacturer does not recommend specific cleaning agents. **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 C [180 to 200 degrees F]. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results.



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



WARNING

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

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

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

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is 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 and wiring
2. Injectors and Fuel Pump
3. Belts and Hoses
4. 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.

Glass or Plastic Bead Cleaning (Continued)

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 sufficient intake manifold pressure to allow for complete combustion.
ATDC:	After Top Dead Center; refers to the position of the piston or the crankshaft rod journal. The piston is moving downward on the power stroke 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.

Definition

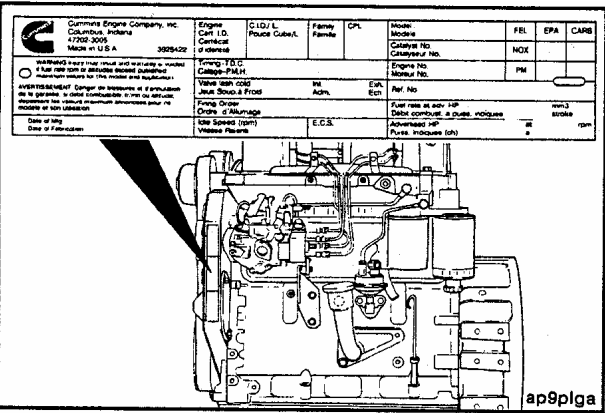
Loctite 609:	A single component anaerobic, liquid adhesive that meets or exceeds the requirements of MIL-R-46082A (MR) TYPE 1. Some of the equivalent products are Loctite 601 and Permabond HL 138.
Lubriplate 105:	A mineral oil base grease with calcium soap (2 percent to 6 percent), and zinc oxide (2 percent to 4 percent) additives.
Magnetic Particle Inspection:	A method of checking for cracks in either steel or iron parts. This method requires a Magnaflux 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 Premium No. 2, Texaco Premium RB, and Shell Dolium R. Aeroshell No. 5 is not compatible with the other greases and must not be mixed. Cummins Engine Company, Inc., uses Aeroshell No.5 on new engines and components.

Section E – Engine and Component Identification

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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.

 <div>Cummins Engine Company, Inc. Columbus, Indiana 47202-3005 Made in U.S.A. 3925422</div>	Engine Cert. I.D. Certificat d'identité		C.I.D./ L. Pouce Cube/L	Family Famille	CPL	Model Modele	FEL	EPA	CARB
	Timing-T.D.C. Calage-P.M.H.		Valve lash cold Jeux Soup.à Froid		Int. Adm.	Exh. Ech	Catalyst No. Catalyseur No.	NOX	
	Firing Order Ordre d'Allumage		Idle Speed (rpm) Vitesse Ralenti		E.C.S.		Engine No. Moteur No.	PM	
	Date of Mfg. Date of Fabrication						Ref. No.		
WARNING Injury may result and warranty is voided if fuel rate rpm or altitudes exceed published maximum values for this model and application. AVERTISSEMENT: Danger de blessures et d'annulation de la garantie, si débit combustible, tr/mn ou altitude, dépassent les valeurs maximum annoncées pour ce modèle et son utilisation.						Fuel rate at adv. HP Débit combust. a puiss. indiquée		mm3 stroke	
						Advertised HP Puiss. indiquée (ch)		at a	
								rpm	

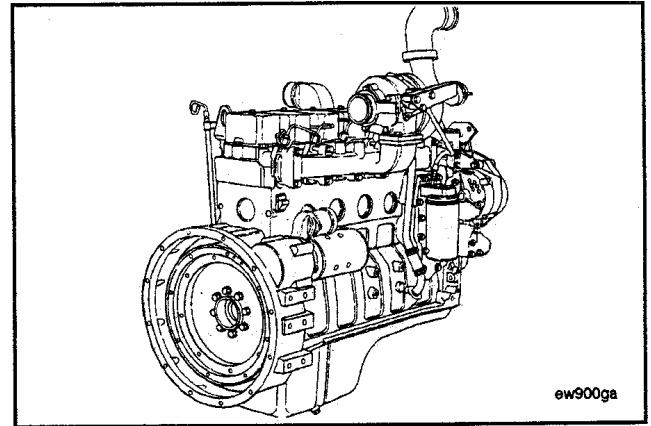
ap9plgb

Automotive Engine Dataplate

Automotive/Industrial Engine Nomenclature

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

B 5.9 - 190

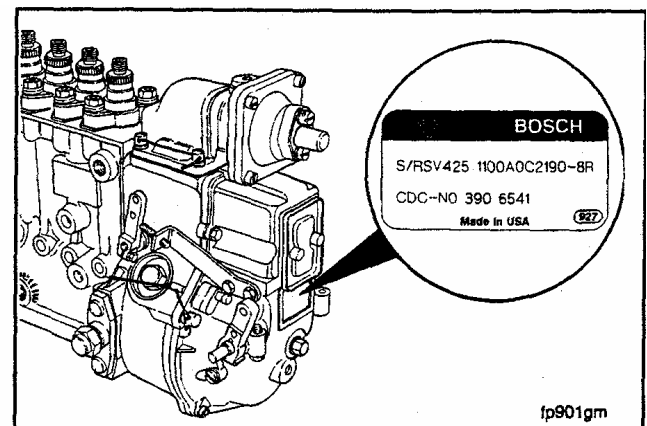


Injection Pump Dataplate

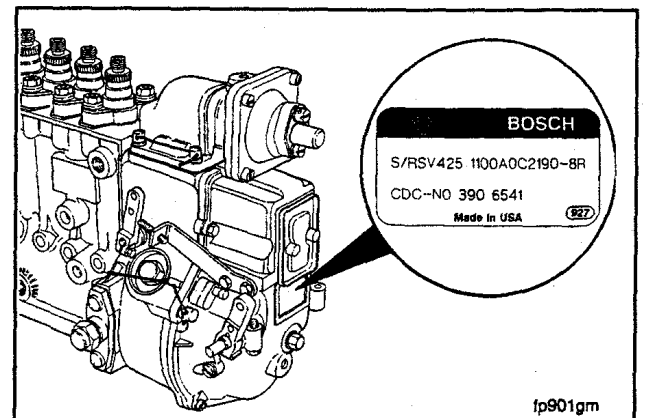
The injection pump dataplate is located on the side of the injection pump. It provides information for fuel pump calibration.

In-Line Injection Pump Dataplate Location

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



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	
6B.....	5.88 liters [359 in ³]
Compression ratio	
B5.9-190 turbocharged and aftercooled.....	17.1:1
Firing order	
6 cylinder	1-5-3-6-2-4
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)	
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	
6 cylinder engines	14.2 liters [15 U.S. Qts.]
Total system capacity	
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)	

NOTE

For General Cooling System Information Refer To TM 5-3810-307-24-1-1.

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

Intake Air and Exhaust System

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

Turbocharged	63.5 cm H ₂ O [25 in H ₂ O]
Maximum turbocharger outlet restriction at rated speed and load	76.2 mm Hg [3 in Hg]
Maximum exhaust restriction at rated speed and load	

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]

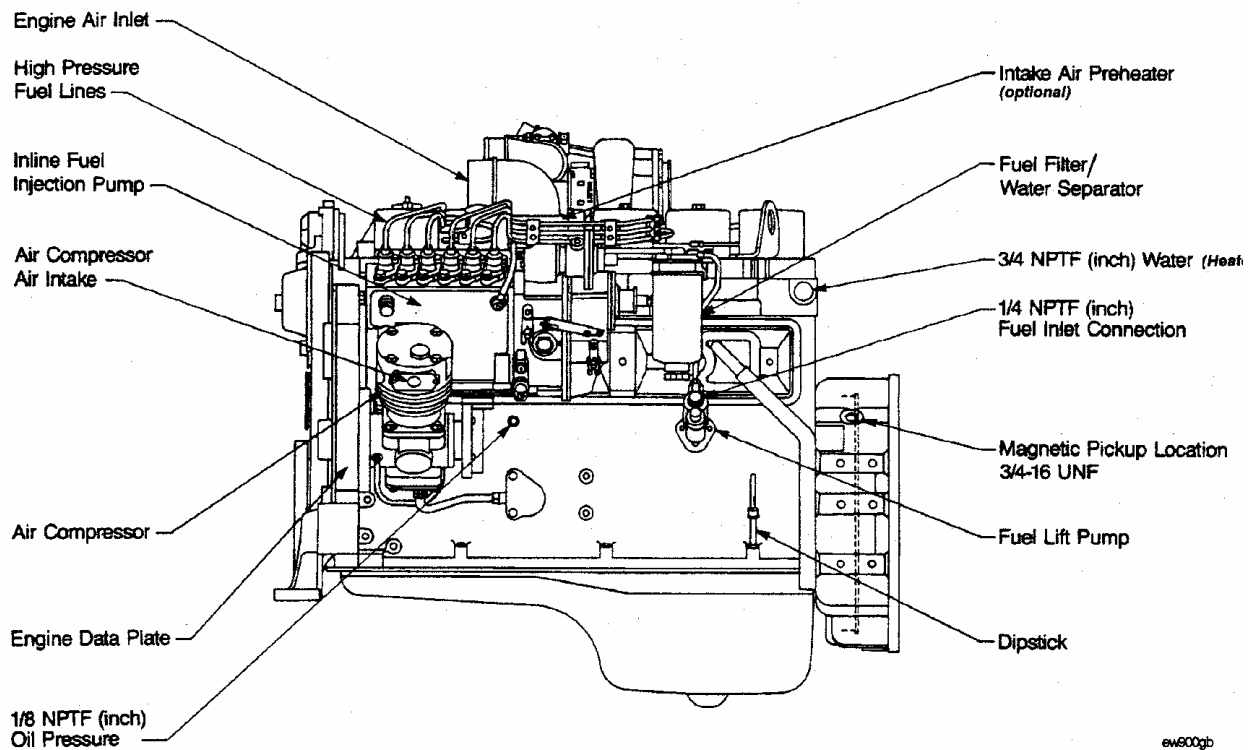
* All 1991 and 1994 automotive engines with charge air cooling are designated as B3.9 or B5.9.

Electrical System

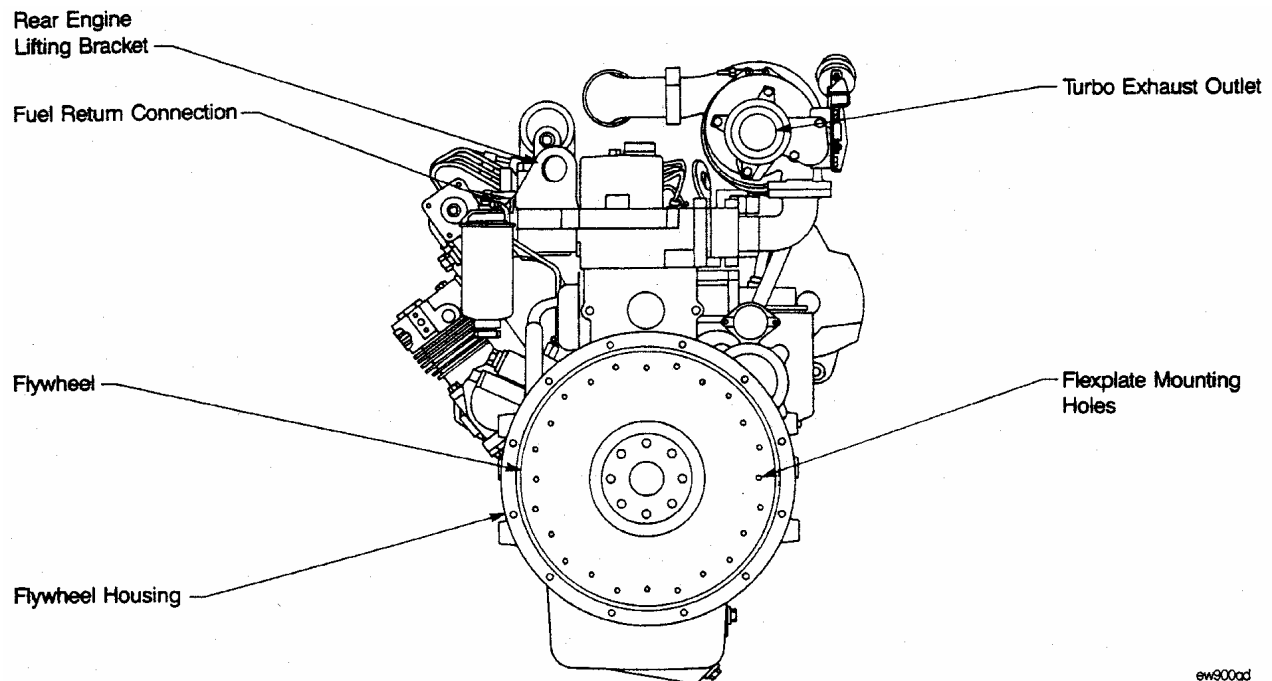
For General Electrical System Information Refer to TM 5-3810-307-24-1, Volume 1.

Engine Diagram - Automotive Engine

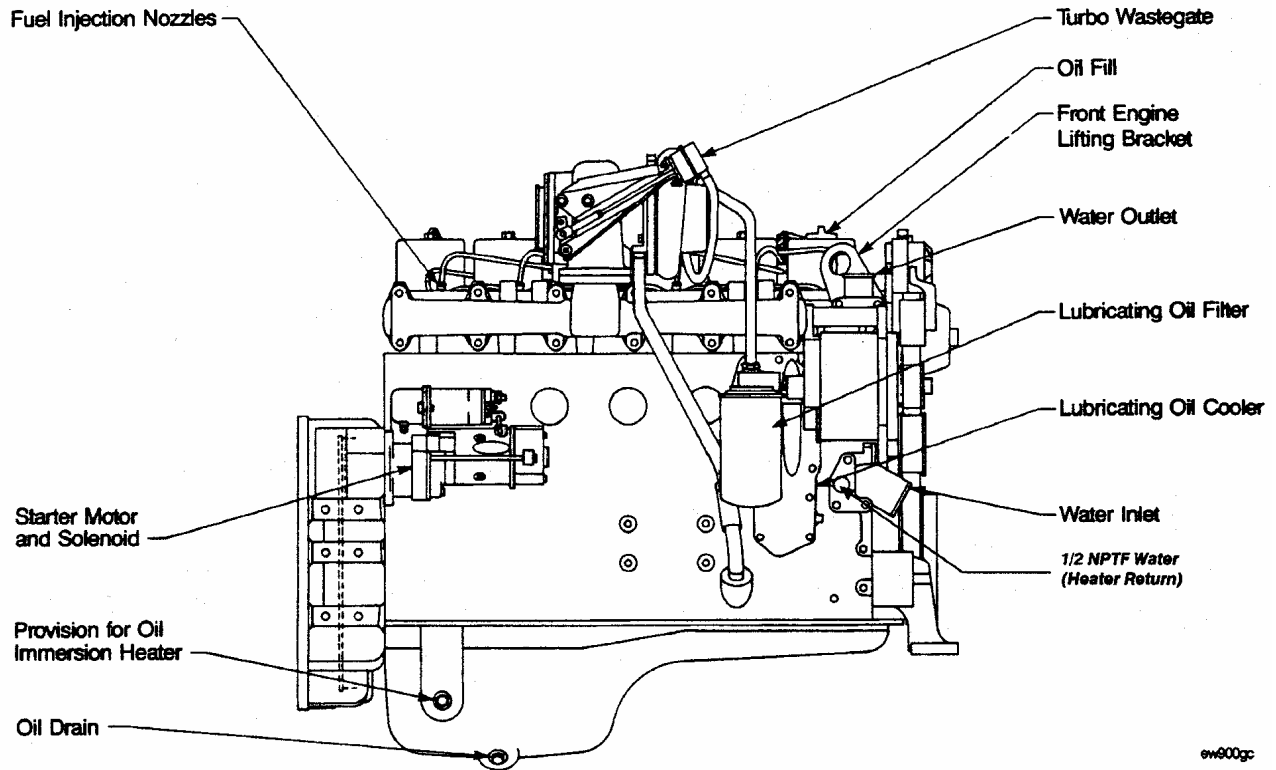
The illustrations which follow show the locations of the major external engine components, the filters, and other service and maintenance points. Some external components will be at different locations for different engine models.



Inlet Side

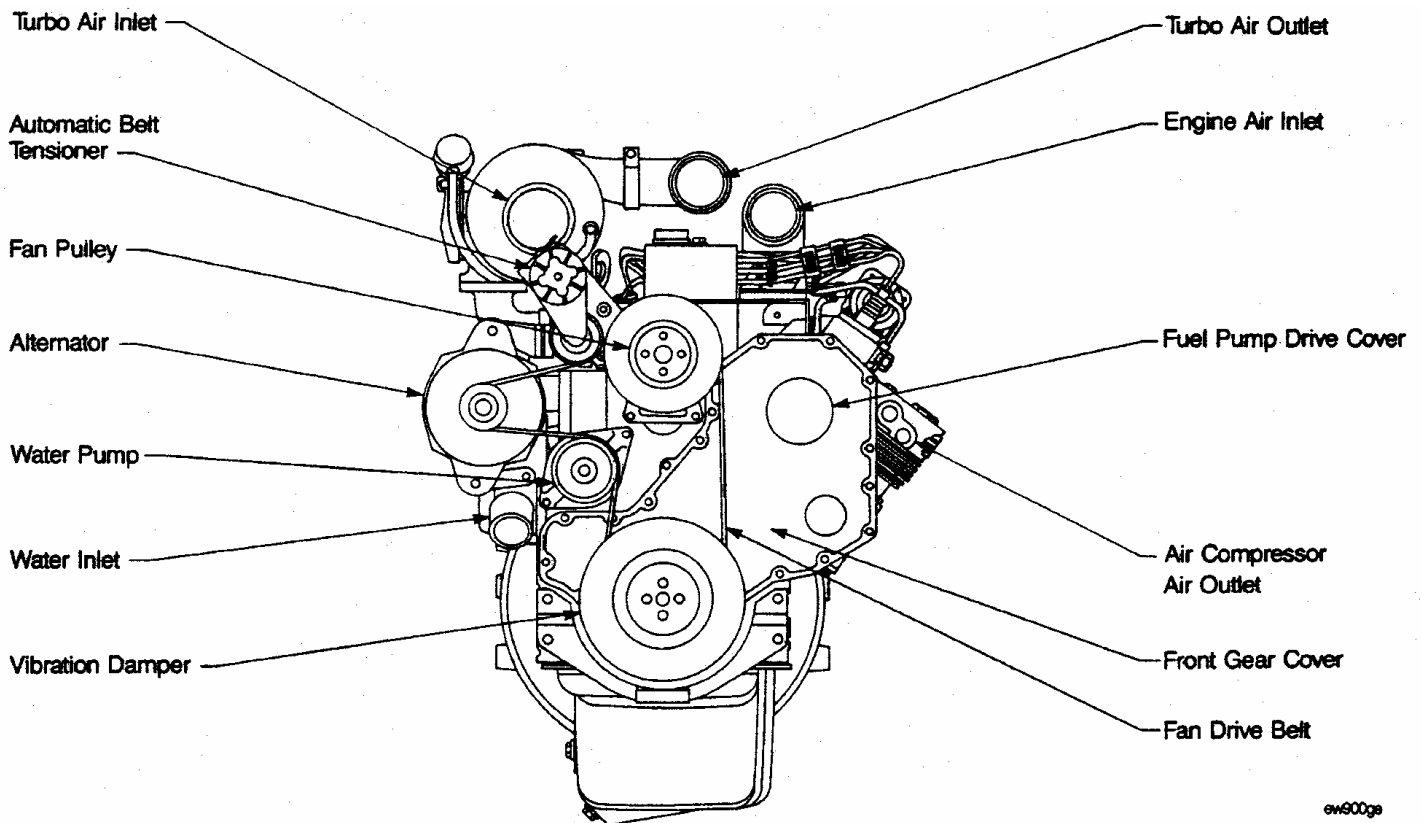


Rear View



ew900gc

Turbocharger Side View



ew900gc

Front View

Section 0 – Engine Disassembly and Assembly – Group 00

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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

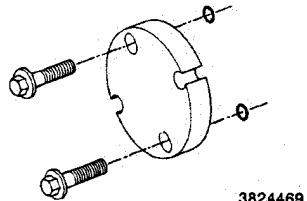
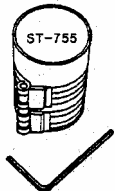
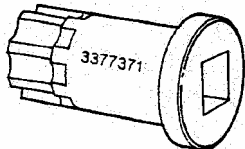
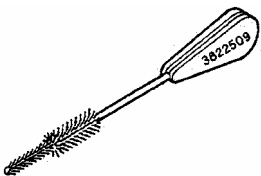
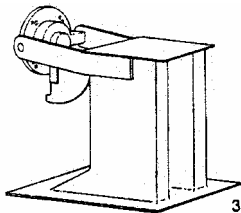
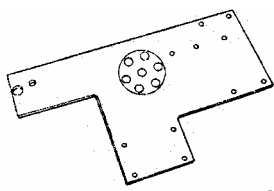
This procedure assumes that all of the components and assemblies have been cleaned, replaced, or rebuilt and are ready to be installed on the engine.

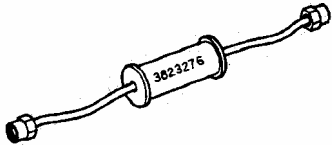
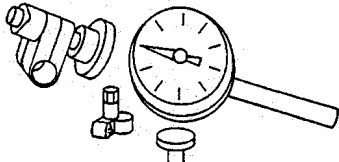
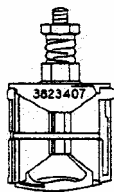
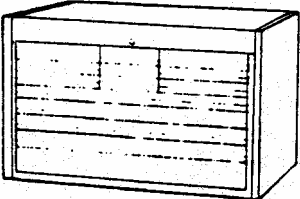
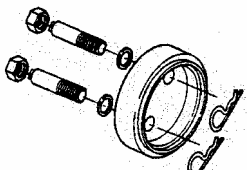
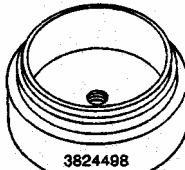
Torque values are listed in each step. If a torque value is **not** specified, use the chart listed in the Specifications, Group 18, to determine the correct torque value.

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.

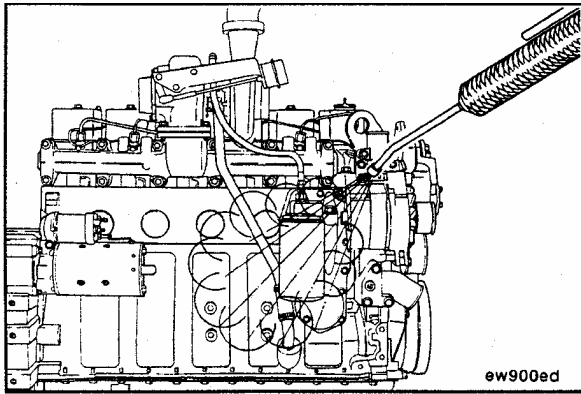
Tool No.	Tool Description	Tool Illustration
3824469	Fuel Pump Drive Gear Puller	 3824469
ST-755	Piston Ring Compressor	 st-755
3377371	Engine Barring Tool	 3377371
3822509	Injector Bore Brush	 3822509
3375193 3375194	Engine Rebuild Stand	 3375193
3376975	Engine Rebuild Stand Adapter	 3376975

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.	
3823407	Ridge Reamer	
3376593	Mechanic's Tool Kit	
3824078	Wear Sleeve Installation Tool Used to install the rear crankshaft lubricating oil wear sleeve.	
3824498	Oil Seal Installation Tool Used to install the front crankshaft lubricating oil seal in the front cover to a specified depth.	

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 | 0.076 - 0.330 mm [0.003 - 0.013 in] |
| 3. Lube pump gear backlash | 0.076 - 0.330 mm [0.003 - 0.013 in] |
| 4. Lube pump idler gear backlash | 0.076 - 0.330 mm [0.003 - 0.013 in] |
| 5. Camshaft End Play | 0.12 - 0.34 mm [0.005 - 0.013 in] |
| 6. Crankshaft End Play | 0.102 - 0.432 mm [0.004 - 0.017 in] |



Engine Disassembly (0-1)

Steam Cleaning The Engine (0-2)

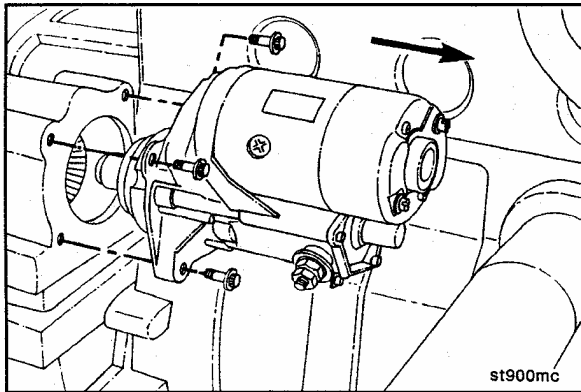
WARNING

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.

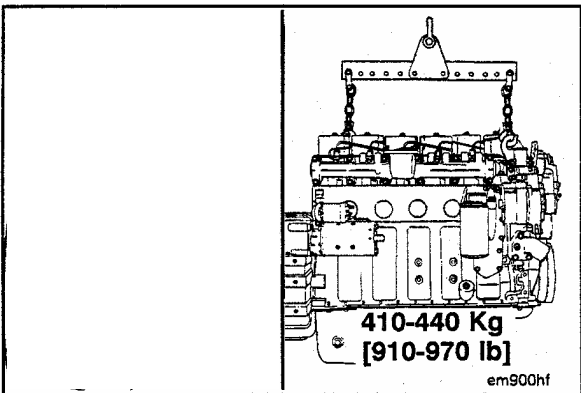
Steam clean the heavy dirt from the exterior of the engine.



Starter - Removal (0-3)

10 mm

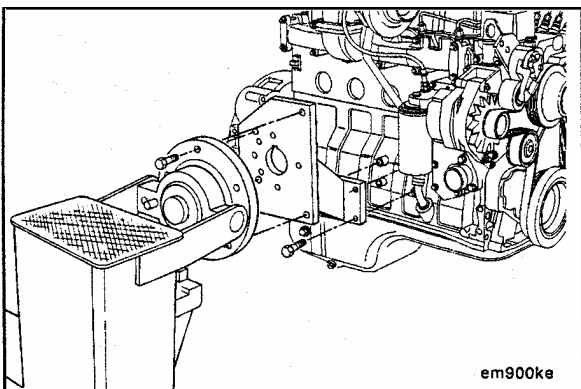
Remove the starting motor.



Engine Weight (0-4)

3822512 Engine Lifting Fixture

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:

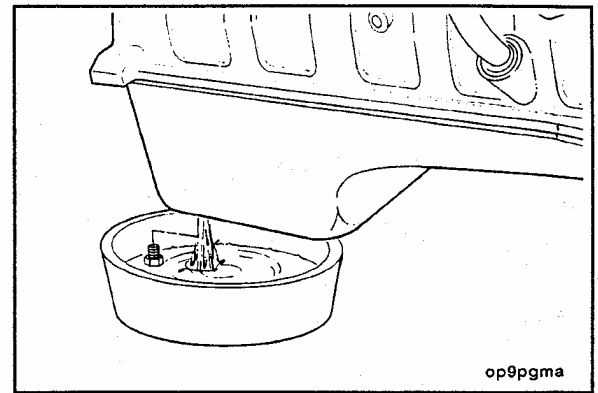
M12 x 1.75

Oil - Draining (0-6)

17 mm

Remove the drain plug.

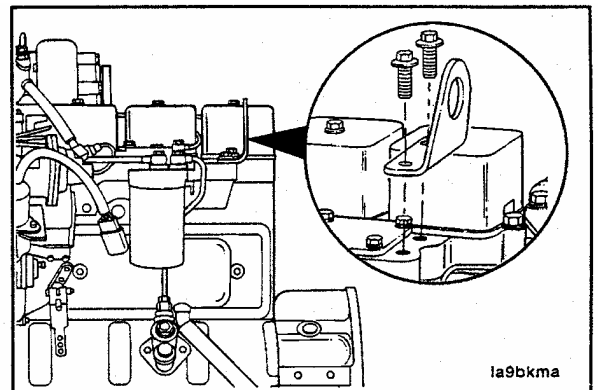
A drain pan with a capacity of 20 litres [5 U.S. gallons] will be adequate.



Lifting Bracket Removal - Rear (0-7)

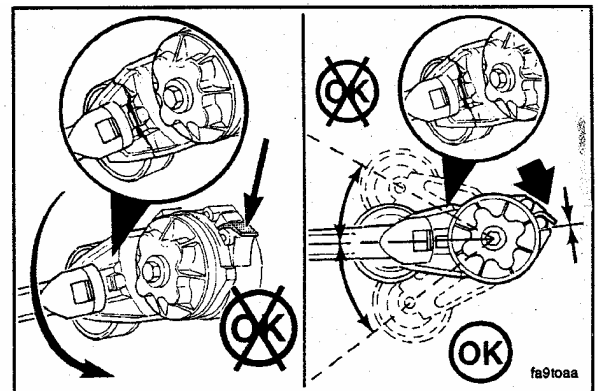
18 mm

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.



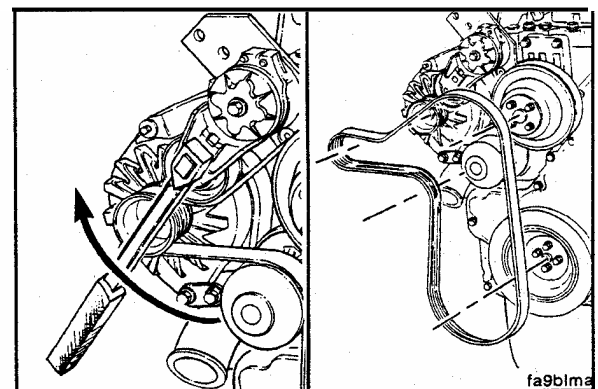
WARNING

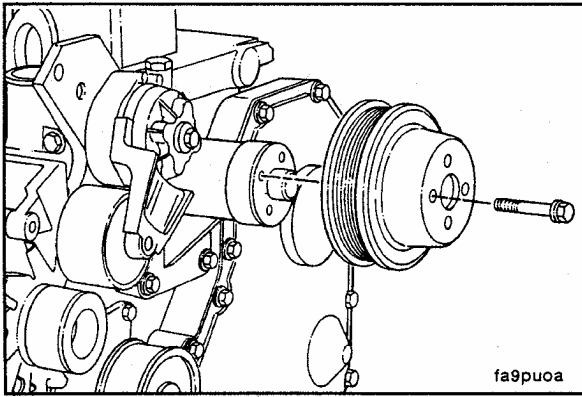
Keep hands out of the path of the spring-loaded tensioner.

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.

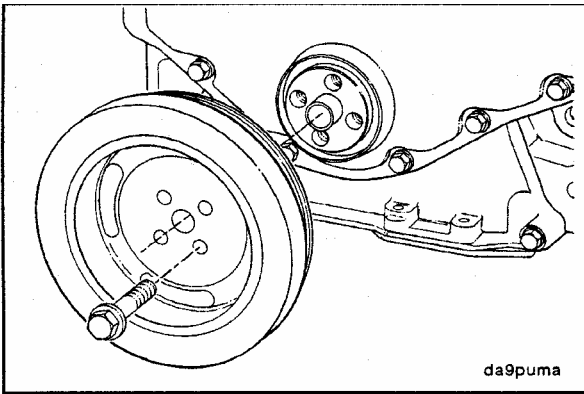




Fan Pulley - Removal (0-9)

13 mm

Remove the fan pulley and capscrews.



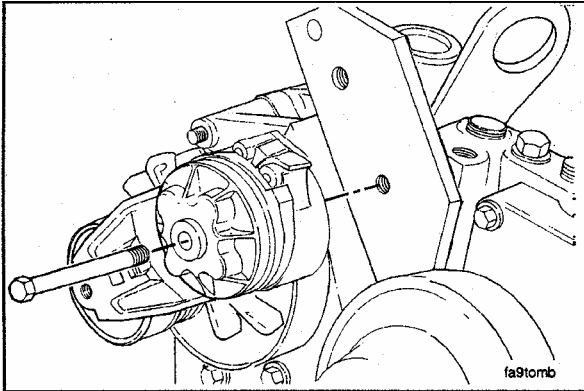
Vibration Damper/Crankshaft Pulley - Removal (0-10)

15 mm

Remove the vibration damper or crankshaft pulley and capscrews.

NOTE

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



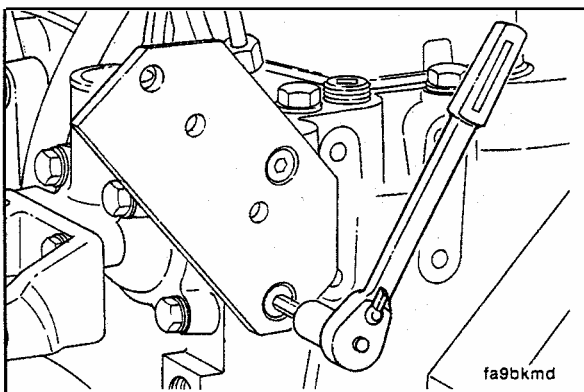
Belt Tensioner - Removal (0-11)

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.

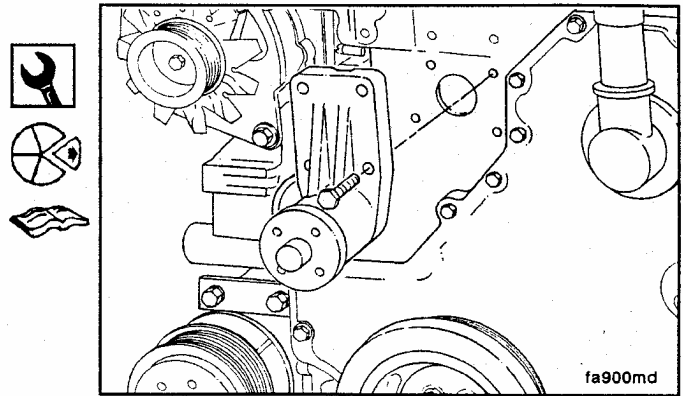
Fan Hub - Removal (0-12)

10 mm

Remove the fan hub.

NOTE

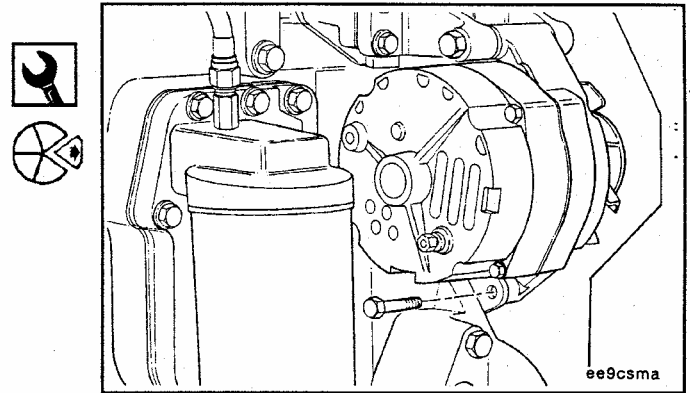
Refer to Component Section 8 for inspection of the fan hub.



Alternator - Removal (0-13)

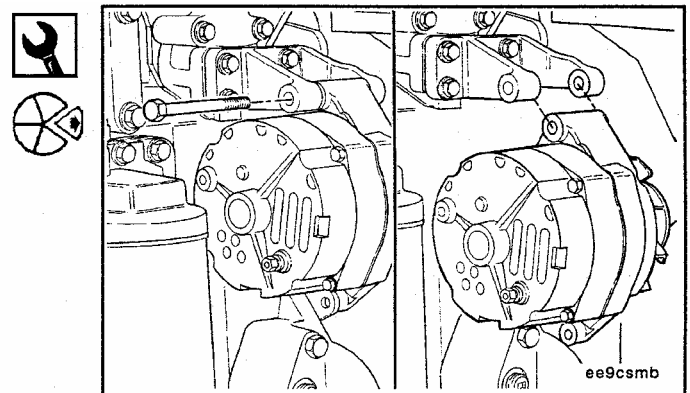
13 mm

Remove the alternator link.



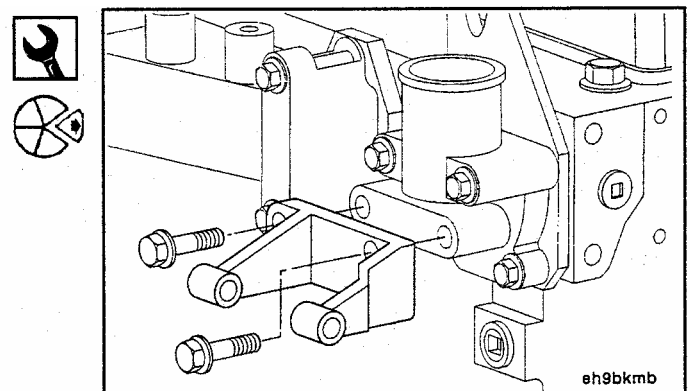
16 mm

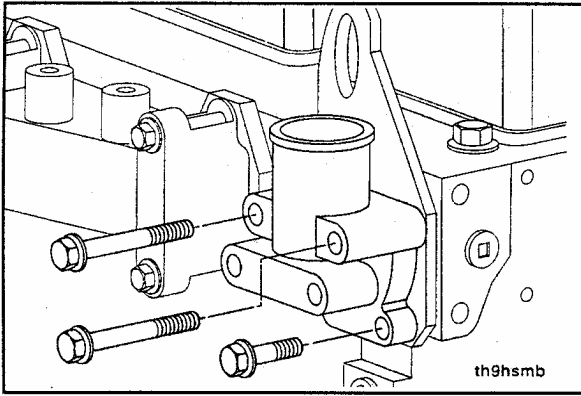
Remove the alternator mounting capscrew and alternator.



13 mm

Remove the alternator bracket.

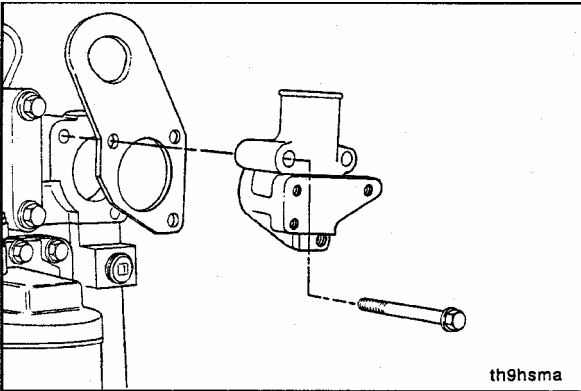




Thermostat - Removal (0-14)

10 mm

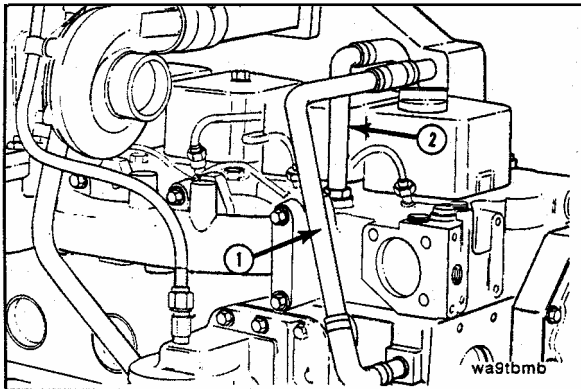
Remove the capscrews from the thermostat housing.



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

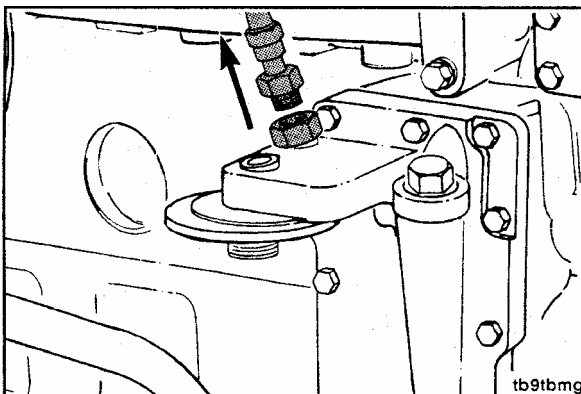
NOTE

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)

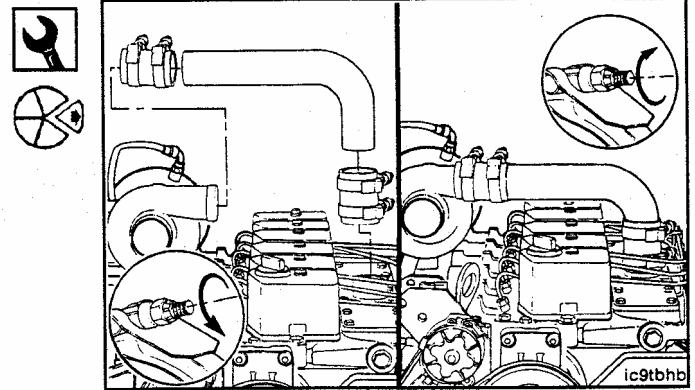
16 mm and 19 mm

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

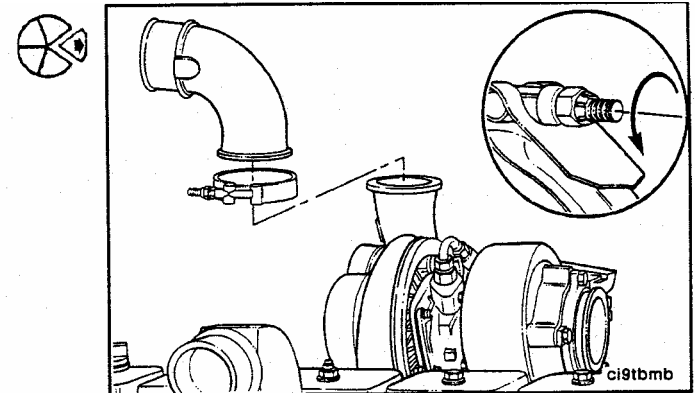


8 mm, Screwdriver

Remove the air crossover tube.

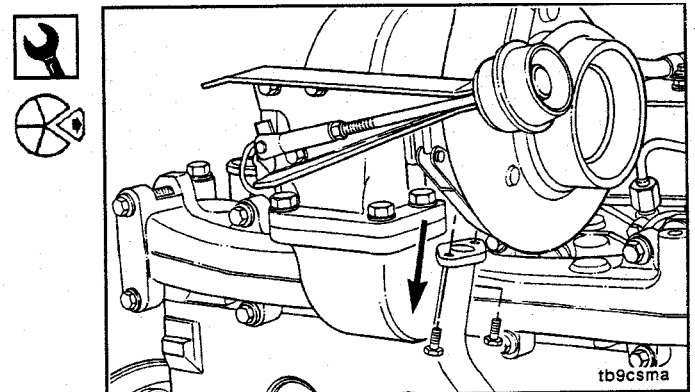


On Automotive engines, loosen the V-Band clamp and hose clamp and remove the charge air cooler inlet tube.



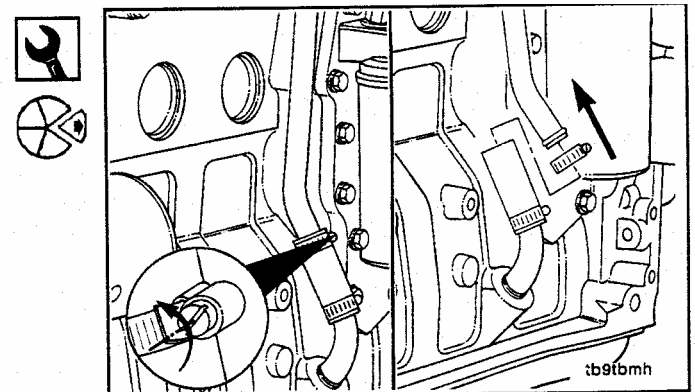
10 mm

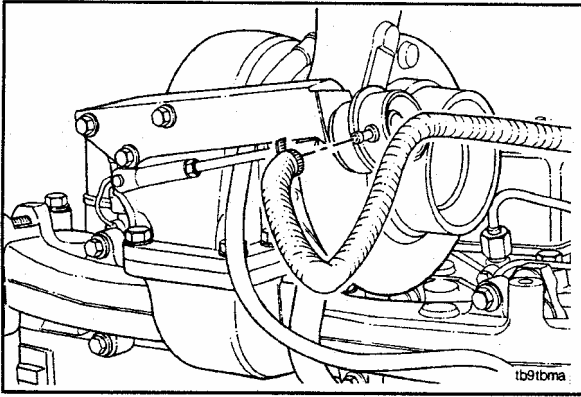
Disconnect the drain tube from the bottom of the turbocharger.



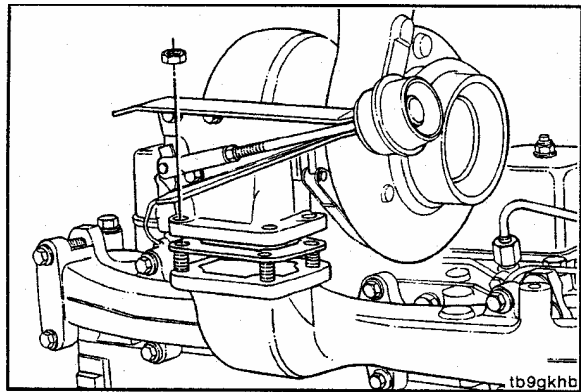
Screwdriver

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





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



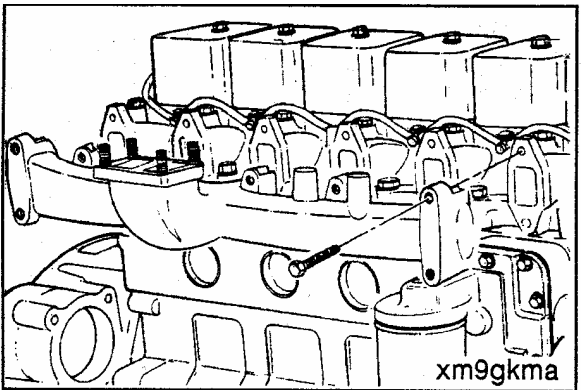
15 mm

Remove the turbocharger mounting nuts, turbocharger and gasket.



NOTE

Inspection of the turbocharger is described in Component Section 10.



Exhaust Manifold - Removal (0-16)

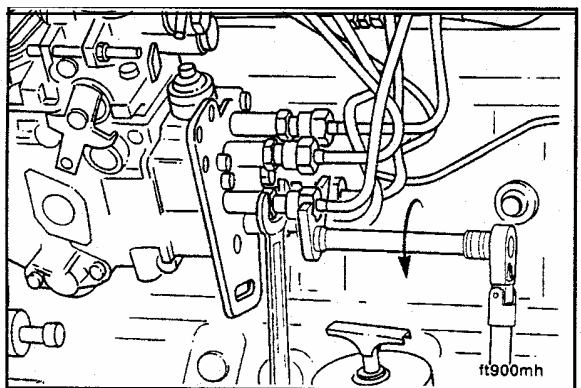
13 mm

Remove the capscrews, exhaust manifold and gaskets.



NOTE

Inspection of the exhaust manifold is described in Component Section 11.



Fuel 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.



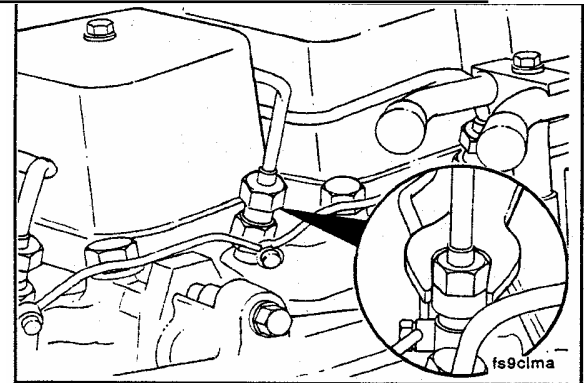
Remove the high pressure line fittings from the injection pump.

17 mm, 19 mm

Remove the high pressure lines from the injectors.

NOTE

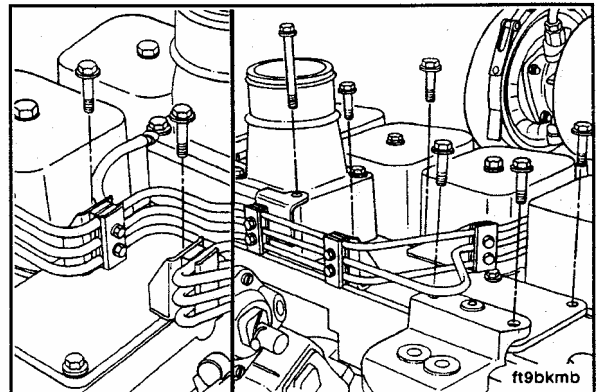
Refer to Component Section 6 for fuel line inspection.



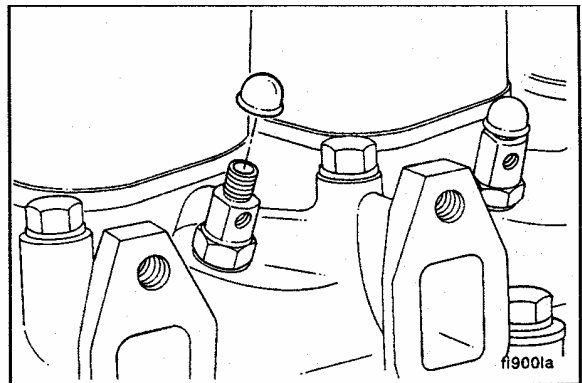
10 mm

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

Remove the high pressure lines as an assembly.

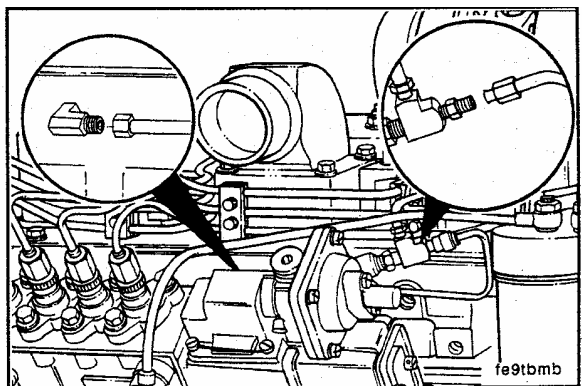


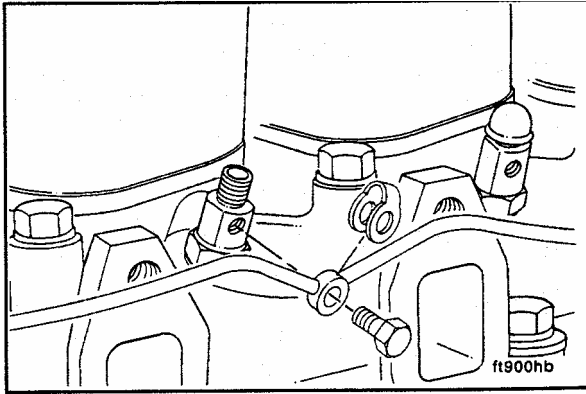
Cap or cover the injector openings.



12 mm and 13 mm

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

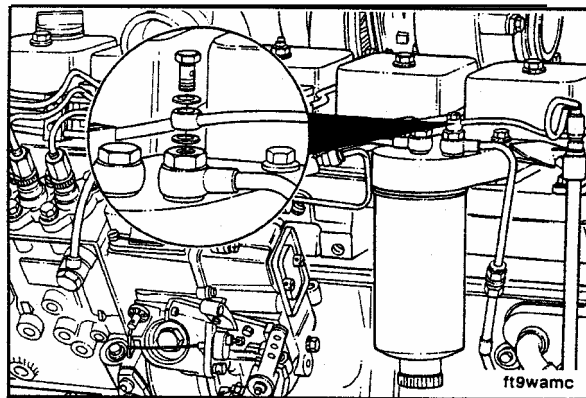




Fuel Drain Manifold - Removal (0-22)

10 mm

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

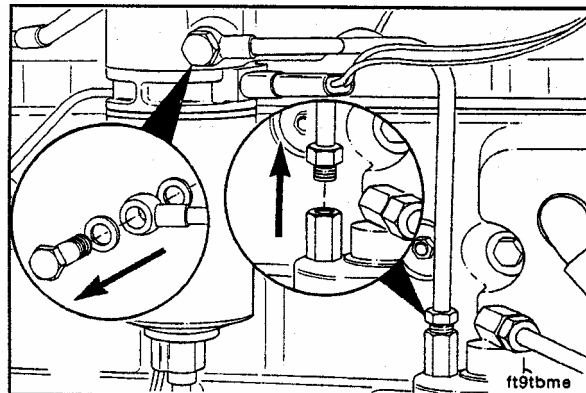


10 mm, 12 mm

In Line Fuel Pump

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

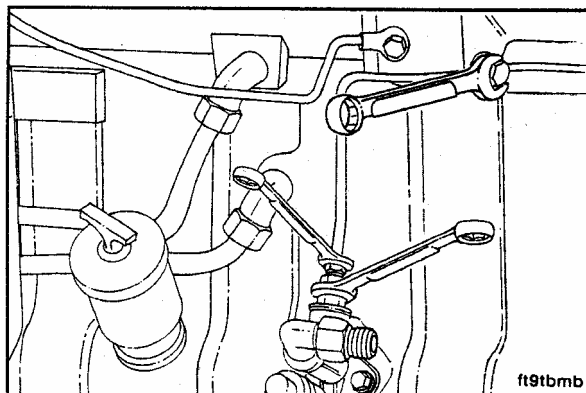
Remove the fuel line support bracket capscrew from the intake manifold.



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.



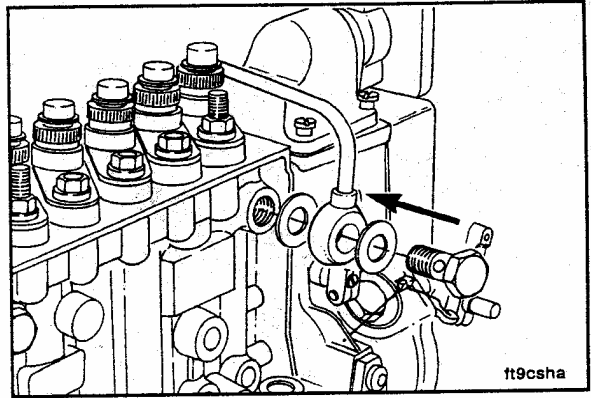
Loosen the nut and remove the fuel line from the lift pump.

14 mm and 17 mm

CAUTION

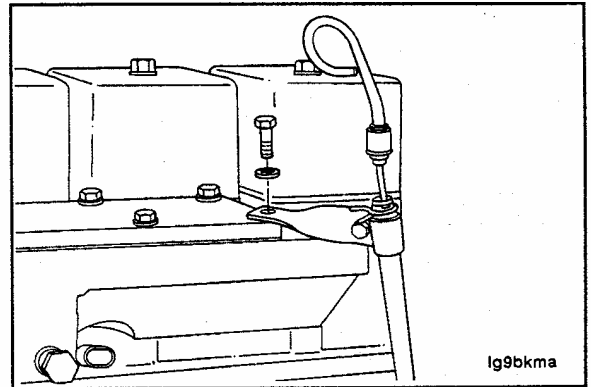
Be sure the fuel transfer pump connection is held securely when loosening the fuel line.

Remove the injection pump supply line.



Dipstick - Removal (0-24)

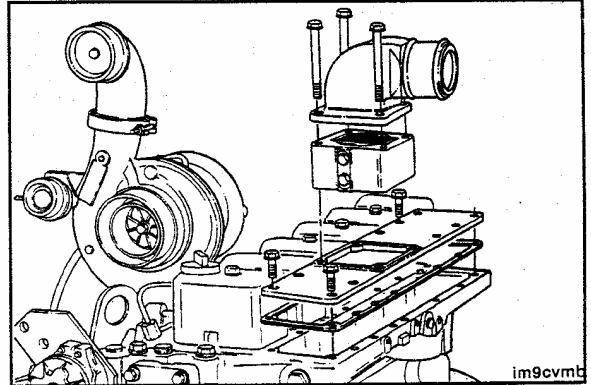
If equipped with a dipstick tube extension, remove the dipstick and extension.



Manifold Cover - Removal (0-25)

10 mm

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



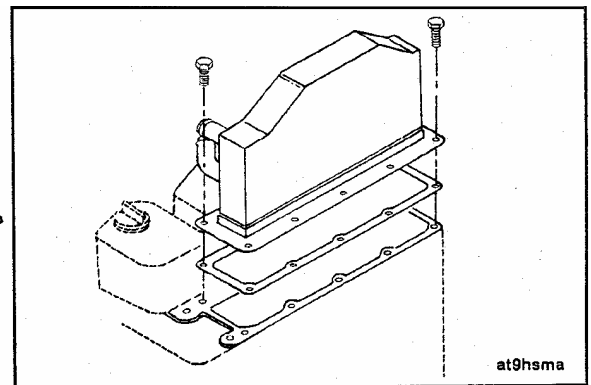
AfterCooler - Removal (0-26)

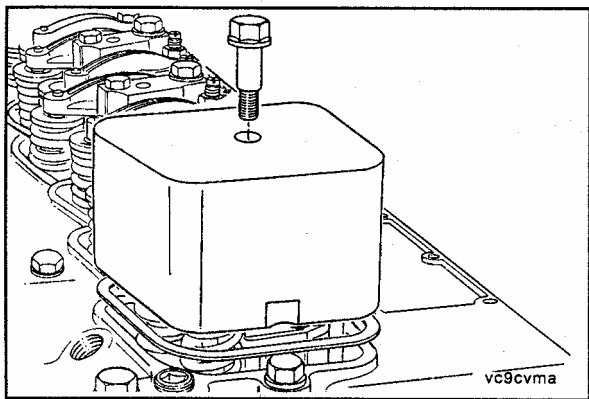
10 mm

If equipped, remove the aftercooler housing.

NOTE

Refer to Component Section 10 for the aftercooler inspection procedure.

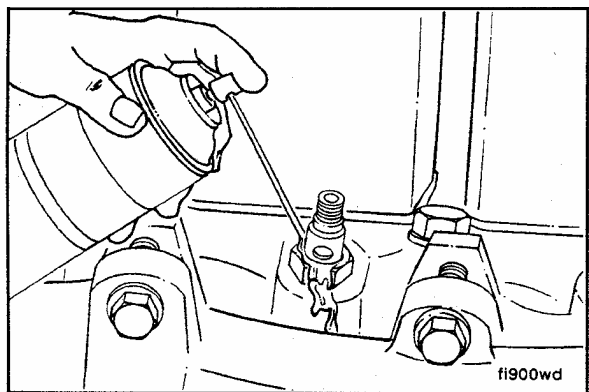




Valve Covers - Removal (0-27)

15 mm

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



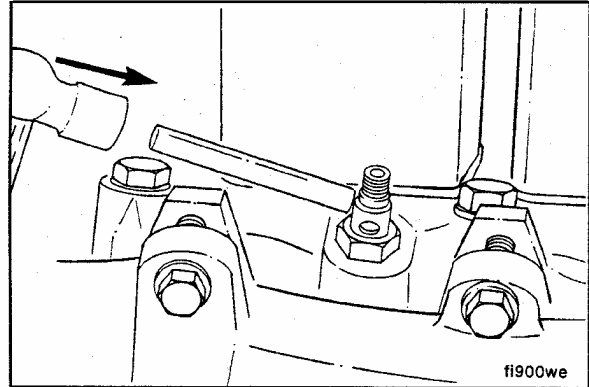
Injector Nozzles - Removal (0-28)

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.

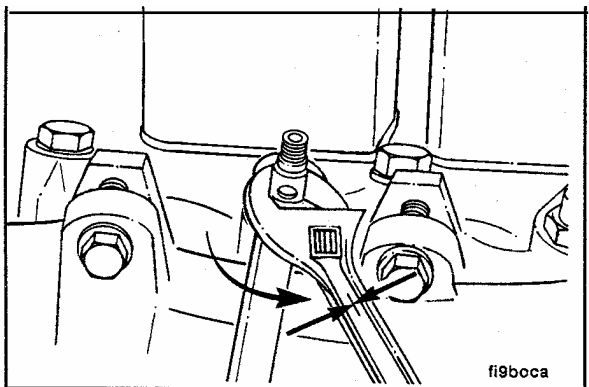


Brass Drift Pin, Hammer

CAUTION

Excessive force will damage the injector.

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



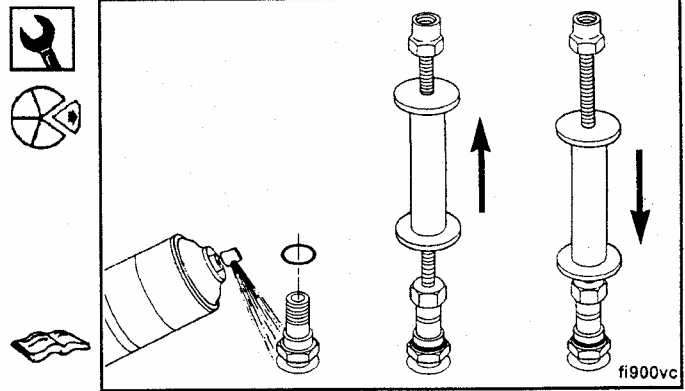
24 mm Box Wrench, Adjustable Wrench

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.

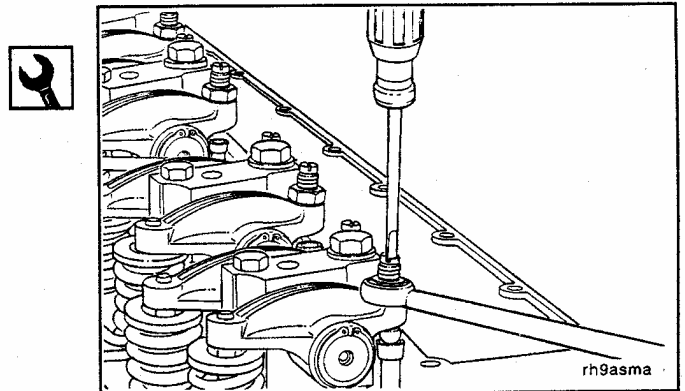
Refer to Component Section 6 for the injector test procedures.



Rocker Levers - Removal (0-29)

14 mm, Screwdriver

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

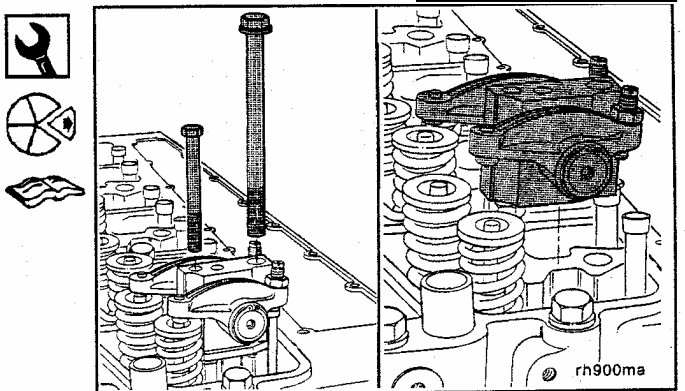


13 mm, 18 mm

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.

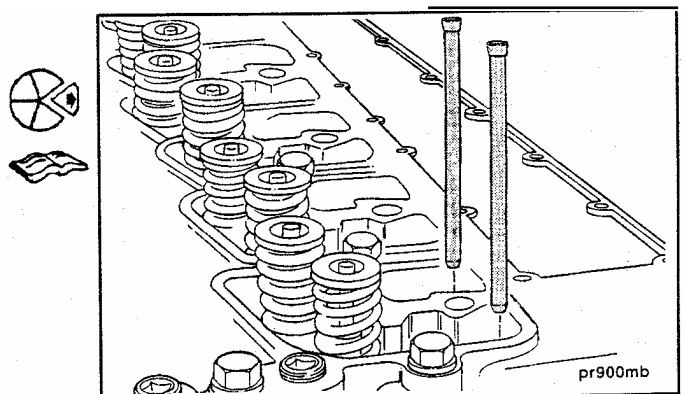


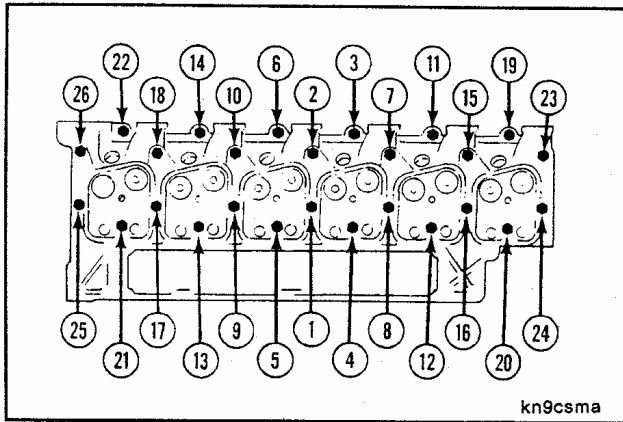
Push Rods - Removal (0-30)

Remove the push rods.

NOTE

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

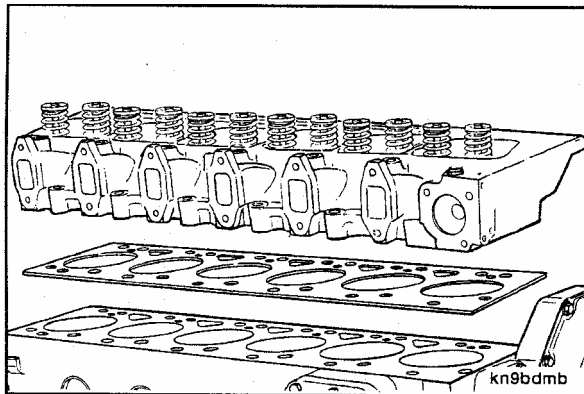




Cylinder Head - Removal (0-31)

18 mm

Remove the remaining cylinder head capscrews in the sequence shown.



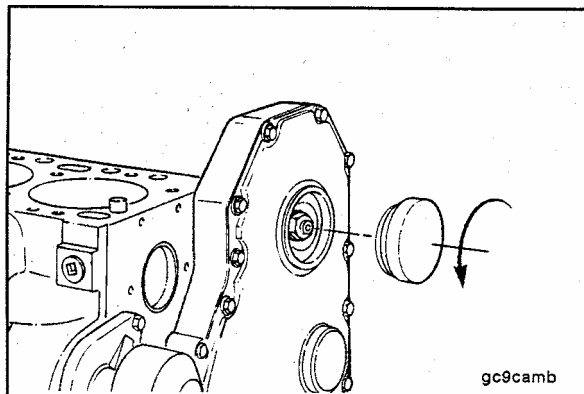
Remove the cylinder head and gasket from the block

Cylinder Head Weight:

6 Cylinder - 52 Kg [114 lb]

NOTE

Disassembly of the head is described in Component Section 2.

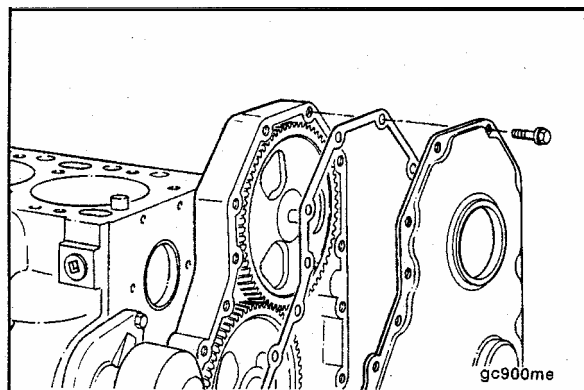


Front Cover - Removal (0-32)

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.

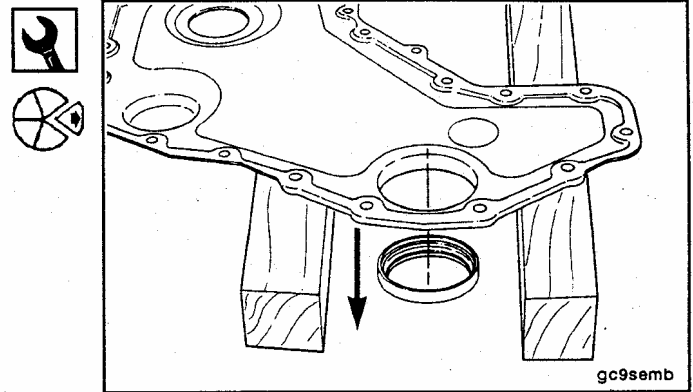


10 mm

Remove the front cover and gasket.

Hammer, Punch

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

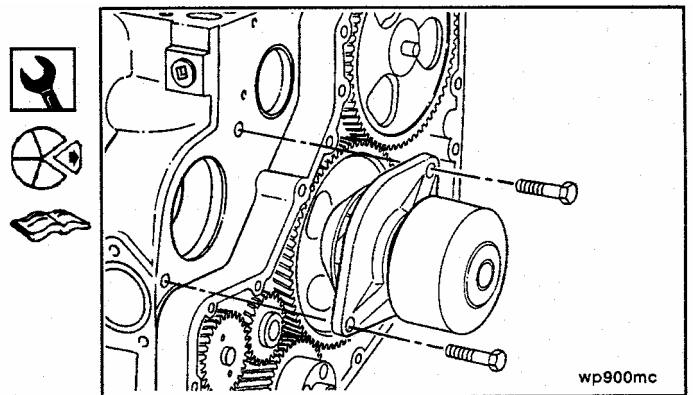


Water Pump - Removal (0-33)

13 mm

Remove the water pump and o-ring.

Refer to Component Section 8 for the water pump inspection.



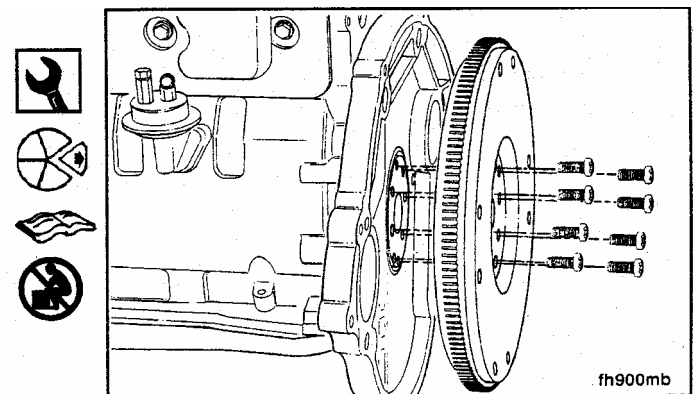
Flywheel - Removal (0-34)

18 mm

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

NOTE

Refer to Component Section 16 for flywheel inspection.



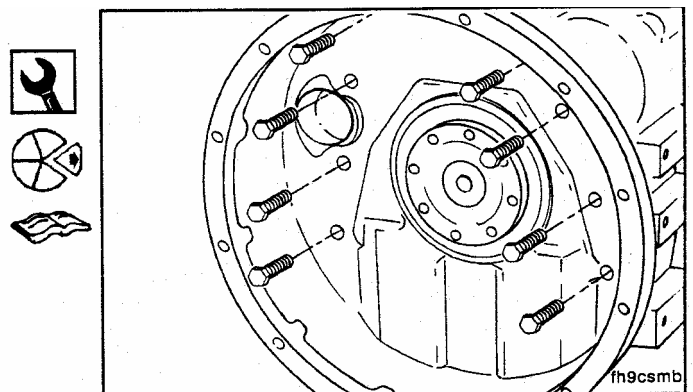
Flywheel Housing - Removal (0-35)

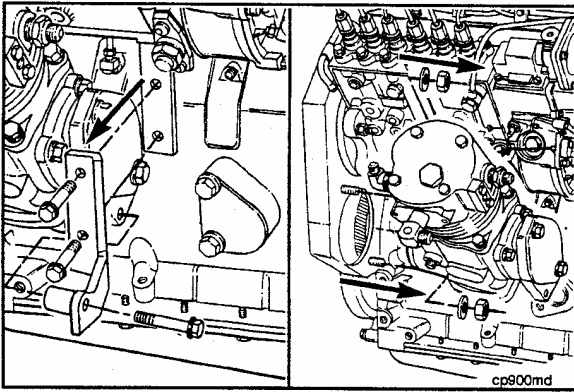
15 mm

Remove the flywheel housing.

NOTE

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





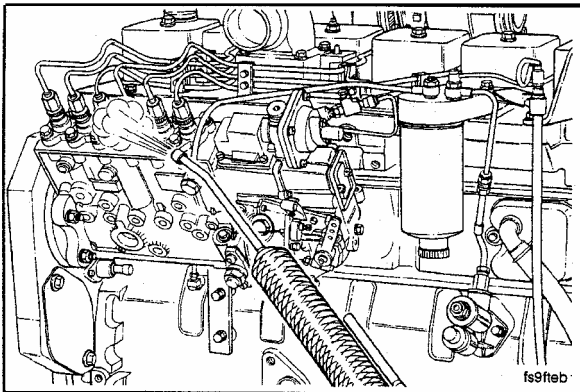
Accessories - Removal (0-36)

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.

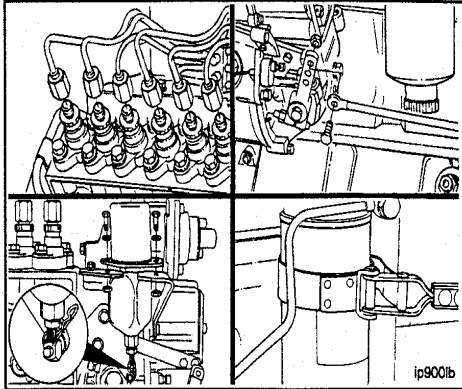


Injection Pump - Removal (In-Line) (0-41)

CAUTION

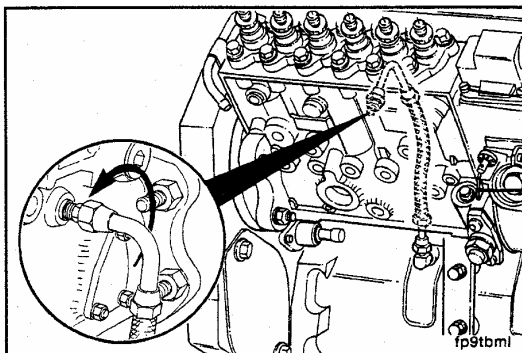
A diesel engine cannot tolerate dirt or water in the fuel system. A tiny piece of dirt or a few drops of water in the injection system can cause damage to the system.

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.

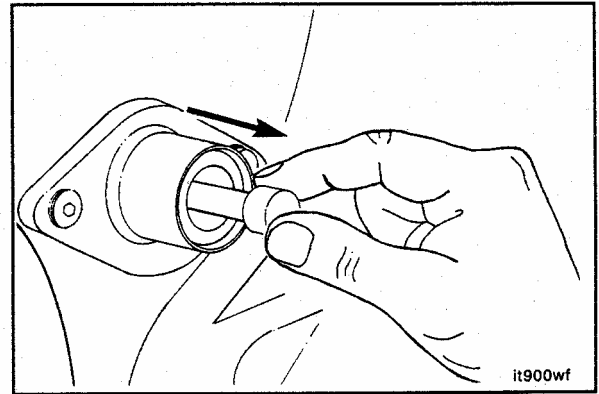
Disconnect the lubricating oil supply line from the engine block.

3377371 Barring Tool

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

Rotate the engine until the timing pin engages.

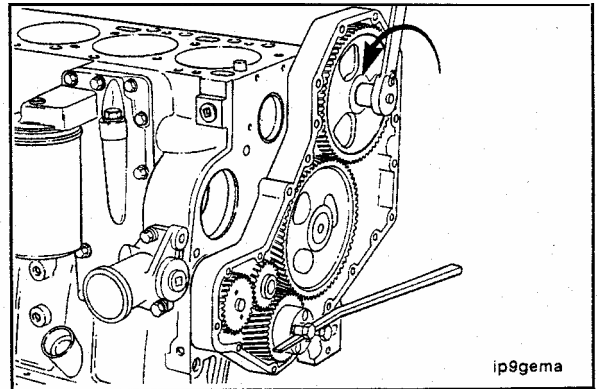
Be sure to disengage the pin after locating TDC.



it900wf

22 mm

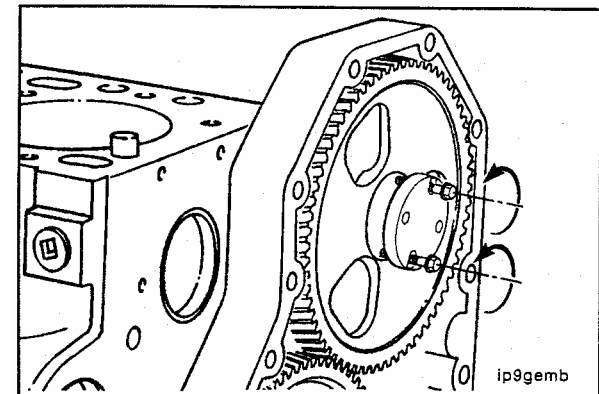
Remove the nut and washer from the fuel pump shaft.



ip9gema

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

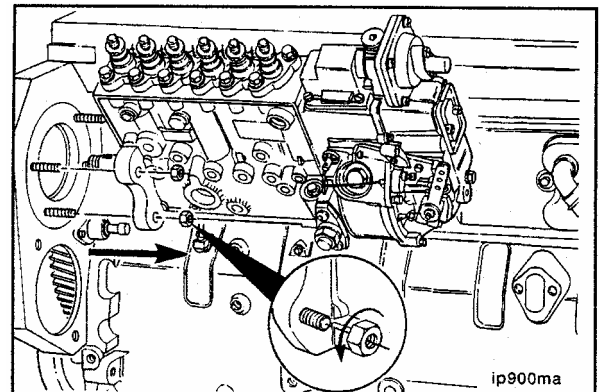
Pull the pump gear from the drive shaft.



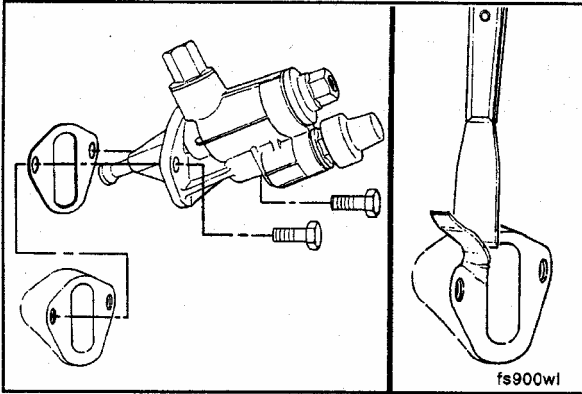
ip9gemb

15 mm

Remove the four mounting nuts and injection pump.



ip900ma



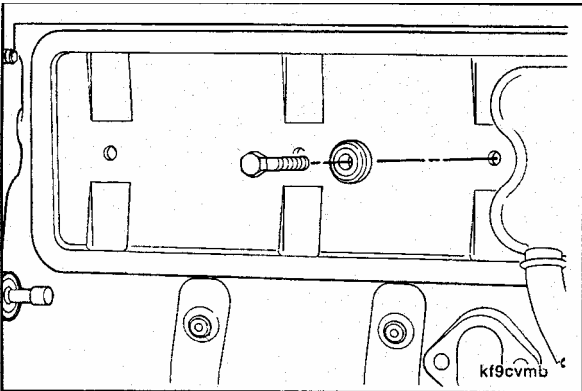
Fuel Transfer Pump - Removal (0-44)

10 mm

Remove the fuel transfer pump, spacer, and gaskets.

NOTE

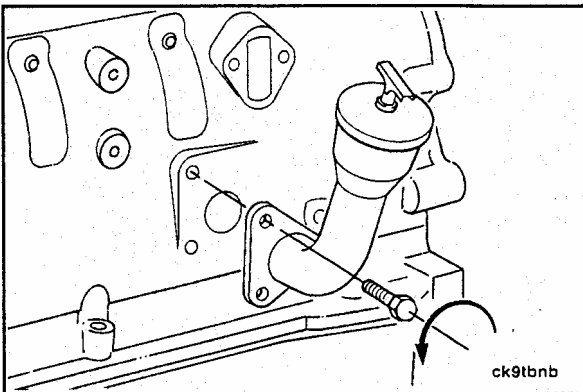
Refer to Component Section 6 for fuel transfer pump test procedures.



Tappet Cover - Removal (0-45)

10 mm

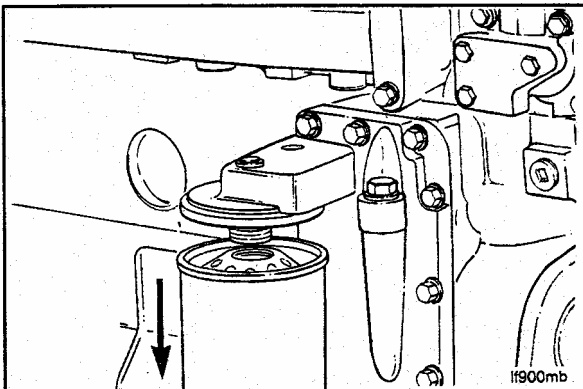
Remove the tappet cover and gasket.



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

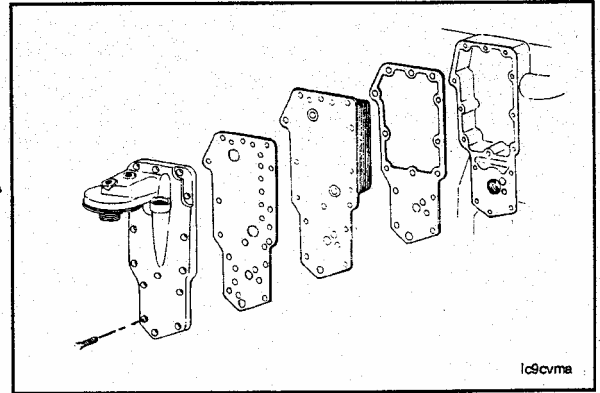
Remove the oil filter.

10 mm

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

NOTE

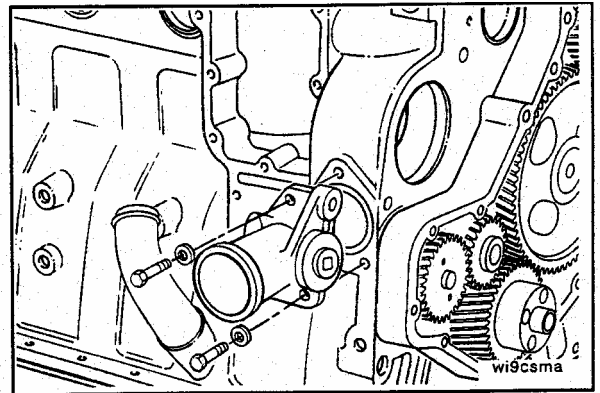
Refer to Component Section 7 for inspection procedures.



Water Inlet Connection – Removal (0-48)

13 mm

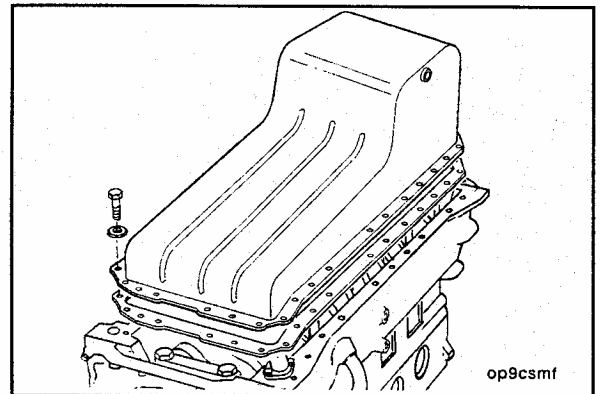
Remove the water inlet connection and rectangular ring seal.



Oil Pan - Removal (0-49)

10 mm

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



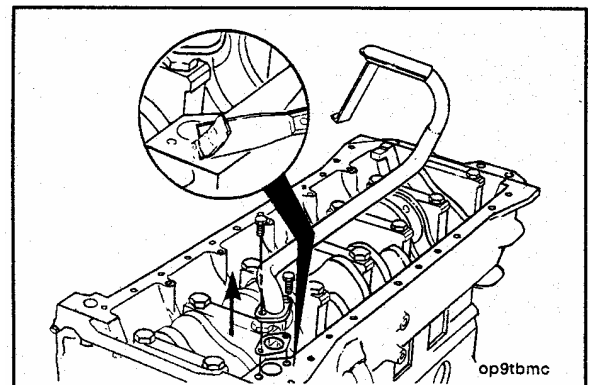
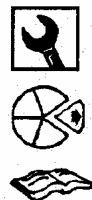
Suction Tube - Removal (0-50)

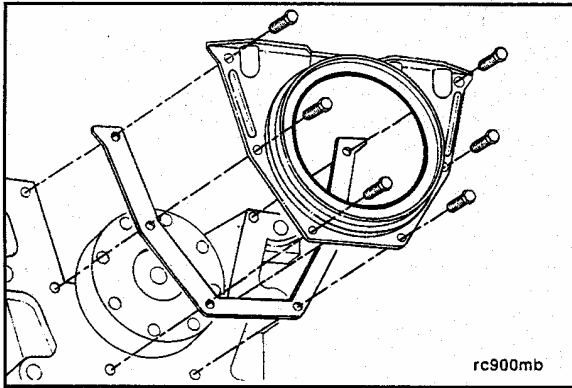
10 mm

Remove the suction tube and gasket.

NOTE

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

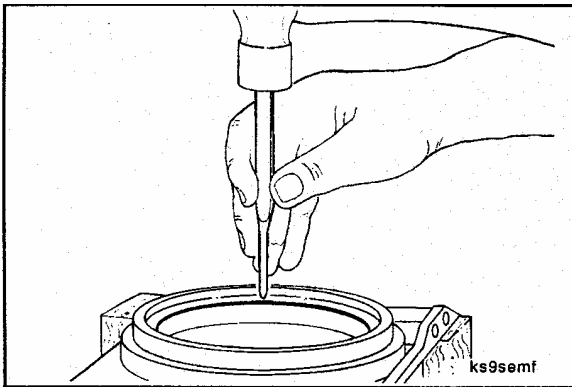




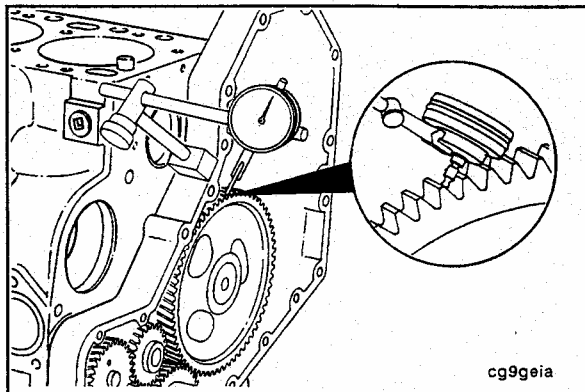
Rear Seal Housing - Removal (0-51)

8 mm

Remove the rear seal housing and gasket.



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



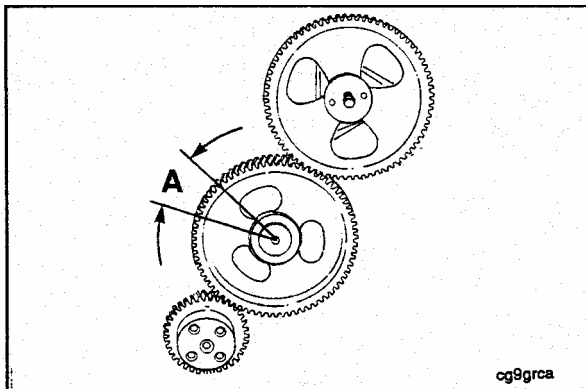
Camshaft - Removal (0-52)

Measuring Gear Lash (0-53)

Position an indicator on a tooth to 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

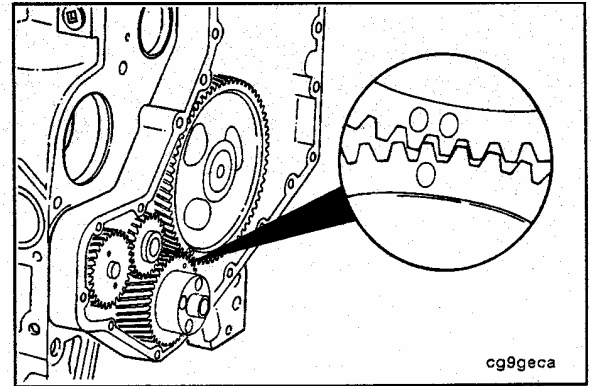
NOTE

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.

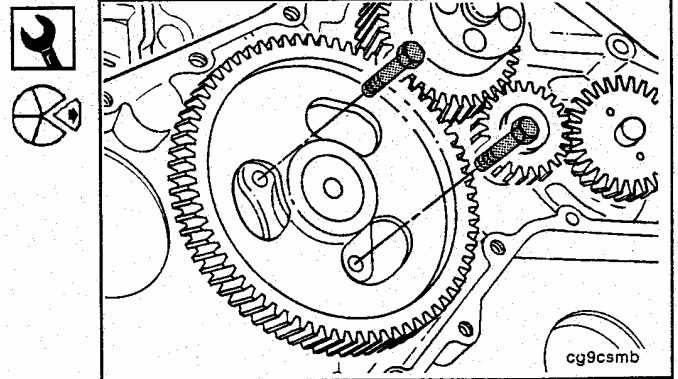
NOTE

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

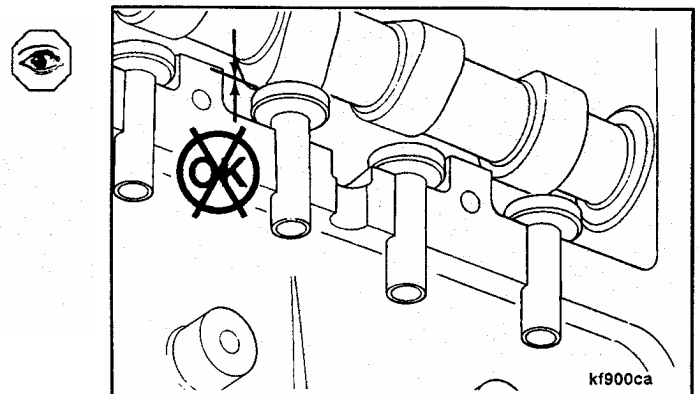


13 mm

Remove the thrust plate capscrews.

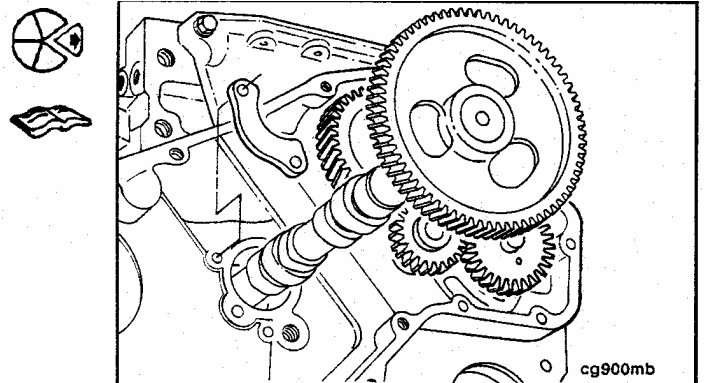


Visually inspect the tappets to make sure they are off the camshaft lobes.



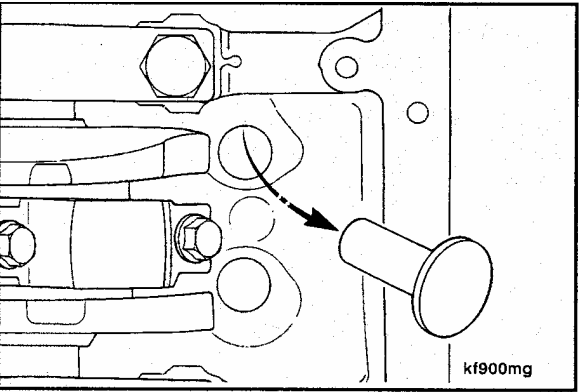
Remove the camshaft and thrust plate from the cylinder block. Take care not to drop the thrust washer.

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



NOTE

Refer to Component Section 1 for disassembly and inspection.

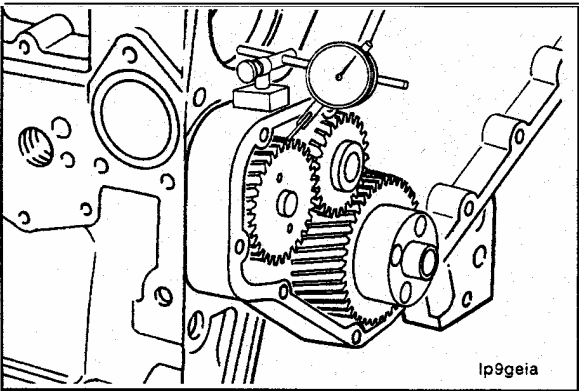


Valve Tappets - Removal (0-54)

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

NOTE

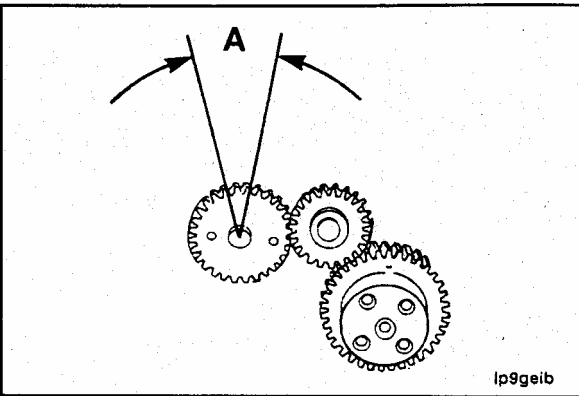
Refer to Component Section 4 for inspection procedures.



Lube Pump - Removal (0-55)

Measuring Backlash (0-56)

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



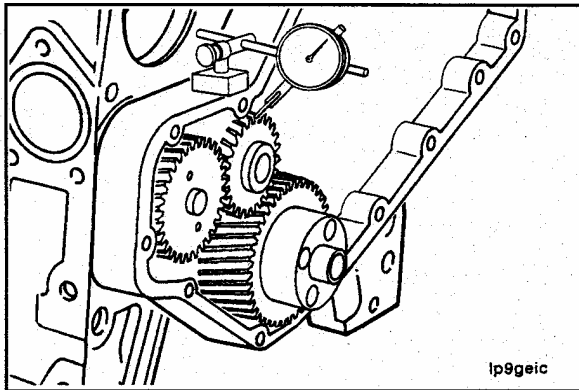
Note the lube pump gear backlash. Mark the lube pump gear and idler gear for additional analysis if the limits are exceeded.

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

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

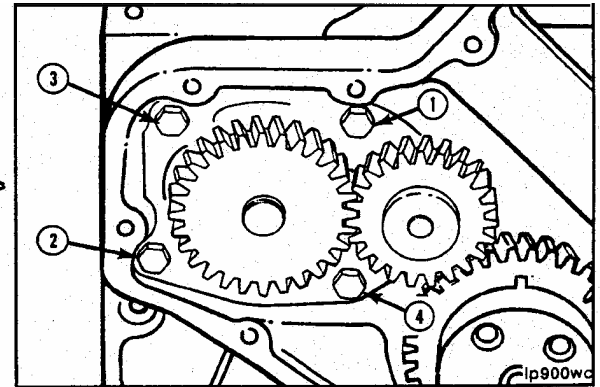
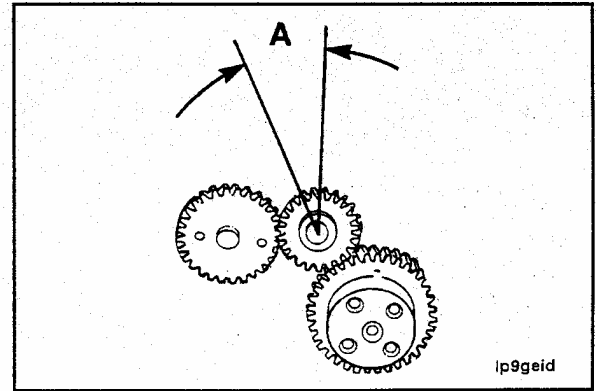
Prevent movement of the adjoining gear when checking backlash or the reading will be the total of both gears.

13 mm

Remove the lube pump.

NOTE

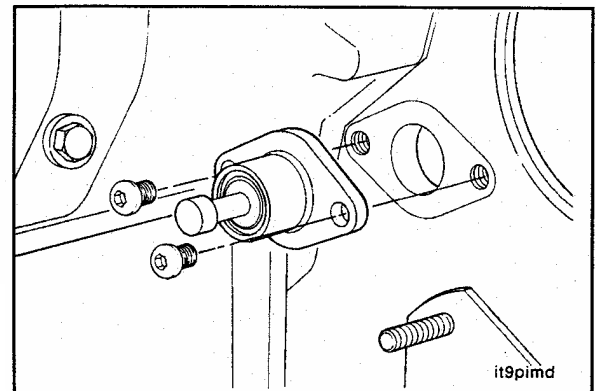
Refer to Component Section 7 for inspection.



Timing Pin Housing - Removal (0-57)

T25 Torx

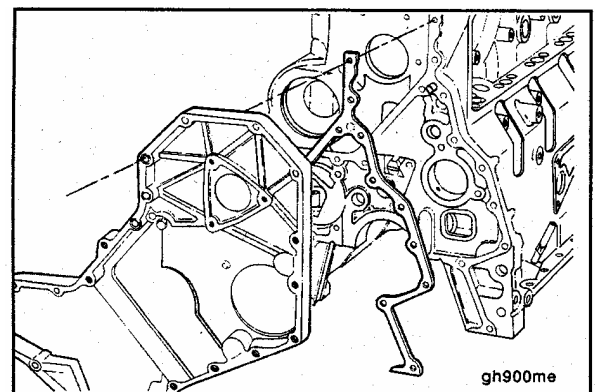
Remove the timing pin assembly.

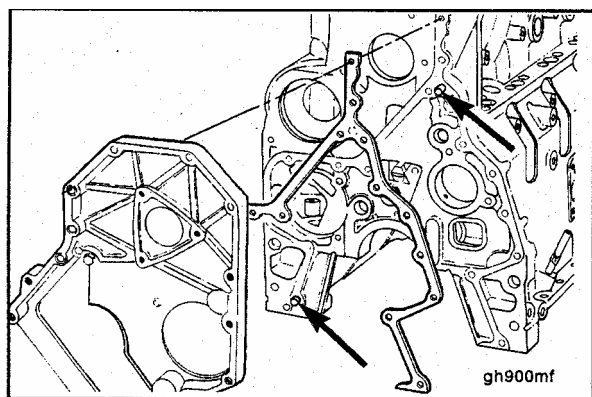


Gear Housing - Removal (0-58)

10 mm

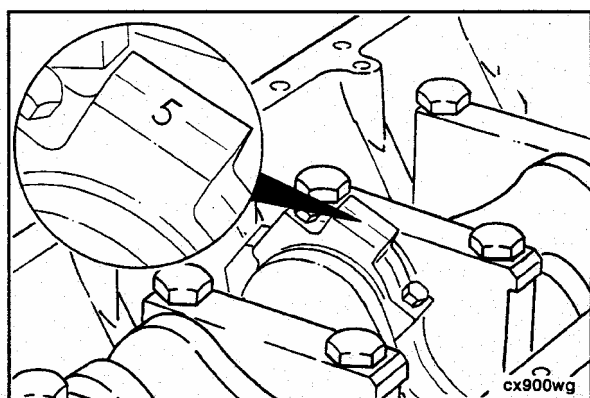
Remove the capscrews, gear housing and gasket.





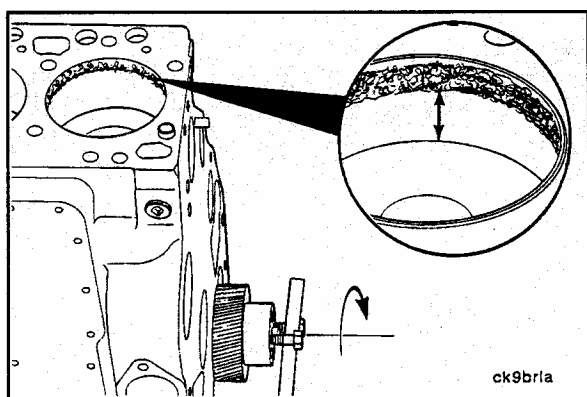
Plastic Hammer

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.



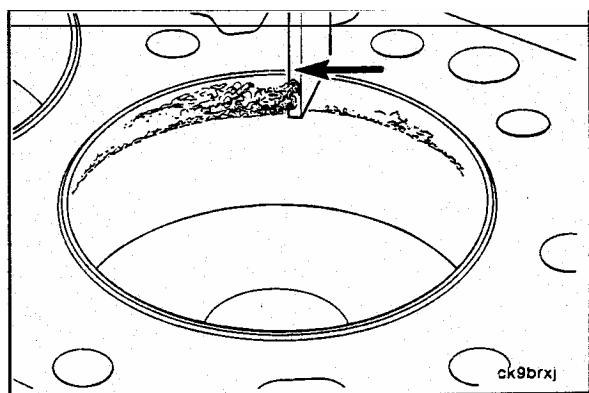
Piston and Rod Assemblies – Removal (0-64)

Mark each rod cap according to cylinder.



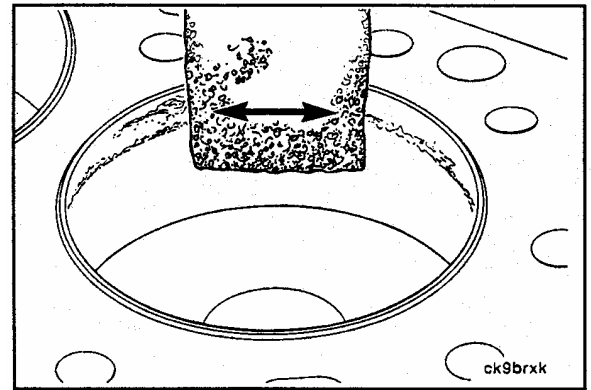
Rotate the engine on the rebuild stand so the cylinder bores are in a horizontal position.

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.

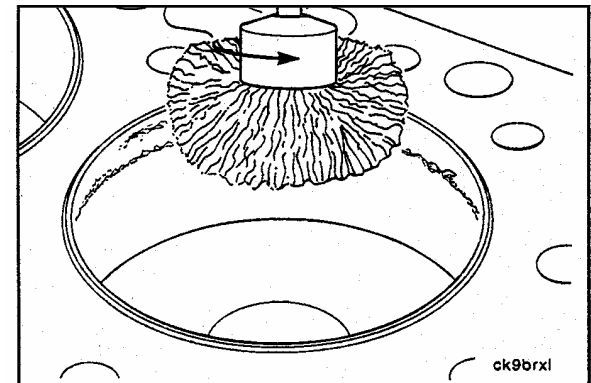
Remove the remaining carbon with a Scotch-Brite® cleaning pad or equivalent.



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.

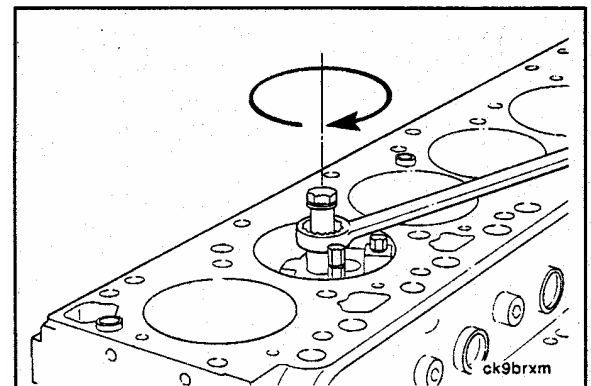
Do not use the steel wire wheel in the piston travel area. Operate the wheel in a circular motion to remove the deposits.

Ridge Reamer

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

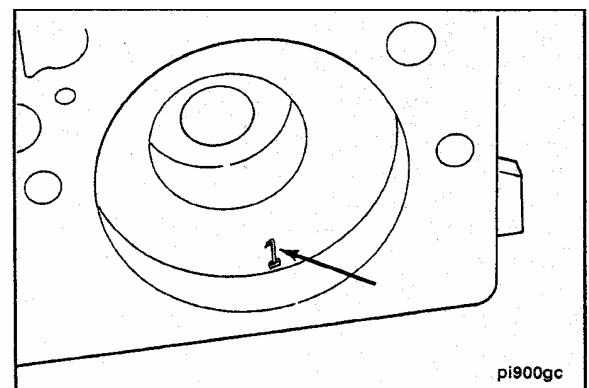


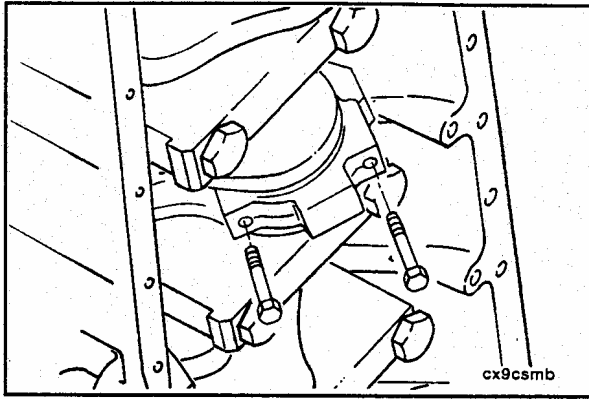
Make sure ridge reamer does not gouge into the cylinder bore or remove more metal than needed.



Mark each piston with the cylinder number.

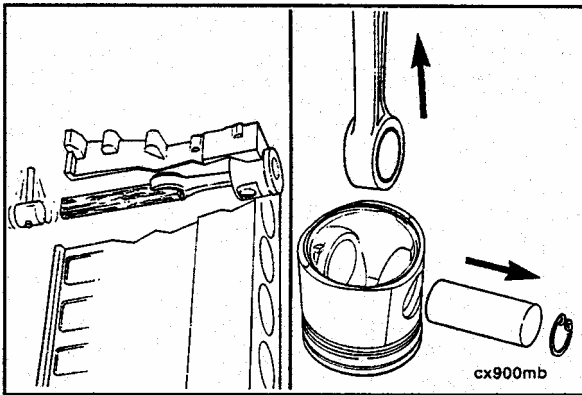
During assembly, the piston **must** be installed into the corresponding cylinder number.





12 mm

Remove the capscrews, rod cap and rod bearings. Mark the cylinder number on the back side of the rod bearings.

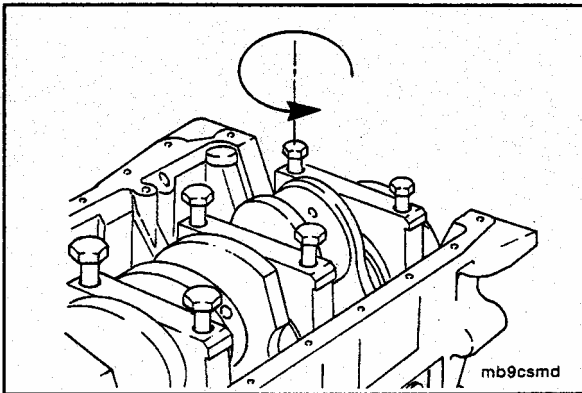


Catch the piston with one hand while pushing the rod and piston assembly out of cylinder bore. Care must be taken not to mutilate the connecting rod or bearing.



NOTE

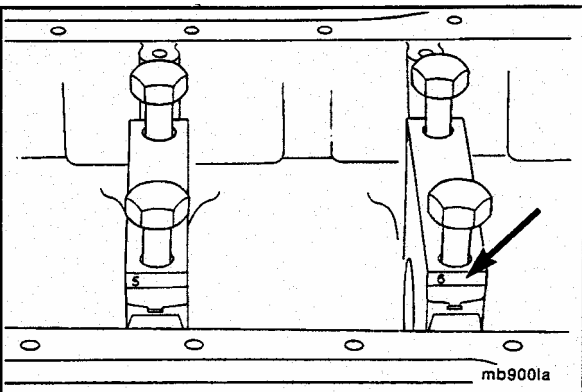
Disassembly of the piston/rod assembly is described in Component Section 1.



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.



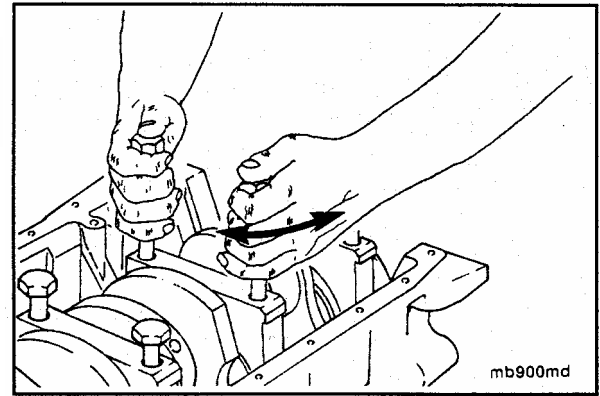
The main caps should be numbered. If they are not, mark them with the correct number.



Remove the main bearing caps.

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

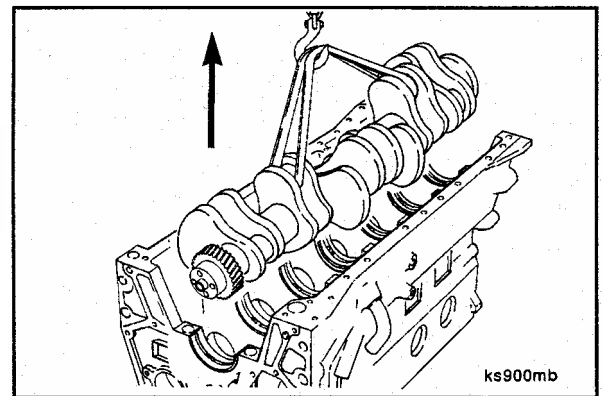
Use two of the main cap bolts to "wiggle" the main cap loose, being careful not to damage the bolt threads.



Crankshaft Weight:

6 Cylinder - 55 Kg [123 lb]

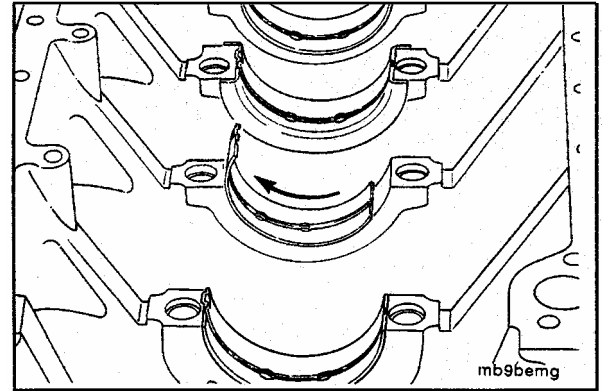
Lift the crankshaft and gear from the cylinder block



NOTE

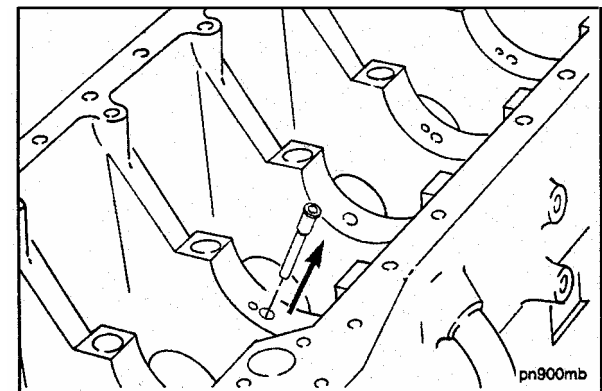
Refer to Component Section 1 for disassembly and inspection.

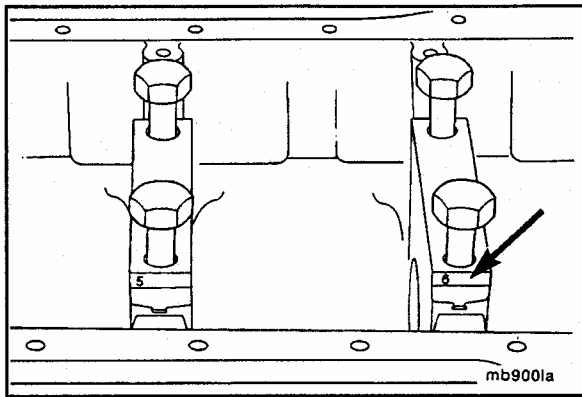
Remove the main bearings from the cylinder block and the main caps.



3/16 Inch Pin Punch

Remove the piston cooling nozzles.

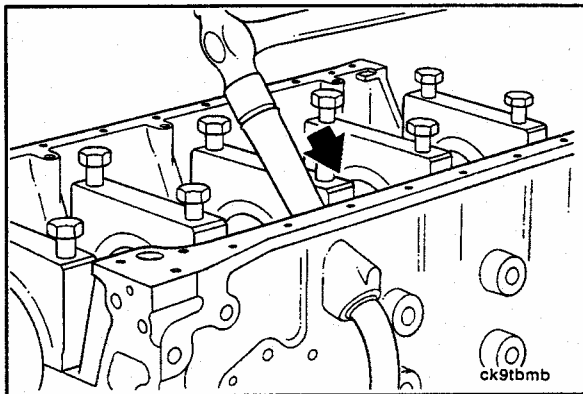




Install the main caps in their corresponding positions. When correctly installed, the tangs (slots) should both be on the same side.

NOTE

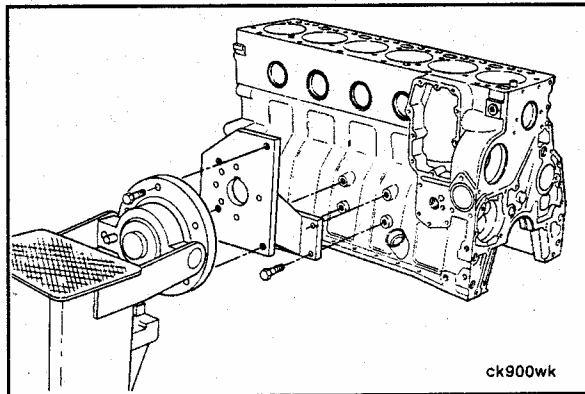
#1 is to the front of the block.



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

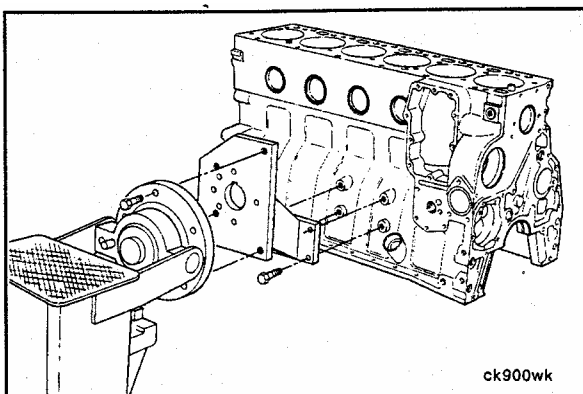
Remove the cylinder block from the rollover stand.

NOTE

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

6B Cylinder Block Weight:

124 Kg [275 lb]



Engine Assembly (0-68)

Cylinder Block - Prepare for Assembly (0-69)

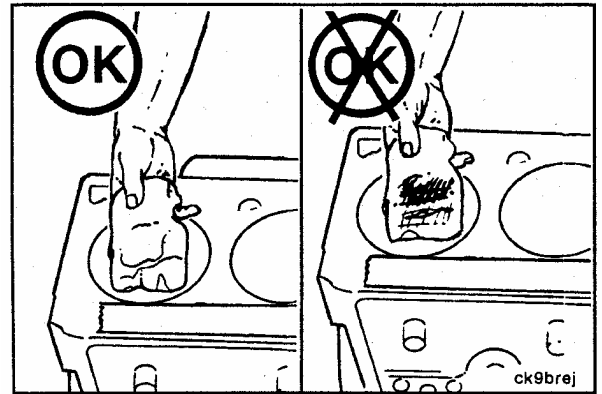
Install the cylinder block to the rollover stand.

NOTE

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

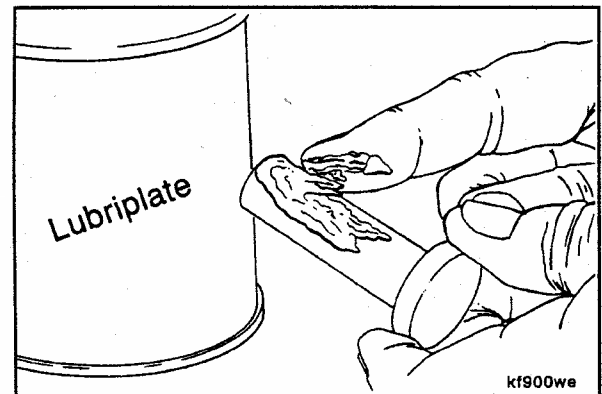
CAUTION

Be sure the cylinder bores are clean.

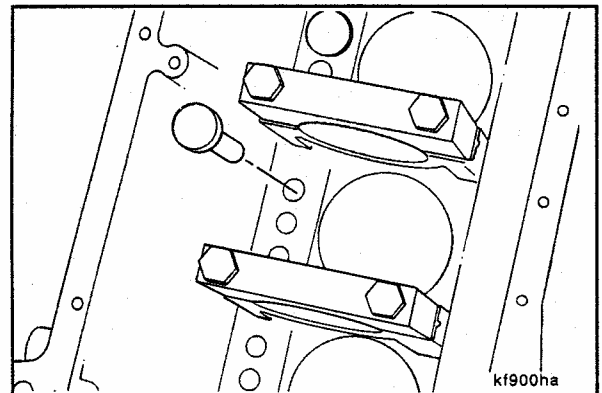


Valve Tappets - Installation (0-70)

Lubricate the tappets with Lubriplate 105®.



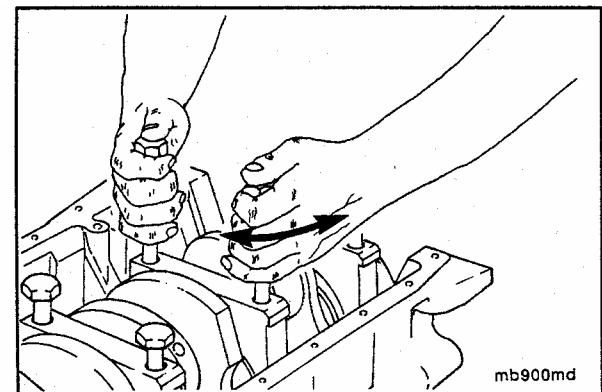
Install the valve tappets.

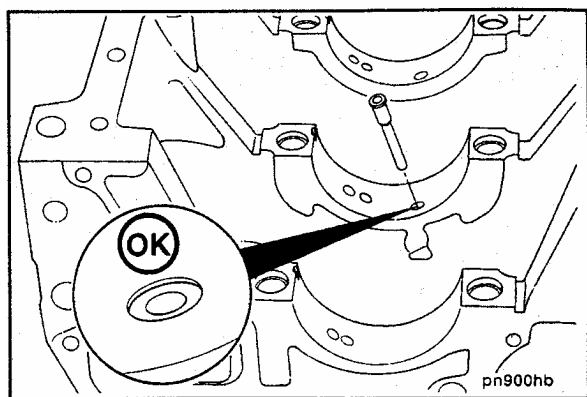


Crankshaft - Installation (0-71)

23 mm

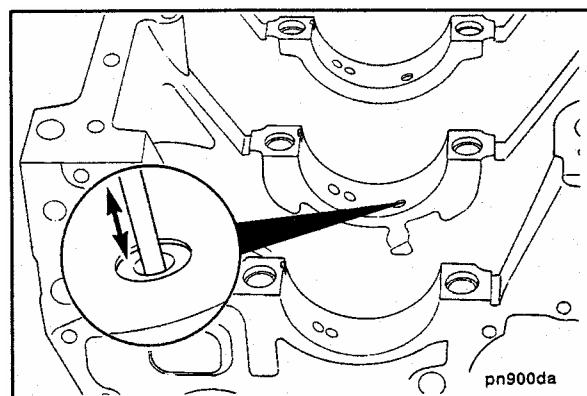
Remove the main bearing caps.





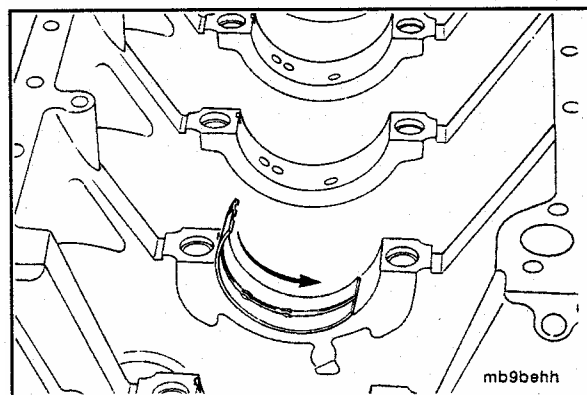
1/2 Center Punch

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



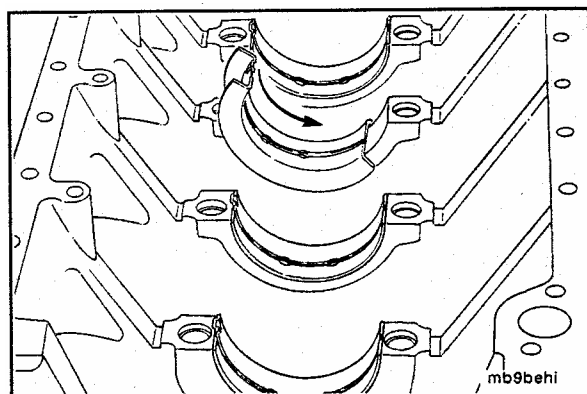
CAUTION

Be sure spray holes are clean and open.



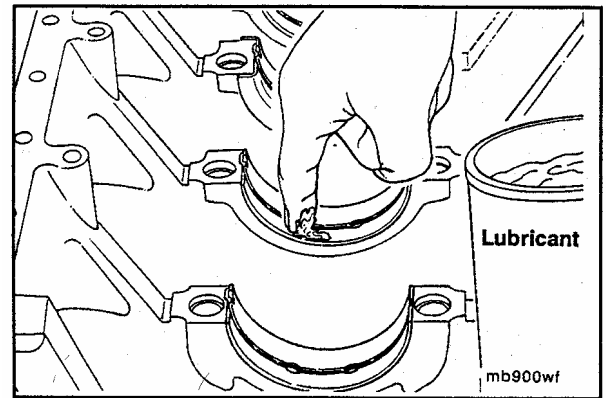
Install the upper main bearings.

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®.



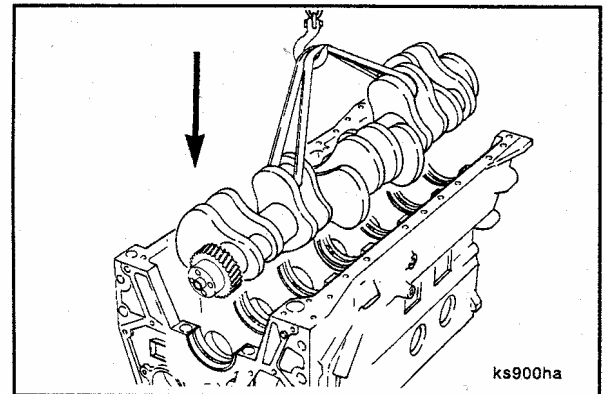
CAUTION

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

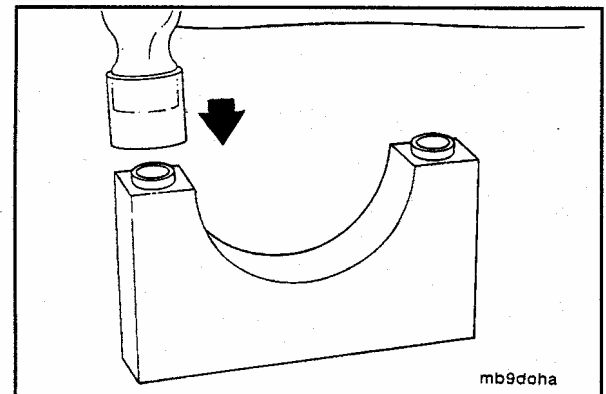
Install the crankshaft.

Crankshaft Weight:

6 Cylinder - 55 Kg [123 lb]



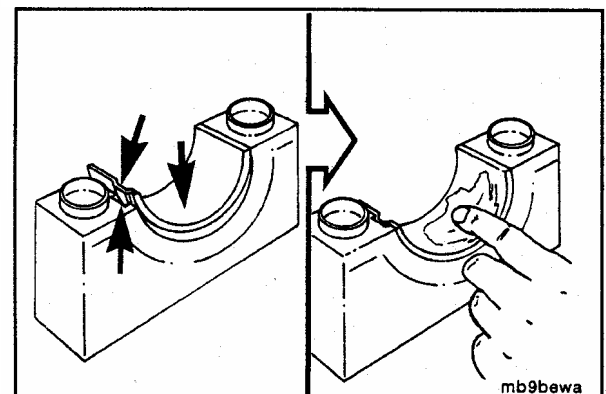
Make sure the ring dowels have been installed into the caps.

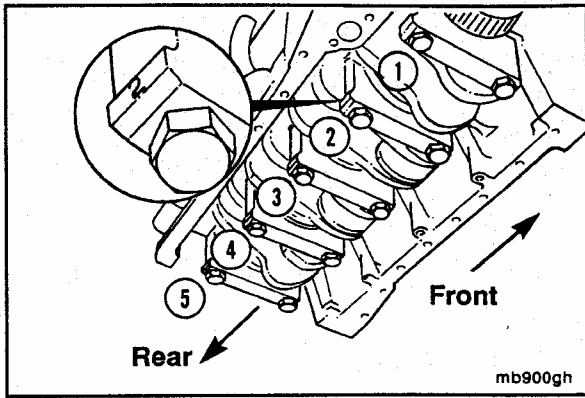


Install the lower main bearings into the caps.

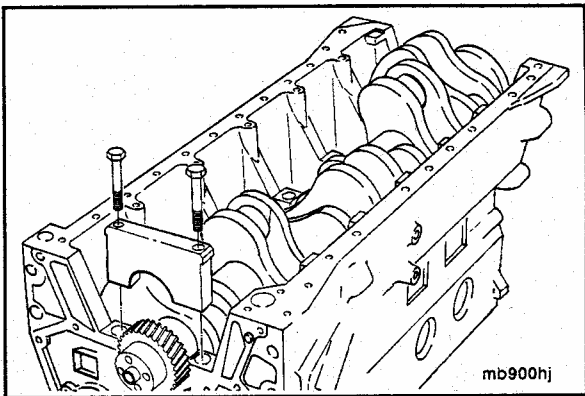
Lubricate the bearings with Lubriplate 105®.

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

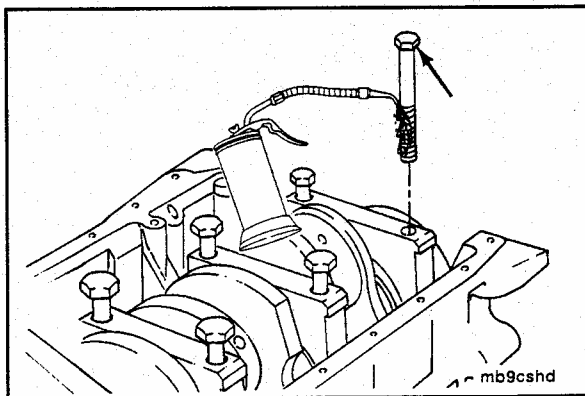




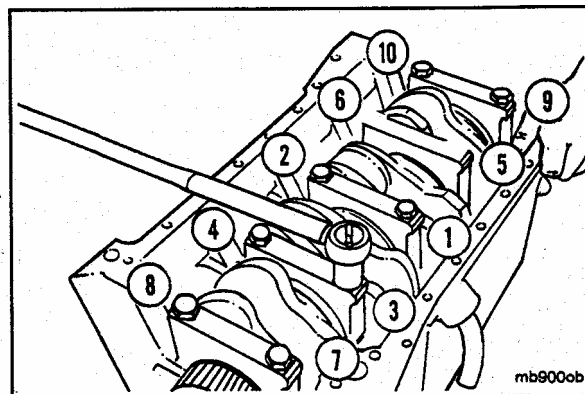
The main bearing caps are numbered for location. Number 1 starts with the front of the block, and the numbers face the oil cooler side of the engine.



Position the main bearings and caps.



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



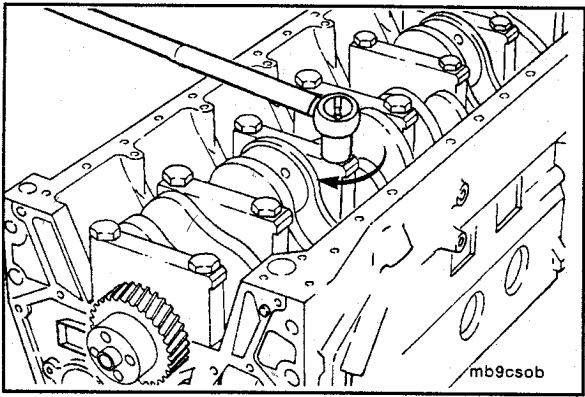
23 mm

Tighten the capscrews evenly following the illustrated sequence.



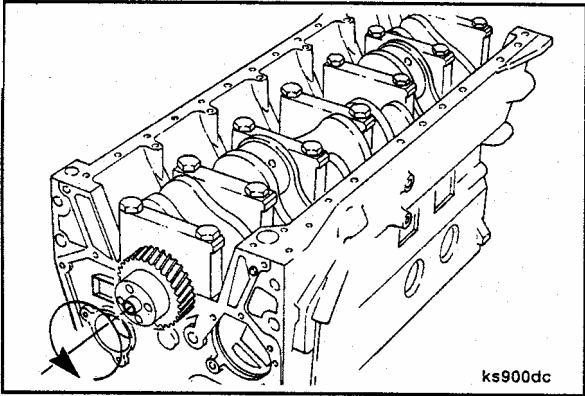
Follow these steps to tighten the capscrews.

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

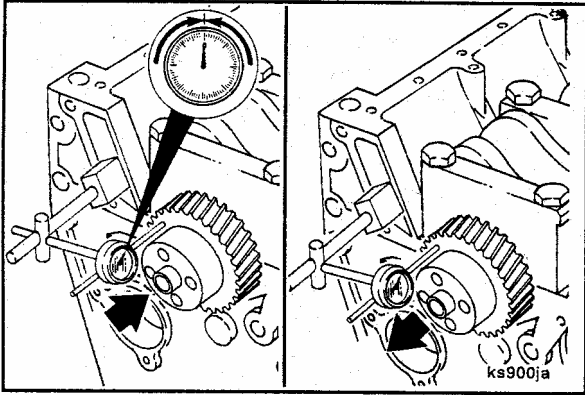


The crankshaft must rotate freely.

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.

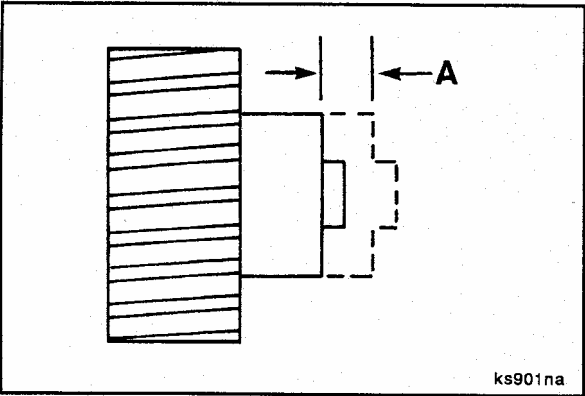


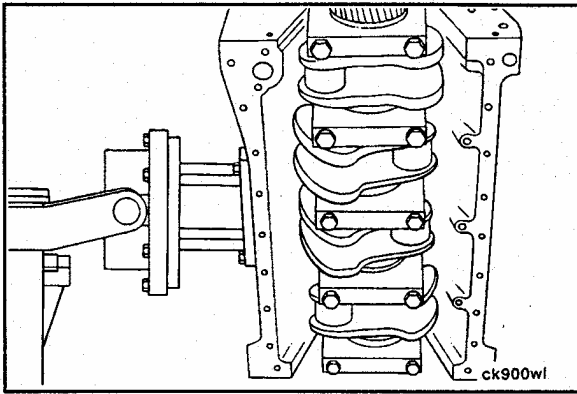
The dimensions of the thrust bearing and crankshaft journal determine end play.

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)

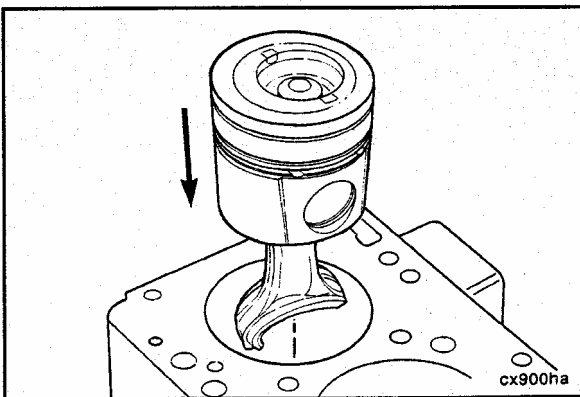
Rotate the engine on the stand until the crankshaft is vertical.

NOTE

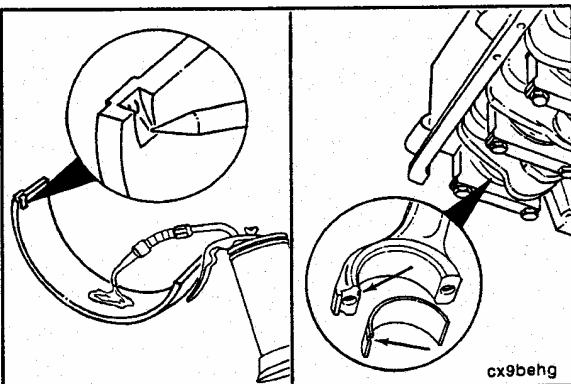
If the engine is rotated more than 90 degrees, the tappets will fall out.

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

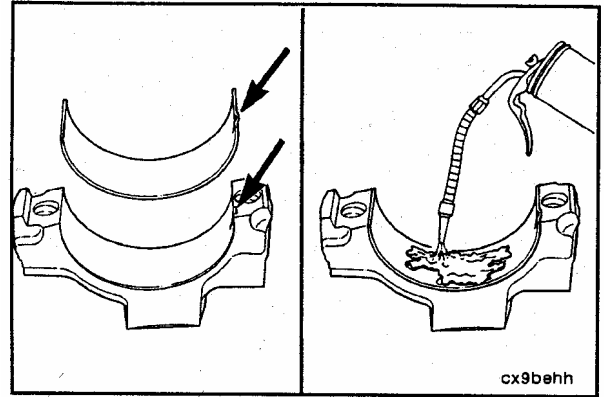
The connecting rod bearing shells must be installed in the original connecting rod and cap.

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.

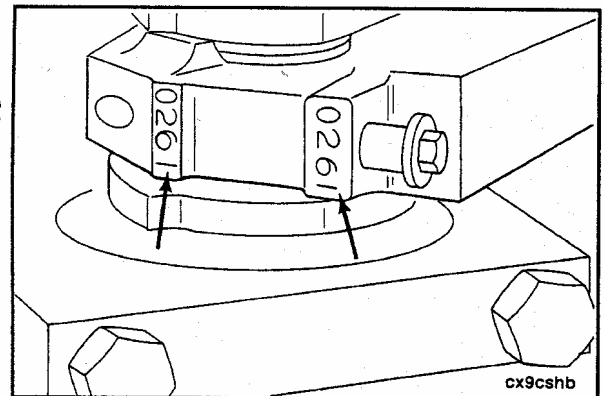
Install the bearing shell in the connecting rod cap with the tang of the bearing in the slot to the cap.

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.

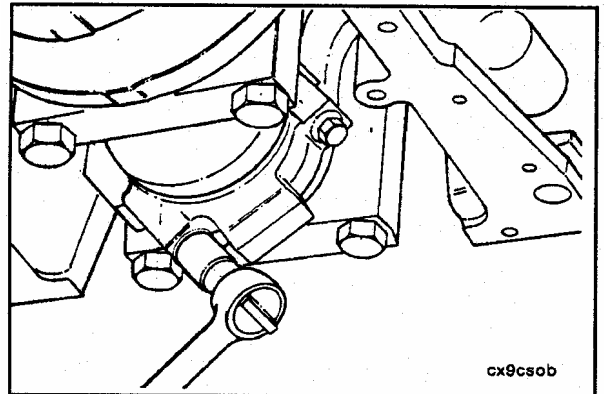
Install the connecting rod cap and capscrews to the connecting rod.



12 mm, Torque Wrench

Tighten the two capscrews.

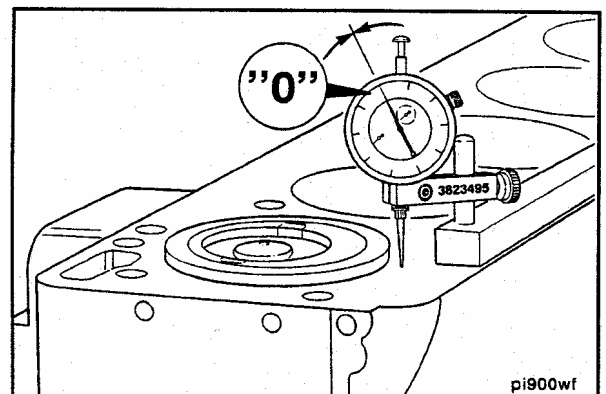
Torque Value: 35 N•m [26 ft-lb]

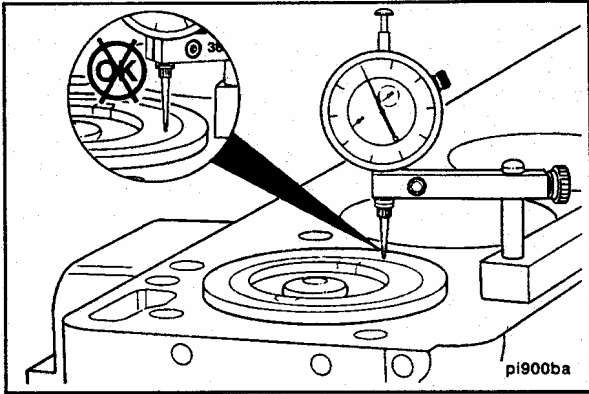


3823495 Dial Indicator

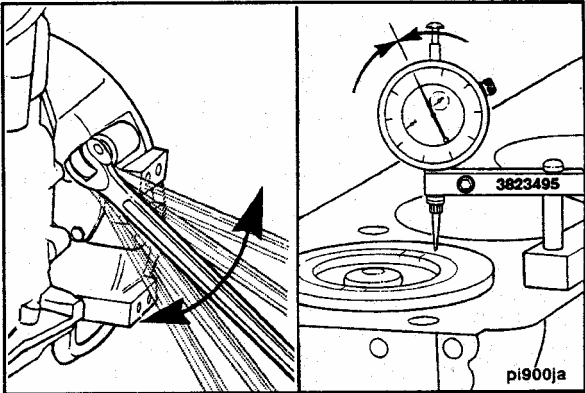
Use a fine grit stone to remove any burrs from the cylinder block head deck.

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



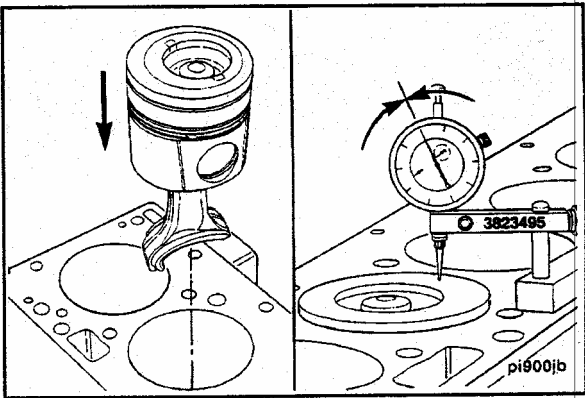


Move the dial indicator over the piston directly over the piston pin to eliminate any side-to-side movement. Do not place the indicator tip on the anodized area.



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

Record the reading.



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.

NG J	PROTRUSION	USE GRADE	PART NUMBER	
			160/173	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



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.

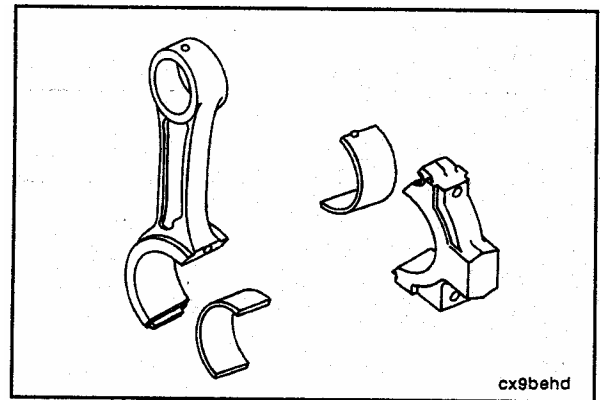
PISTON PROTRUSION

MEASURING PISTON	MEASURED PROTRUSION	USE GRADE	PART NUMBER	
			160/175	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

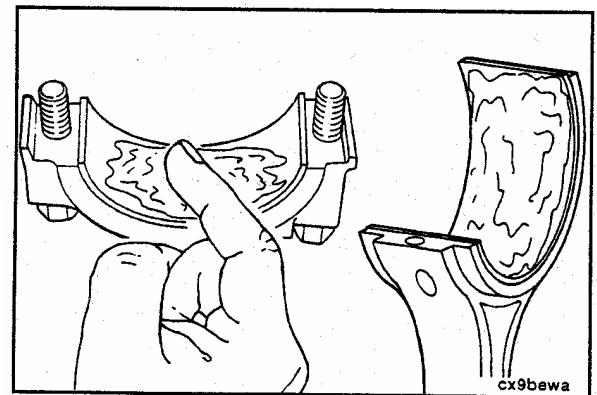
The specification for Piston Protrusion is 0.024 to 0.028 inch for emission controlled engines built after 1-1-94.

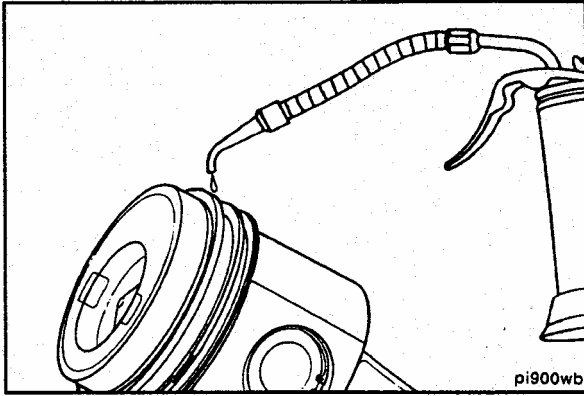
Piston and Connecting Rod Assemblies - Installation

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.

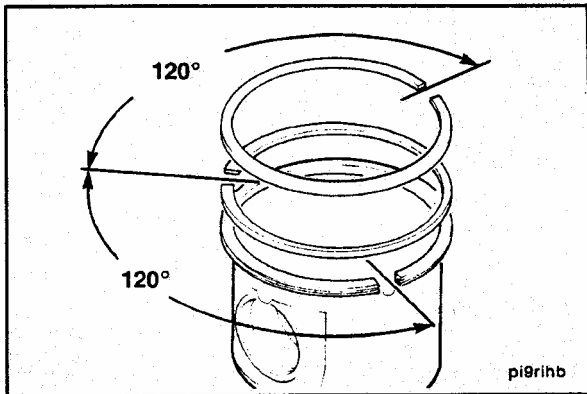


Lubricate the rod bearings with a light film of Lubriplate 105®.





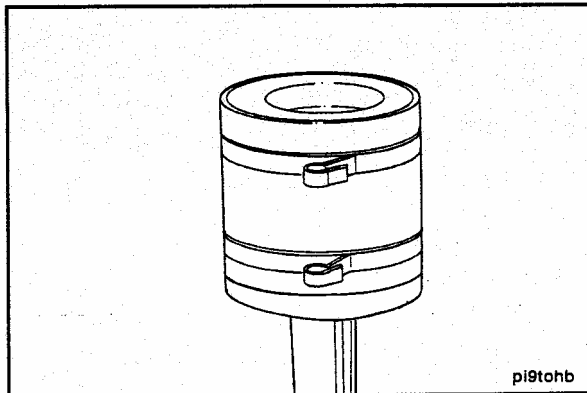
Lubricate the rings and piston skirts with clean engine oil.



Position the rings.

NOTE

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

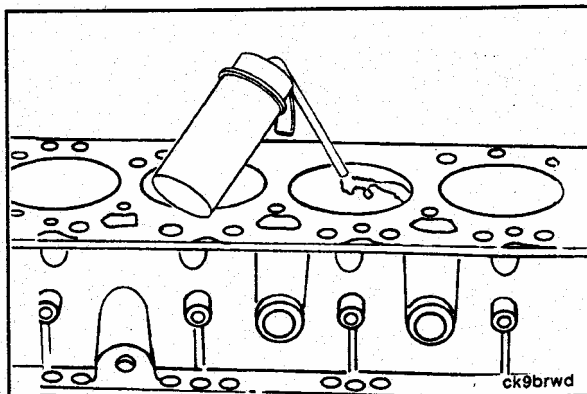


75 - 125 mm [3-5 inch] ring compressor

CAUTION

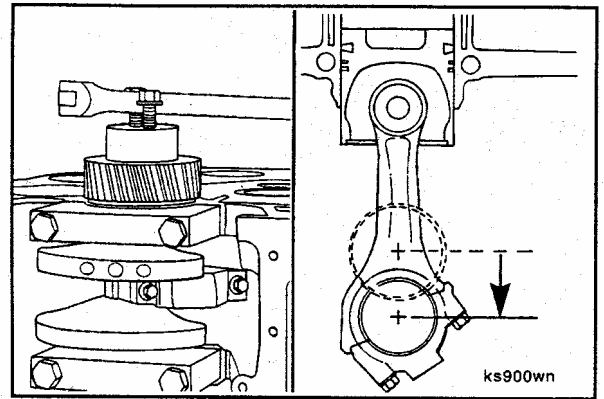
If using a strap type ring compressor, make sure the inside end of the strap does not hook on a ring gap and break the ring.

Compress the rings.



Lubricate the cylinder bore with clean engine oil.

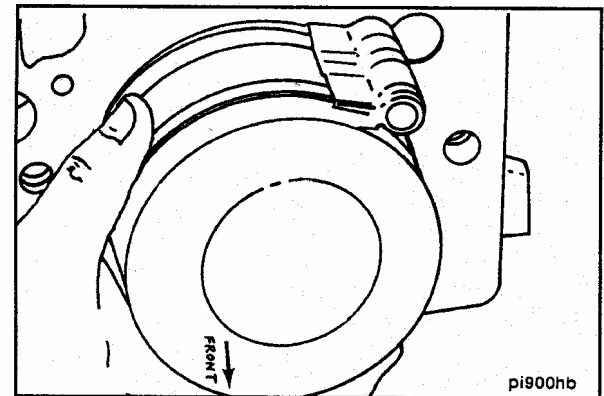
Position the rod journal for the piston to be installed to bottom dead center (BDC).



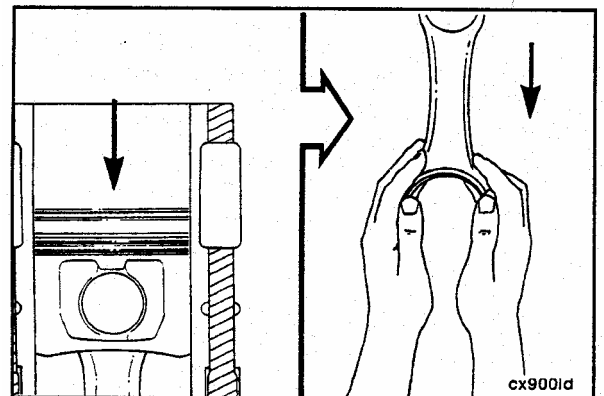
CAUTION

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

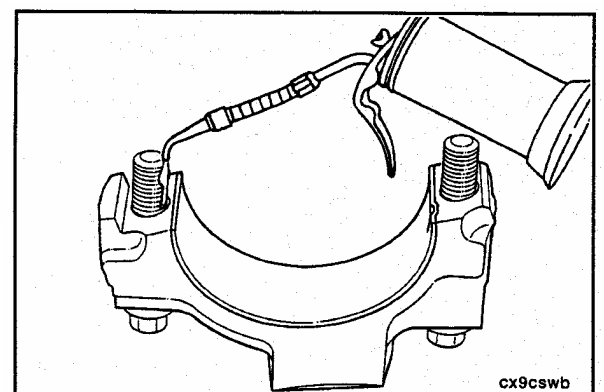
Position the piston and rod assembly into cylinder bore with the word "front" on piston towards the front of the cylinder block.

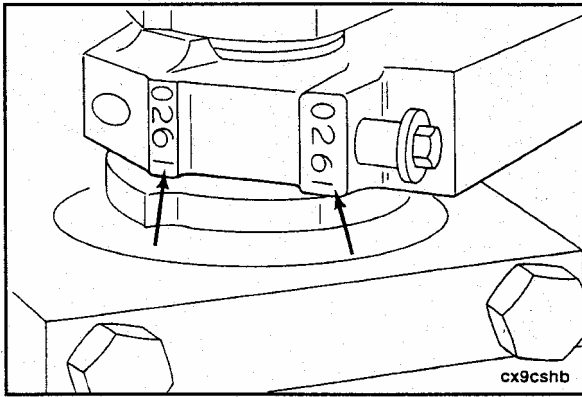


Carefully push the piston into the bore while guiding the connecting rod to the crankshaft journal.



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

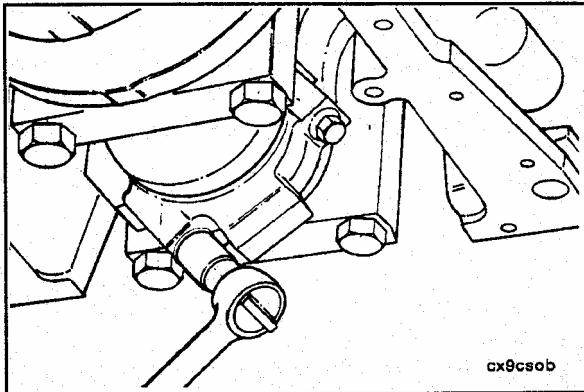




CAUTION

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.

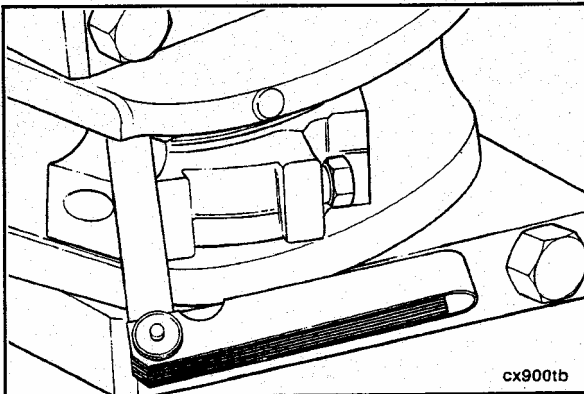


12 mm, Torque Wrench

Alternately, tighten the two capscrews



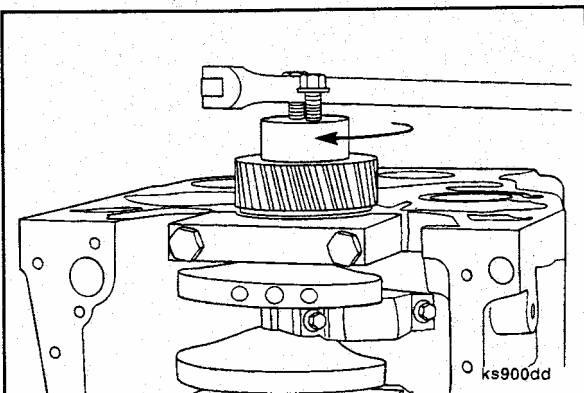
Step	Torque Value
1	35 N•m [26 ft-lb]
2	70 N•m [52 ft-lb]
3	100 N•m [74 ft-lb]



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.

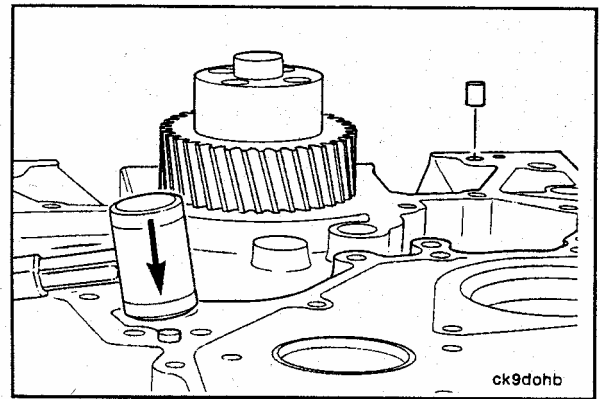
Check for freedom of rotation as the rod caps are installed. If the crankshaft does not rotate freely, check the installation of the rod bearings and the bearing size.

Gear Housing - Installation (0-73)

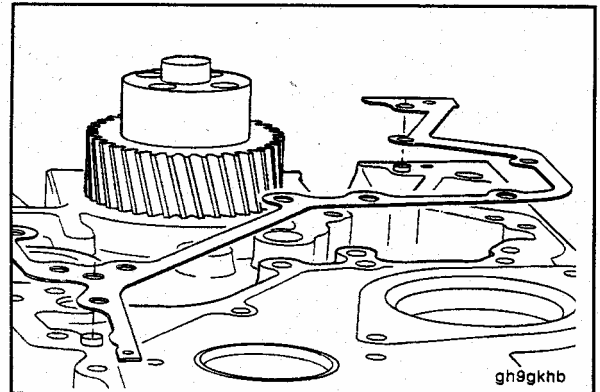
Mallet

It 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.

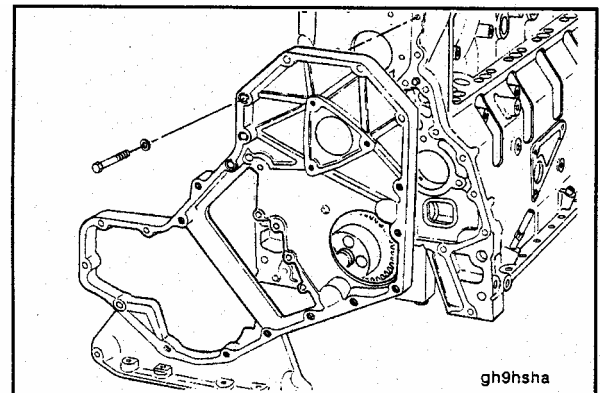


10 mm

Install the gear housing and capscrews.

Apply Loctite 205 to the capscrews.

Torque Value: 24 N•m [18 ft-lb]

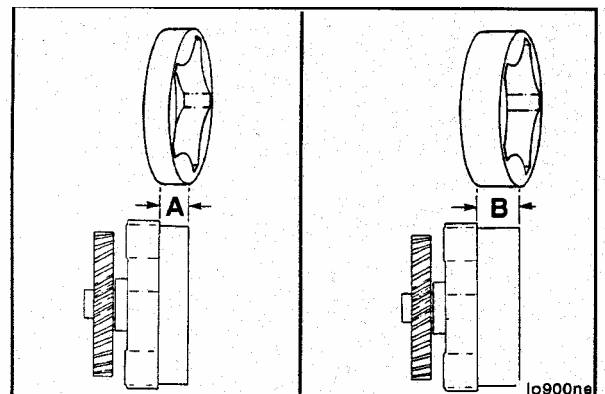


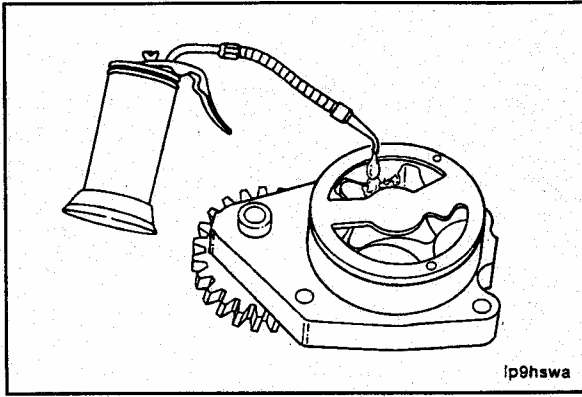
CAUTION

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]



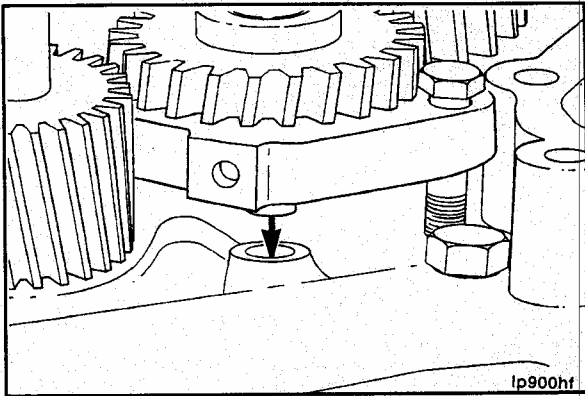


Lube Pump - Installation (0-74)

Lubricate the pump with clean engine oil.

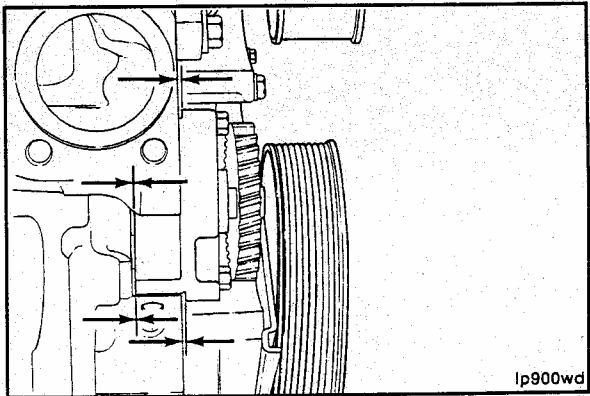
CAUTION

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

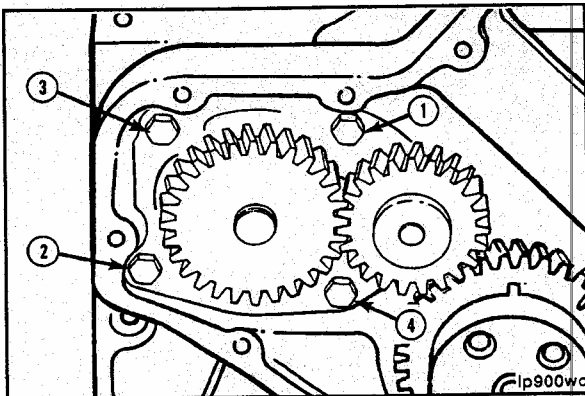


The idler gear pin fits into a locating bore in the cylinder block.

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

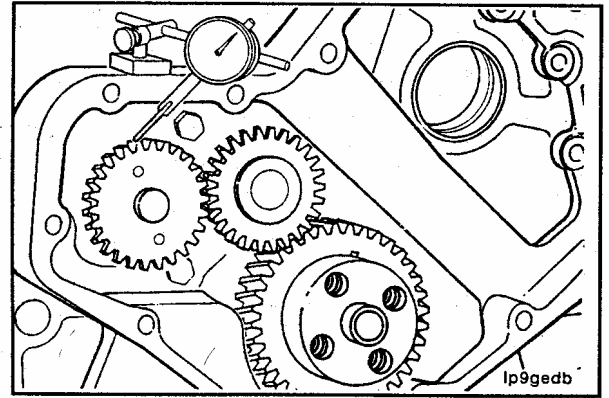
Tighten the capscrews in the sequence shown.

Torque Value: 24 N•m [18 ft-lb]

CAUTION

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

Use a dial indicator to measure gear backlash.

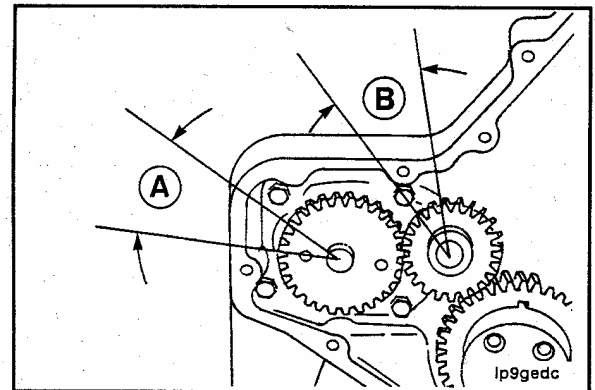


Measure gear backlash.

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

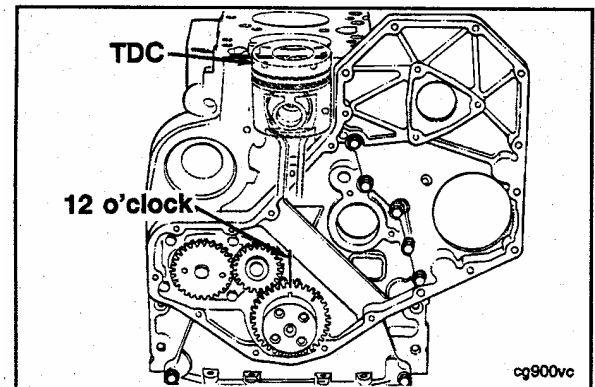
Prevent movement of adjoining gears when checking backlash or the reading will be the total of both gears.

**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.

CAUTION

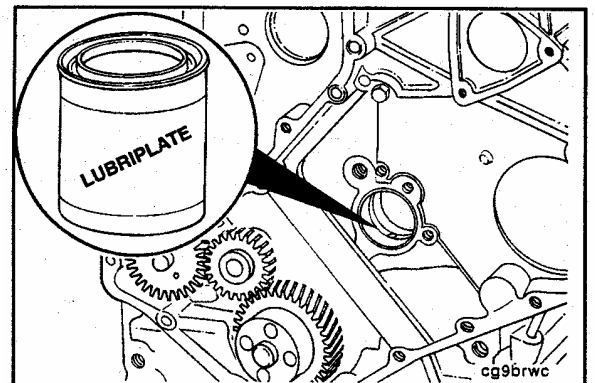
If the crankshaft is not properly positioned, the camshaft may contact the connecting rods during installation.

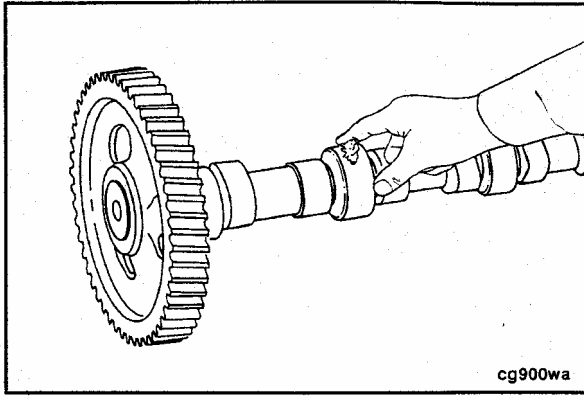


Lubricate the camshaft bores with Lubriplate.

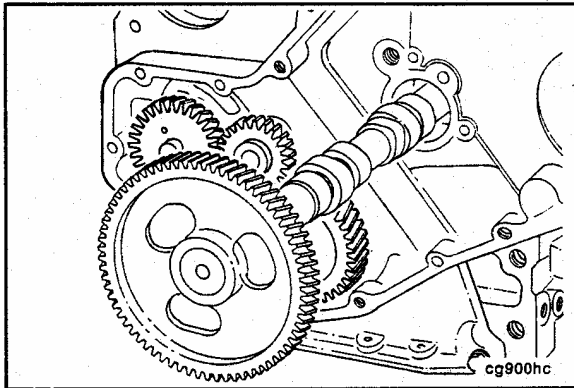
NOTE

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





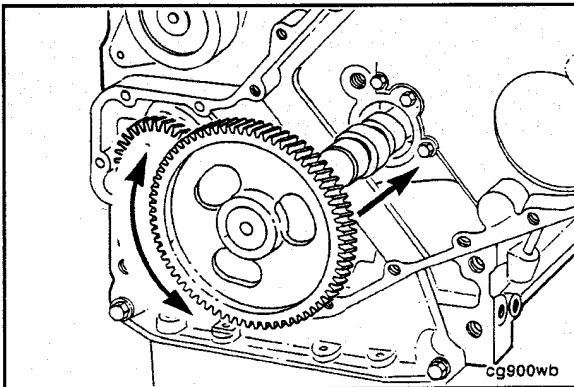
Lubricate the camshaft journals and lobes with Lubriplate 105®.



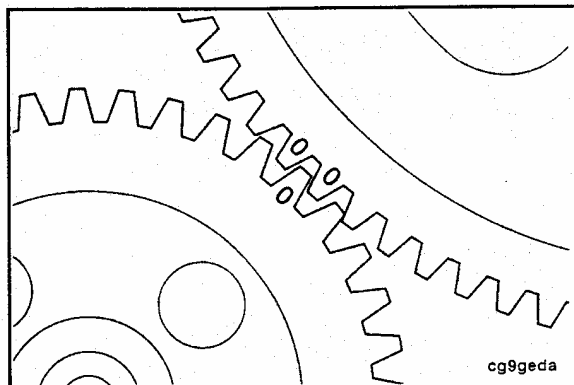
Position the camshaft/cam gear assembly into the cylinder block up to the last journal.

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®.

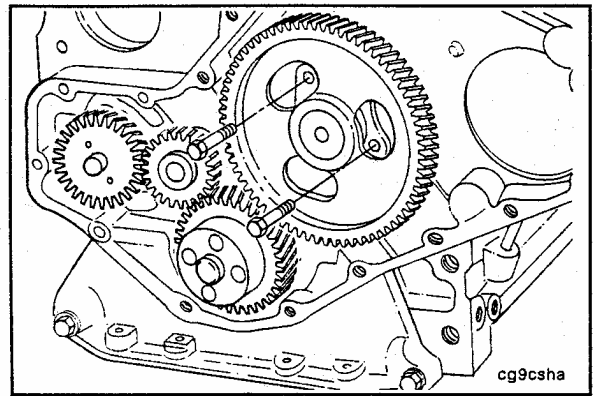
Align the timing marks as illustrated and install the thrust washer.



13 mm

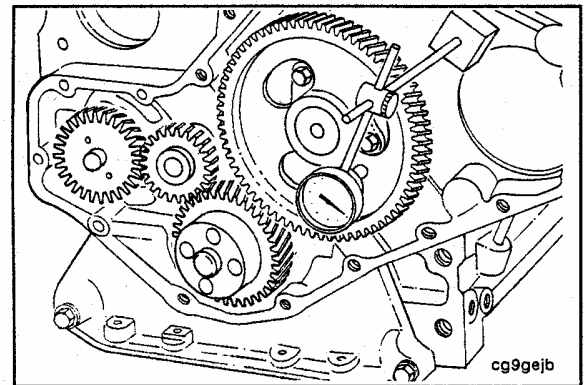
Push the camshaft into the cylinder block and install the thrust plate capscrews.

Torque Value: 24 N•m [18 ft-lb]



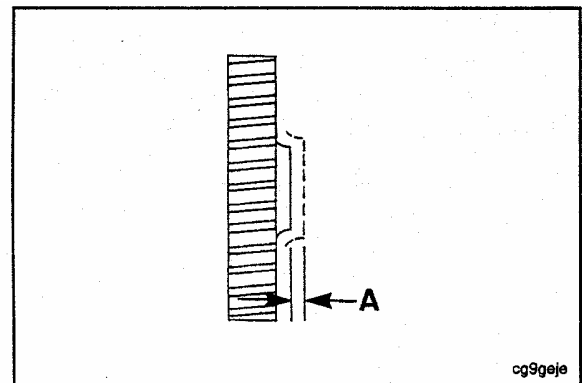
Measure the camshaft end play.

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



Camshaft End Play - Measuring (0-76)

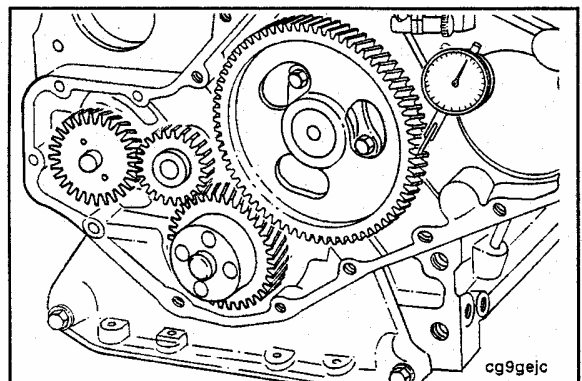
Camshaft End Play Limits (A)		
mm		in
0.12	MIN	0.005
0.34	MAX	0.013

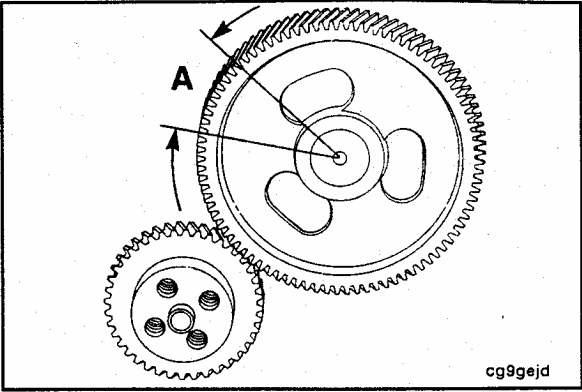


CAUTION

Be sure the backlash is correct for any replaced gears.

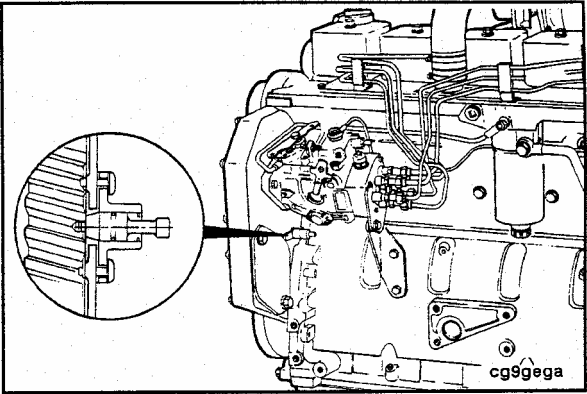
Use an indicator to measure backlash.





Camshaft Gear Backlash - Measuring (0-77)

Camshaft End Play Limits (A)		
mm		in
0.076	MIN	0.003
0.380	MAX	0.013



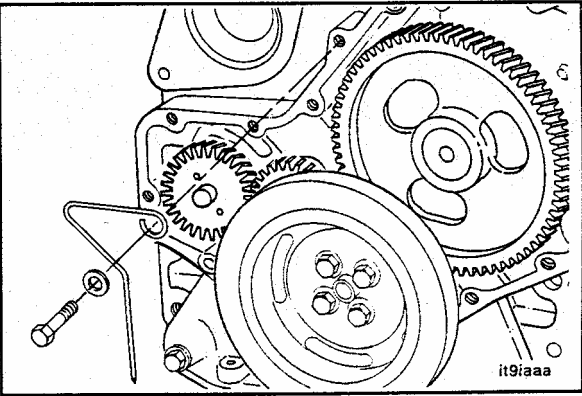
Timing Pin - Installation (0-78)

CAUTION

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

CAUTION

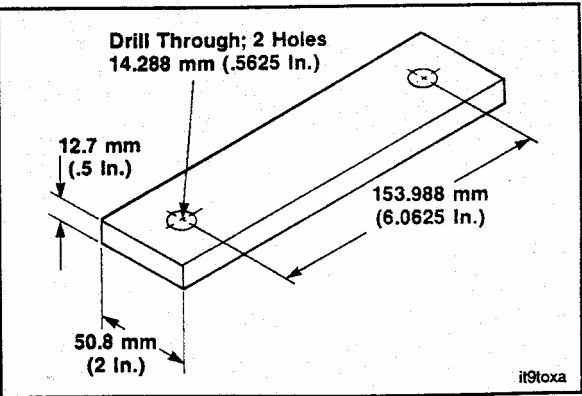
The timing pin assembly must be relocated if gear housings are interchanged.



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.

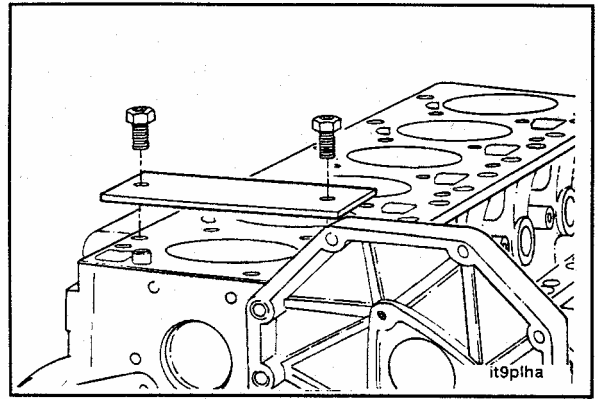
To relocate the assembly, temporarily install the crankshaft pulley and a fabricated wire pointer. Put a flat washer between the pointer and gear housing to prevent damage to the gear housing.



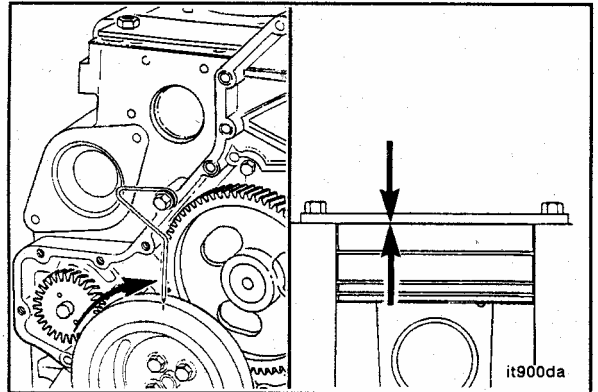
Fabricate a steel plate as shown in the illustration.

15 mm

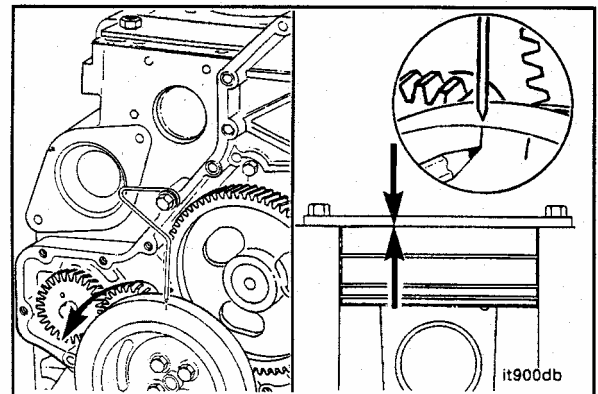
Use two flywheel housing capscrews to assemble the plate over Cylinder Number 1.



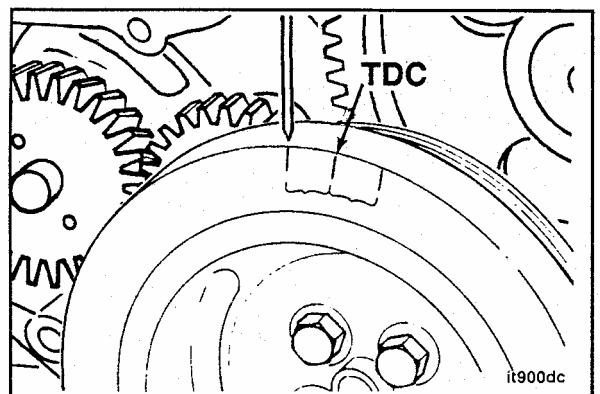
Rotate the crankshaft until the piston contacts the plate.
Mark the pulley.

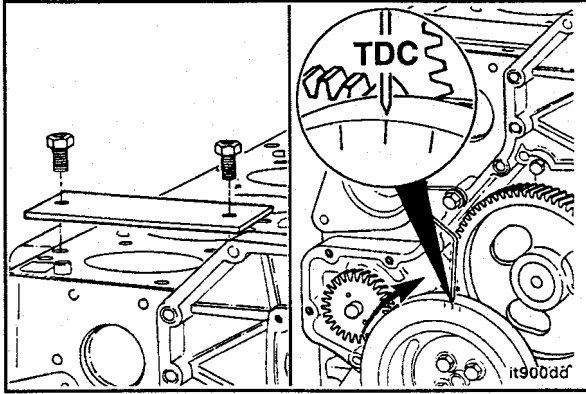


Rotate the engine in the opposite direction until the piston contacts the plate.
Mark the pulley.



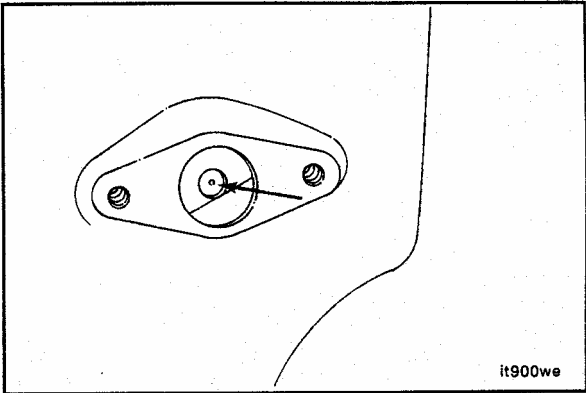
Mark the pulley for TDC which is one-half the distance between the first two marks.



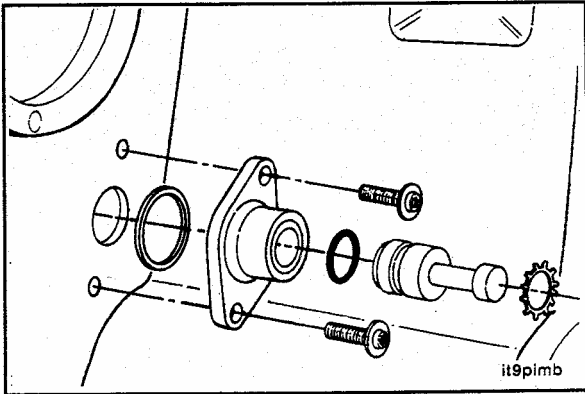


15 mm

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

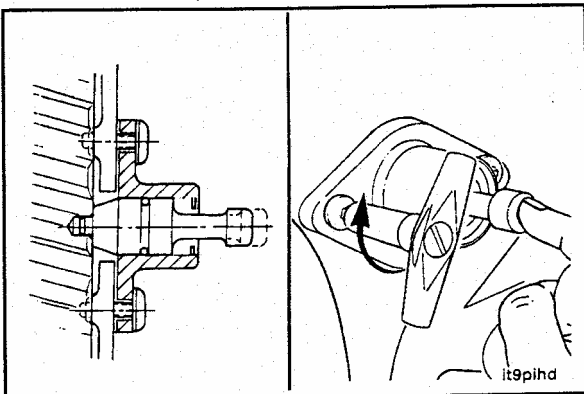


Look for the timing pin hole in the camshaft gear. If it is not visible, rotate the crankshaft one complete turn and align the pointer with the TDC mark.



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.

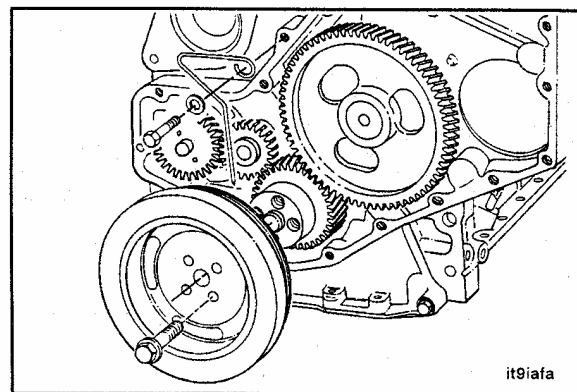
Torque Value: 5 N•m [48 in-lb]

10 mm, 15 mm

CAUTION

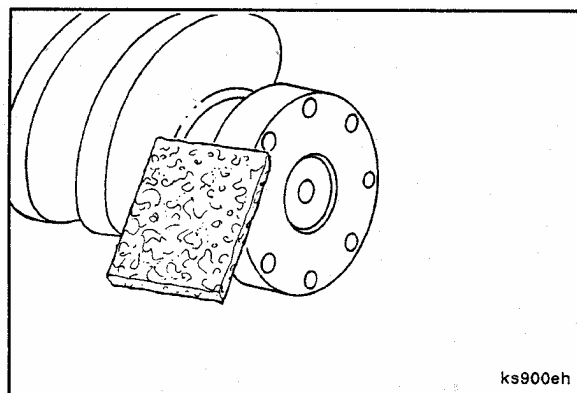
Be sure timing pin is disengaged before rotating the engine.

Remove the crankshaft pulley and wire pointer.

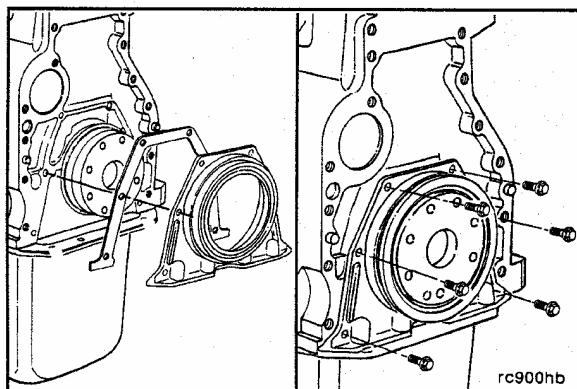


Rear Seal - Installation (0-81)

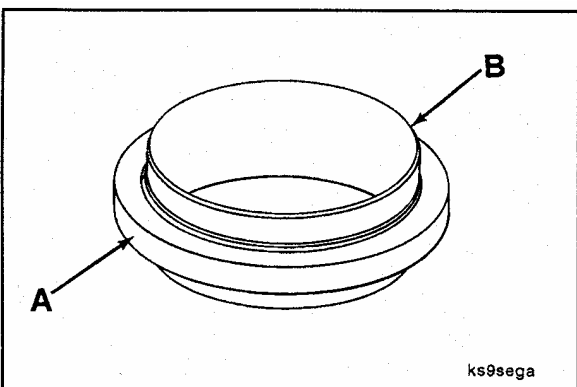
Inspect the crankshaft flange and rear cover for dirt and damage. Use a cleaning pad, Part No. 3823258, to remove dirt or rust deposits. Wipe the crankshaft flange dry.

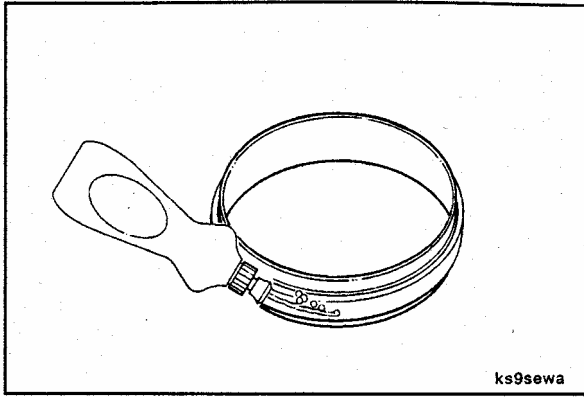


Install the rear cover and gasket. Do not tighten the capscrews to the correct torque value at this time.

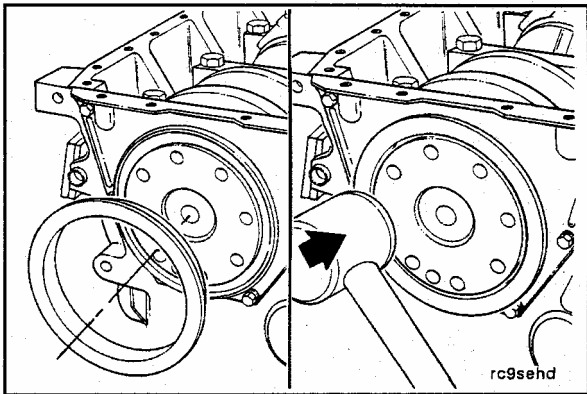


The replacement rear seal has a pilot tool installed. Do not remove the pilot tool at this time.





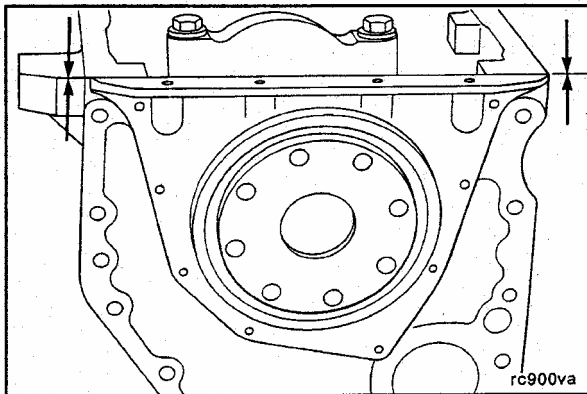
Apply a mild soap to the rubber outside diameter of the oil seal.



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

NOTE

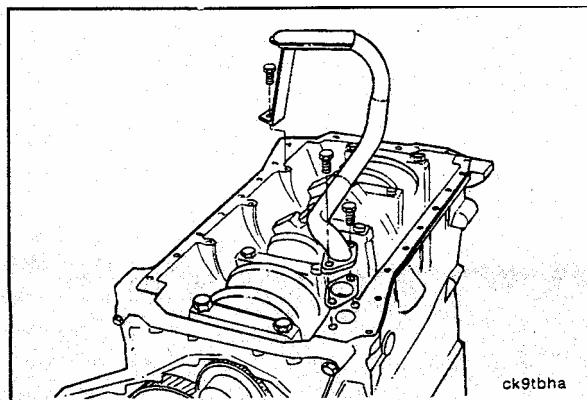
Alternately, drive the seal at the 12, 3, 6 and 9 o'clock positions to install the seal square to the crankshaft flange.



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)

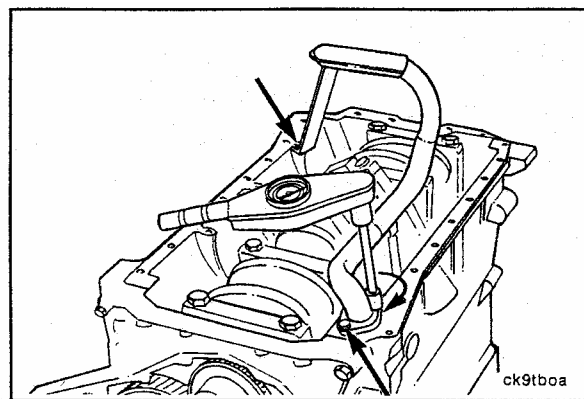


Position the suction tube and gasket on the cylinder block.

10 mm, 13 mm

Tighten the oil suction tube and brace capscrews.

Torque Value: 24 N•m [18 ft-lb]



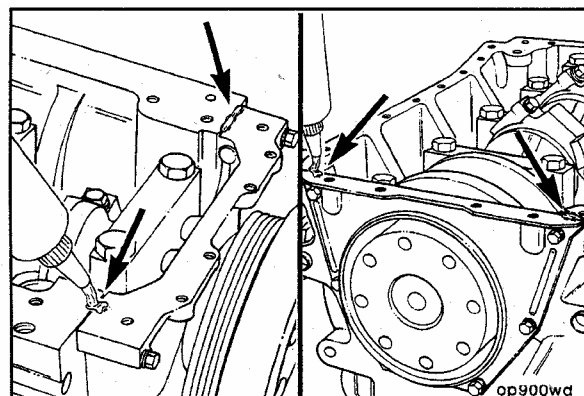
Oil Pan - Installation (0-83)

Oil Pan Sealing Surfaces - Sealants

Use Three Bond 1207-C® (Cummins P/N 3823494) to fill the joints between the pan rail, gear housing, and rear cover.

NOTE

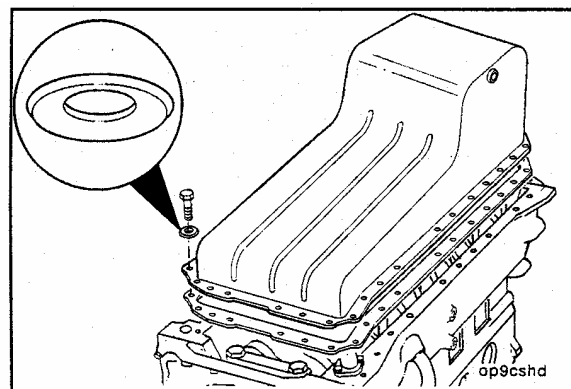
See Sealants information in TM 5-3810-307-24-2, Volume 1, page V-17.



10 mm

Assemble the oil pan and capscrews as illustrated.

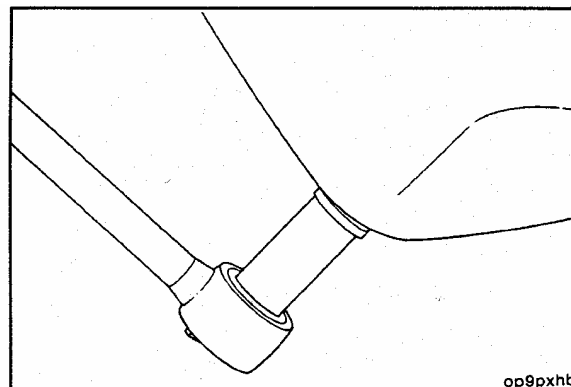
Torque Value: 24 N•m [18 ft-lb]

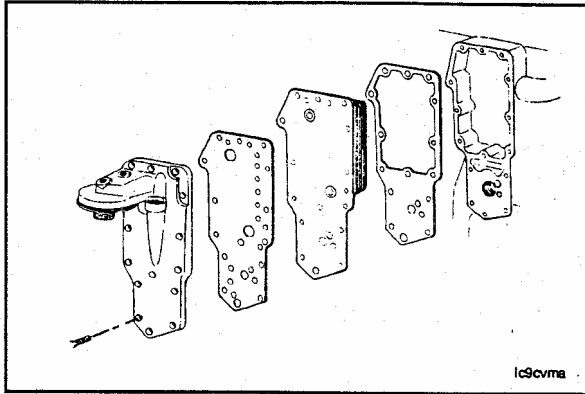


17 mm

Install the drain plug and a new sealing washer.

Torque Value: 80 N•m [59 ft-lb]



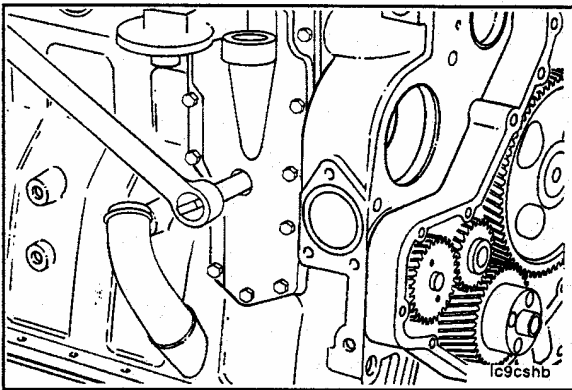


Oil Cooler - Installation (0-84)

CAUTION

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

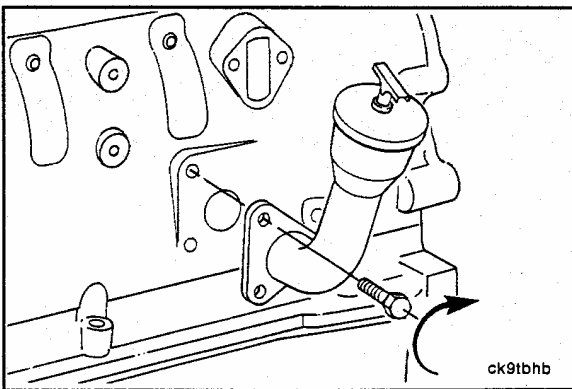
Insert two capscrews through the oil cooler cover. Package the cooler cover gasket, oil cooler, oil cooler gasket and oil cooler cover.



10 mm

Install the "package" on the cylinder block.

Torque Value: 24 N•m [18 ft-lb]

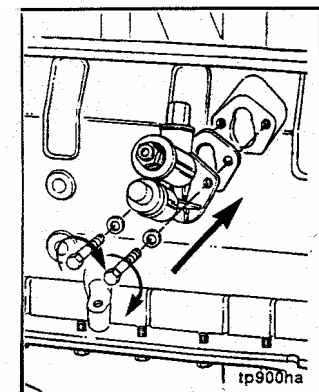


Side Oil Fill - Installation (0-85)

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

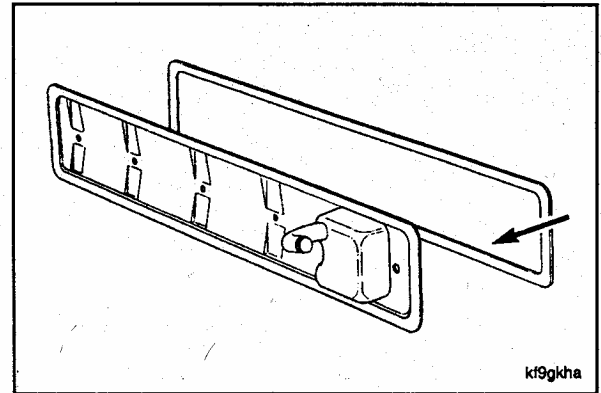
When installing piston style transfer pumps, alternately tighten the mounting capscrews. As the capscrews are tightened, the transfer pump plunger is pushed into the pump. Failure to tighten the capscrews in an even manner can result in the plunger being bent or broken.

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

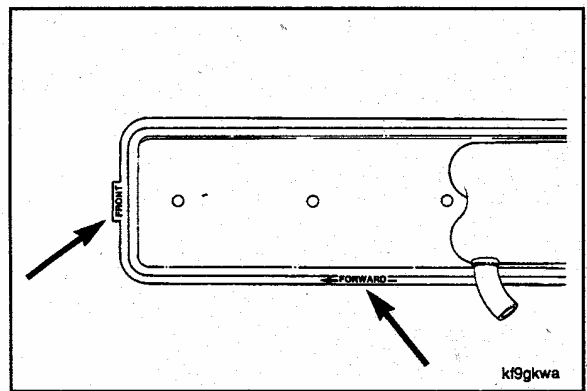
Torque Value: 24 N•m [18 ft-lb]

Tappet Cover - Installation (0-87)

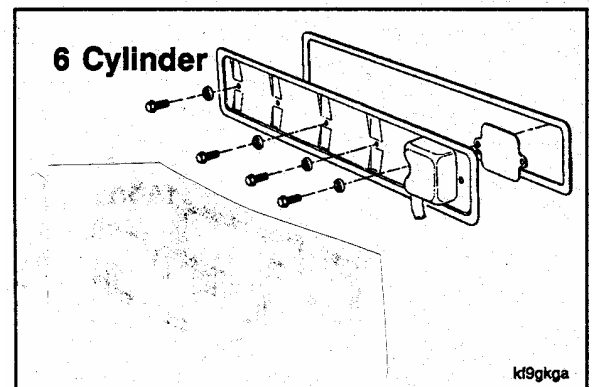
Install the tappet cover gasket.



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

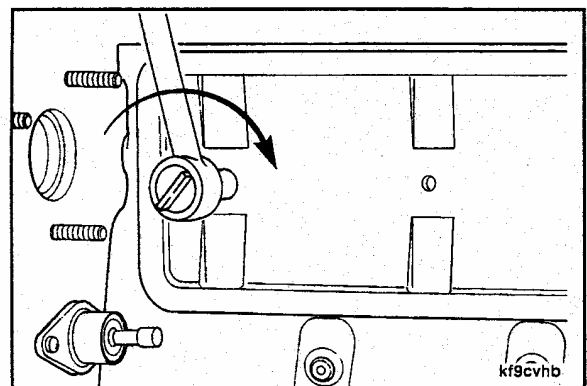


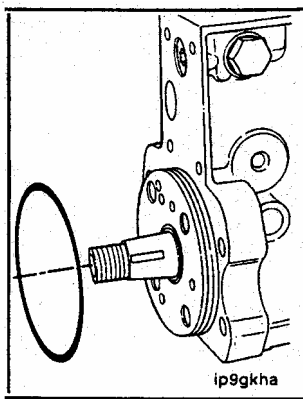
Install the tappet cover and baffle with the illustrated mounting capscrews and rubber seals. The remaining capscrews and rubber seals will be installed later with the fuel drain line.



10 mm

Torque Value: 24 N•m [18 ft-lb]





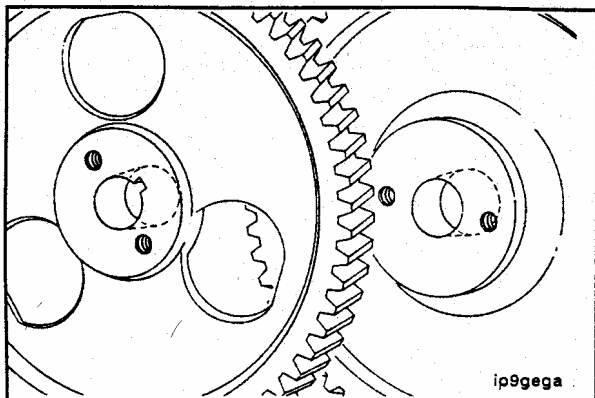
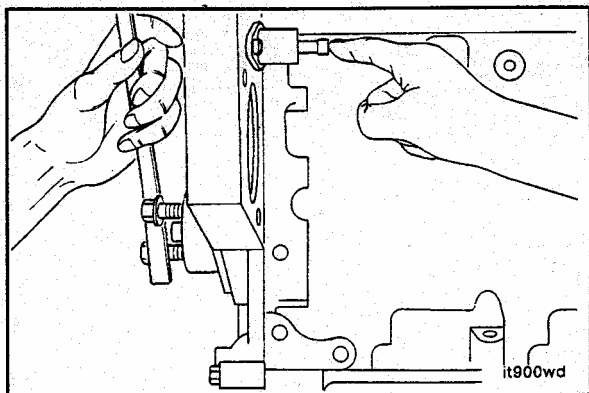
Injection Pump - Installation (0-88)

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.

NOTE

If the mounting flange o-ring has a colored stripe, it can not be reused. Replace with a new O-ring. Furthermore, do not lubricate the new type O-ring. Instead, lubricate the seating area of the gear housing.

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



The injection pump drive gear has a tapered bore. Orient the wide end of the taper toward the engine.

Set the gear into the front housing and engage teeth of gear with teeth of camshaft gear.

NOTE

The P7100 fuel 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.

Locked Timed Injection Pump - Installation (0-89)

CAUTION

The fuel pump drive gear inside diameter and the shaft outside diameter must be clean and dry before installing the shaft into the gear. A non-petroleum based cleaner should be used to clean the drive gear and shaft mounting surfaces. Failure to do so will result in gear slippage in the retarded direction.

Lubricate the mounting flange of the fuel injection pump with clean engine oil and install the pump.

If the pump was not locked in position before removal, refer to installing an unlocked pump, procedure (0-93).

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]

NOTE

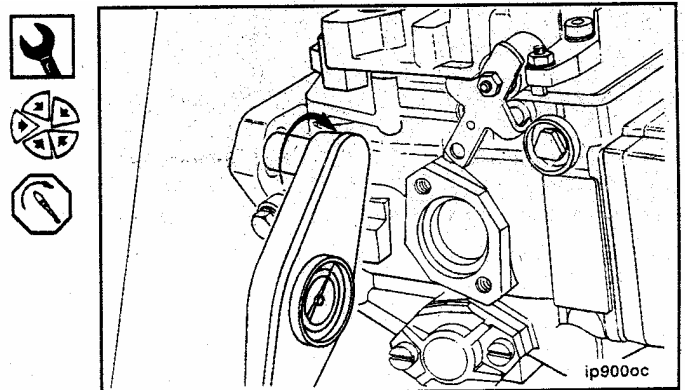
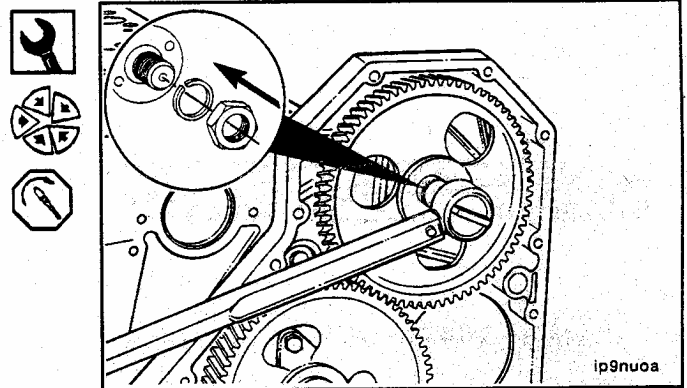
This is not the final torque. The drive shaft nut will be torqued to the final specification after the pump is unlocked.

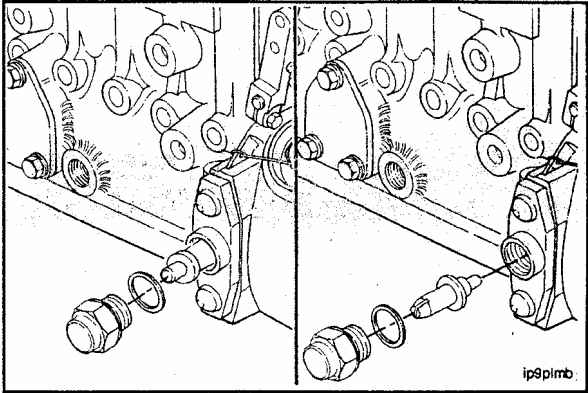
13 mm or 15 mm

Tighten the mounting nuts.

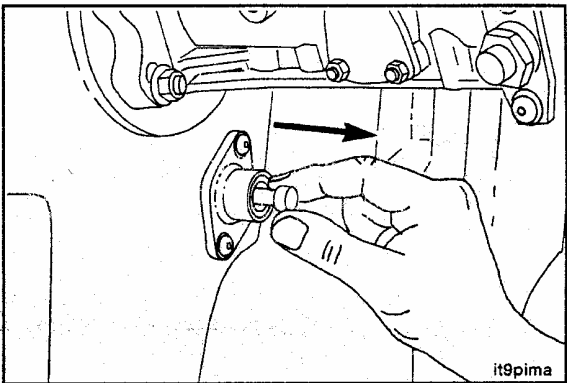
Torque Value

Bosch P7100	43 N•m [32 ft-lb]
-------------	-------------------

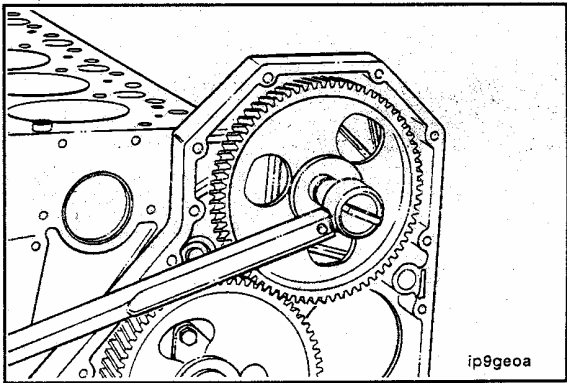




The Bosch P7100 has a timing pin located under a cap on the outboard side of the governor. To unlock the pump the position of the pin is reversed under the cap.



Disengage the timing pin.



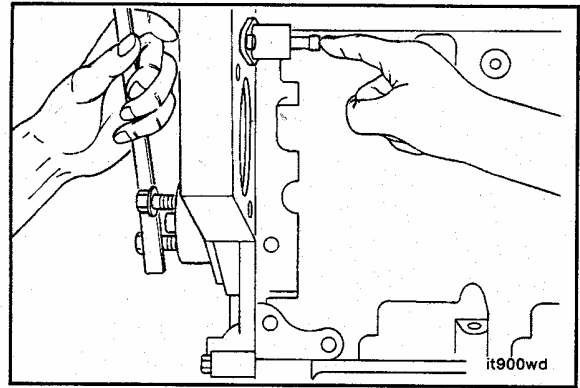
22 mm or 27 mm

Tighten the drive gear mounting nut.

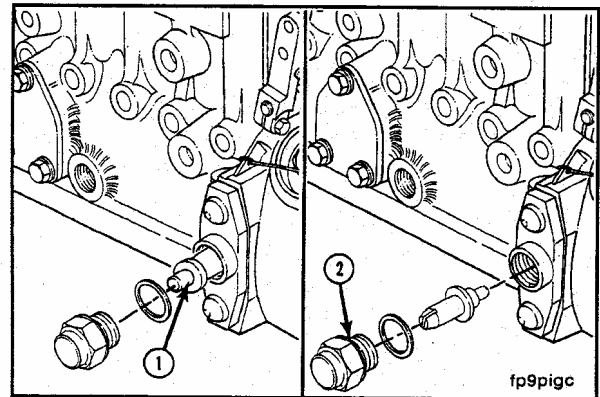
Torque Value	
Bosch P7100	165 N•m [122 ft-lb]

P7100 Injection Pump Installation

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

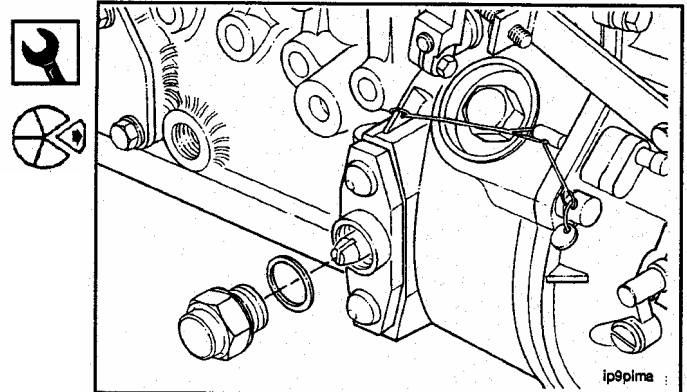


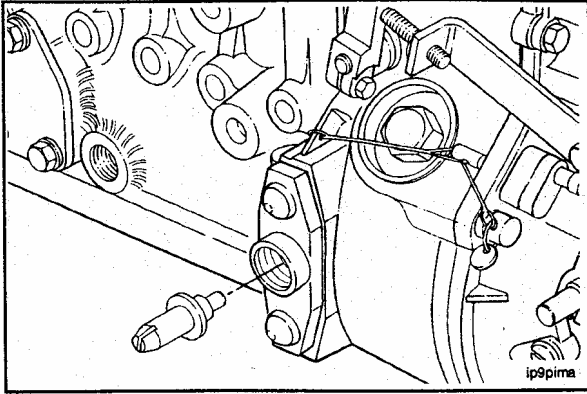
The injection pump also has a timing pin (1), located in the governor housing, to position the pump shaft to correspond with TDC for Cylinder No. 1. The pin is to be reversed and stored in the housing (2) after the pump is installed.



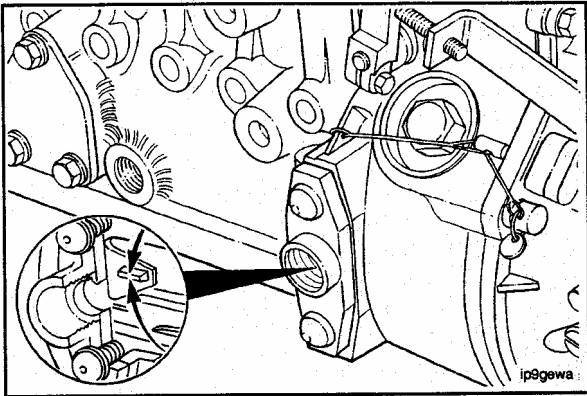
24 mm

Remove the access plug.

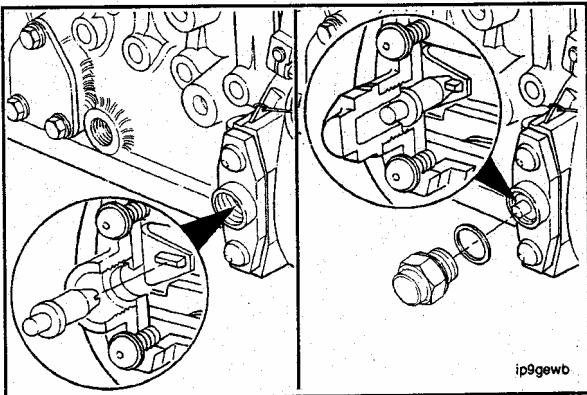




Remove the timing pin.

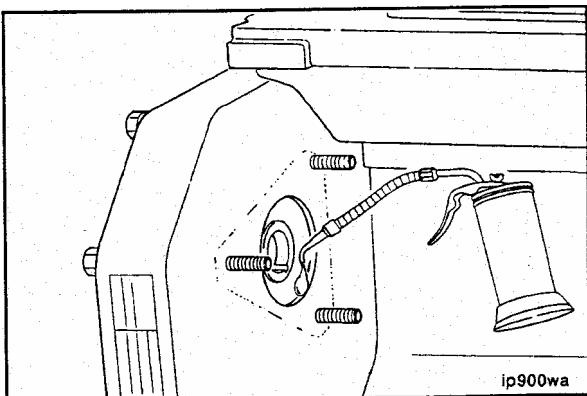


If the timing tooth is not aligned with the timing pin hole, rotate the pump shaft until the timing tooth aligns.



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.

CAUTION

The fuel pump drive gear inside diameter and the shaft outside diameter must be clean and dry before installing the shaft into the gear. A non-petroleum based cleaner should be used to clean the drive gear and shaft mounting surfaces. Failure to do so will result in gear slippage in the retarded direction.

NOTE

If the mounting flange O-ring has a colored stripe, it can not be reused. Replace with a new O-ring. Furthermore, do not lubricate the new type O-ring. Instead, lubricate the seating area of the gear housing.

NOTE

The P7100 fuel 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.

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.

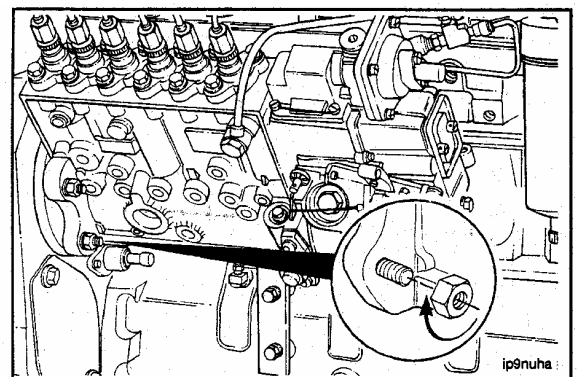
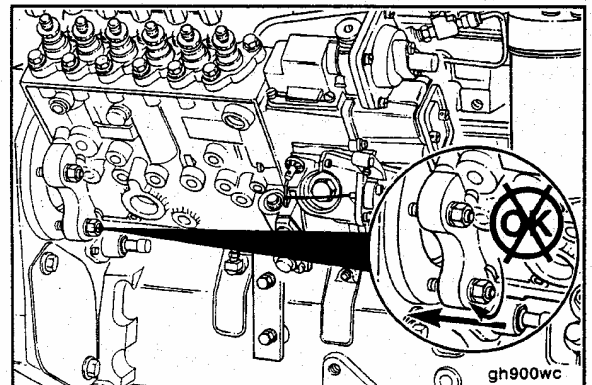
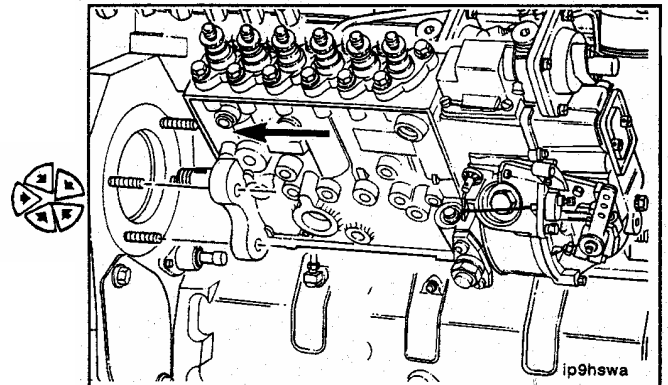
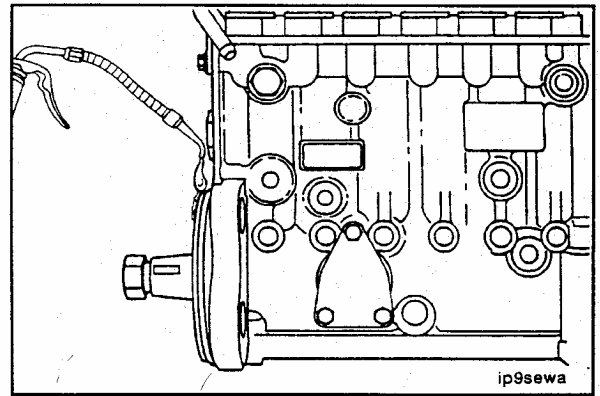
CAUTION

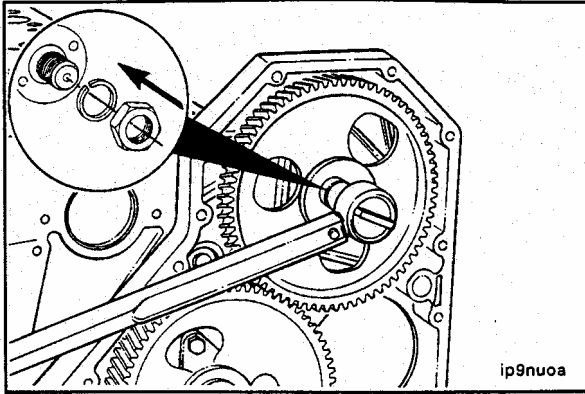
Do not attempt to pull the pump flange into the gear housing with the mounting nuts as damage to housing will occur.

15 mm

Install the mounting nuts.

Torque Value: 43 N•m [32 ft-lb]



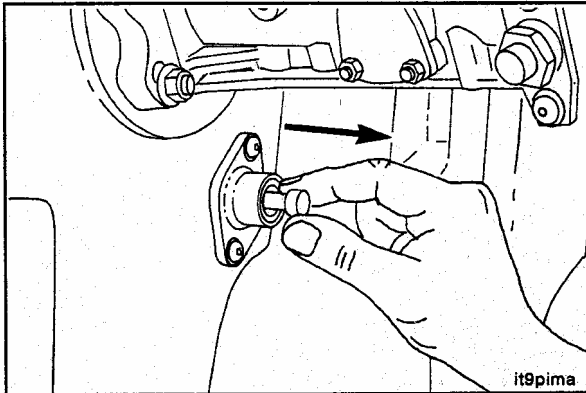


30 mm

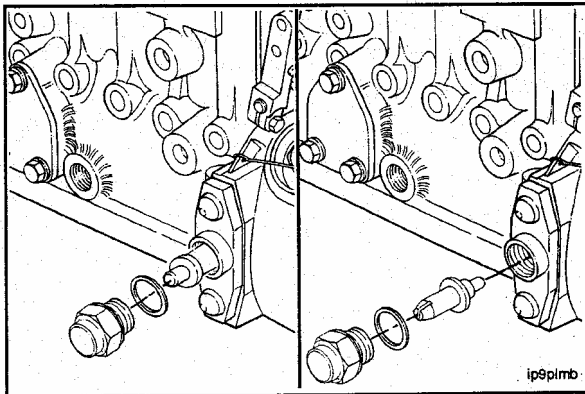
Install the retaining nut and washer.

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.



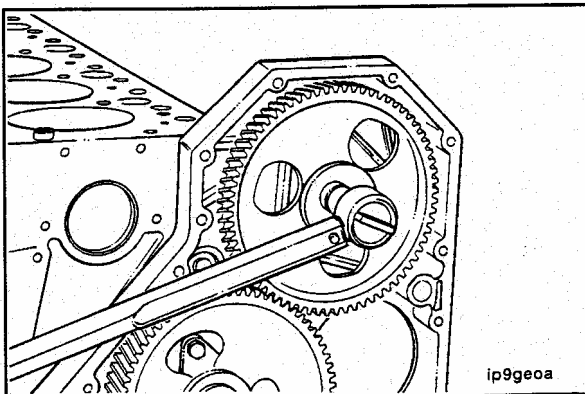
Disengage the engine timing pin.



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

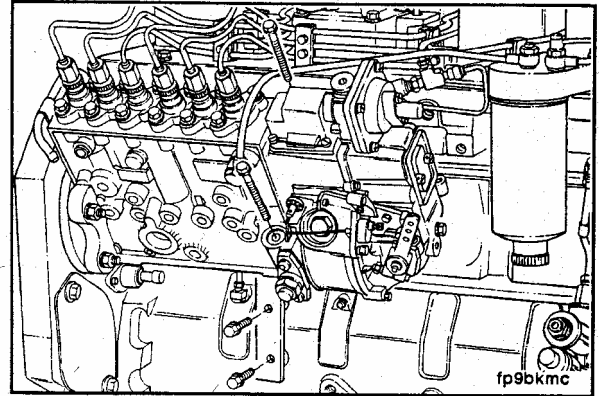
Tighten the fuel pump drive nut.

Torque Value: 165 N•m [122 ft-lb]

Install the gear cover access cap hand tight.

10 mm

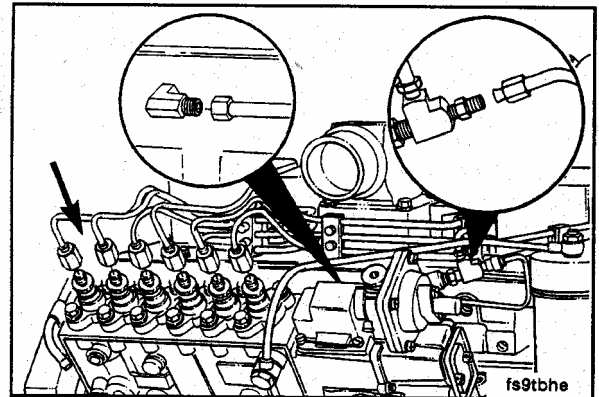
Install the fuel pump mounting bracket capscrews.



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

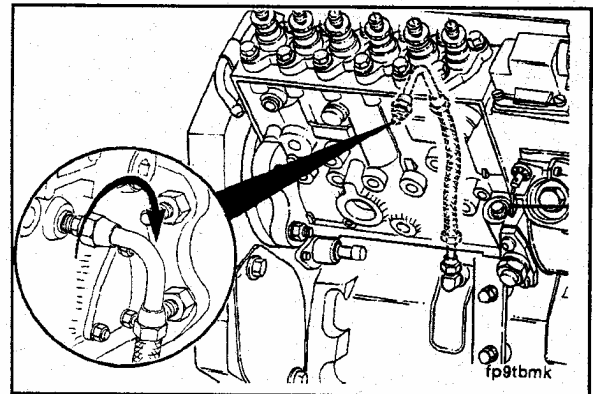
Torque Values:

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]

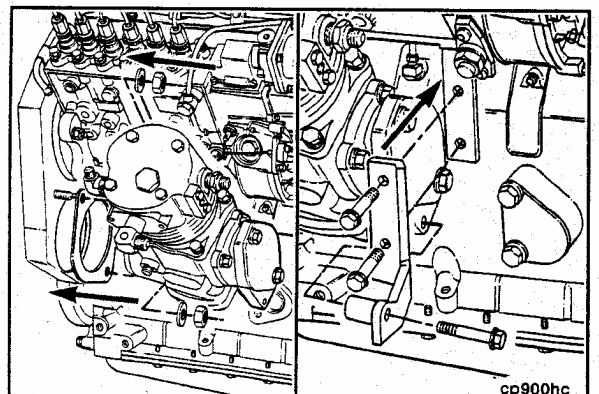
**9/16 in**

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

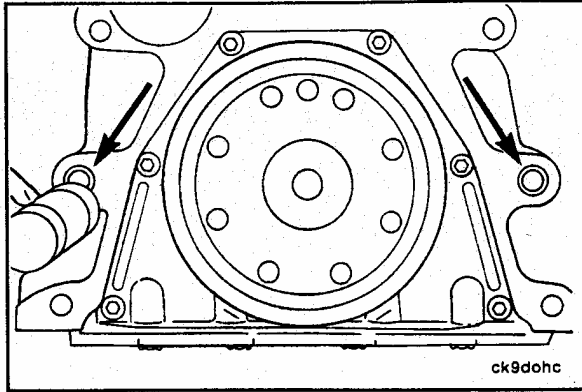
Torque Value: 10 N•m [7 ft-lb]

**Accessories - Installation (0-94)**

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

**NOTE**

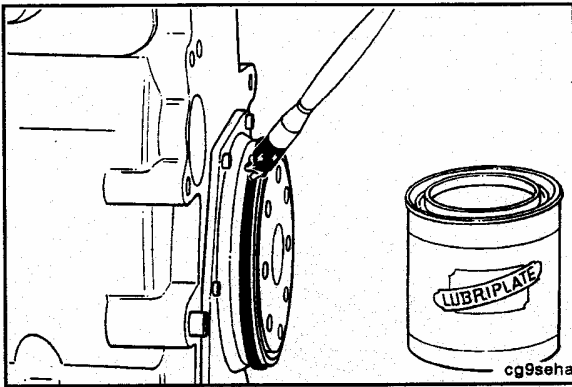
When gear driven accessories are installed, be sure to install the correct support bracket.



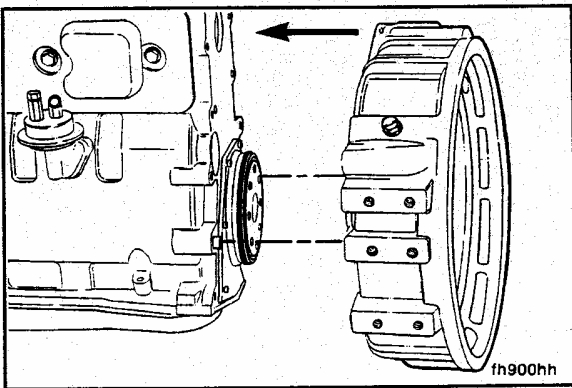
Flywheel Housing - Installation (0-95)

If removed, install the two ring dowels.

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



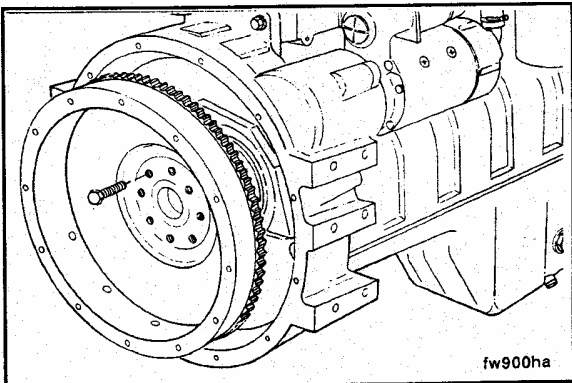
Install the rectangular seal and lubricate with Lubriplate® 105.



15 mm

Install the flywheel housing.

Torque Value: 77 N•m [57 ft-lb]



Flywheel - Installation (0-96)

Install the flywheel.

CAUTION

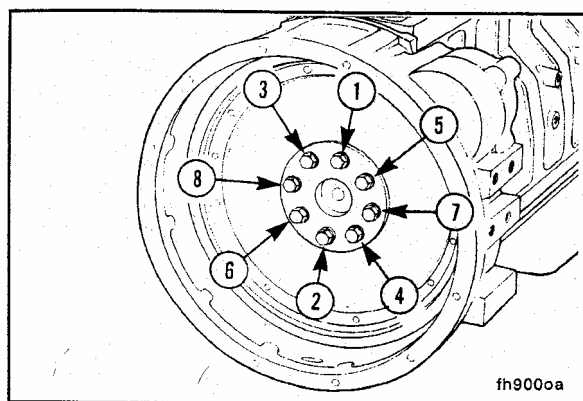
Install two capscrews in the front of the crankshaft or otherwise lock the crankshaft to tighten the flywheel capscrews. Do not use the timing pin to lock the engine.



18 mm

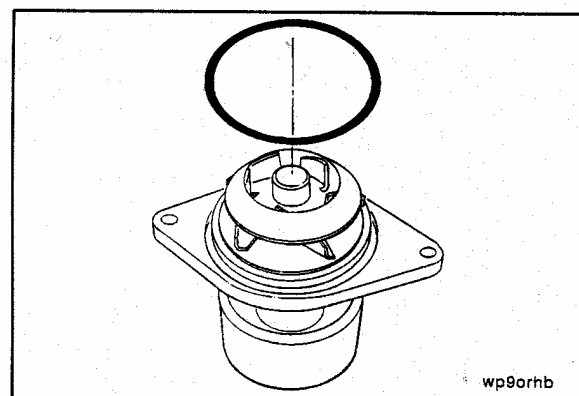
Follow the illustrated sequence to tighten the capscrews.

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



Water Pump - Installation (0-97)

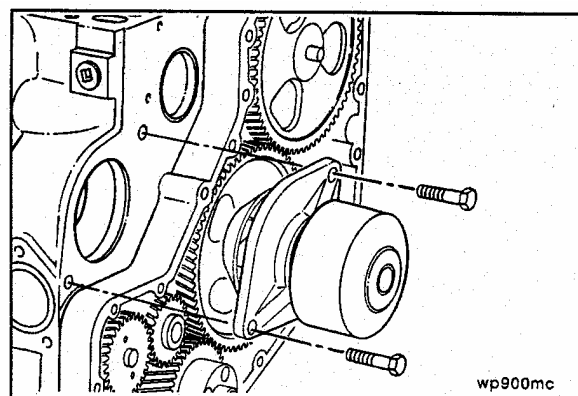
Install the o-ring in the groove in the water pump housing



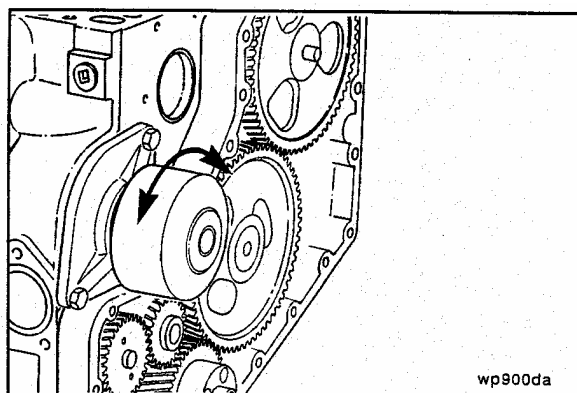
13 mm

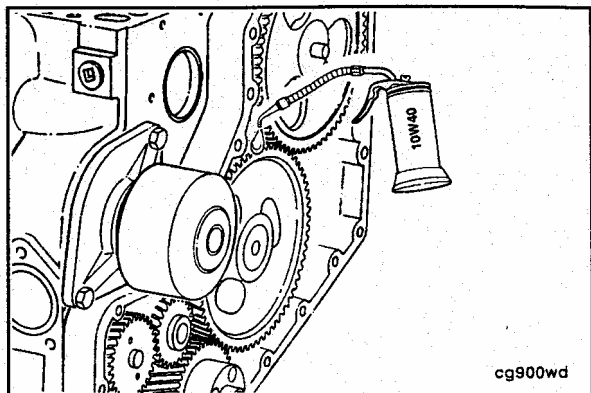
Install the water pump.

Torque Value: 24 N•m [18 ft-lb]



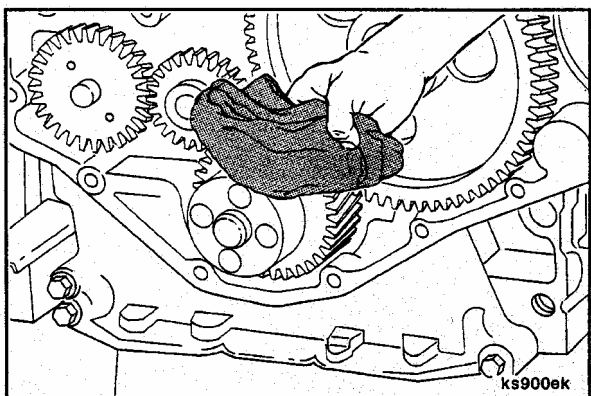
Rotate the water pump to make sure it turns freely.





Front Cover - Installation (0-98)

Lubricate the front gear train with clean engine oil.

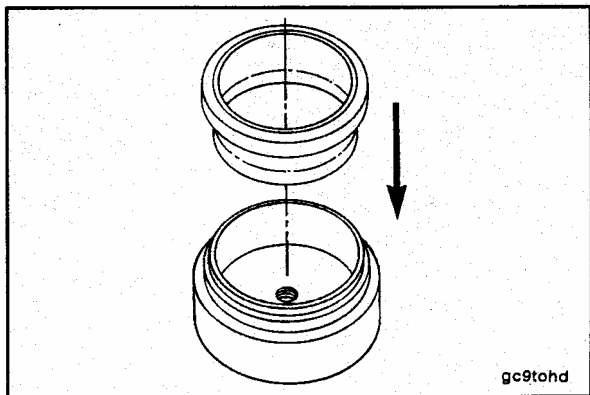


CAUTION

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



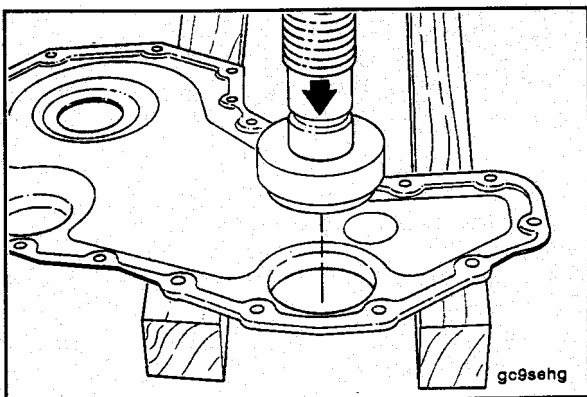
Thoroughly clean and dry the front seal area of the crankshaft.



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.

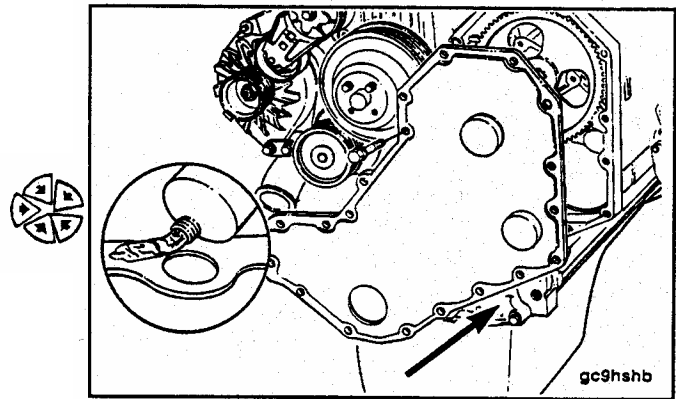
Press the lubricating oil seal until the service tool bottoms against the front cover.

Apply a thin bead of compound (NSN 8030-00-252-3391) 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.

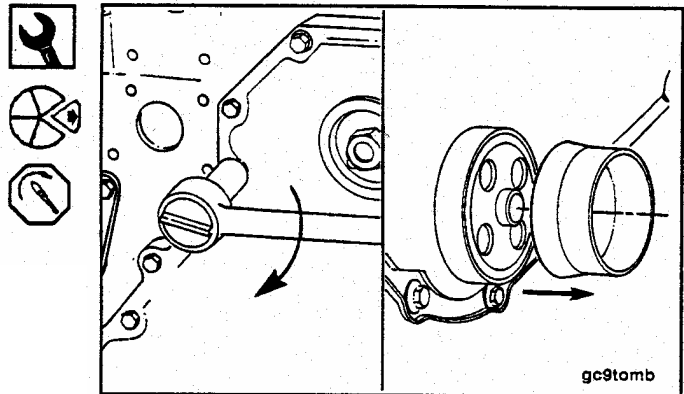
Install the gasket and front cover on the engine.



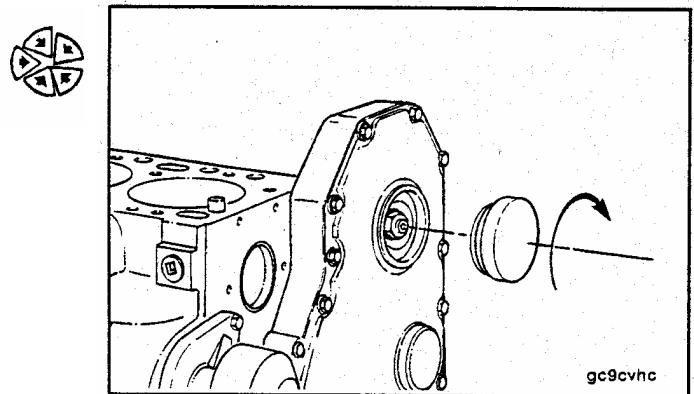
10 mm

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.



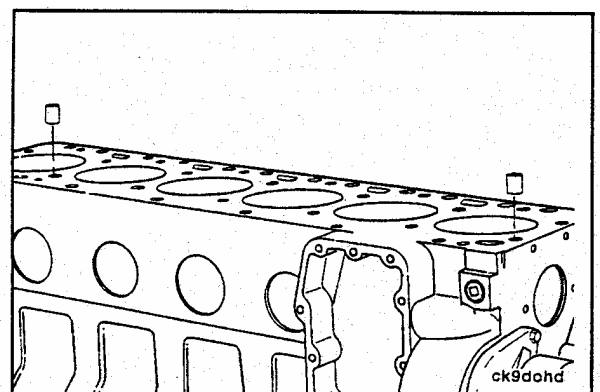
Cylinder Head - Installation (0-99)

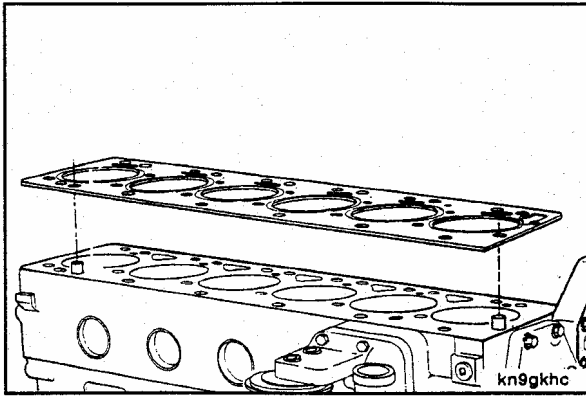
CAUTION

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

Mallet

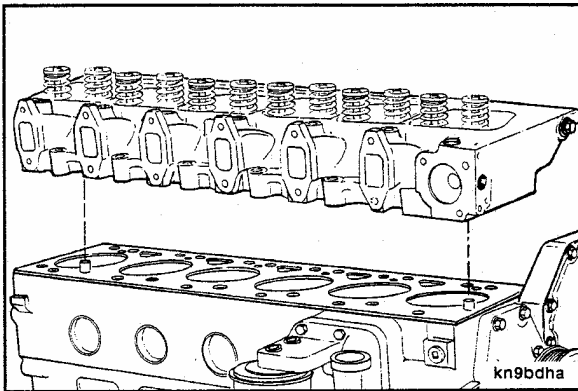
If removed, install the two cylinder head dowels. Drive the dowels to the bottom of the dowel bore.





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

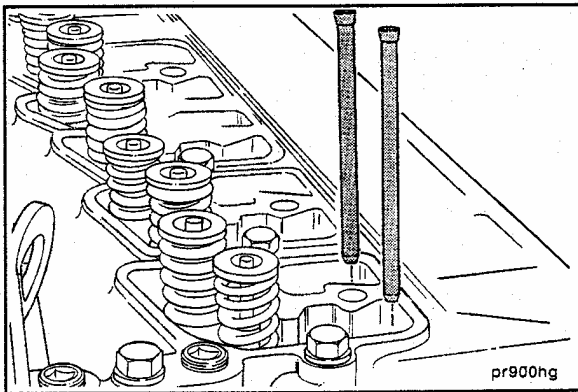
Position the head gasket over the dowels.



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

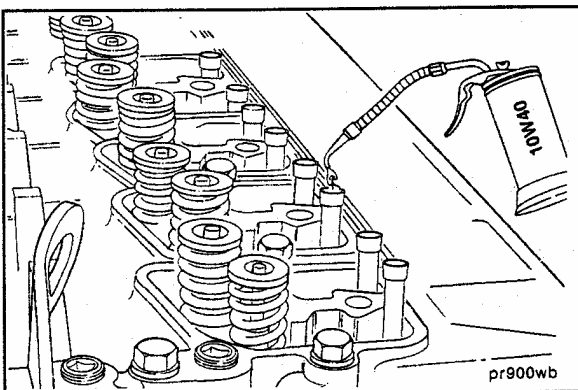
Cylinder Head Weight:

6 Cylinder - 51.3 Kg [114 lb]



Push Rods - Installation (0-100)

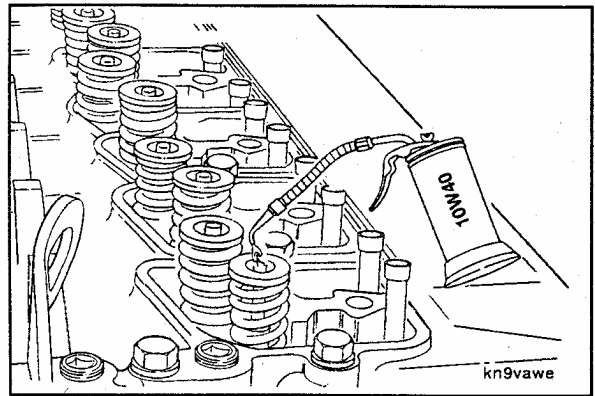
Position the push rods into the valve tappets.



Lubricate the push rod sockets with engine oil.

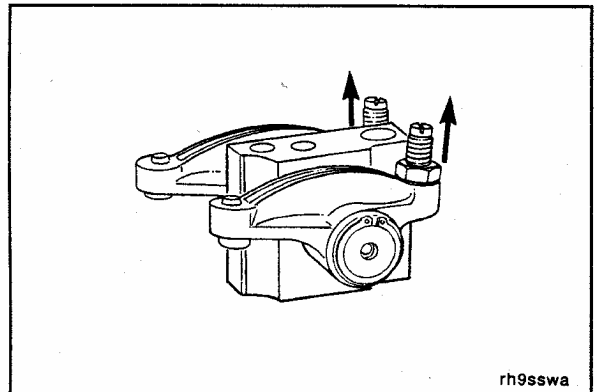
Rocker Levers - Installation (0-101)

Lubricate the valve stems with engine oil.



14 mm, Flat Blade Screwdriver

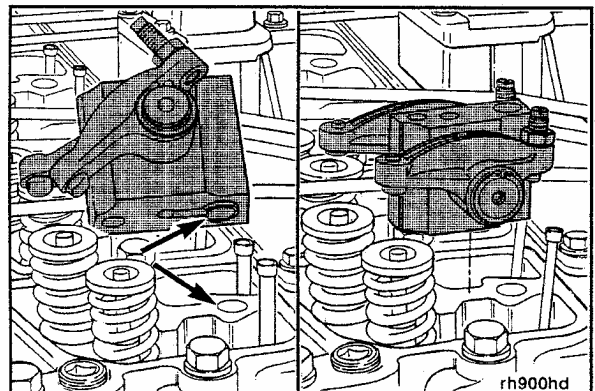
Completely loosen the rocker lever adjusting screws.



NOTE

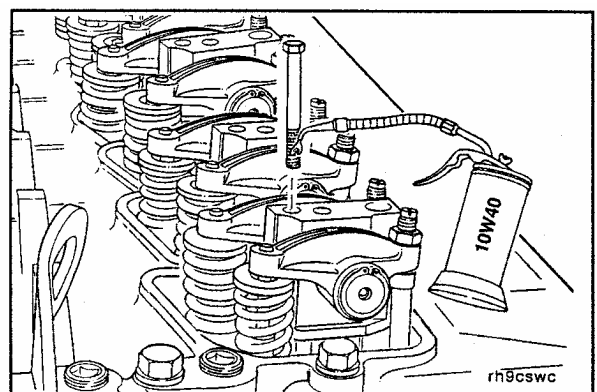
The rocker lever pedestals are aligned with dowels.

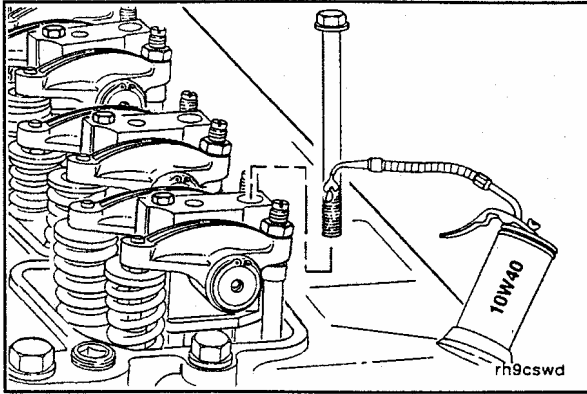
Install the pedestals.



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

Install the capscrews finger tight.

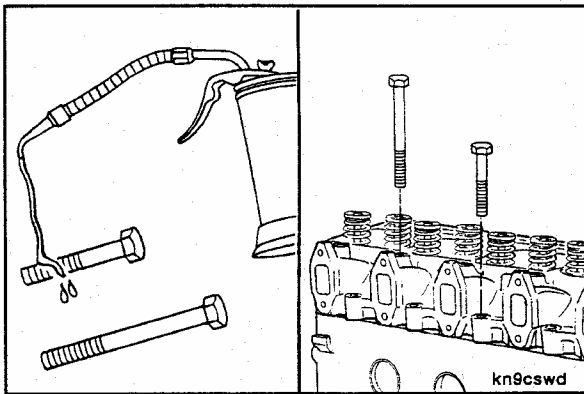




Lubricate the 12mm pedestal/head capscrew bolt threads and under the capscrew heads with engine oil.



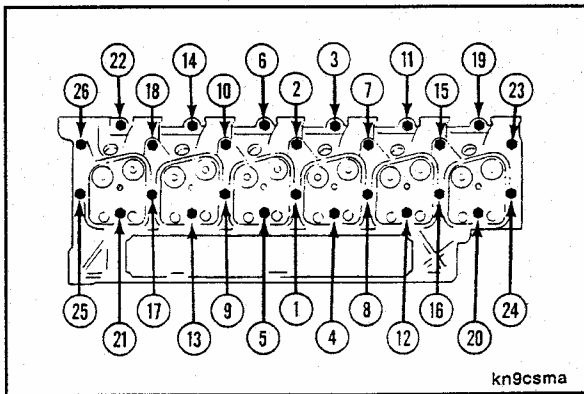
Install the capscrews finger tight.



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

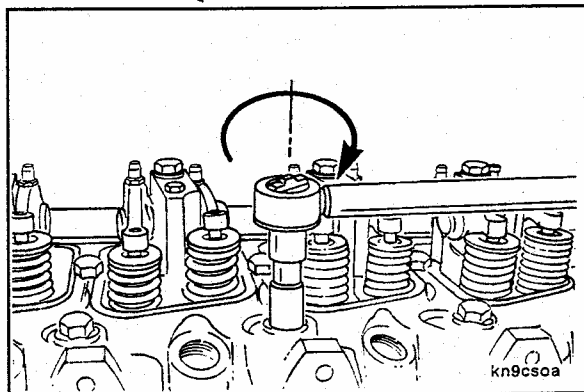


Install the capscrews finger tight.



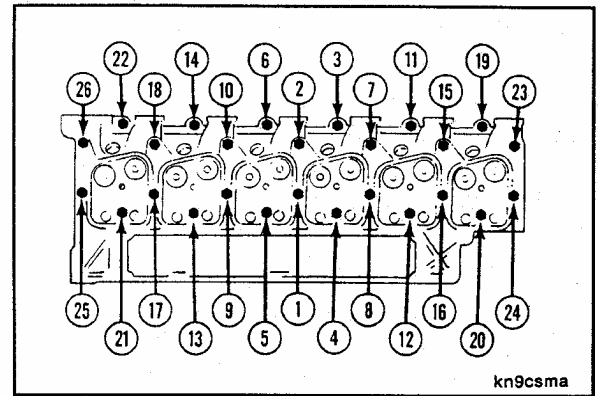
Cylinder Head - Tightening (0-102)

Use the illustrated sequence to tighten the cylinder head capscrews.

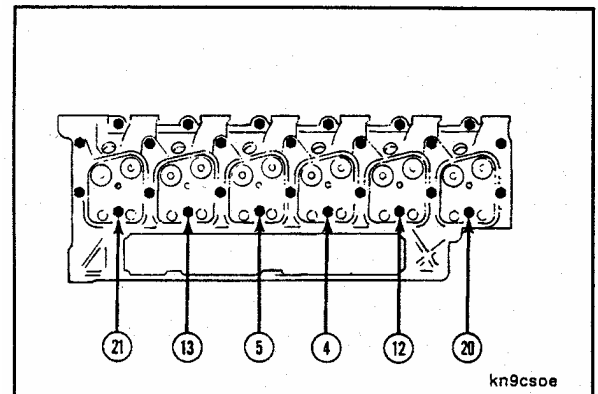


Follow the numbered sequence as shown above and tighten all capscrews to 90 N•m [66 ft-lb].

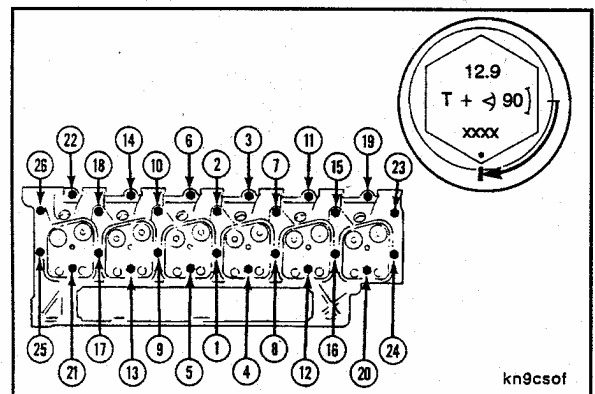
Follow the numbered sequence and recheck the torque on all capscrews to 90 N•m [66 ft-lb].



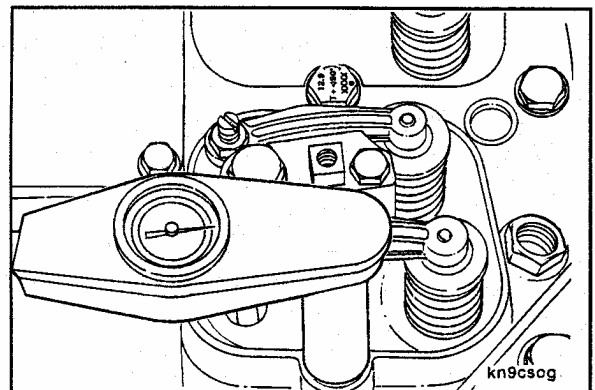
Follow the numbered sequence and tighten ONLY THE SIX LONG CAPSCREWS (No. 4, 5, 12, 13, 20, 21) to 120 N•m [89 ft-lb].

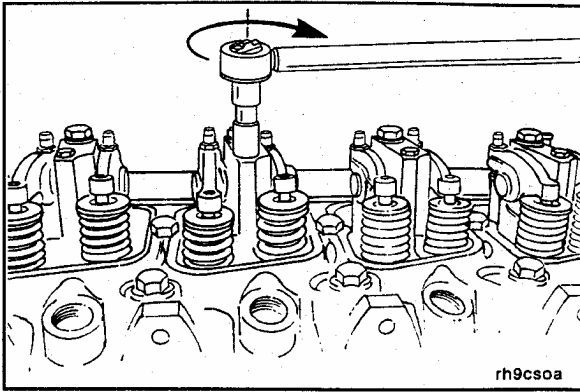


Follow the numbered sequence and turn all capscrews an additional 90° of rotation.



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



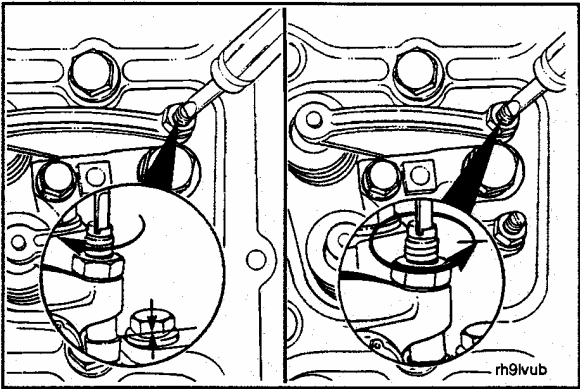


13 mm

Tighten the 8mm pedestal capscrews.

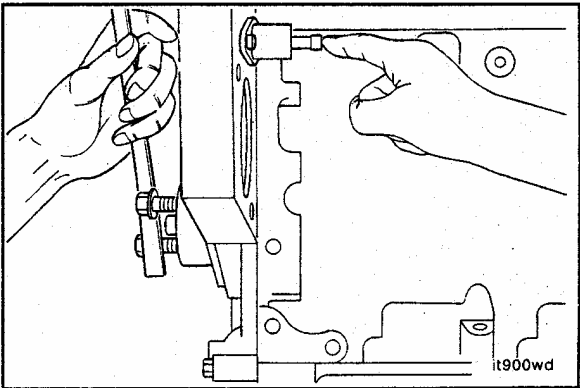


Torque Value: 24 N•m [18 ft-lb]

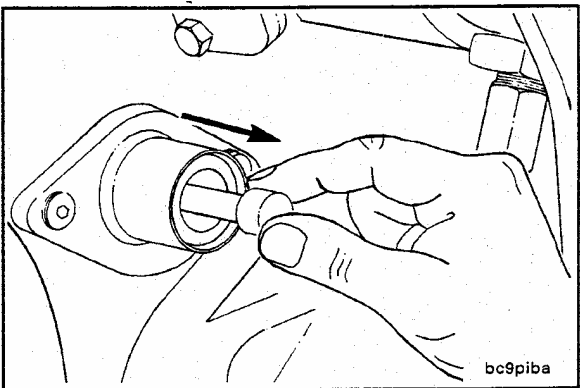


Valve Clearance - Adjustment (0-103)

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	0.508
[0.010 in]	[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 – Six Cylinder

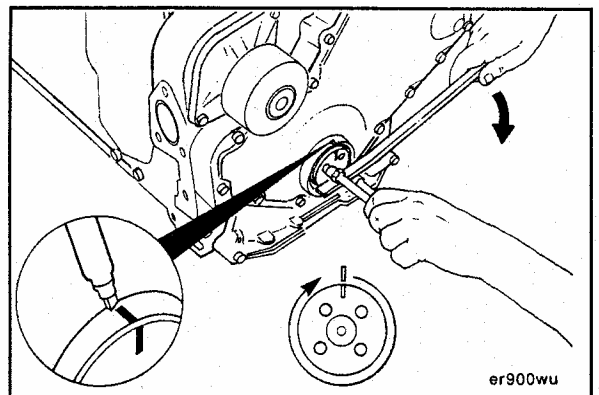
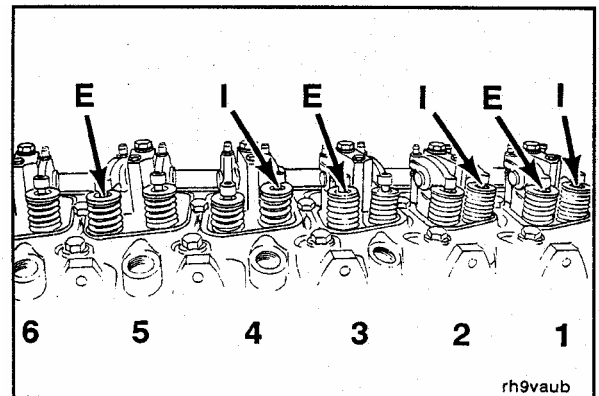
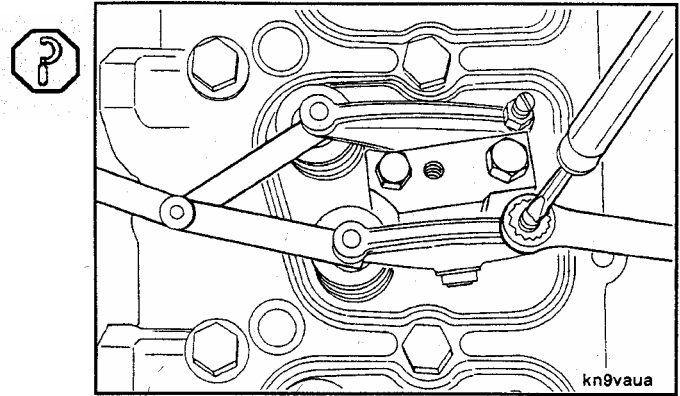
Cylinder	Valve	
	I = Intake	E = Exhaust
1	*	*
2	*	-
3	-	*
4	*	-
5	-	*
6	-	-

(* = 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.

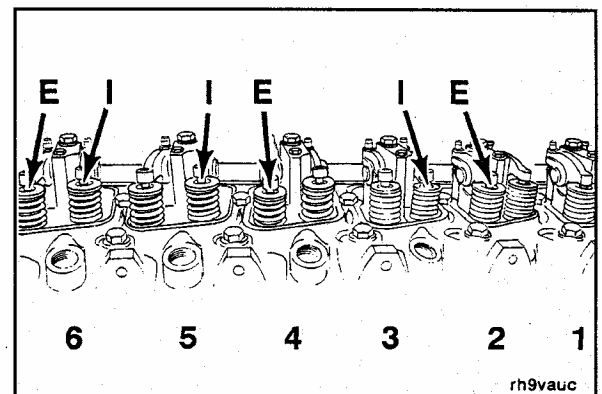


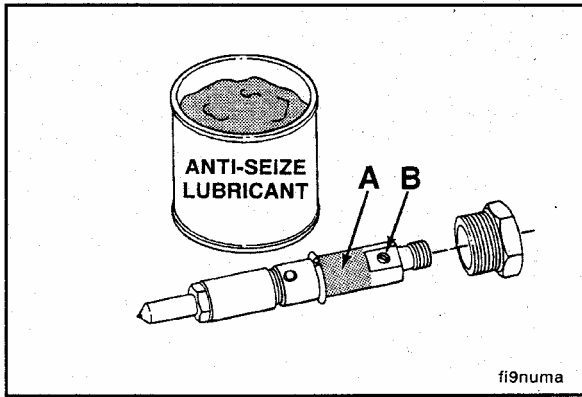
Step B – Six Cylinder

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

(* = Set)

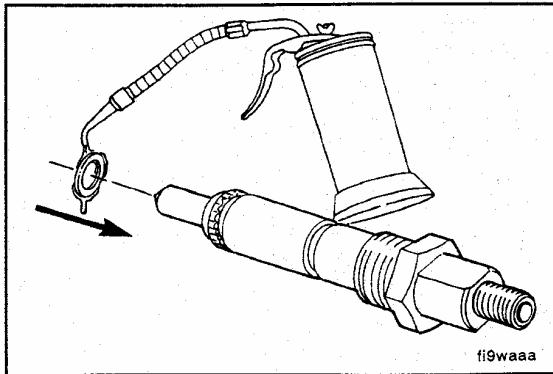
(- = Do not Set)





Injector Nozzles - Installation (0-104)

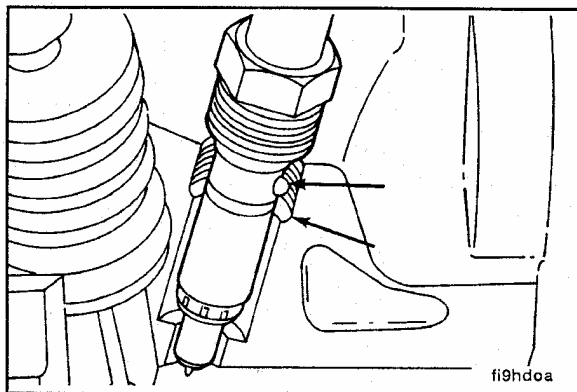
Apply a coat of anti-seize compound (NSN 8030-00-664-6146) to the threads of the injector hold-down nut and between the top of the nut and injector body (A). Avoid getting anti-seize compound in the fuel drain hole (B).



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



24 mm Deep Well Socket

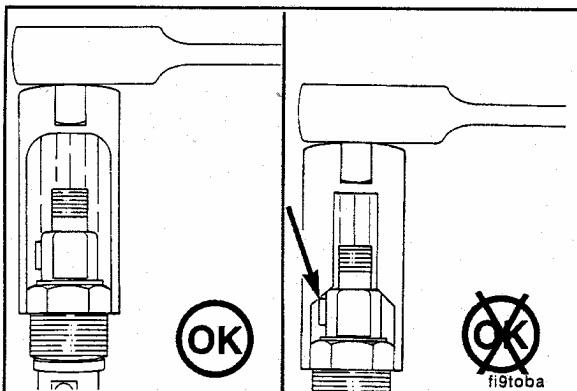
Install the injectors.

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

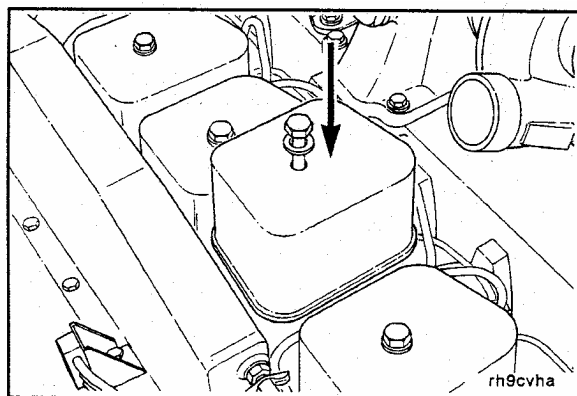
Some sockets can damage the sealing surface of the fuel drain outlet.

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]



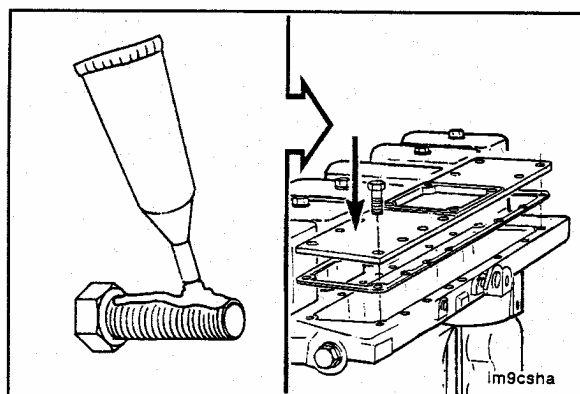
Manifold Cover - Installation (0-106)

3375066 Sealant

Apply sealant to the capscrews as shown in the illustration.

Install the manifold cover, gasket, fuel filter assembly, and capscrews.

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

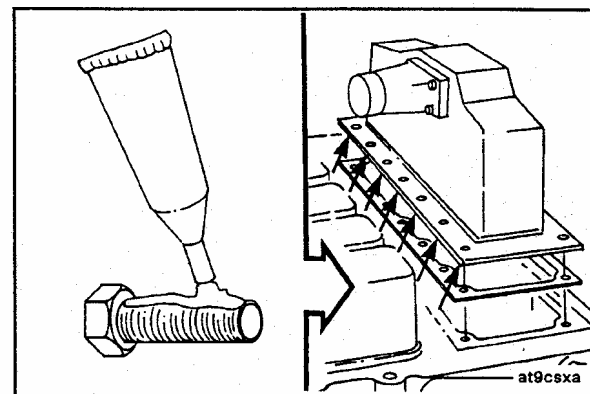


Aftercooler - Installation (0-107)

3375066, 3823494 Sealant

Apply sealant, Cummins P/N 3375066, Loctite P/N 59231, or NSN 8030-01-054-0740 to the capscrews as shown in the illustration.

Apply a 4 mm (0.16 in.) bead of Three Bond 1207-C® sealant (Cummins P/N 3823494) around the sealing surface of the aftercooler as shown in the illustration.



NOTE

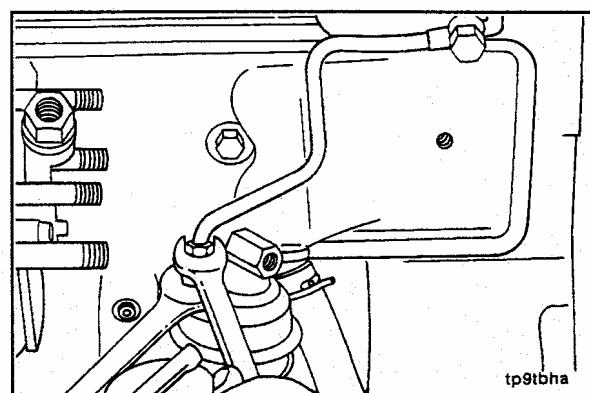
See Sealants information in TM 5-3810-307-24-2, Volume 1, page V-17.

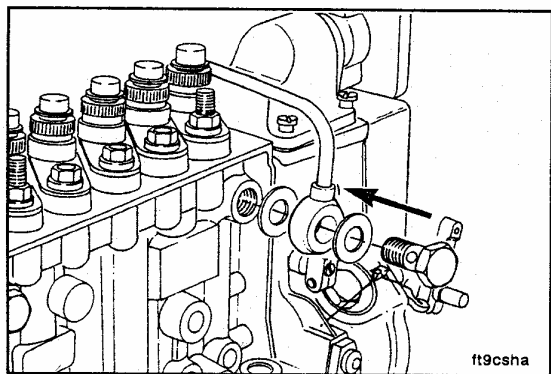
Fuel Lines - Installation (0-108)

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.

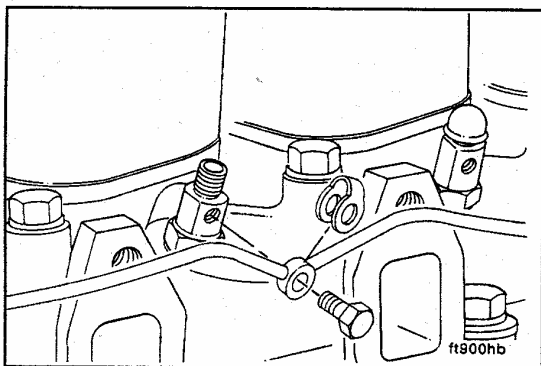




19 mm and 17 mm

Install the Bosch P7100 injection pump fuel supply line.

Torque Value: 32 N•m [24 ft-lb]



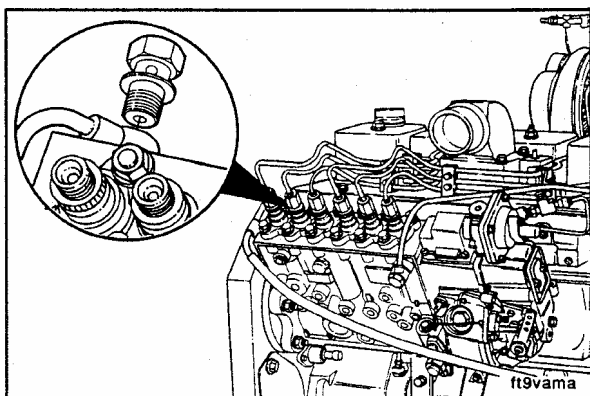
Fuel Drain Manifold - Installation (0-110)

10 mm

Use new sealing washers for the fuel drain manifold.

Install the fuel drain manifold.

Torque Value: 9 N•m [80 in-lb]



19 mm

Connect the Bosch P7100 injection pump vent.

Torque Value: 32 N•m [24 ft-lb]

High Pressure Fuel Lines - Installation (0-110)

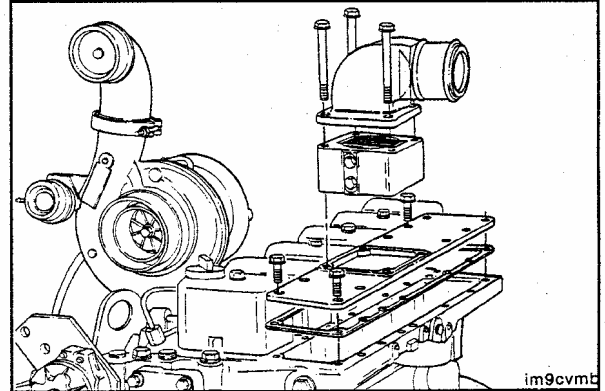
Assemble the high pressure fuel lines.

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

13 mm

Tighten all of the manifold cover capscrews.

Torque Value: 24 N•m [18 ft-lb]

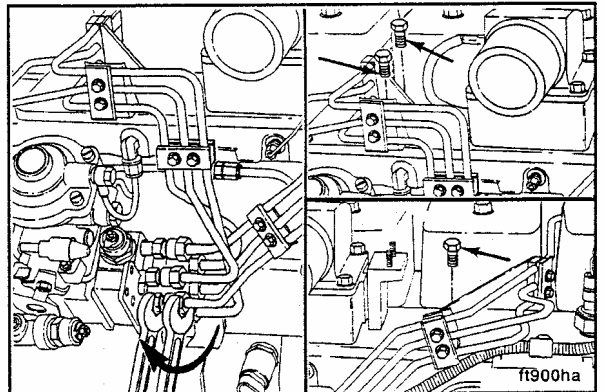


14 mm, 17 mm

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

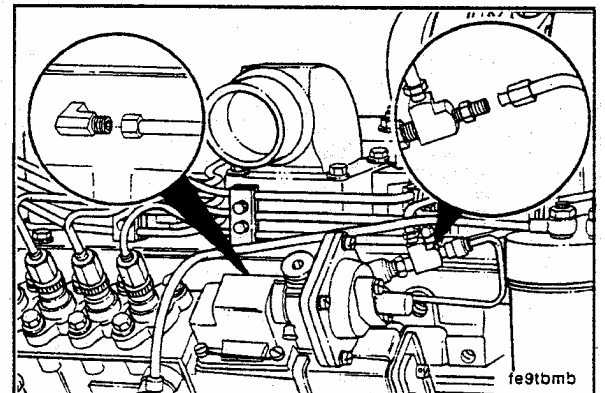
Tighten the high pressure lines at the injection pump and injectors securely.

Torque Value: 24 N•m [18 ft-lb]



12 mm and 13 mm

Install the air/fuel control tube and turbocharger wastegate line.



Exhaust Manifold - Installation (0-113)

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

NOTE

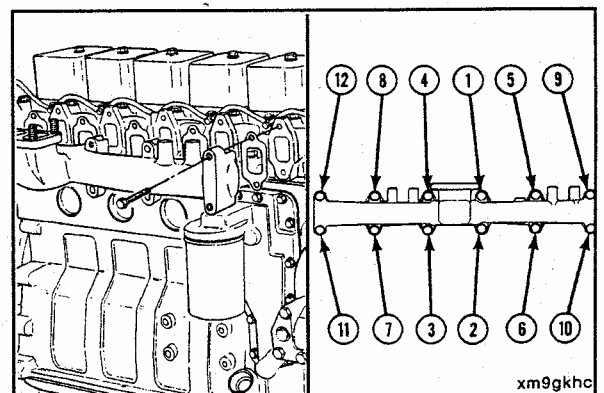
The bead on the exhaust manifold gasket can be installed in either direction.

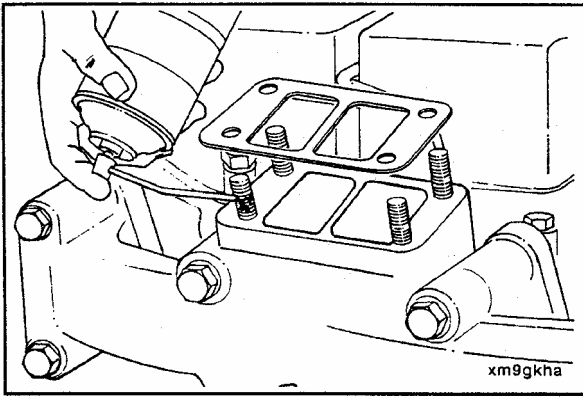
13 mm

Install the exhaust manifold and gaskets.

Torque Value: 43 N•m [32 ft-lb]

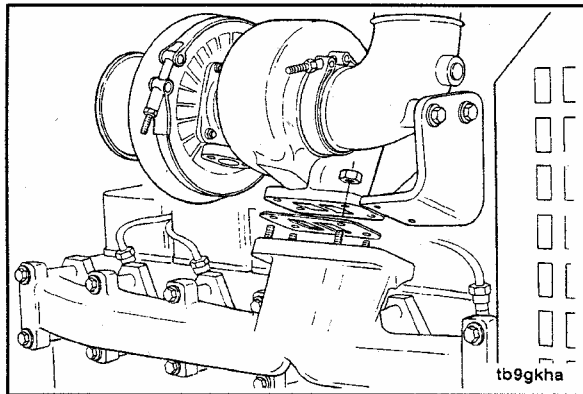
Follow the sequence shown.





Turbocharger - Installation (0-116)

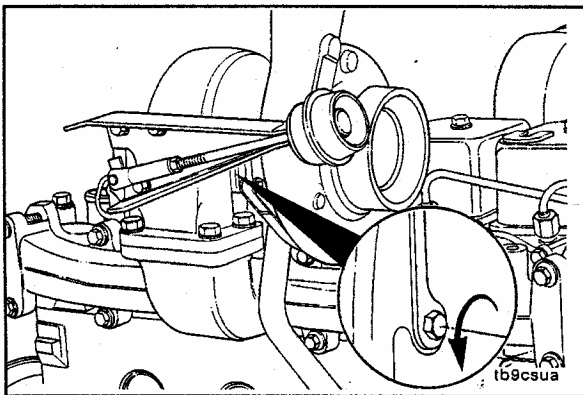
Install the turbocharger gasket and apply anti-seize compound to the mounting studs.



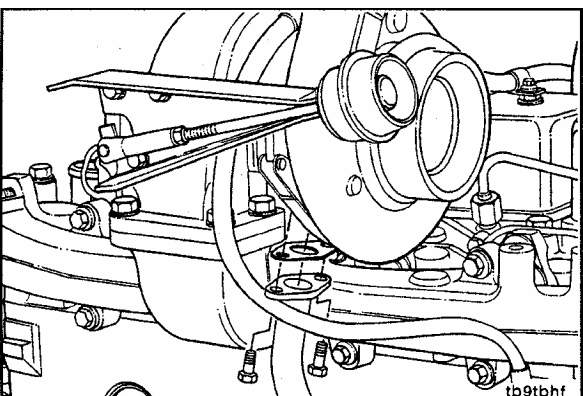
15 mm

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]



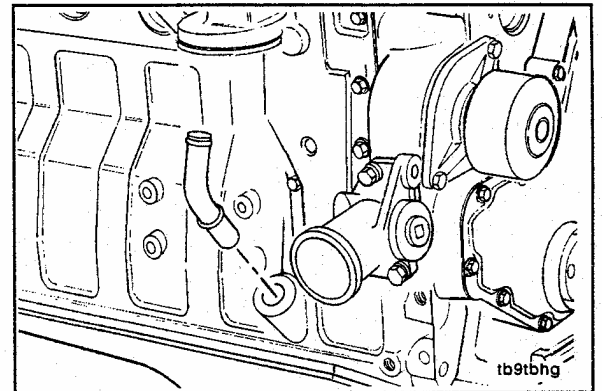
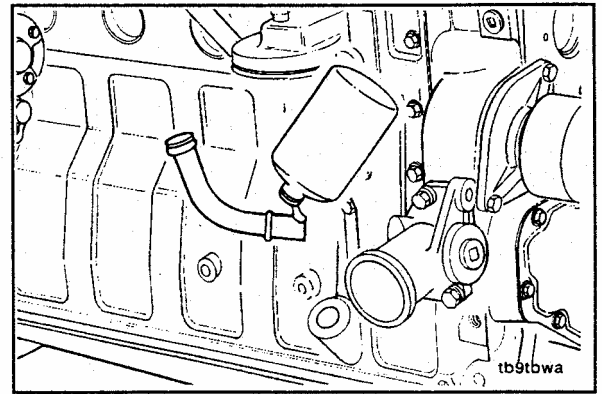
If the drain tube in the block was removed, apply sealant, Cummins P/N 3375068, Loctite P/N 24231, or NSN 8030-01-014-5869 to the sealing surfaces.

NOTE

See Sealants information in TM 5-3810-307-24-2,-1, page V-17.

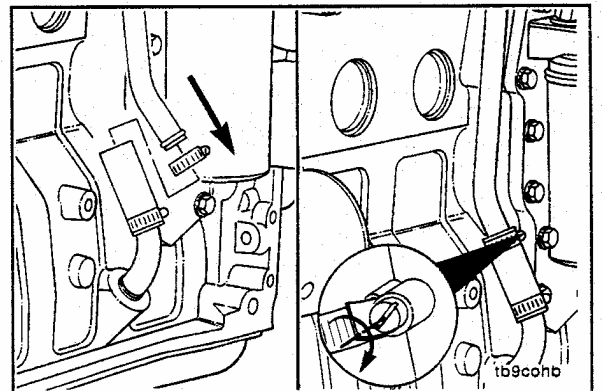
22 mm Open End Wrench, Hammer

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



Screwdriver

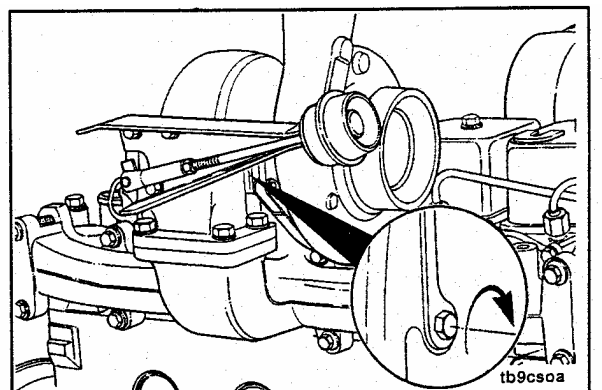
Position the turbocharger drain hose to connect the drain tubes; tighten the clamps.

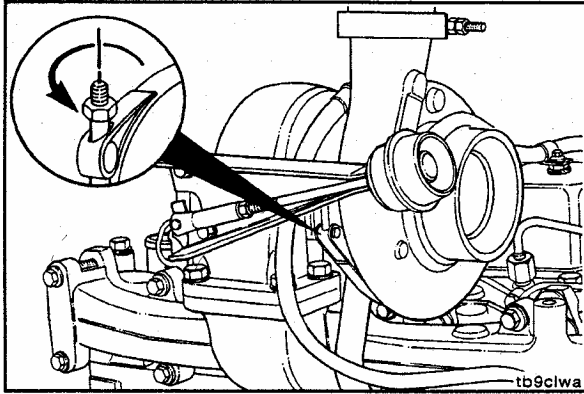


13 mm

If loosened, tighten the turbocharger turbine housing capscrews.

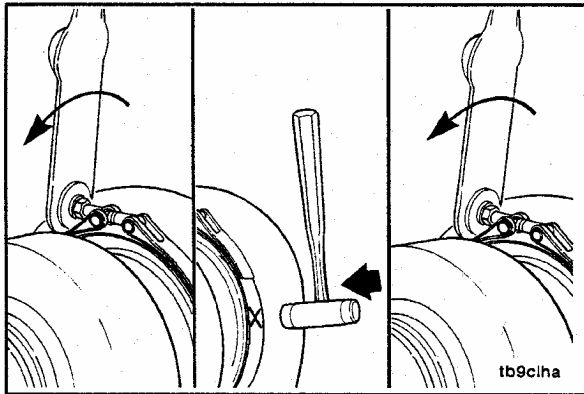
Torque Value: 20 N•m [15 ft-lb]





7/16 Inch

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

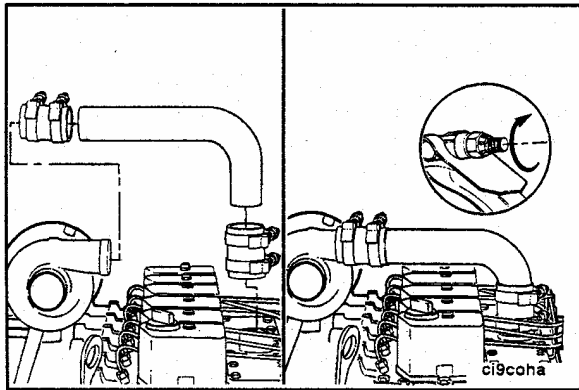


7/16 Inch Plastic Hammer

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



Torque Value: 8.5 N•m [75 in-lb]

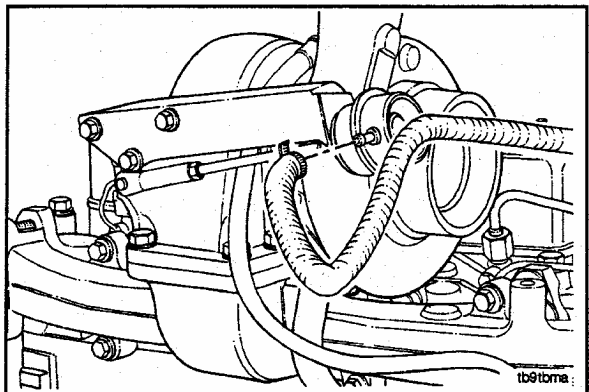


Screwdriver or 5/16 inch

Install the air crossover tube and clamps and tighten.



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

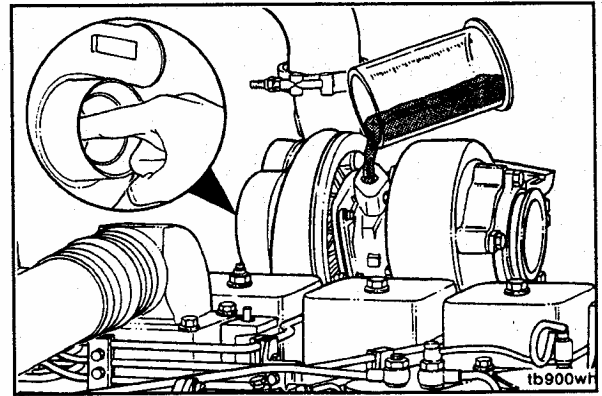


Install the boost control capsule actuator hose.

CAUTION

The Turbocharger must be prelubricated.

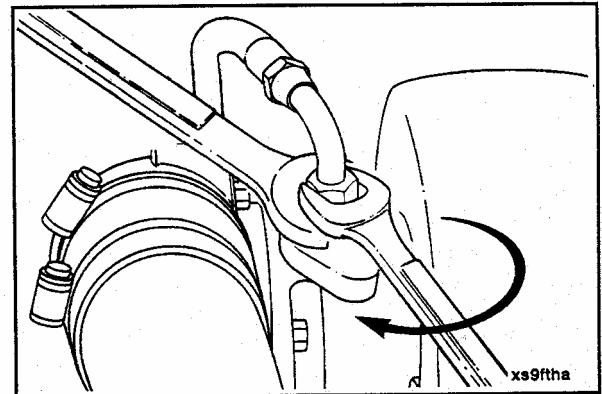
Pour 50 to 60cc [2 to 3 oz.] of clean engine oil into the oil inlet fitting on top of the turbocharger while spinning the turbocharger impeller to distribute the oil in the bearing.

**16 mm and 19 mm**

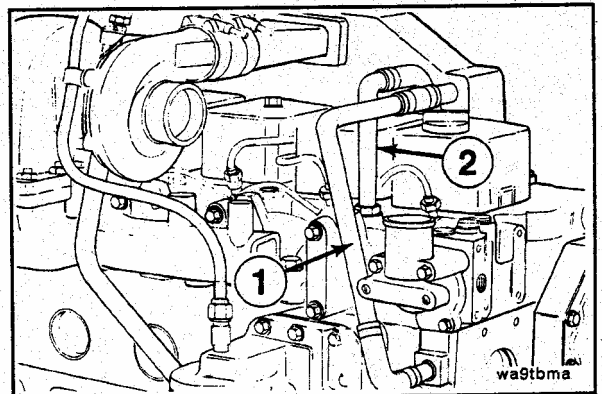
Install the oil supply line.

Tighten the fittings securely.

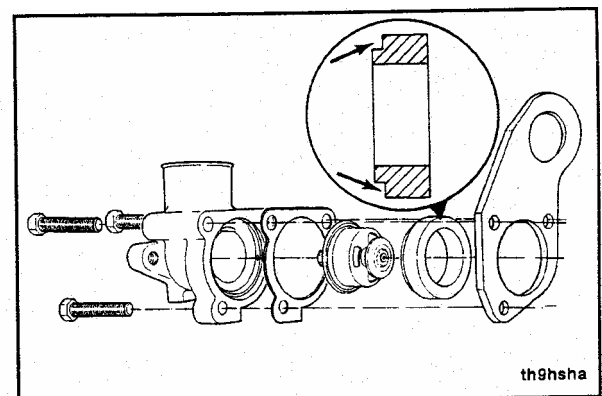
Torque Value: 15 N•m [11 ft-lb]
35 N•m [26 ft-lb] (on turbocharger)

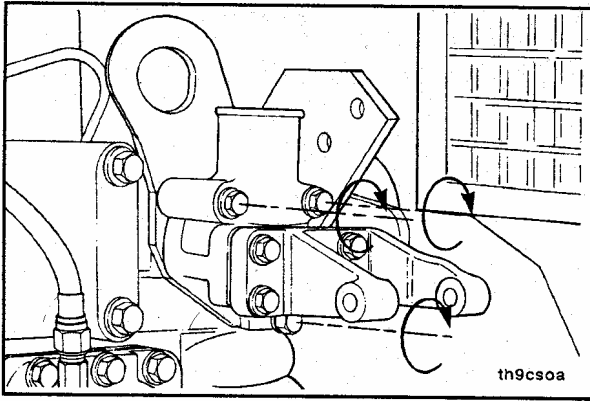


Connect the aftercooler coolant supply tube (1) and the coolant return tube (2).

**Thermostat - Installation (0-117)**

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

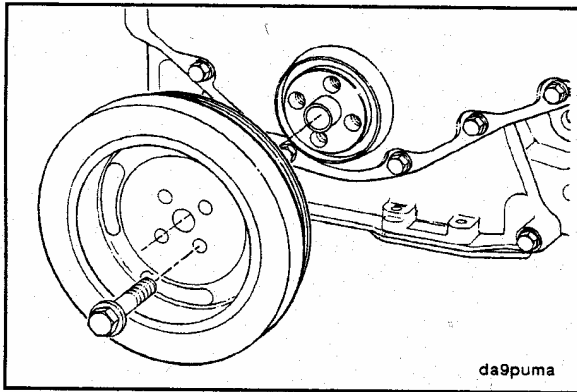




10 mm

Install the "package".

Torque Value: 24 N•m [18 ft-lb]

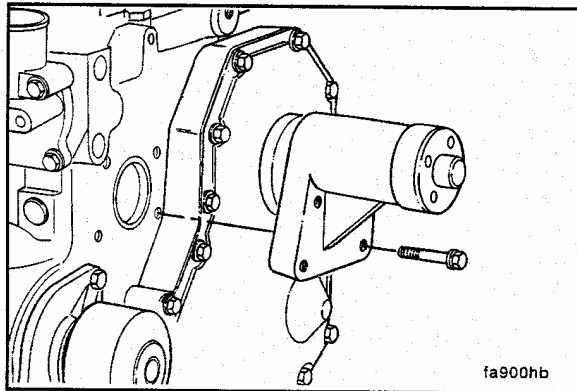


Vibration Damper - Installation (0-118)

15 mm

Install the crankshaft pulley/vibration damper.

Torque Value: 125 N•m [92 ft-lb]

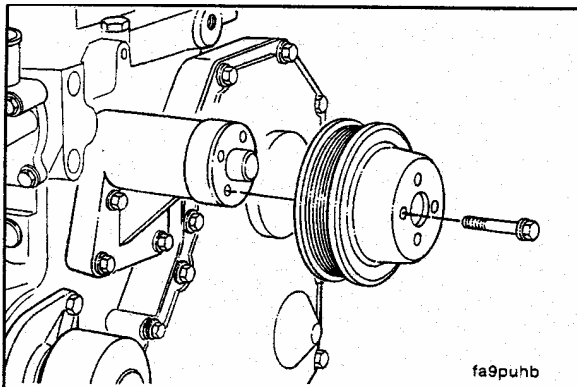


Fan Hub - Installation (0-119)

10 mm

Install the fan hub.

Torque Value: 24 N•m [18 ft-lb]



13 mm

Install the fan hub pulley.

Torque Value: 43.4 N•m [32 ft-lb]

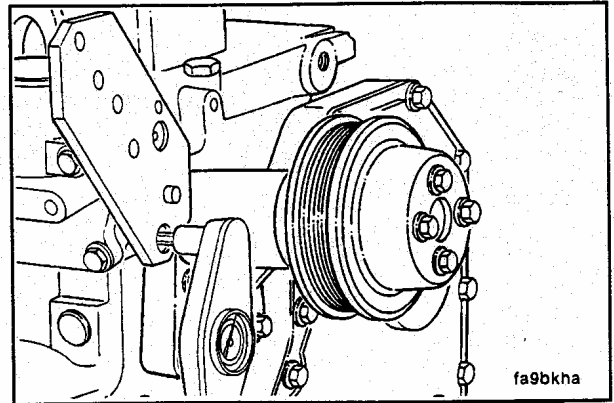
Belt Tensioner - Installation (0-120)

5 mm Allen

Install the tensioner bracket to the cylinder head.

Tighten the socket head screws.

Torque Value: 24 N•m [18 ft-lb]



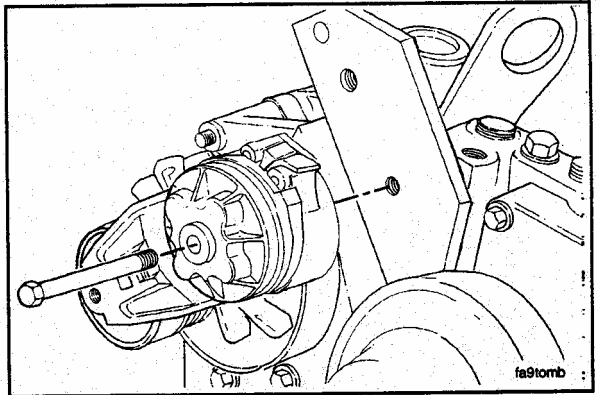
13 mm

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.

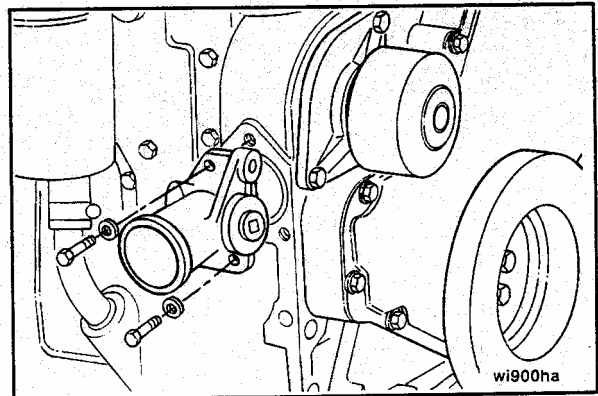


Water Inlet Connection - Installation (0-121)

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.

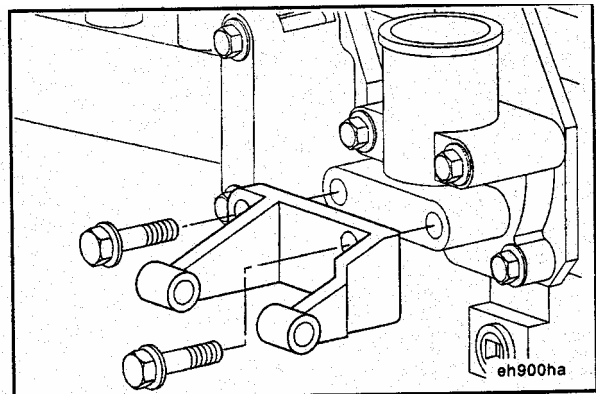


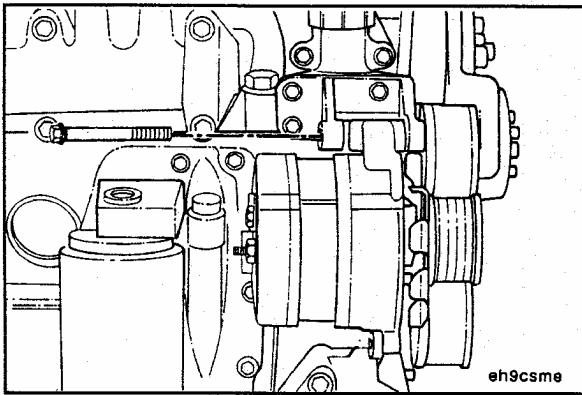
Alternator - Installation (0-122)

10 mm

Assemble the alternator bracket to the thermostat housing.

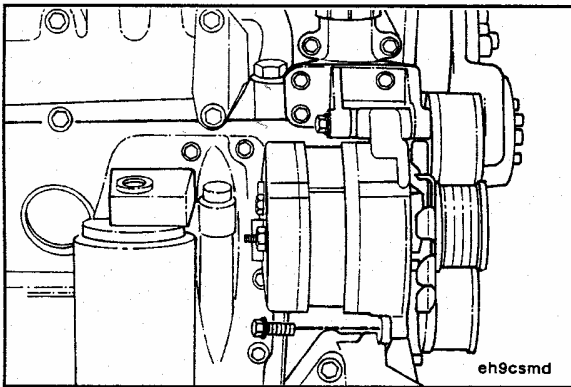
Torque Value: 24 N•m [18 ft-lb]





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

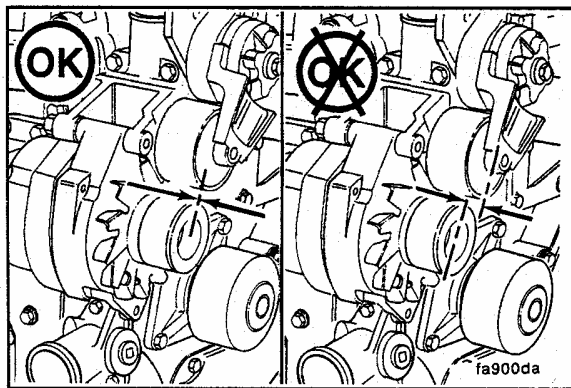
Do not tighten at this time.



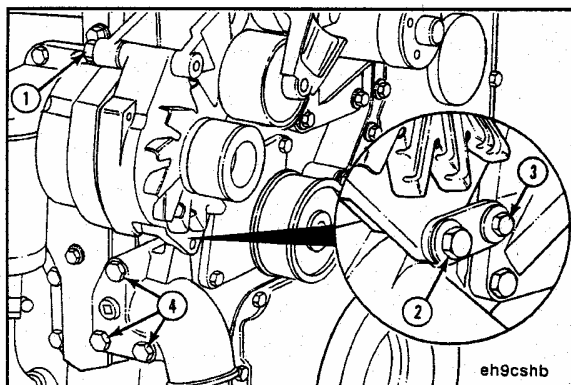
CAUTION

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

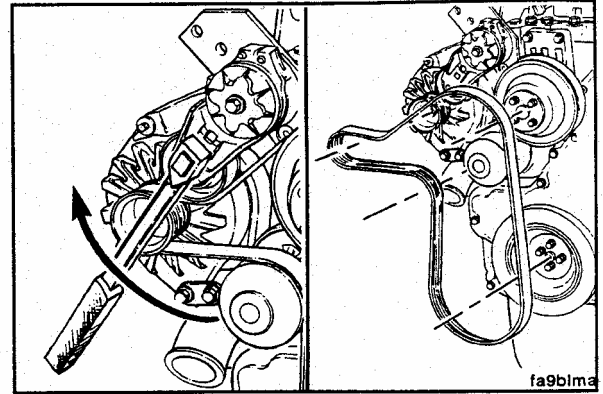
Wrench size and torque value is determined by the make and model of alternator. Refer to the Engine Component Torque Values.

Drive Belt - Installation (0-123)

3/8 inch Square Drive

Lift the tensioner and install the belt.

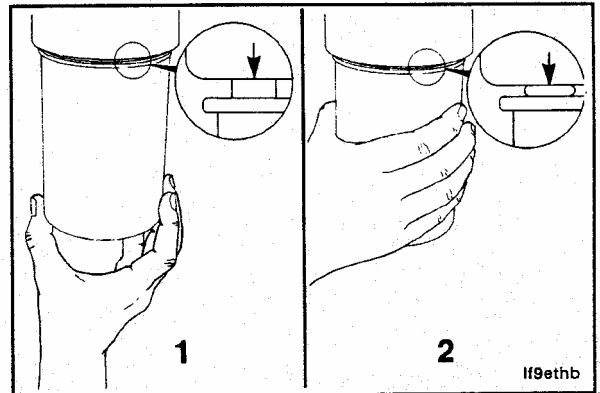
Service Tip: If difficulty is experienced installing the drive belt (the belt seems too short), position the belt over the grooved pulleys first and then while holding the tensioner up, slide the belt over the water pump pulley.



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 LF3349, Grove P/N 6908615 [9-414-100813 (12361)], or NSN 2940-01-280-8419 (all are interchangeable).

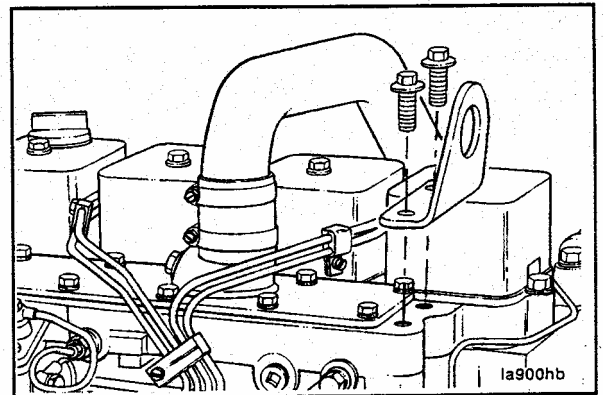


Rollover Stand - Engine Removal (0-125)

18 mm

Install the rear lifting bracket.

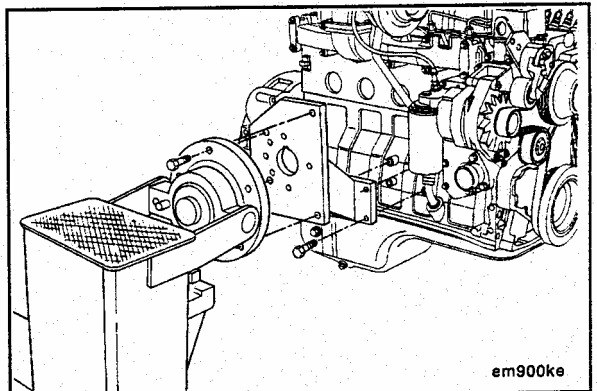
Torque Value: 77 N•m [57 ft-lb]

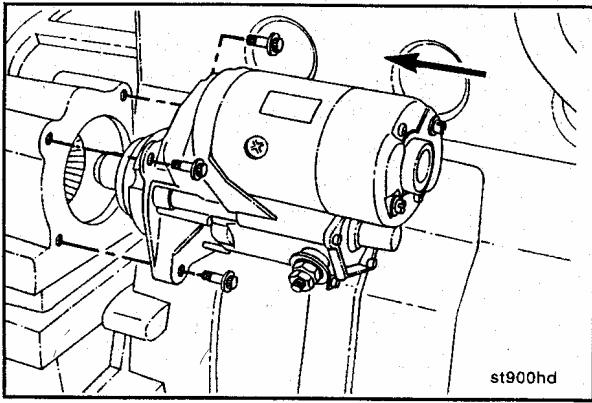


Remove the engine from the rollover stand.

Engine Weight

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

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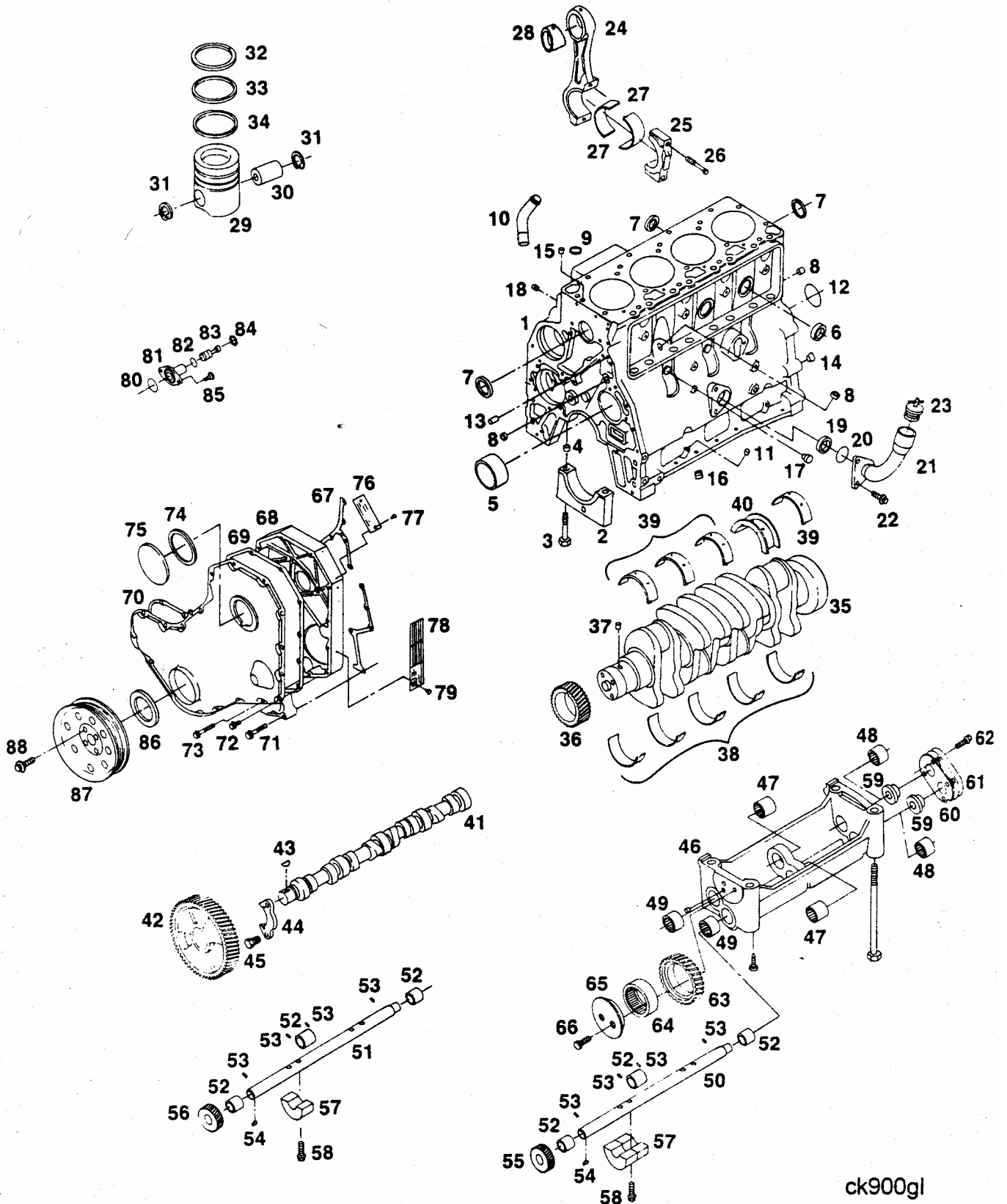
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NOTES

[illegible]

Cylinder Block – Exploded View



ck900gl

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	M5-0.8x17
85	Screw, Round Hex (Torx)	2	
86	Seal, Front Crank	1	
87	Pulley, Crankshaft	1	M12-1.25x36
88	Screw, Hex Head (Flange)	4	

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.

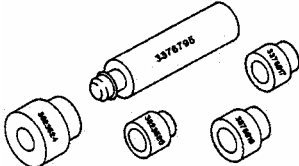
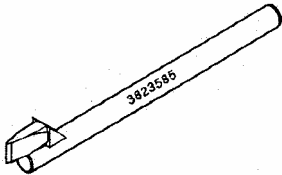
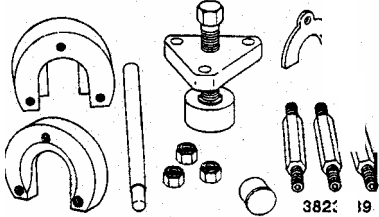
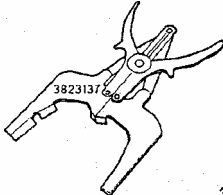
Vibration Damper

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.

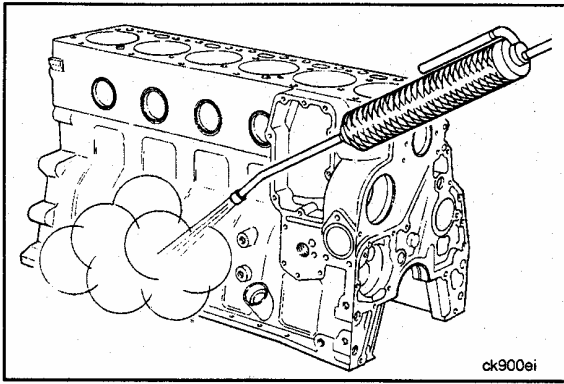
Cylinder Block - Service Tools

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

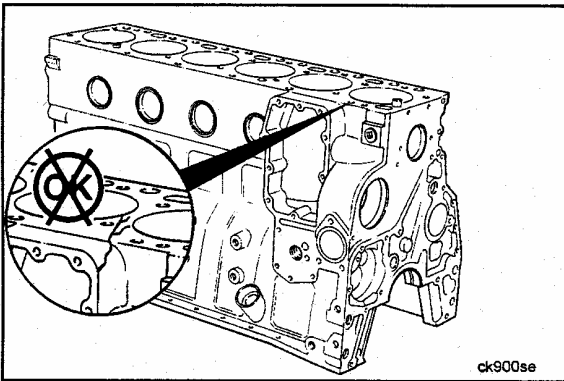
Cylinder Block Group Inspection Checklist

- 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..... ☐

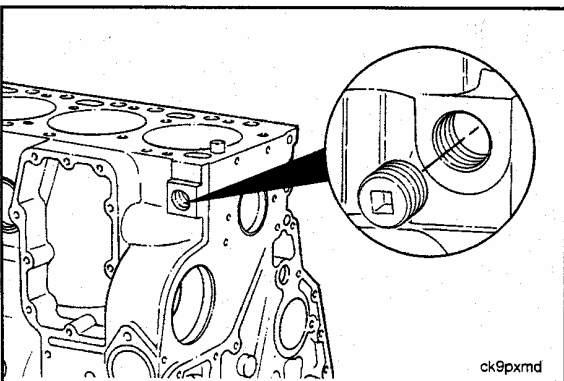


Cylinder Block Precheck Before Disassembly (1-01)

Thoroughly clean the cylinder block with steam.



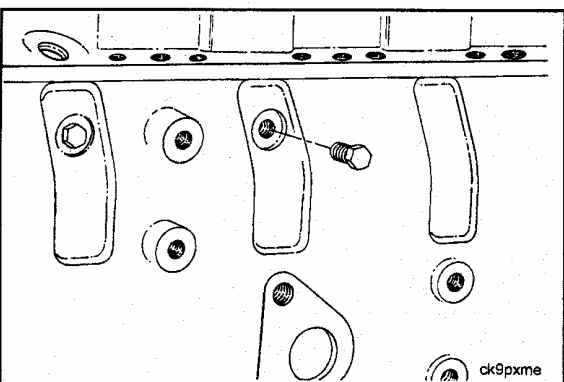
Visually inspect the cylinder block for damage that would prohibit reuse.



Cylinder Block - Disassembly (1-02)

3/8 Inch Square Drive

Remove the pipe plug from the water passage.



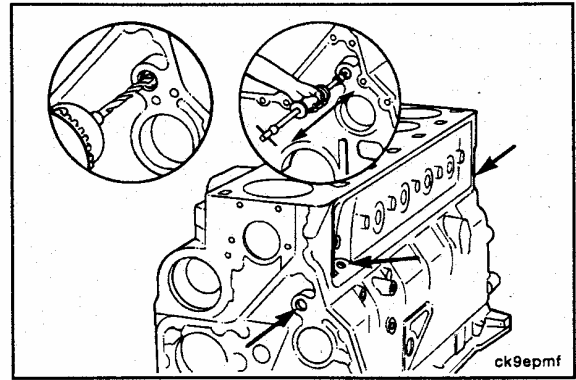
11mm

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.

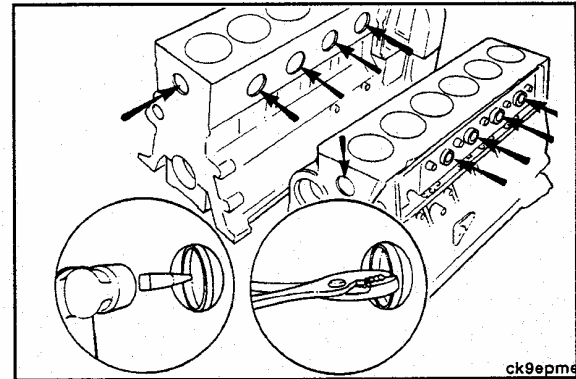


Punch, Visegrips®, Hammer

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

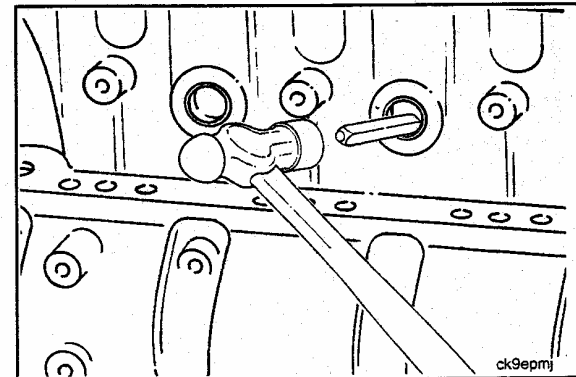
Care should be taken not to drive the expansion plug into the water jacket, especially the plug on the end of the block.

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.



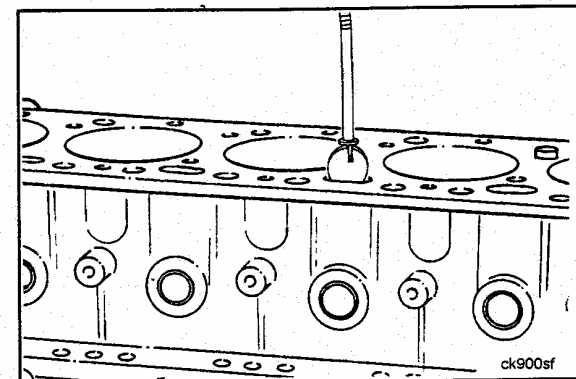
Hammer, Punch

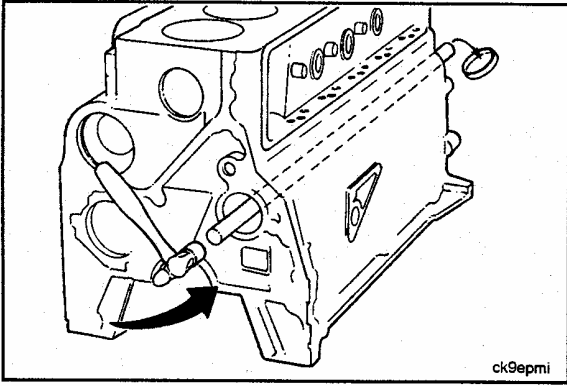
Remove the small expansion plugs (25.07 mm [1 in.]) by driving the plugs into the water jacket.



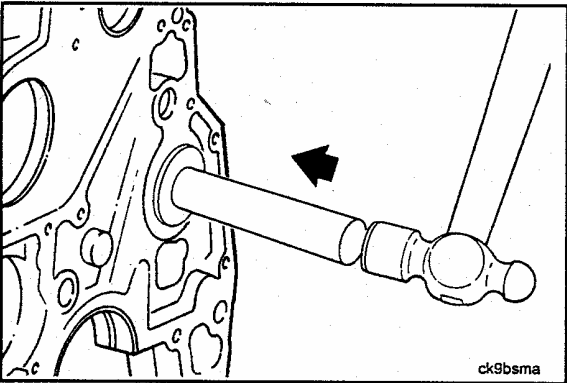
Mechanical Fingers

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



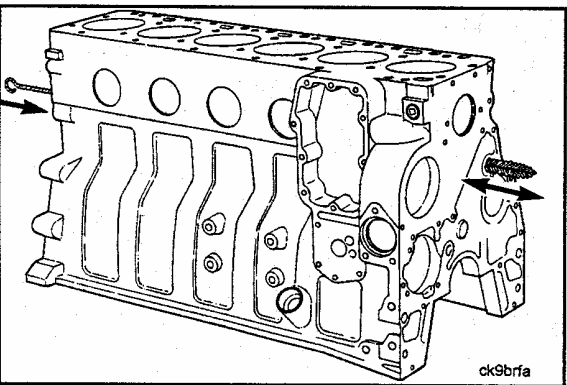


Remove the expansion plug from the camshaft bore.



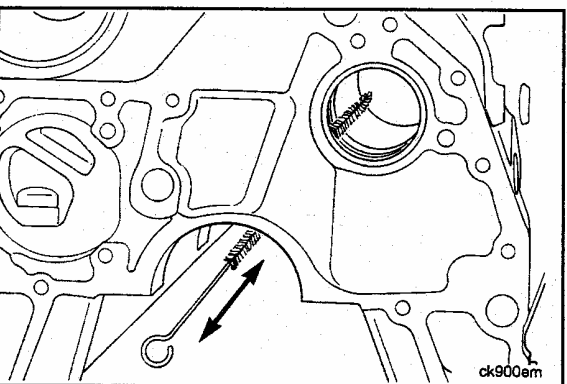
Universal Bushing Installation Tool

Remove the camshaft bushing.



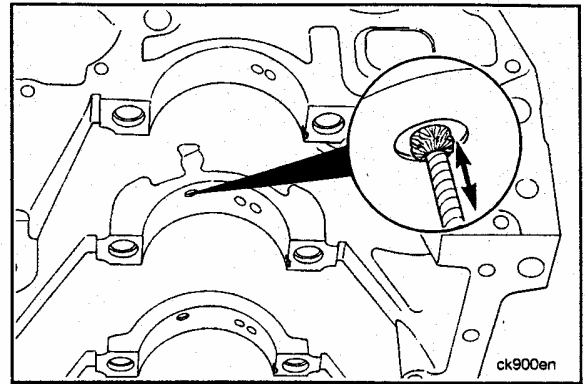
Cylinder Block - Cleaning (1-03)

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

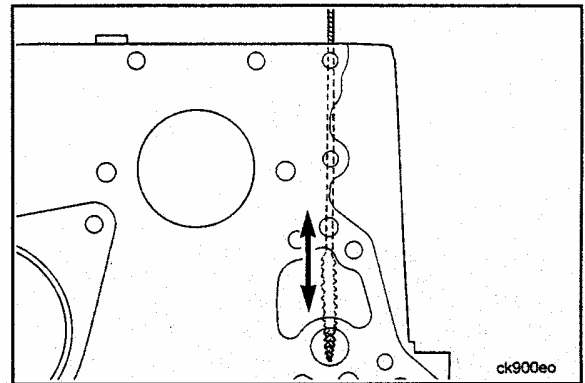


Use clean solvent and a brush to clean the main bearing to cam bore oil drilling.

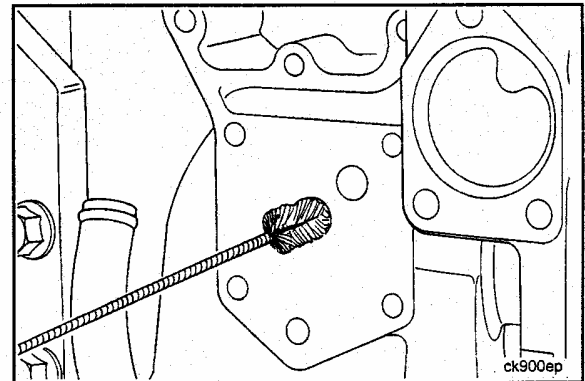
Use clean solvent and a brush to clean the piston cooling nozzle bores.



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

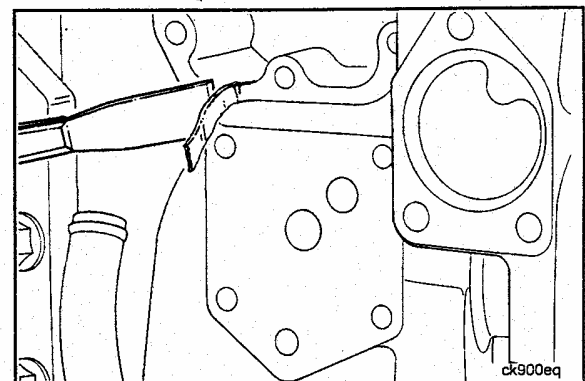


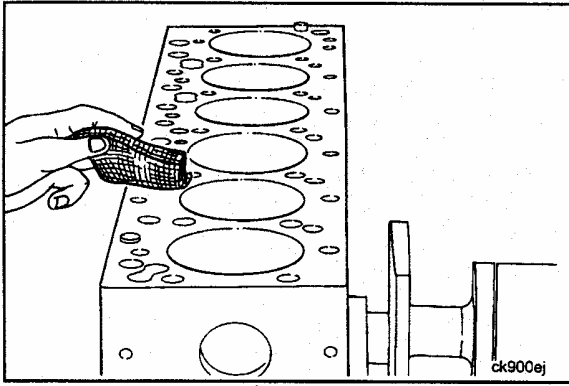
Use clean solvent and a brush to clean the oil cooler oil passages.



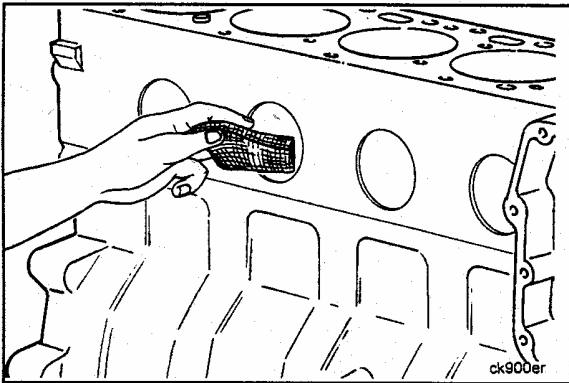
Gasket Scraper

Thoroughly clean all gasket sealing surfaces.



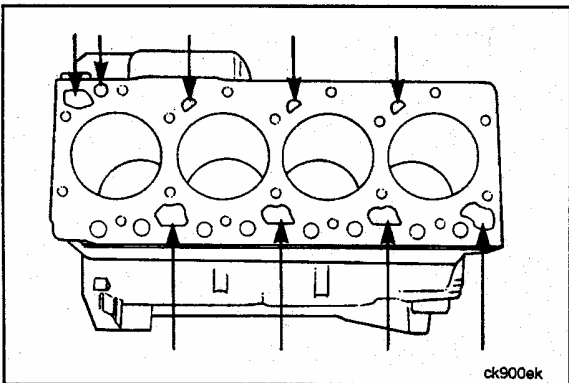


Clean the combustion deck with a Scotch-Brite® cleaning pad or equivalent and diesel fuel or solvent.



Brush, 400 Grit Sandpaper, Diesel Fuel

Thoroughly clean all cup plug holes.

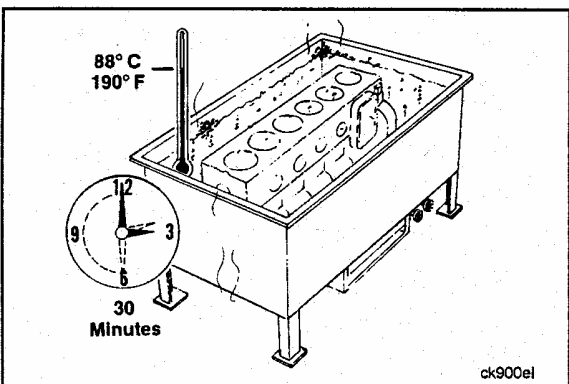


CAUTION

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.

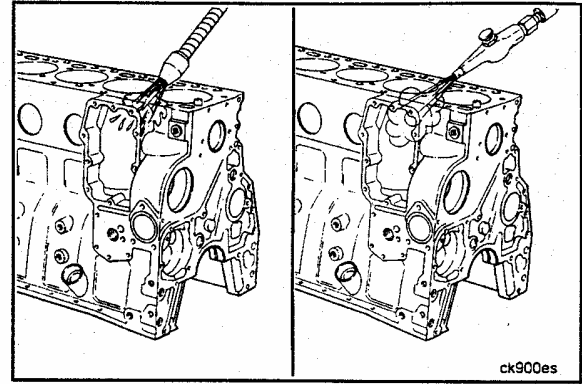


WARNING

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.

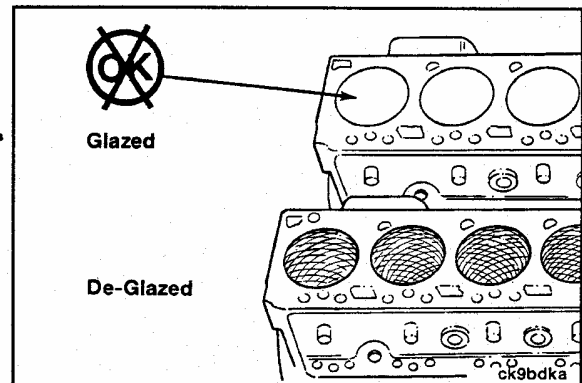


Cylinder Block - Inspection (1-01)

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.

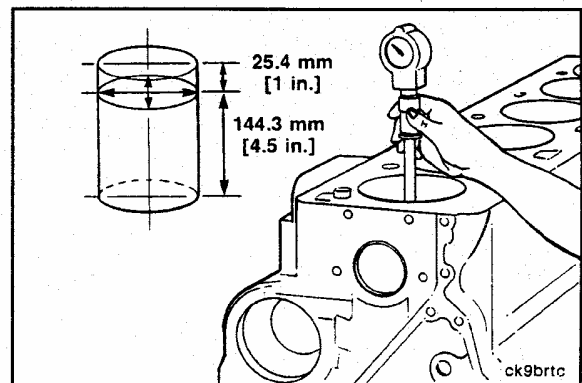
Measure the cylinder bores.

Diameter		
mm		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.

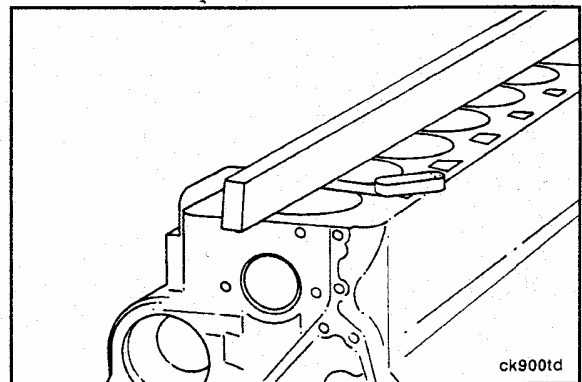


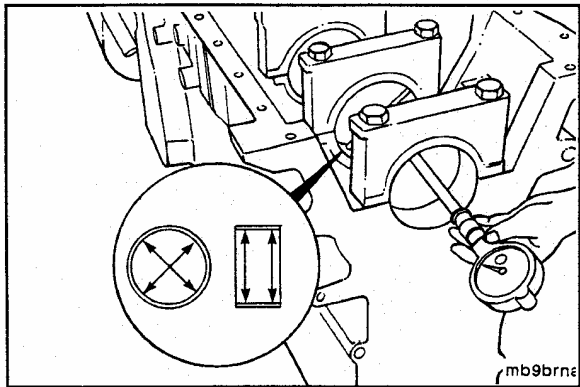
Measure the cylinder block overall flatness:

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.





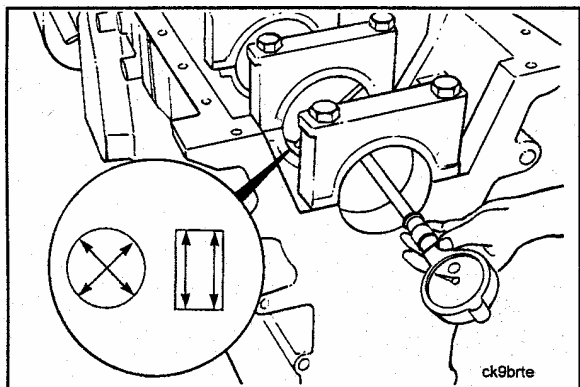
Inspect the main bearing bores for damage or abnormal wear.

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

NOTE

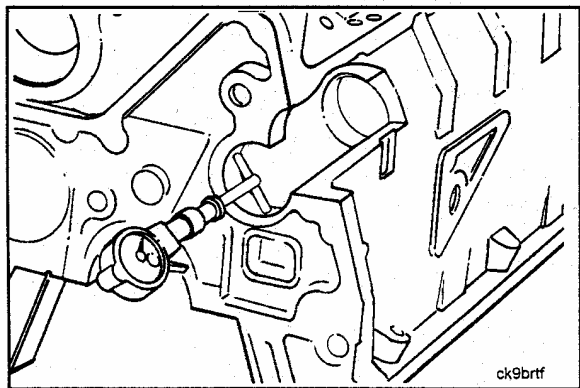
Record this measurement for use in determining main bearing clearance as described in procedure (1-12).

Diameter		
mm		in
83.106	MAX	3.2720



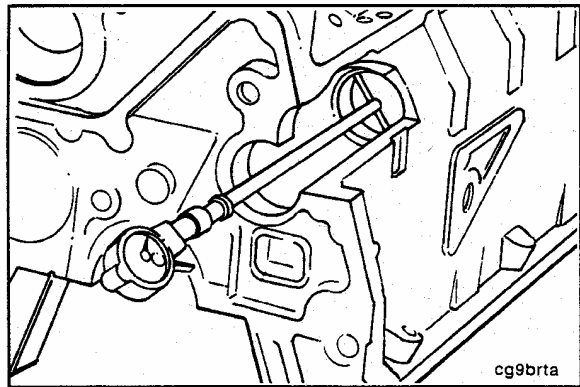
Remove the bearing and install the main bearing cap. Torque the main bearing capscrews to 176 N•m [130 ft-lb]. Measure the main bearing bore with the bearing removed.

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



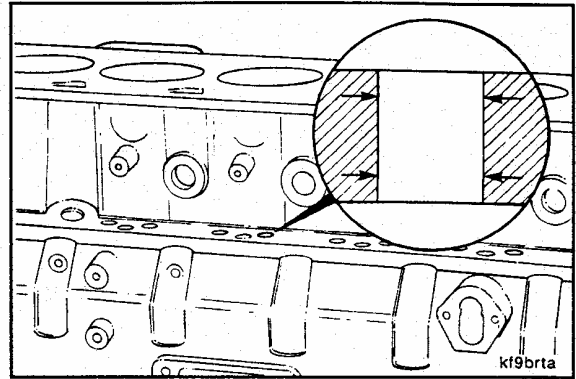
Measure the diameter of camshaft bores No. 2 through No. 5.

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.

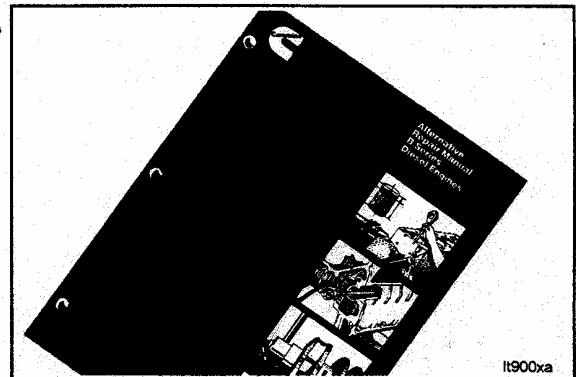
Inspect the tappet bores for scoring or excessive wear.

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 resurfacing information.

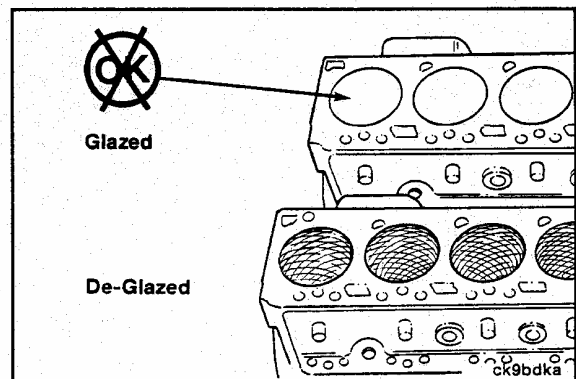


Cylinder Block - De-Glazing (1-05)

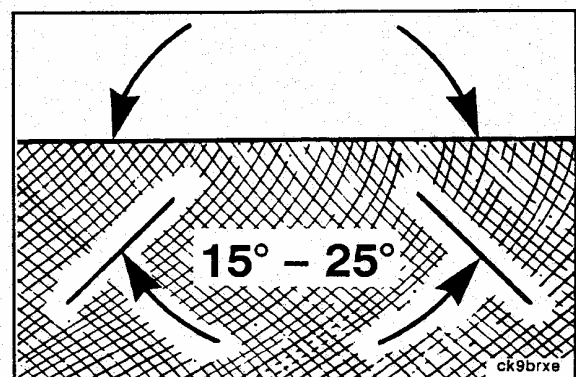
New piston rings may not seat in glazed cylinder bores.

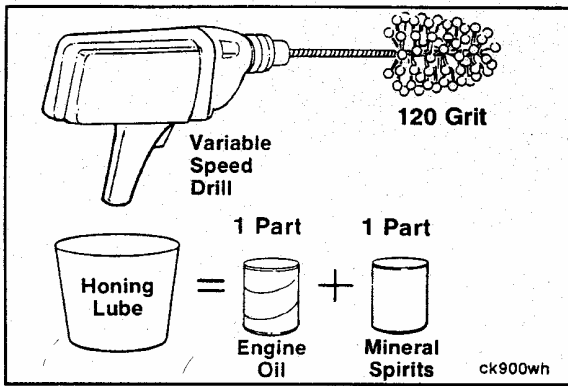
De-glazing makes the bore "rough" to help seat the rings. The size of the bore is not changed by proper de-glazing.

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

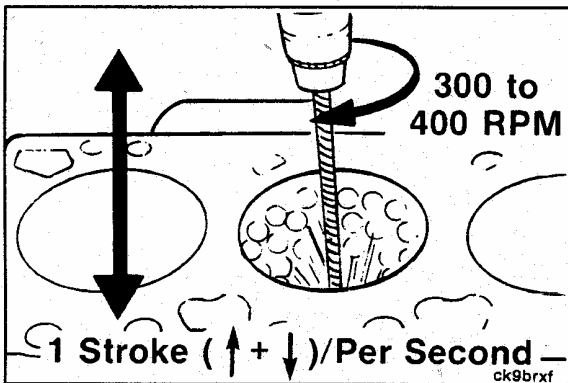


A correctly de-glazed surface will have a crosshatched appearance with the lines at 15 to 25 degree angles with the top of the cylinder block.

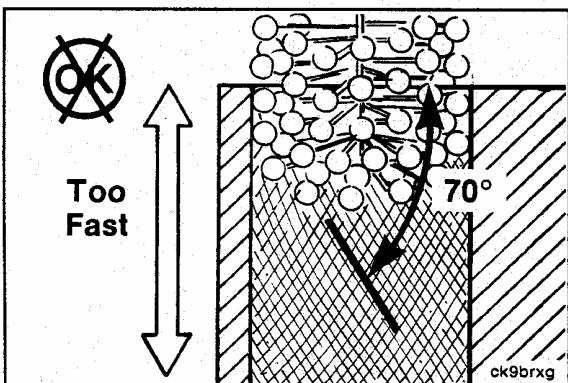




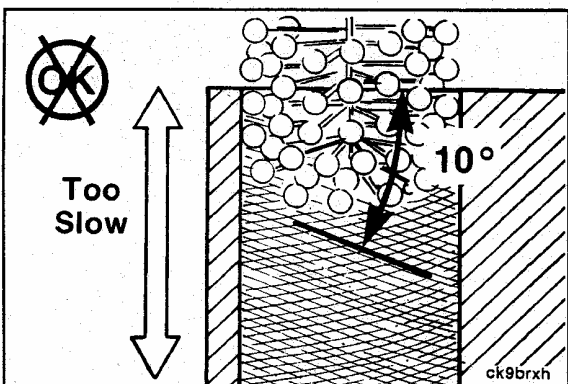
Use a drill, a medium grit Flexi-Hone and a mixture of equal parts of diesel fuel and SAE 30W engine oil to de-glaze the bores.



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**.

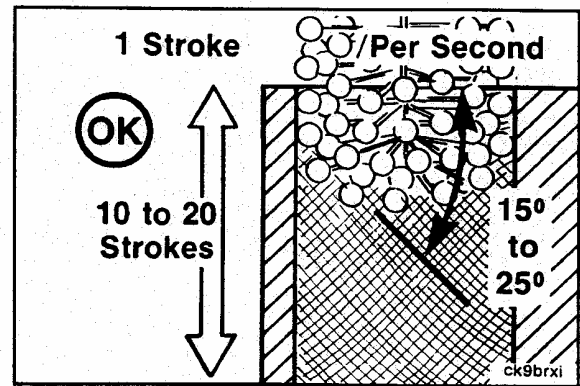


This illustration shows the result of the drill speed is too fast or the vertical stroke is **too slow**.

NOTE

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

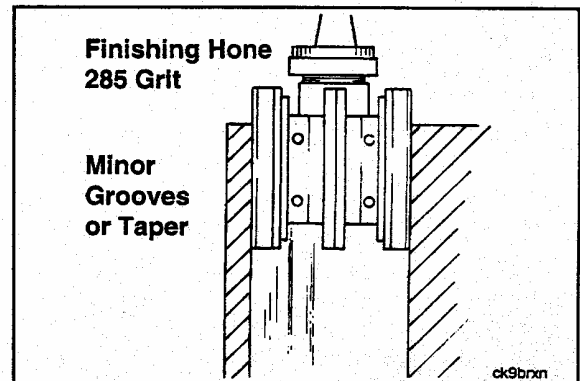
Inspect the bore after 10 strokes.

**CAUTION**

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

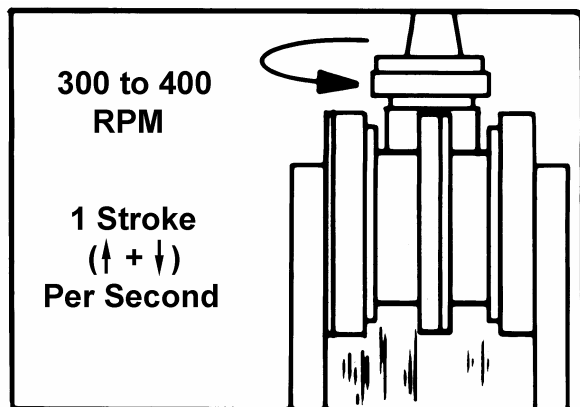
A sizing hone can be used to remove minor grooves or to correct minor out of taper.

Taper: 0.076 mm [0.003 in]



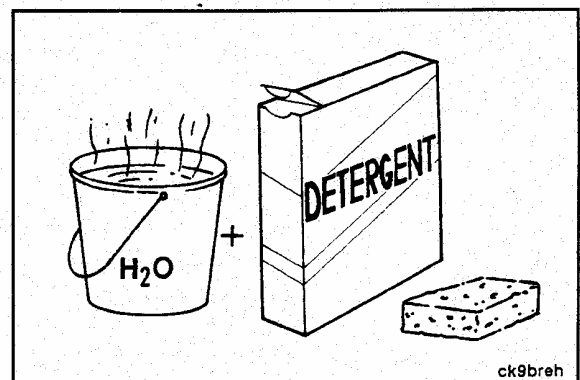
Operate the sizing hone similarly to the Flexi-Hone.

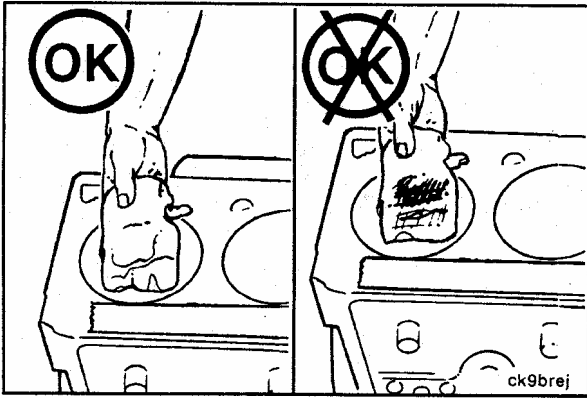
Inspect the bore after 10 strokes.



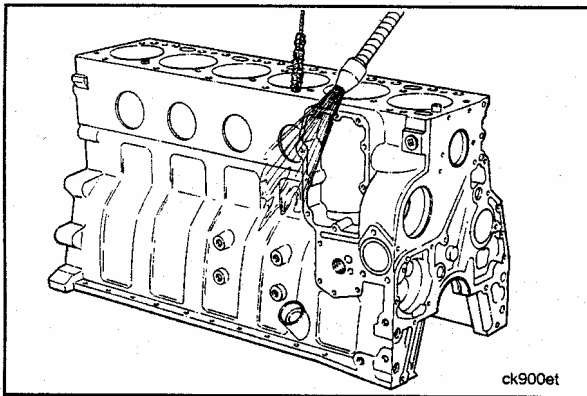
Immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, use compressed air to dry the block.

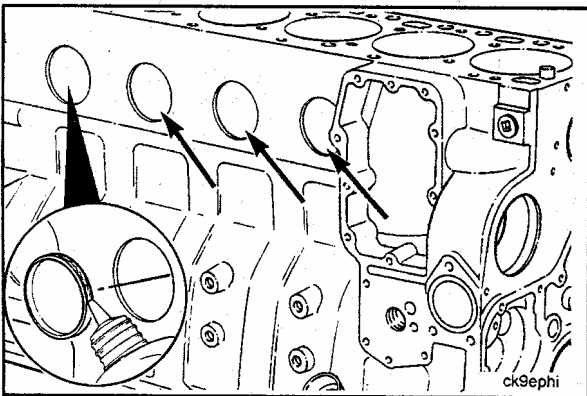




Check the bore cleanliness by wiping with a white, lint free, lightly oiled cloth. If grit residue is still present, re-clean.



Wash the block in solvent.
Use a brush to clean all oil passages.



Expansion and Pipe Plug – Installation (1-06)

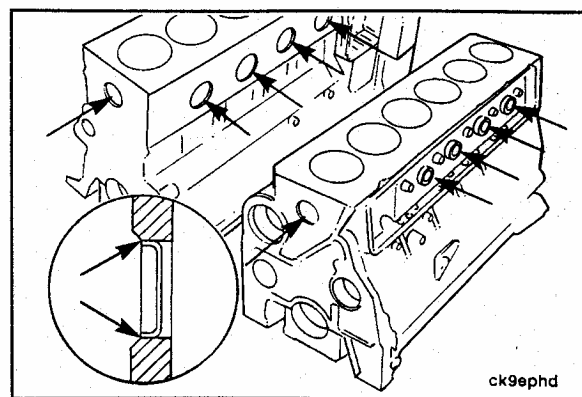
All expansion plug bores in the block are machined to a standard english dimension (i.e., 11/16 in, 1-1/4 in, etc.). To achieve the correct press fit of the expansion plug in the bore, the expansion plug must be larger than the bore diameter and the expansion plug driver must be smaller than the bore 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 countersink in the block.

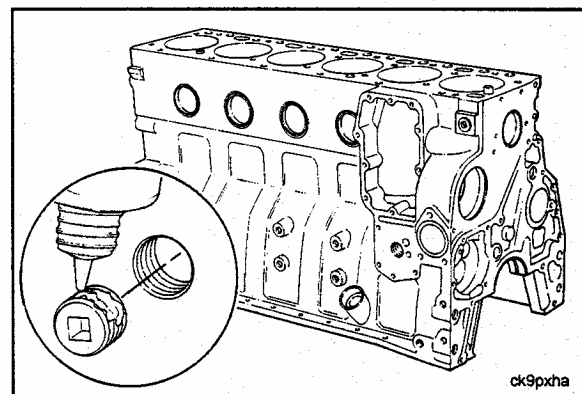
Refer to procedure (1-07) for camshaft expansion plug installation.



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.



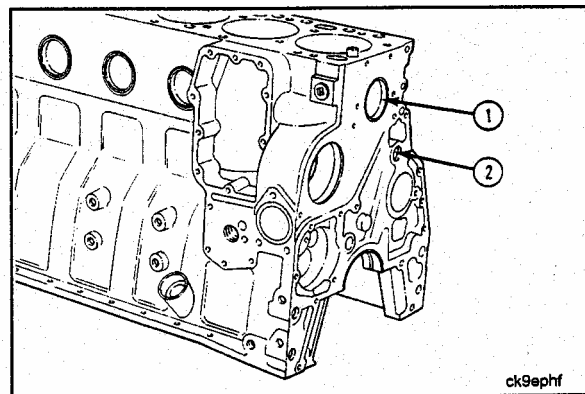
Pipe Plug Torque Values						
Size			Torque		Torque	
Thread	Actual Thread O.D.		In Aluminum Components		In Cast Iron or Steel Components	
	mm	[in]	Nom	[ft-lbs]	Nom	[ft-lbs]
1/16	8.1	[0.32]	5	[45 in-lb]	15	[10]
1/8	10.4	[0.41]	15	[10]	20	[15]
1/4	13.7	[0.54]	20	[15]	25	[20]
3/8	17.3	[0.68]	25	[20]	35	[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]
1 1/4	42.2	[1.66]	75	[55]	115	[85]
1 1/2	48.3	[1.90]	85	[65]	135	[100]

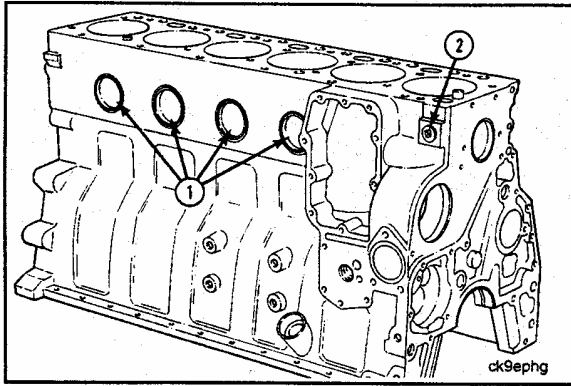
ck8ppoa

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

Expansion plug locations. Front of block.

1. Expansion Plug Part No. 3922072 (58.06 mm)
2. Expansion Plug Part No. 3900956 (17.73 mm)

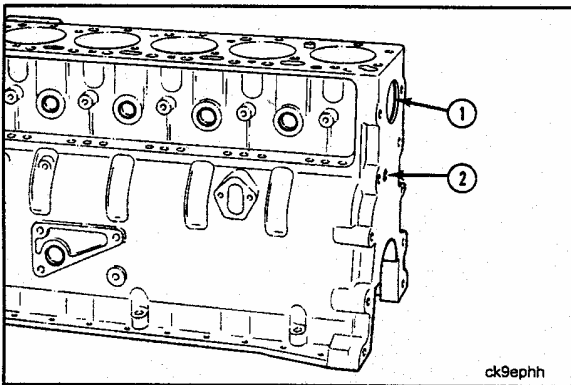




Driver Part No. 3823524 (Coolant Passages)

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

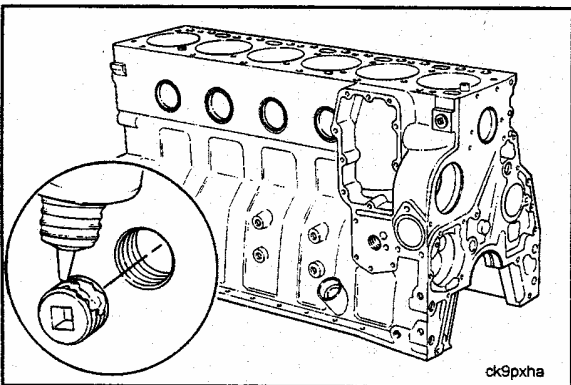
1. Expansion Plug Part No. 3922072 (58.06 mm)
2. Pipe Plug Part No. 3008468, 0.50 in (1/2 in)
3. Pipe Plug Part No. 3008469, 0.75 in (3/4 in) NPT
4. Expansion Plug Part No. 3900956 (17.73 mm)



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

Expansion plug locations. Rear of block.

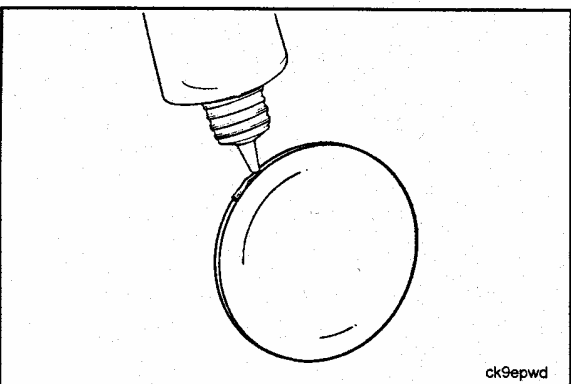
1. Expansion Plug Part No. 3922072 (58.06 mm)
2. Expansion Plug Part No. 3900956 (17.73 mm)



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. 3914035 (25.75 mm)
2. Expansion Plug Part No. 3900955 (9.80 mm)
3. Expansion Plug Part No. 3900958 (32.03 mm)
4. Pipe Plug P/N 3678923, 0.125 in (1/8 in) NPTF Hex Head
5. Threaded Plug Part No. 3678921 M10 x 1.00 x 9.5
6. O-ring Plug Part No. 3932296 and Screw Part No. 3926047

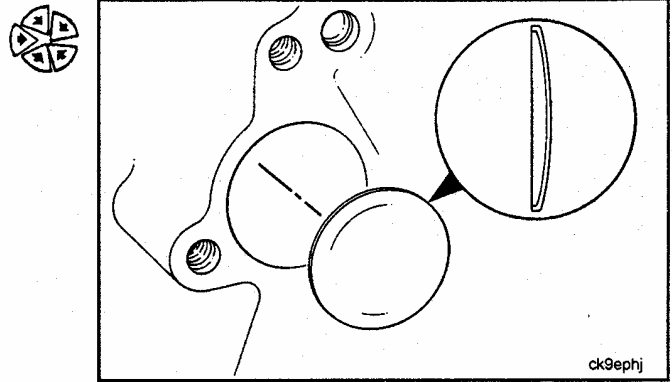


Camshaft Expansion Plug – Installation (1-07)

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

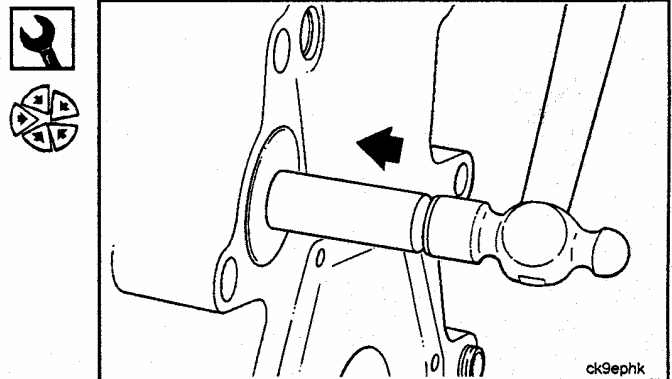
1. Expansion Plug Part No. 3900687

Position the plug with the convex side out.

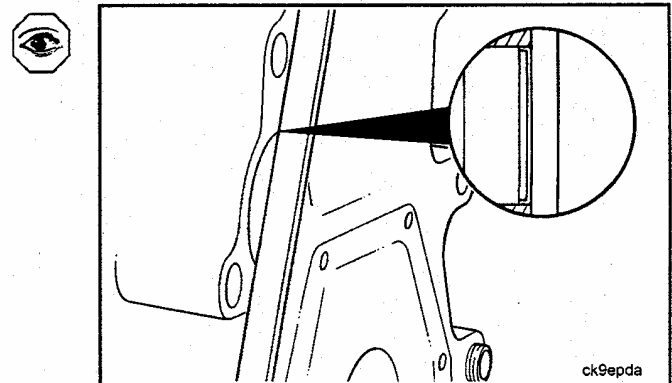


Large Drift, Hammer

Expand the plug with a large drift and a hammer.

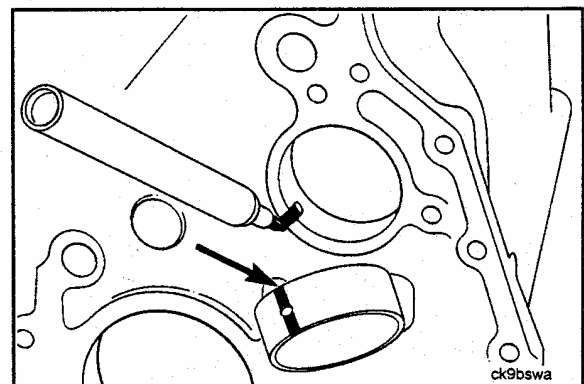


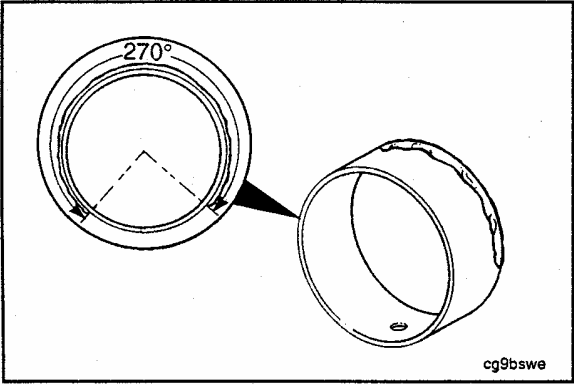
Expand the plug until the convex side is flush with the block.



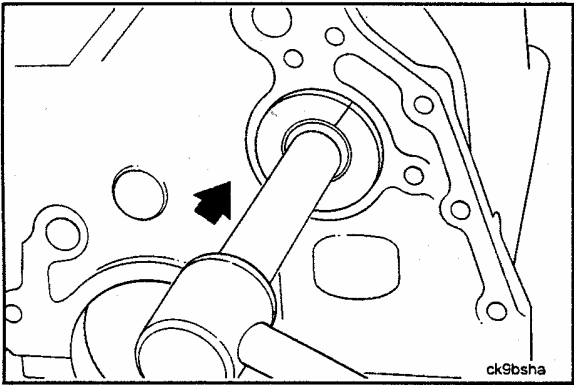
Camshaft Bushing – Installation (1-08)

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



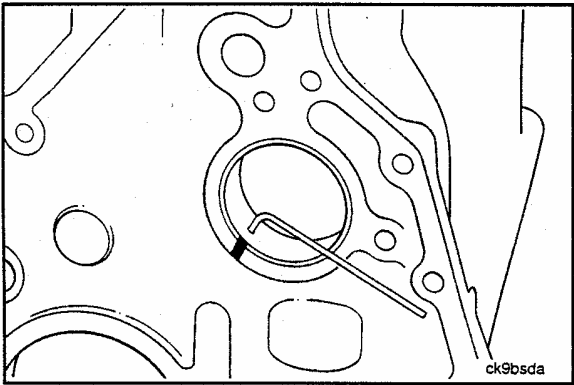


Apply a bead of Loctite™ 609 to the edge of the bushing that will be installed to the rear of the bore. Apply the Loctite™ to 270 degrees of the diameter of the bushing, see the illustration. Use care to not apply Loctite™ near to or in line with the oil hole.



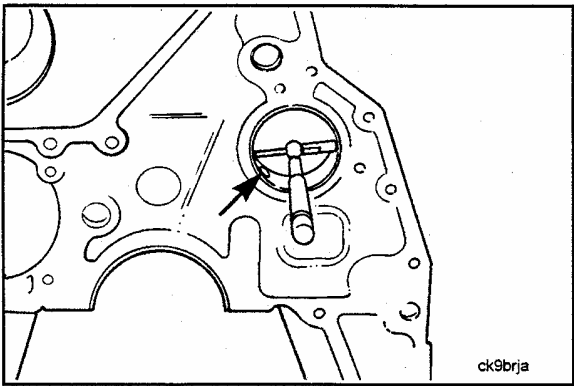
Universal Bushing Installation Tool

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.



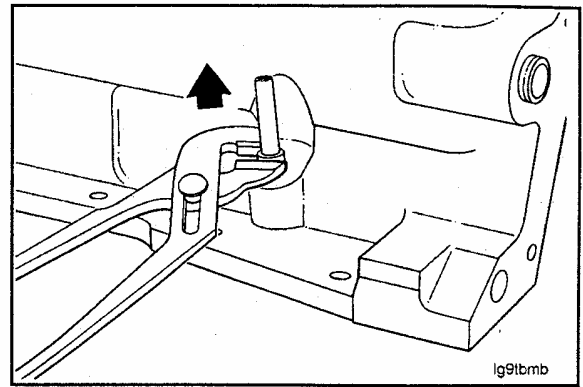
Measure the installed camshaft bushing.

Camshaft Bushing Bore		
mm		in
54.107	MIN	2.1302
54.146	MAX	2.1317

Dipstick Tube - Replacement (1-09)

Pliers

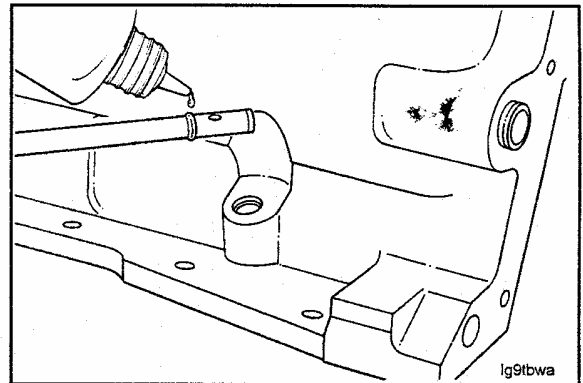
If the dipstick tube is loose or damaged, remove it from the cylinder block.



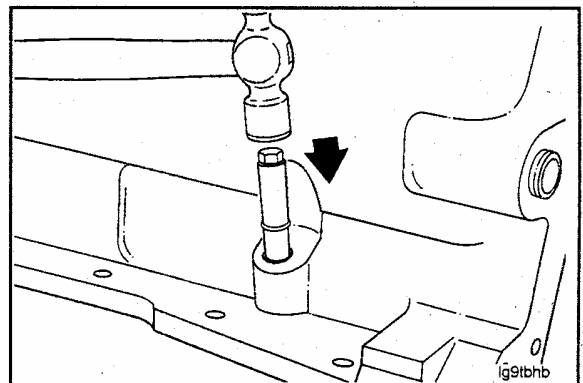
Apply sealant, Cummins P/N 3375068, Loctite P/N 24231, or NSN 8030-01-054-0740 to the new dipstick tube.

NOTE

See Sealants information in TM 5-3810-307-24-2-1, page V-17.

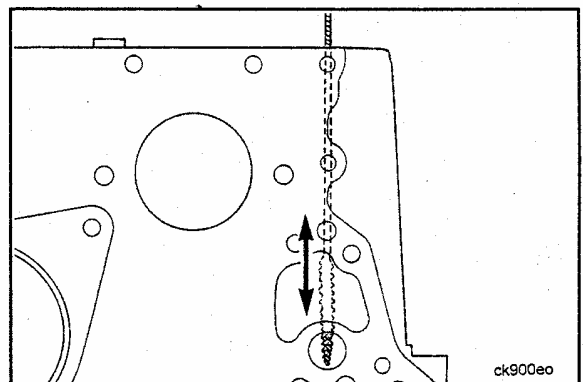


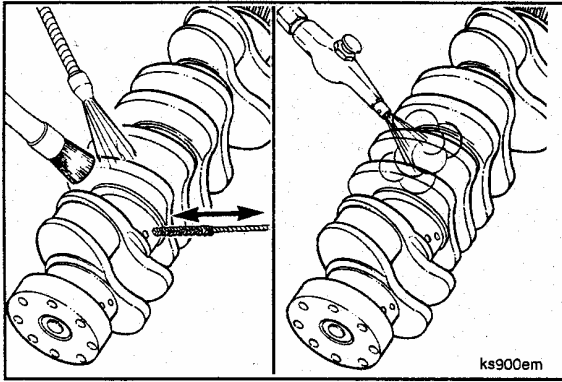
Use a hex head capscrew to drive the tube into the block.



Cylinder Block - Storing (1-10)

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

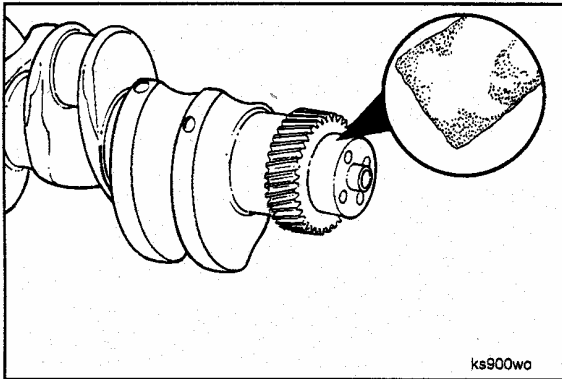




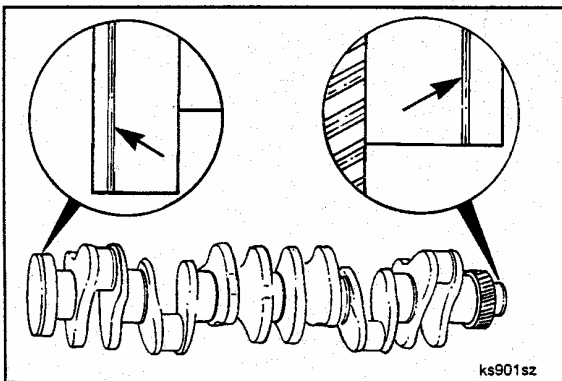
Crankshaft - Cleaning (1-11)

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.

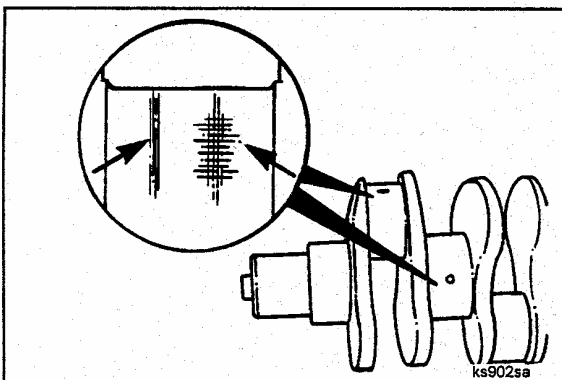


Crankshaft - Inspection (1-12)

Inspect the crankshaft seals wear surfaces for scratches or grooving.

NOTE

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.

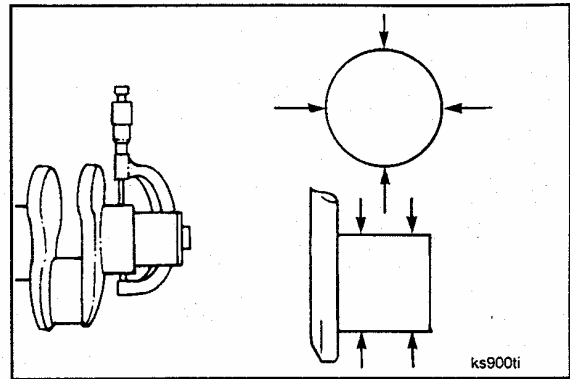
Main Bearing Journal Diameter		
mm		in
82.962	MIN	3.2662
83.013	MAX	3.2682

Out-of-Roundness: 0.050mm [0.002 in]

Taper: 0.013mm [0.0005 in]

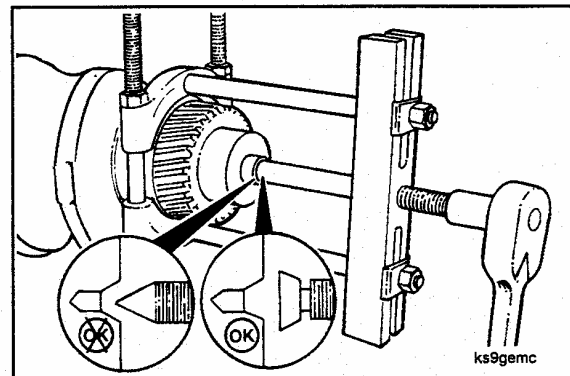
Bearing Clearance = Main Bore Diameter with bearing installed minus (-) Crankshaft Main Journal Diameter.

Maximum Bearing Clearance: 0.119mm [0.0047 in]

**Crankshaft Gear - Replacement (1-13)**

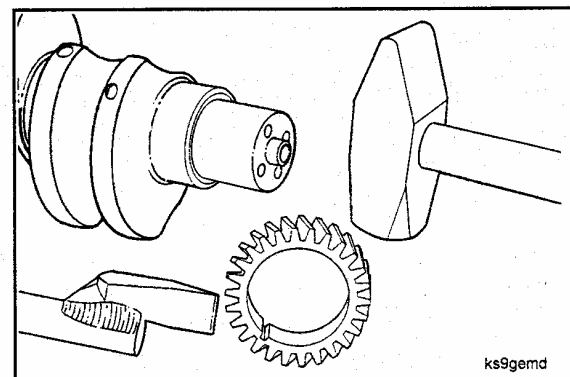
Remove the crankshaft gear.

Use a heavy duty puller.

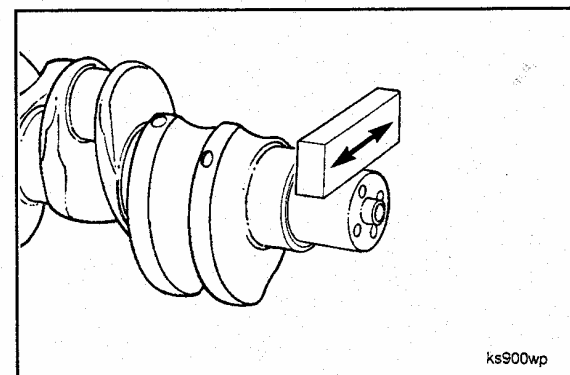
**2 lb Steel Hammer, Gear Splitter Part No. 3823585**

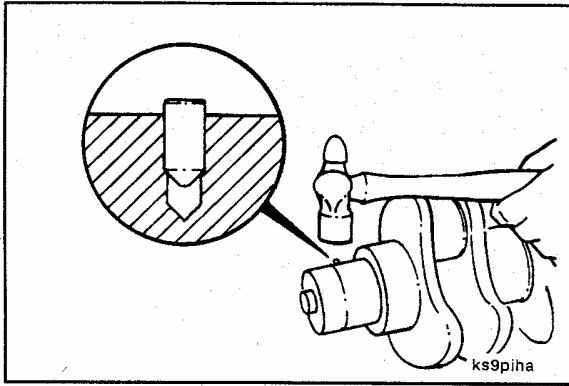
An optional tool is available to split the crankshaft gear off of Pre-1991 crankshafts.

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



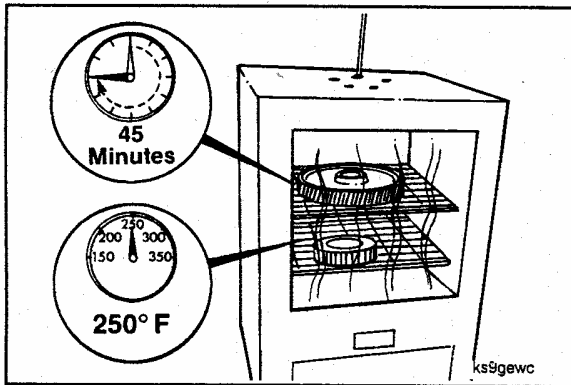
Remove all burrs and make sure the gear surface on the end of the crankshaft is smooth.





Hammer

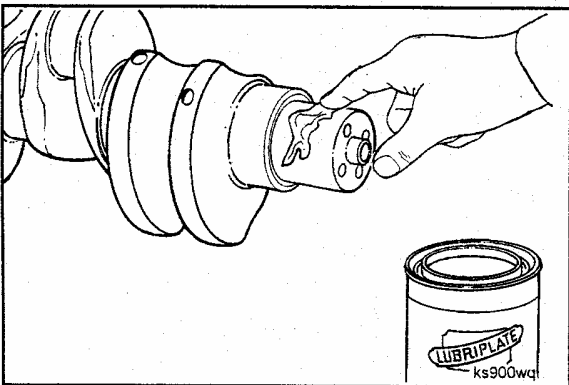
If previously removed, install the alignment pin until it bottoms.



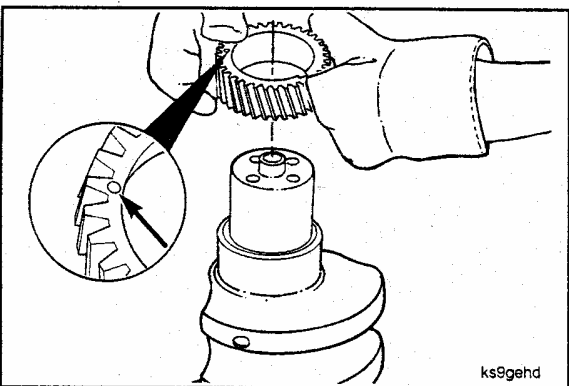
CAUTION

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.



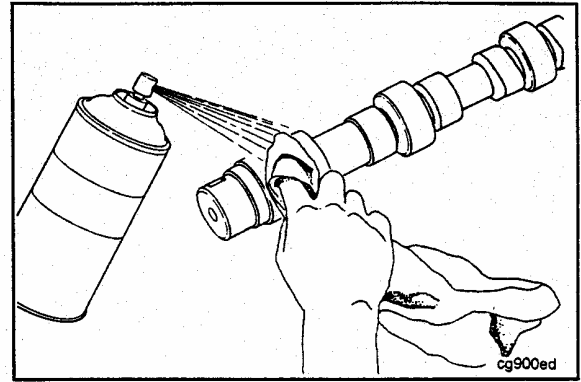
WARNING

Wear protective gloves to prevent personal injury.

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

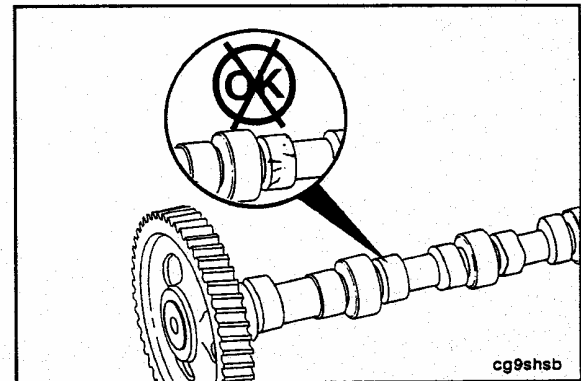
Camshaft - Cleaning (1-14)

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

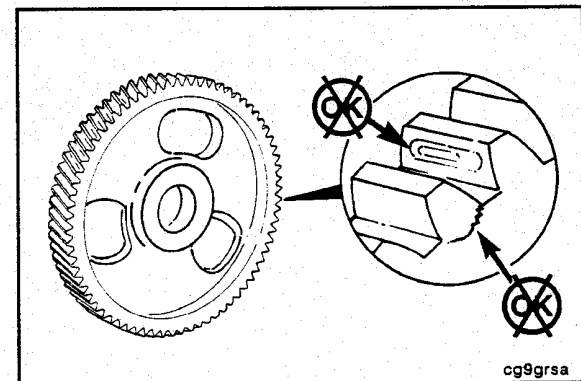


Camshaft and Gear - Inspection (1-15)

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

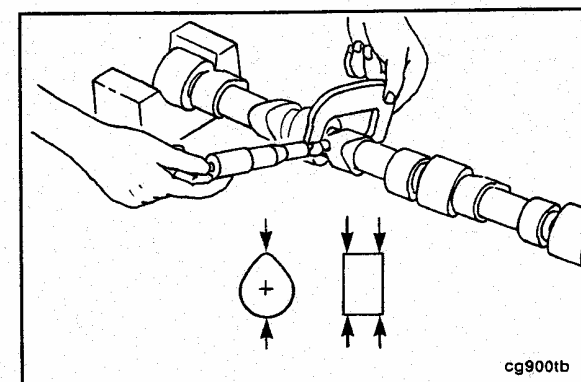


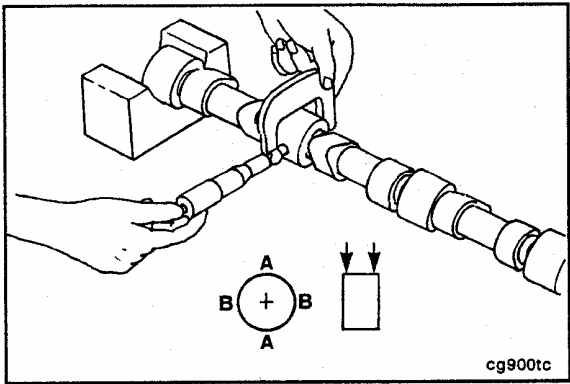
Inspect the gear teeth for puffing; look for cracks at the root of the teeth.



Measure the fuel transfer pump lobe and valve lobes.

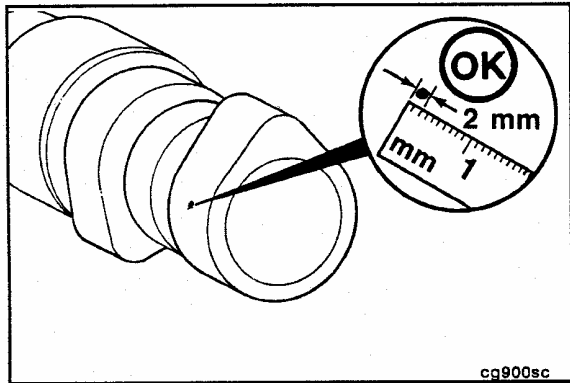
	Diameter at Peak of Lobe		
	mm		in
Intake	47.040	MIN	1.852
	47.492	MAX	1.870
Exhaust	46.770	MIN	1.841
	47.222	MAX	1.859
Lift Pump	35.500	MIN	1.398
	36.260	MAX	1.428





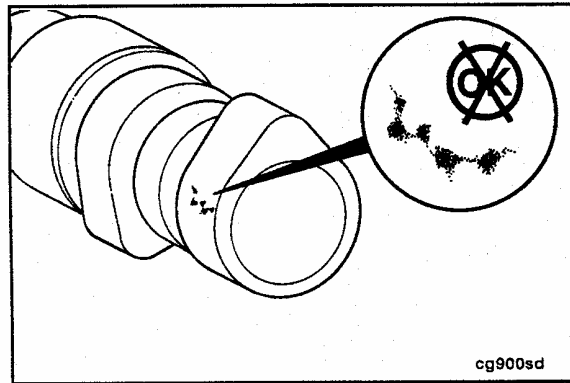
Measure the bearing journals.

Journal Diameter		
mm		in
53.962	MIN	2.1245
54.013	MAX	2.1265

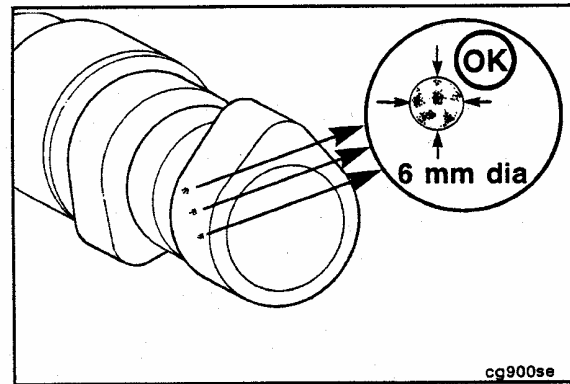


Camshaft Lobe Pitting Reuse Criteria (1-16)

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

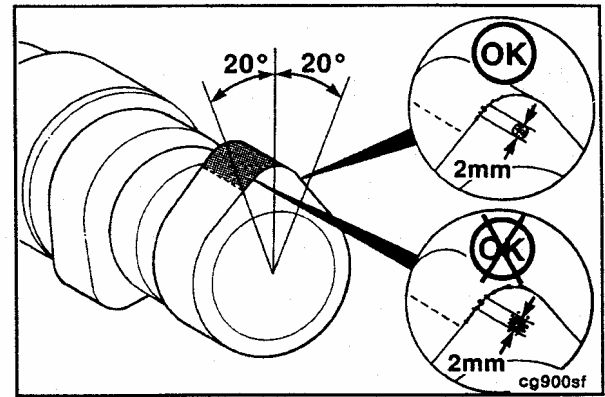


Interconnection of pits is not allowable and is treated as one pit.



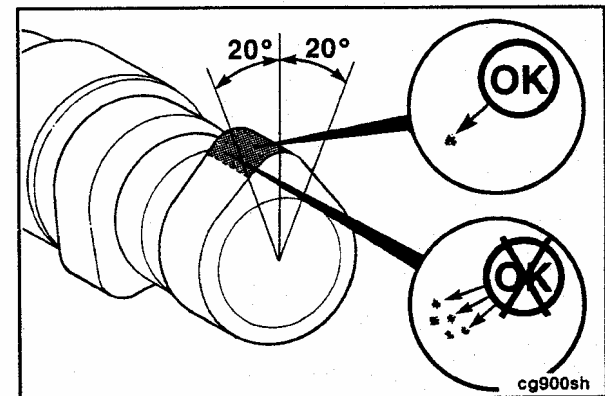
The total pits, when added together, should not exceed a circle of 6 mm [0.236 in].

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

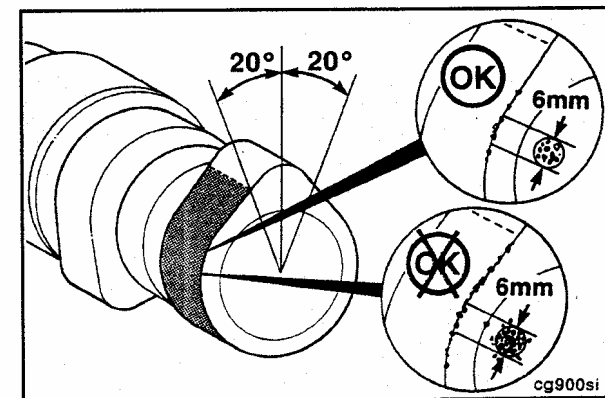


Camshaft Lobe Edge Deterioration (Breakdown) Criteria (1-17)

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.

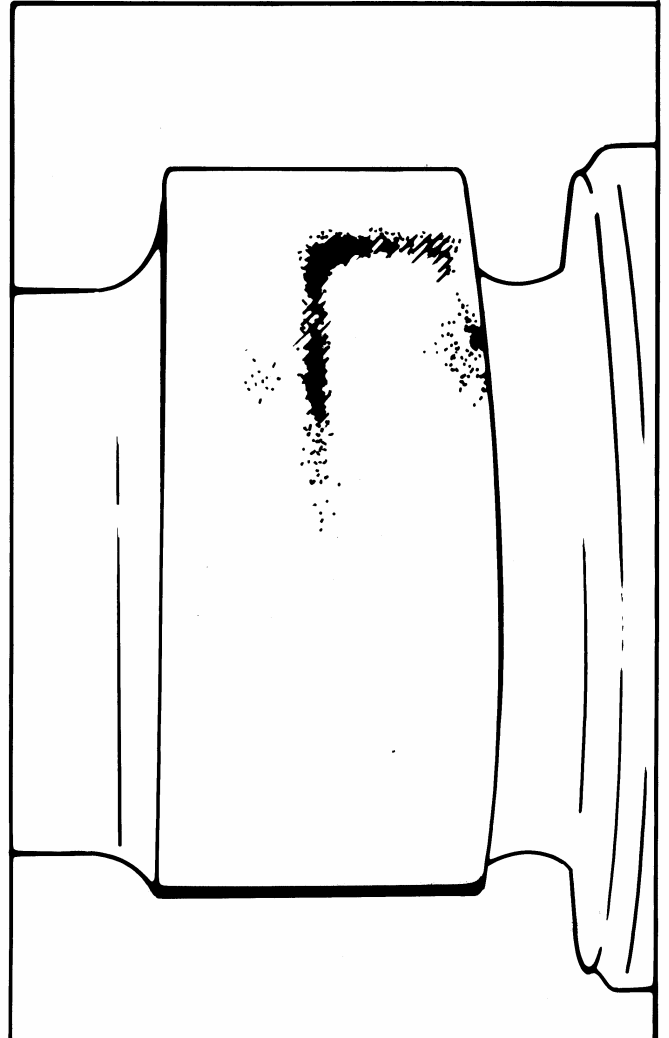
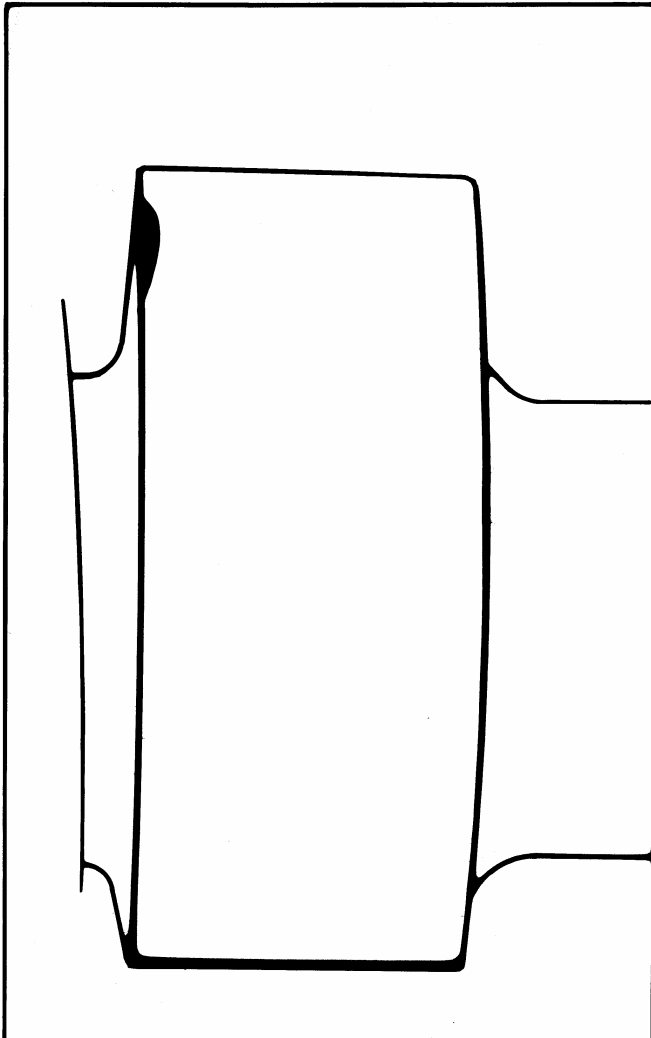


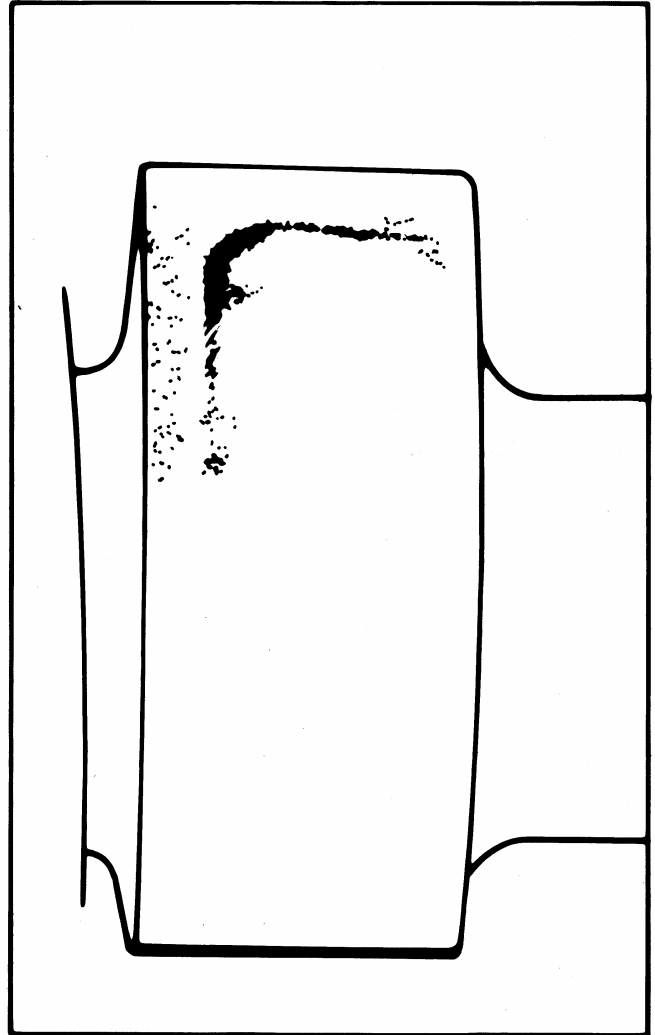
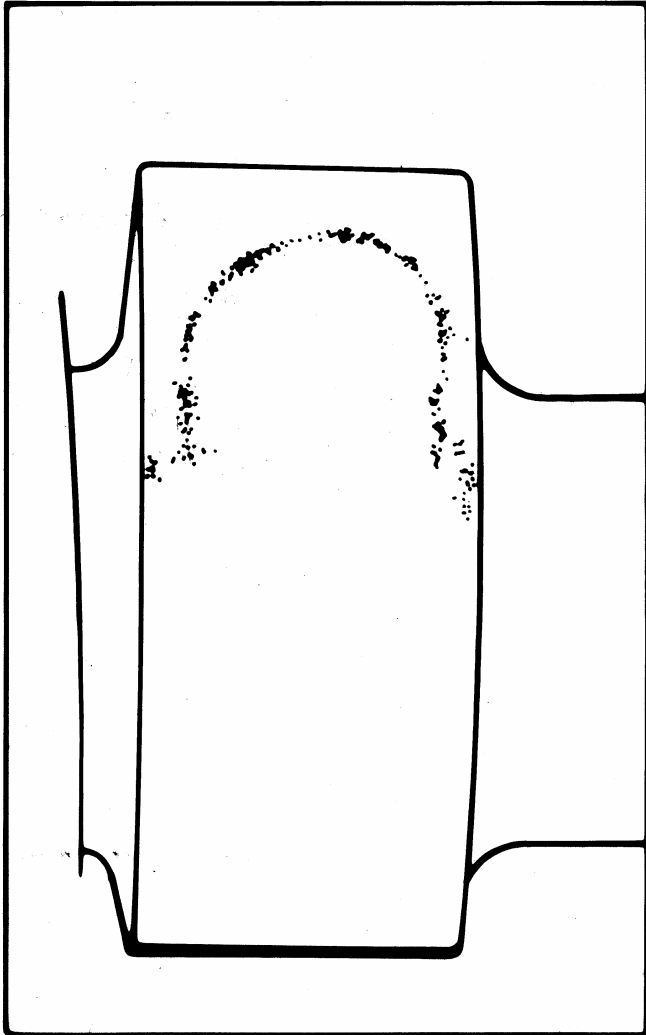
Outside of the + or – 20 degrees of the nose of the cam lobe, the areas of edge deterioration should not be greater than the equivalent area of a 6 mm [0.236 in] circle.

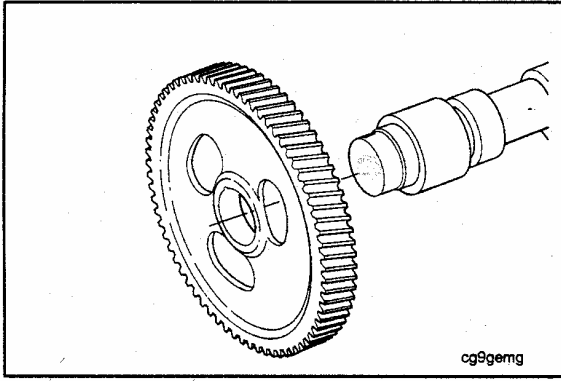


The first of the following illustrations shows normal polish and a casting flaw within the nose area. Both of these conditions are acceptable for reuse.

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



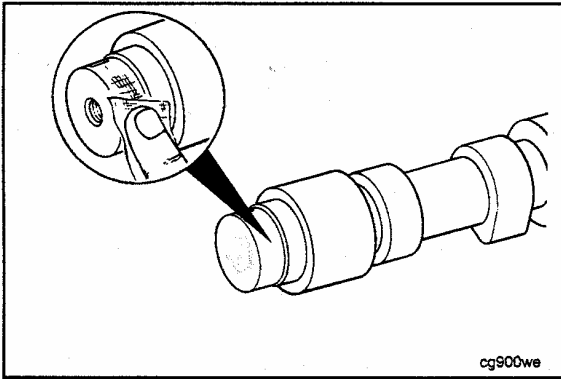




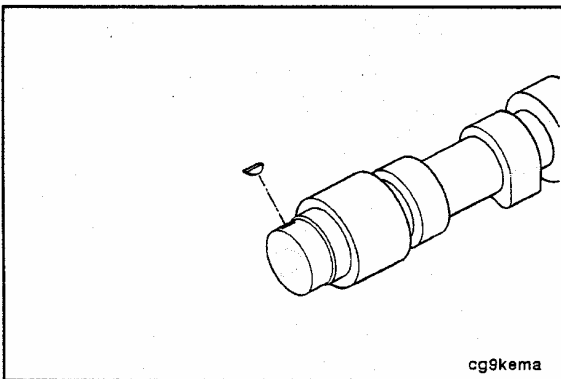
Camshaft Gear - Replacement (1-18)

Camshaft Gear - Removal (1-19)

Remove the gear.

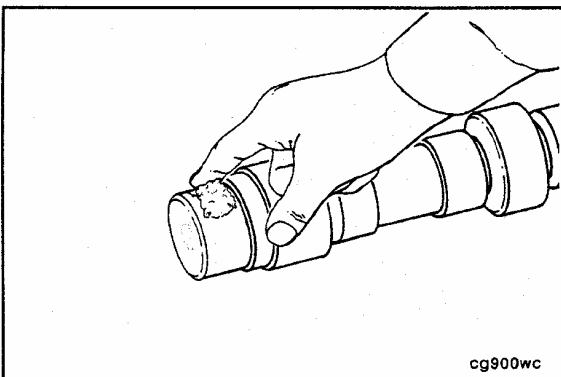


Remove all burrs and smooth any rough surfaces caused by removing the gear.



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

Install the key.



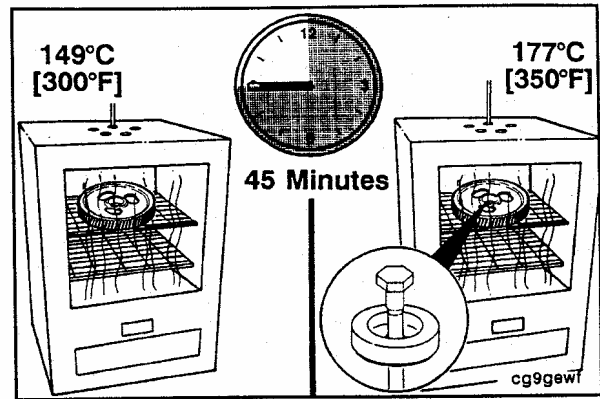
Lubricate the camshaft surface with Lubriplate 105.

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].

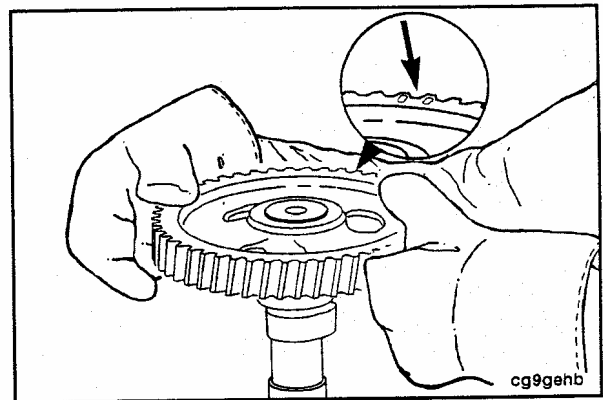


WARNING

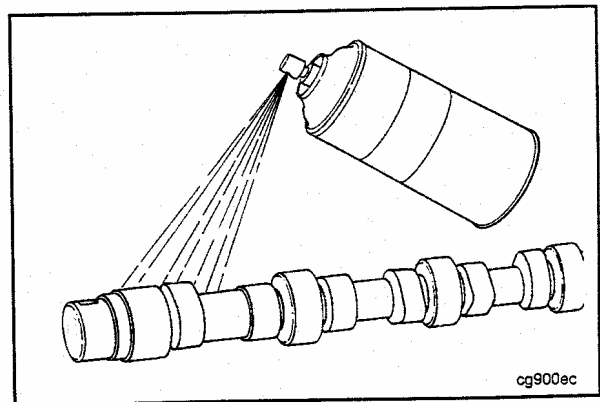
Wear protective gloves to prevent personal injury.

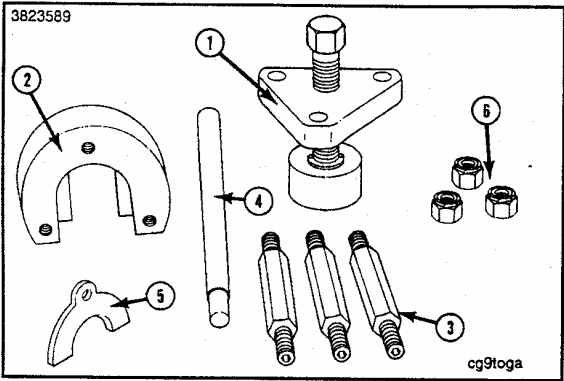
Install the gear with the timing marks away from the camshaft.

Be sure the gear is seated against the camshaft shoulder.



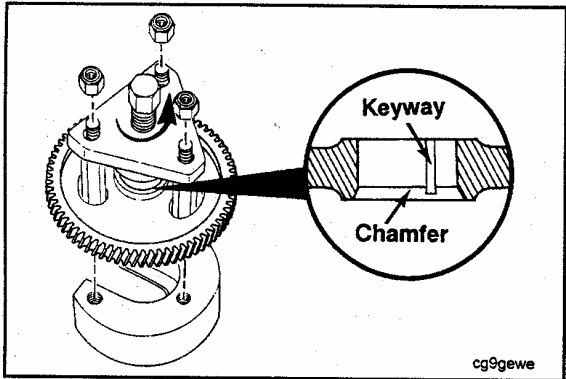
If the camshaft is not to be used immediately, lubricate the lobes and journals to prevent rusting.



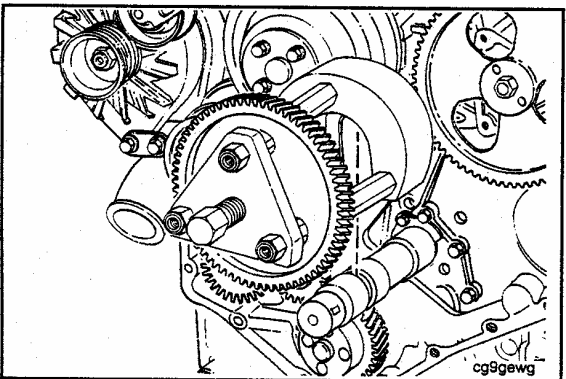


Camshaft Gear - Installation (With Special Tool 3823589) (1-21)

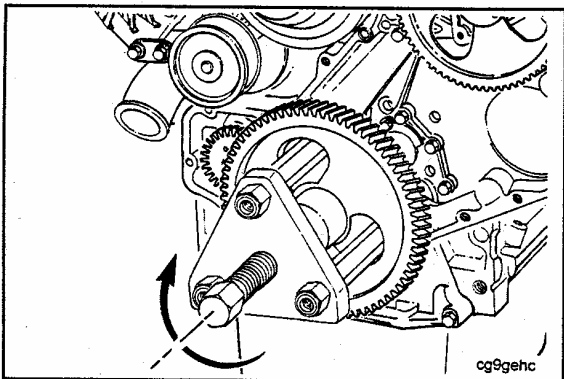
No.	Description	Qty.
1	Screw Press	1
2	Yoke	1
3	Rods	3
4	Torque Arm	1
5	Retainer	1
6	Nuts	3



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.



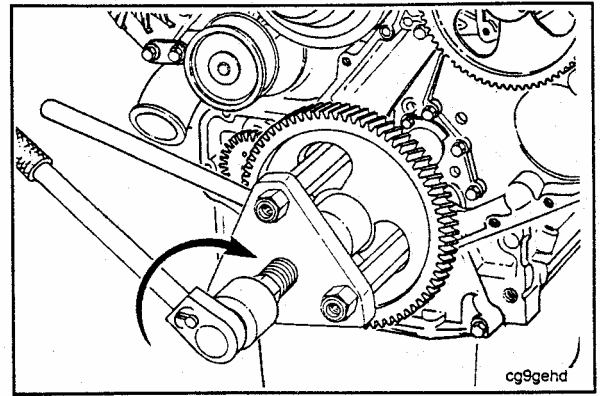
Hand-tighten the screw press and engage the gear to the camshaft and keyway.

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.



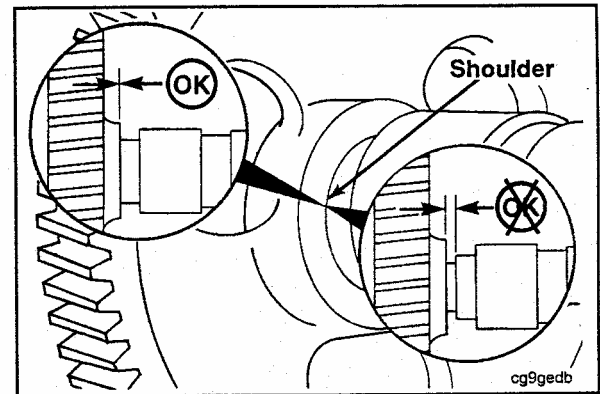
NOTE

Do not exceed 135.6 Nm [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.

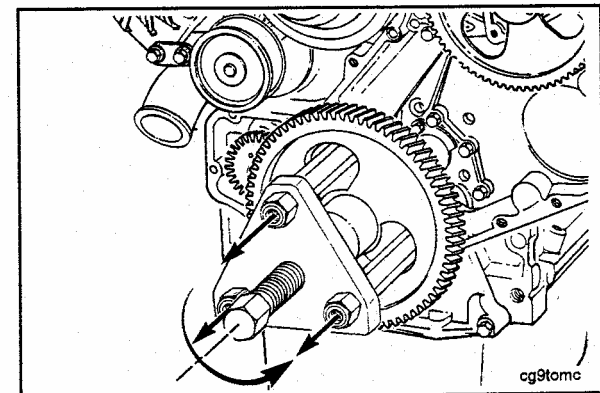


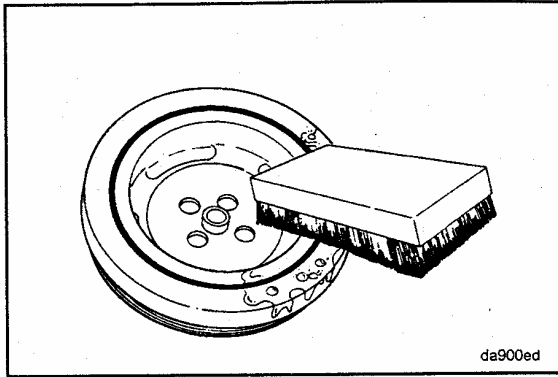
While turning the screw, the effort required should increase steadily until the gear seats against the camshaft shoulder.

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



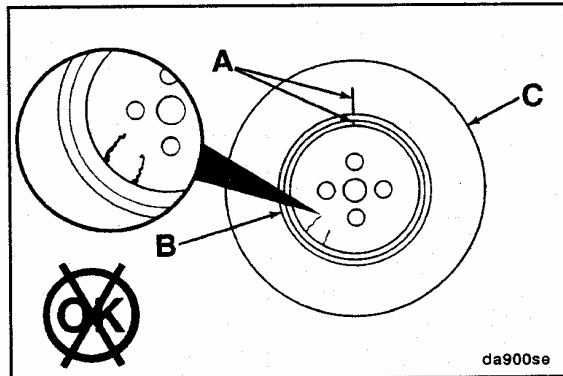
Disassemble the camshaft gear installation tool and remove the camshaft retainer.



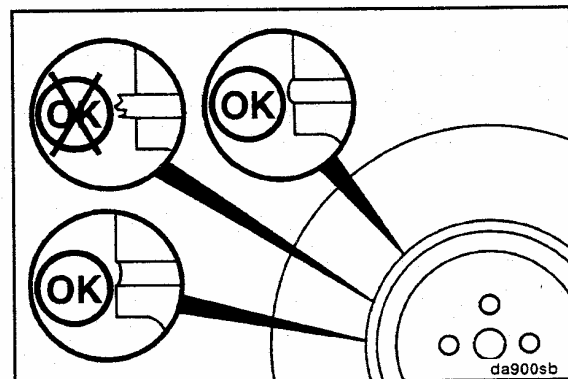


Rubber Element Vibration Damper - Cleaning and Inspection (1-23)

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



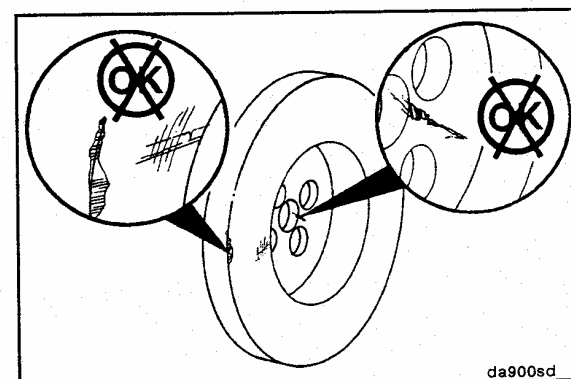
Check the index lines (A) on the damper hub (B) and inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the damper.



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

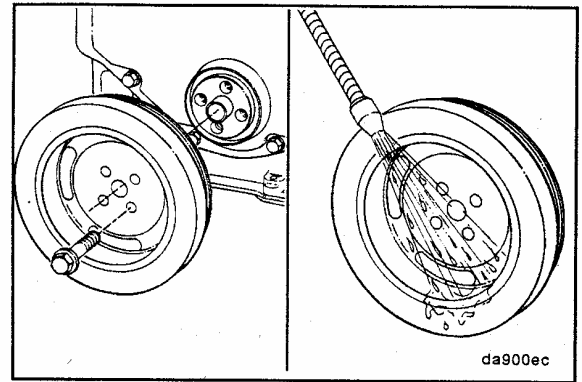
Also look for forward movement of the damper ring on the hub. Replace the damper if any movement has occurred.



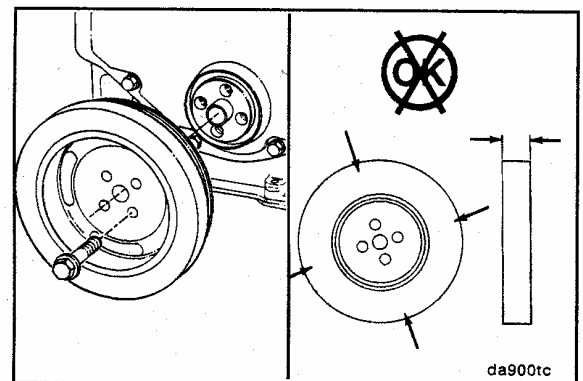
Viscous Vibration Damper - Cleaning and Inspection

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.

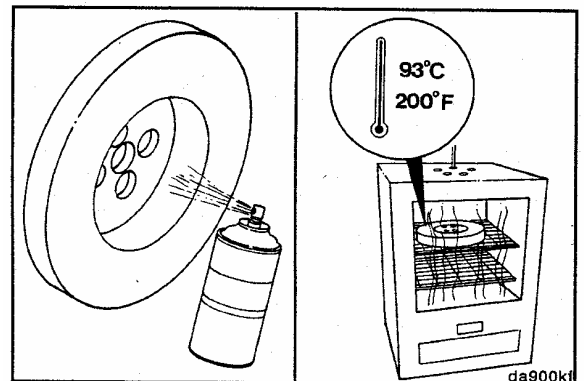
Clean the damper with a solvent cleaner.



The viscous damper is filled with a silicone fluid. After many hours of 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 3.175mm [0.125 inch] from the outside of the damper. Replace the damper if its thickness varies by more than 0.25 mm [0.010 inch].



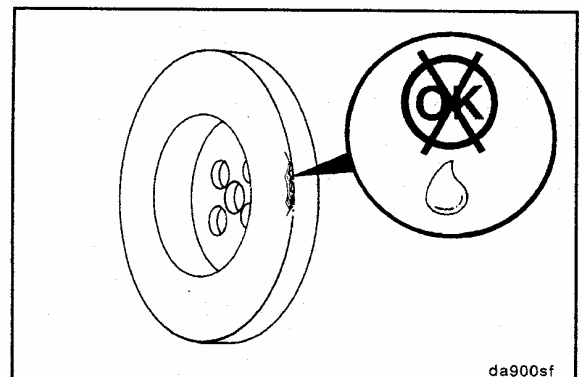
Spray the damper with spot check developer, Type SKD-NF or its equivalent. Heat the damper in an oven (rolled lip side down) at 93°C [200°F] for 2 hours.

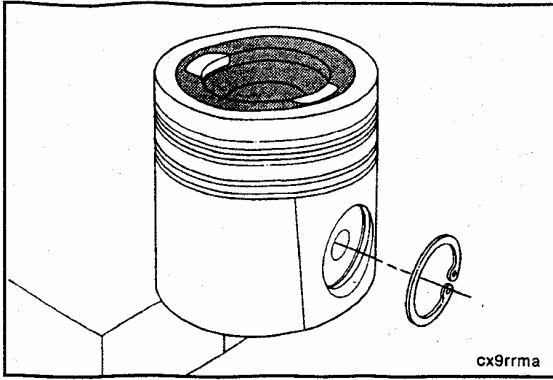


WARNING

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

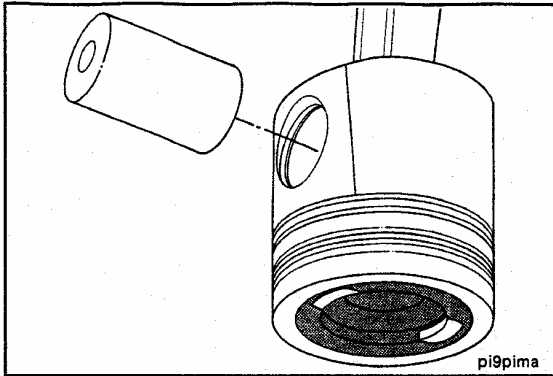
Remove the damper from the oven and check for fluid leakage. If there is leakage, replace the damper.





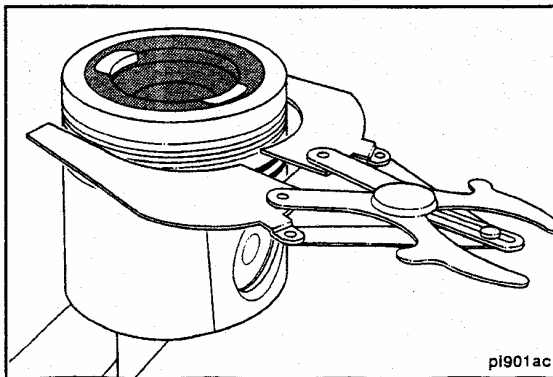
Piston and Connecting Rod - Disassembly (1-24)

Remove the retaining rings.



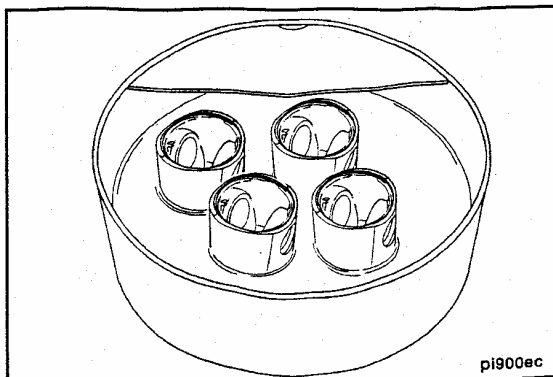
Remove the piston pin.

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.



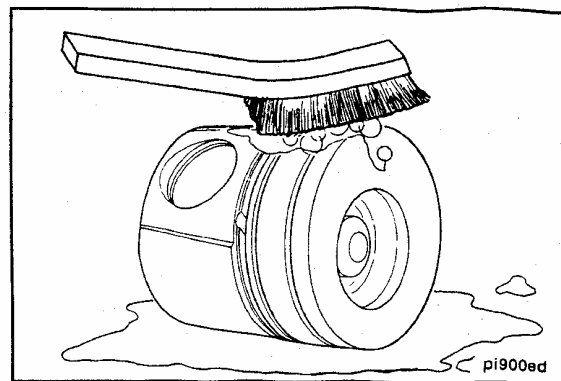
Soak the pistons in cold parts cleaner.

Soaking the pistons overnight will usually loosen the carbon deposits.

CAUTION

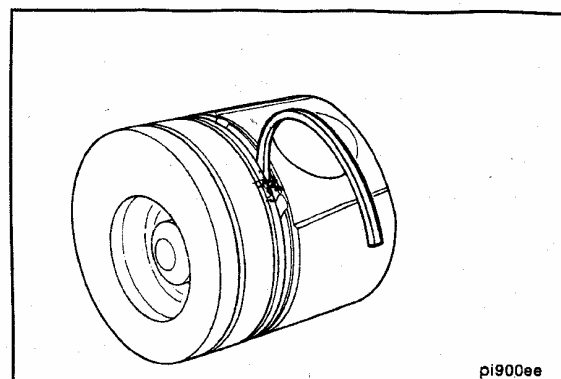
Do not clean the pistons and rods in an acid tank.

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

**CAUTION**

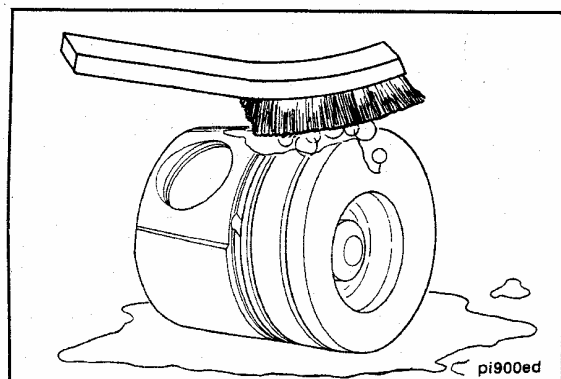
Do not use a ring groove cleaner and be sure not to scratch the ring sealing surface in the piston groove.

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

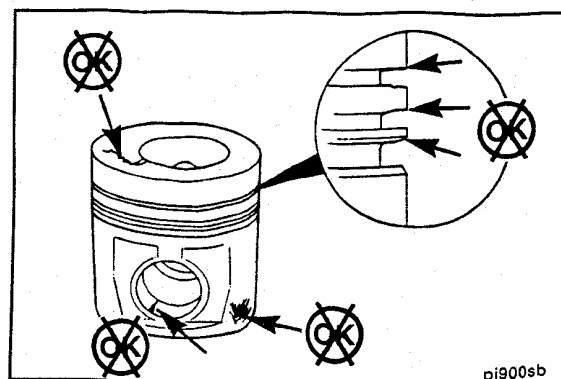


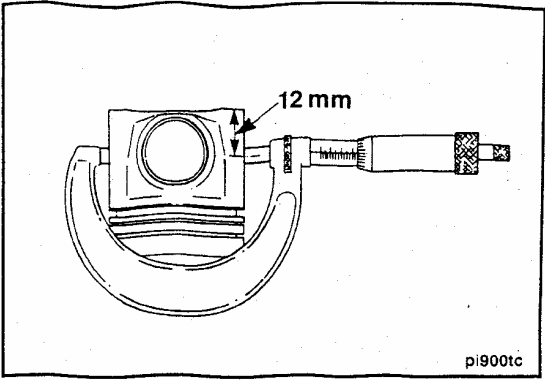
Wash the pistons again in a detergent solution or solvent.

After rinsing, use compressed air to dry.

**Piston Inspection (1-26)**

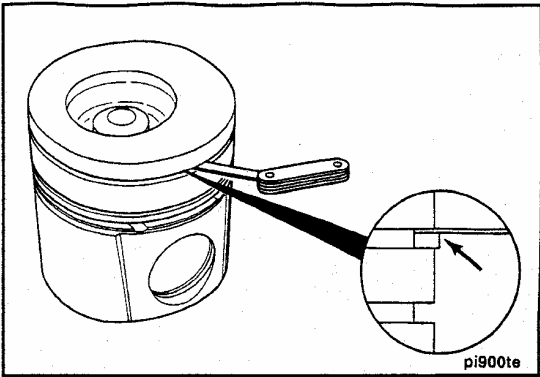
Inspect the piston for damage and excessive wear. Check the top, ring grooves, skirt and pin bore.





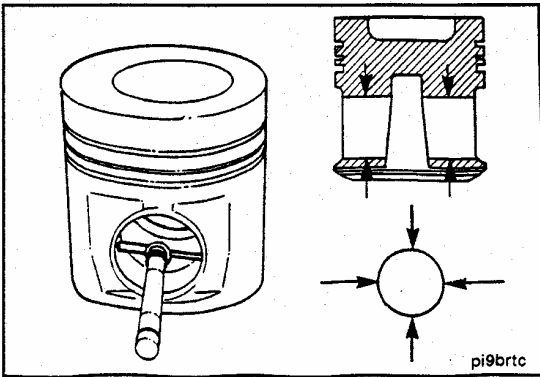
Measure the piston skirt diameter as illustrated.

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



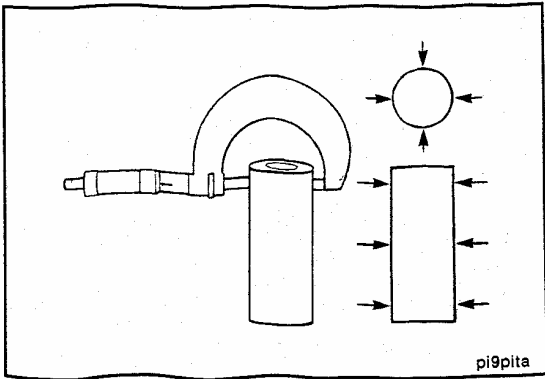
Use a new piston ring to measure the clearance in the ring groove.

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	0.040	MIN	[0.002]
Control	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.

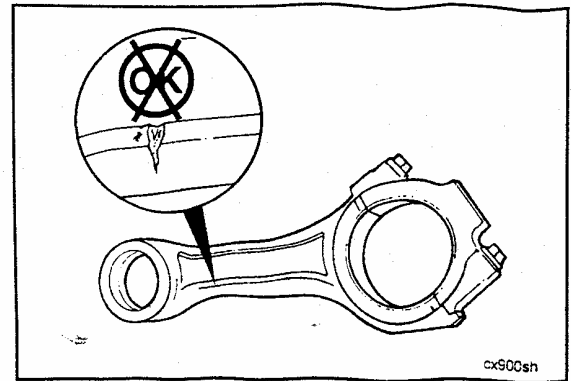
Diameter		
mm		in
39.990	MIN	[1.5744]
40.003	MAX	[1.5749]

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.



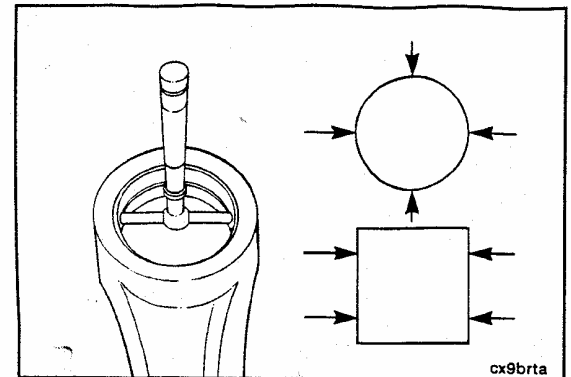
Measure the pin bore (with bushing installed).

1991 Specifications

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

1994 Specifications

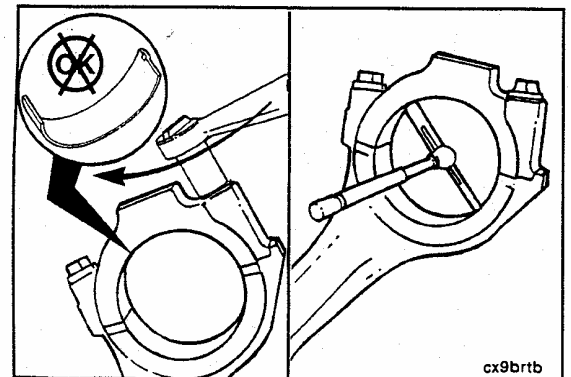
Diameter		
mm		in
40.019	MIN	1.5756
40.042	MAX	1.5765



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.

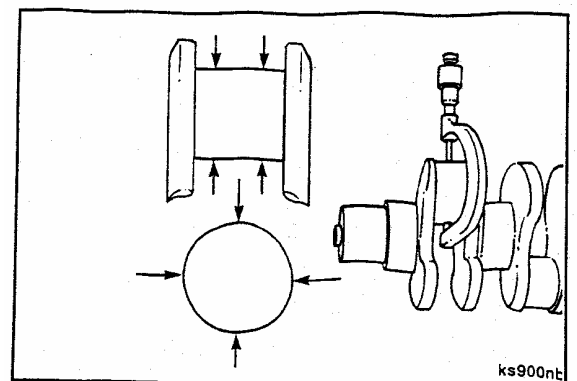
Diameter		
mm		in
68.962	MIN	[2.7150]
69.013	MAX	[2.7170]

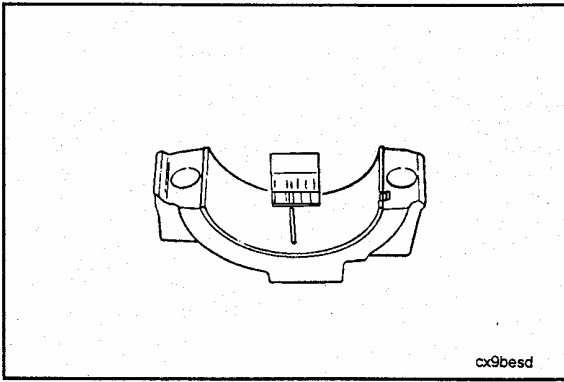
Out-of-Roundness: 0.050mm [0.002 in]

Taper: 0.013mm [0.0005 in]

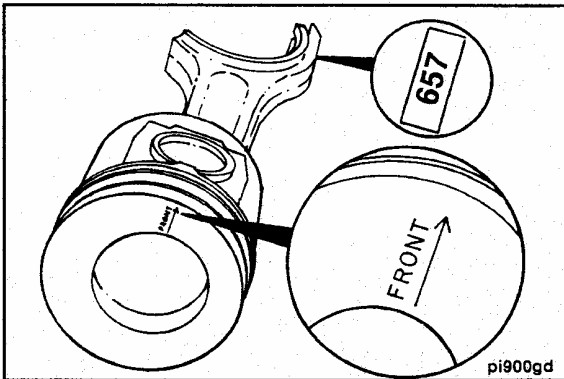
Bearing clearance = Rod Inside Diameter Minus Crankshaft journal Diameter.

Clearance: 0.114mm [0.0045 in] maximum.





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

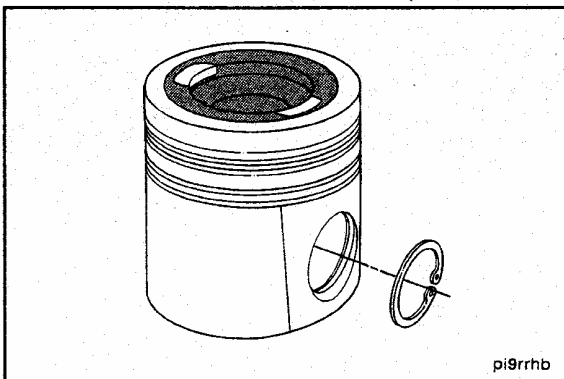


Piston and Connecting Rod - Assembly (1-30)

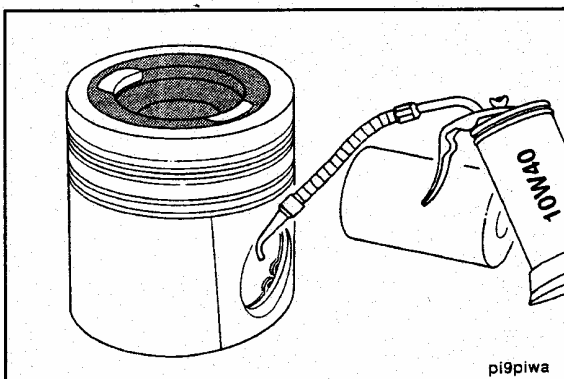
Be sure "front" marking on piston and the numbers on the rod and cap are oriented as illustrated.

NOTE

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



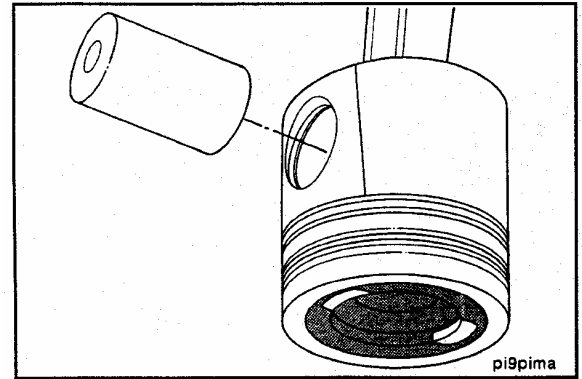
Install the retaining ring in the pin groove on the "front" side of the piston.



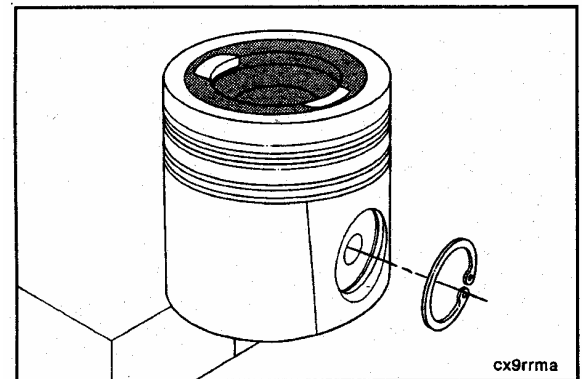
Lubricate the pin and pin bores with engine oil.

Install the pin.

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

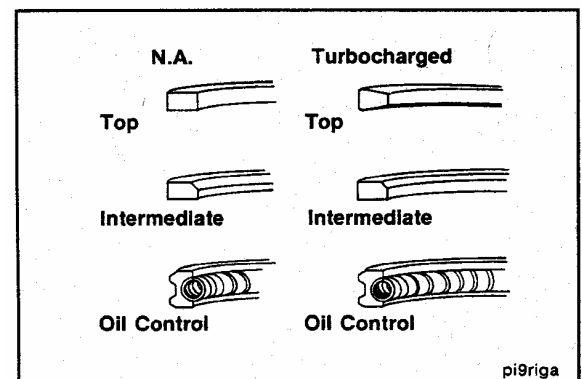


Install the second retaining ring.



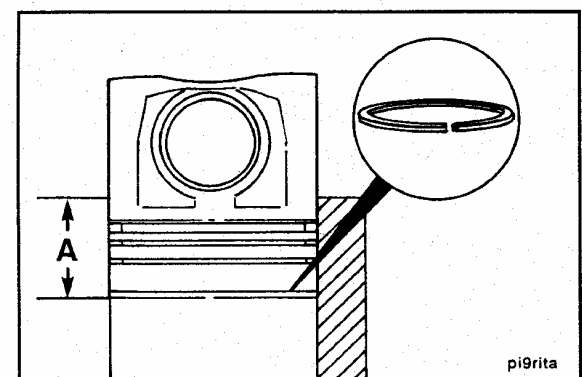
Piston Ring Gap - Checking (1-31)

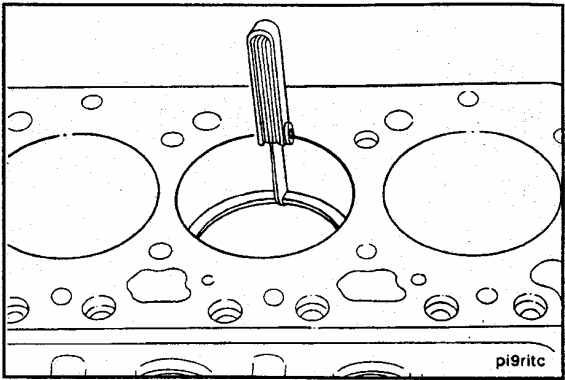
The top ring for a turbocharged engine is not the same as the top ring for a naturally aspirated engine.



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

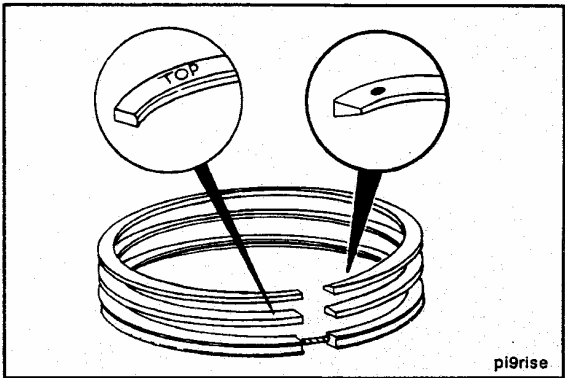
A = 89mm [3.5 in]





Use a feeler gauge to measure the gap.

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



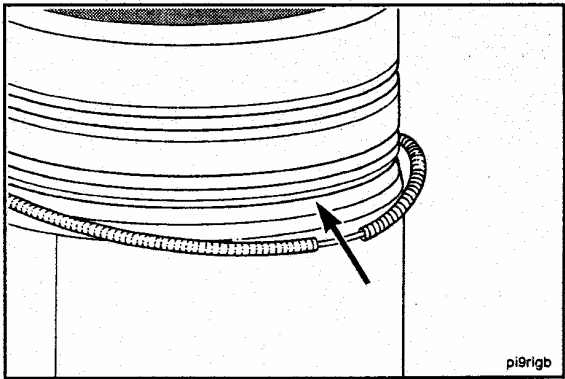
Piston Rings - Installation (1-32)



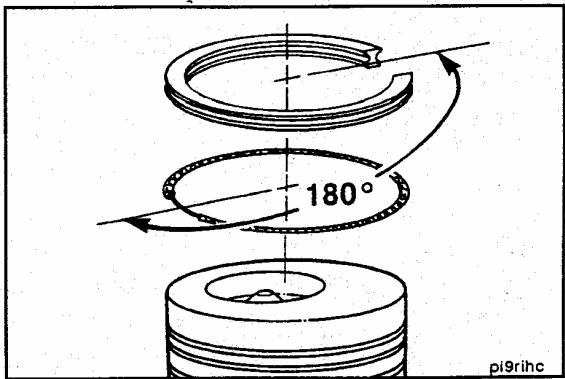
CAUTION

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.



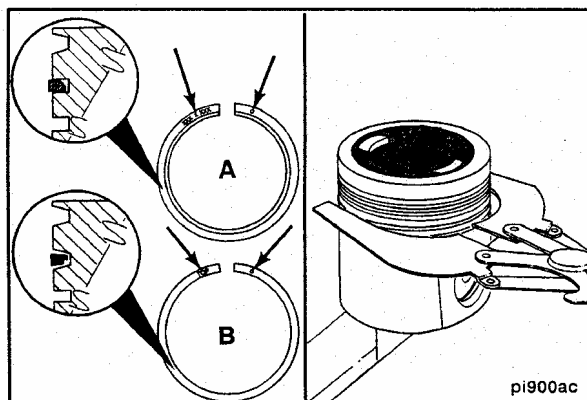
Position the oil ring expander in the control ring groove.



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

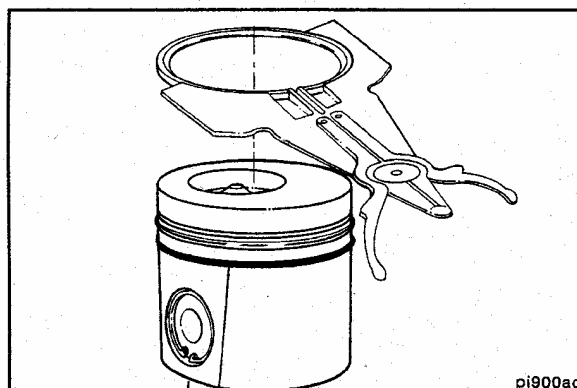
Piston Ring Expander, Part No. 3823137

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.

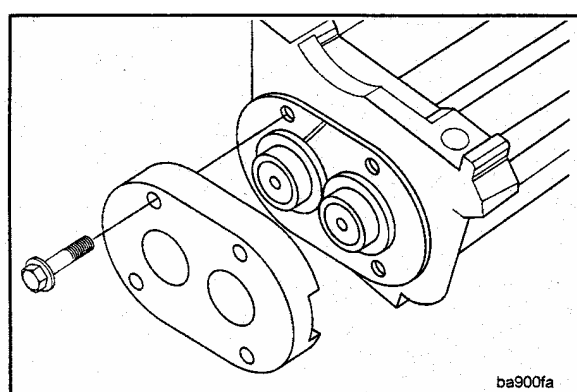
**Balancer - Disassembly (1-33)**

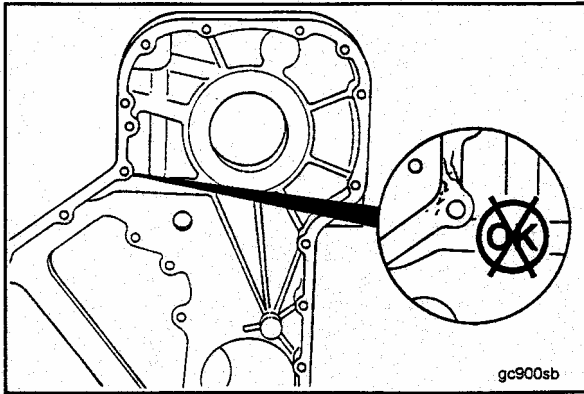
Refer to the procedures and specifications given in the engine disassembly section, procedure (0-59), (0-60) and (0-61).

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

13 mm

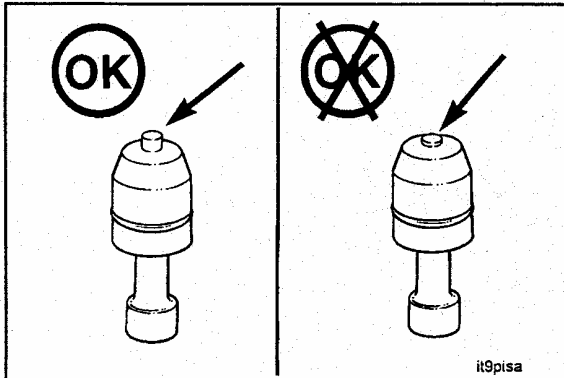
Remove the thrust housing.



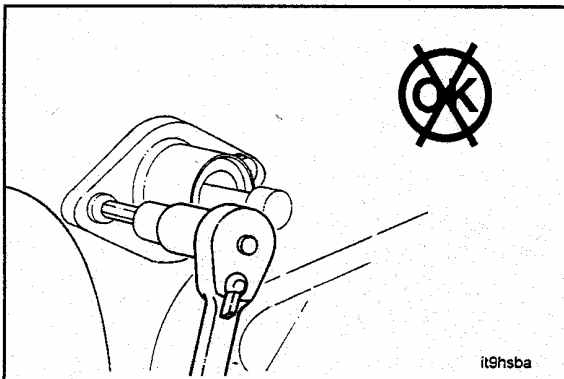


Gear Housing and Timing Pin Assembly - Inspection (1-35)

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

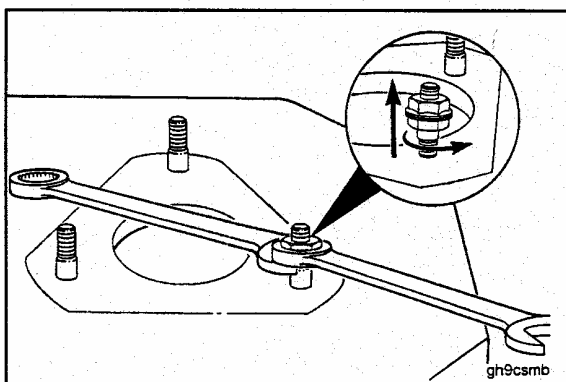


Inspect the timing pin housing and pin for damage.



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 0-47 for replacement procedures.



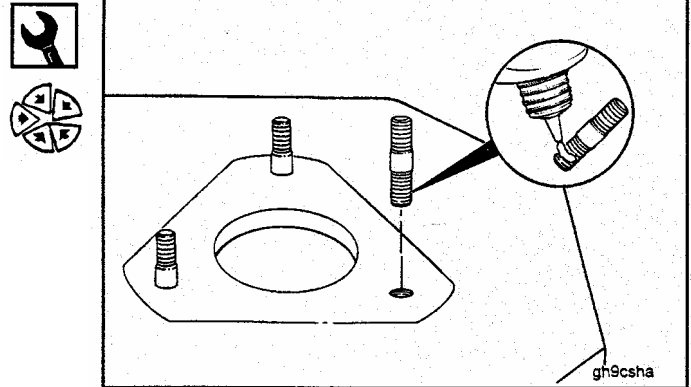
Fuel Pump Stud - Replacement (1-37)

13 mm

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

13 mm

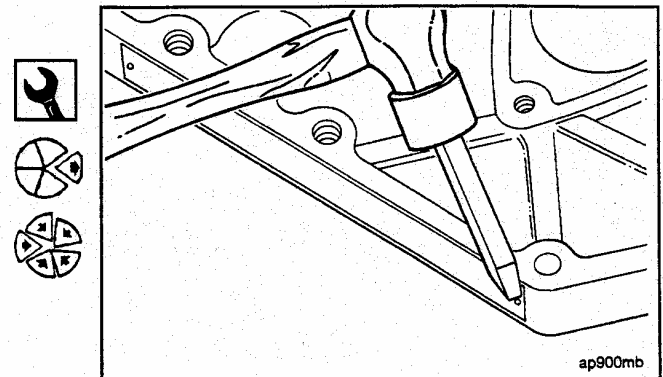
Coat the threads with Loctite™ 601 prior to installation.



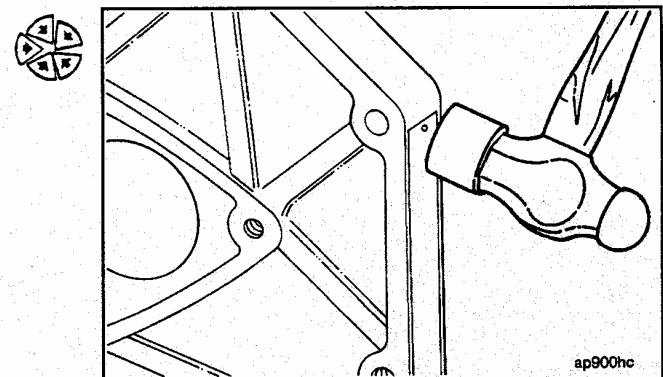
Data Plate - Replacement (1-38)

Small Chisel and Hammer

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

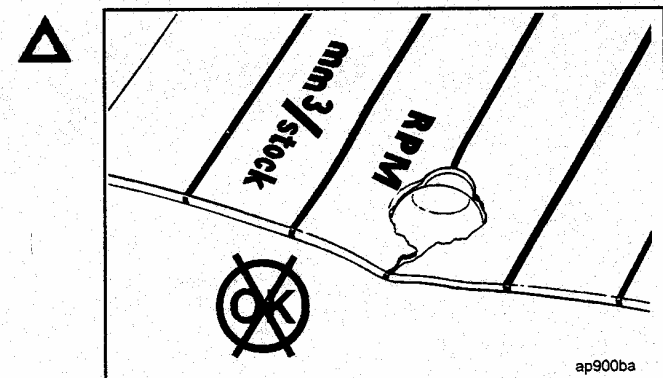


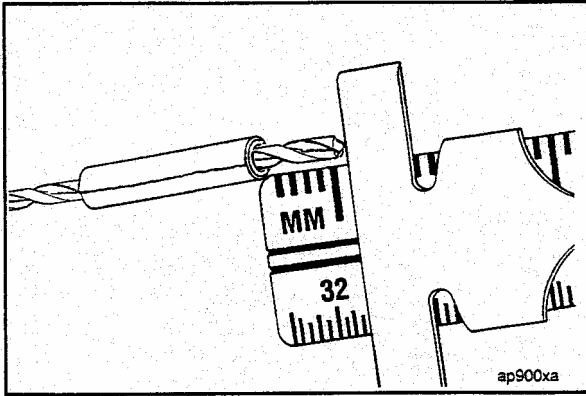
Drive the rivets in until they contact the data tag.



CAUTION

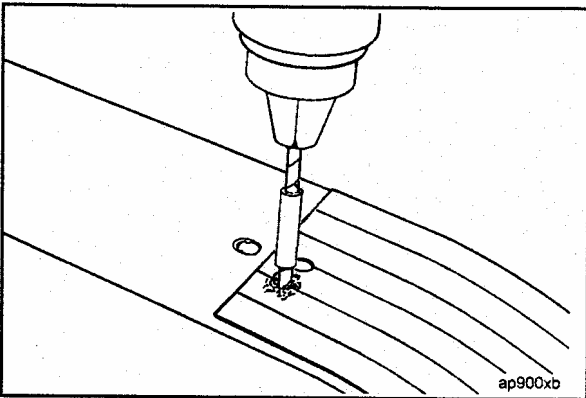
If the rivets are driven in too far, they will cut through the data tag.



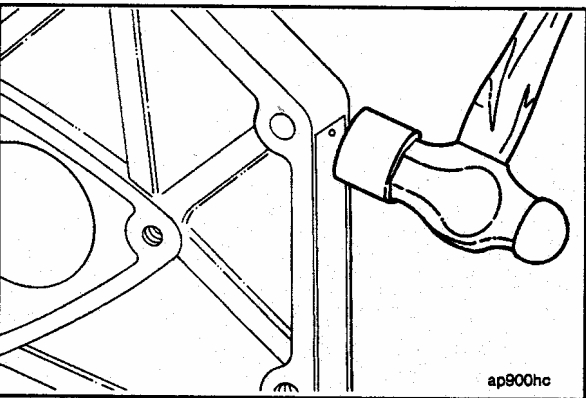


2.0 mm Drill Bit

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.


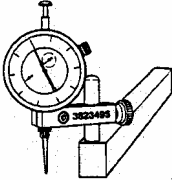
Section 2 – Cylinder Head – Section 2

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Cylinder Head - Cleaning	2-7
Cylinder Head - Disassembly	2-6
Cylinder Head - Exploded View	2-3
Cylinder Head - General Information	2-5
Cylinder Head - Precheck Before Disassembly	2-6
Cylinder Head - Service Tools	2-2
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Valve Seats - Grinding	2-16
Calculating the Grinding Depth	2-16
Measuring the Valve Depth	2-16
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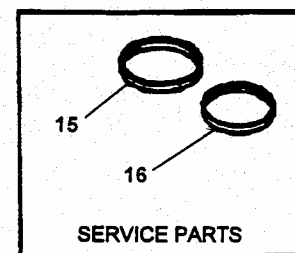
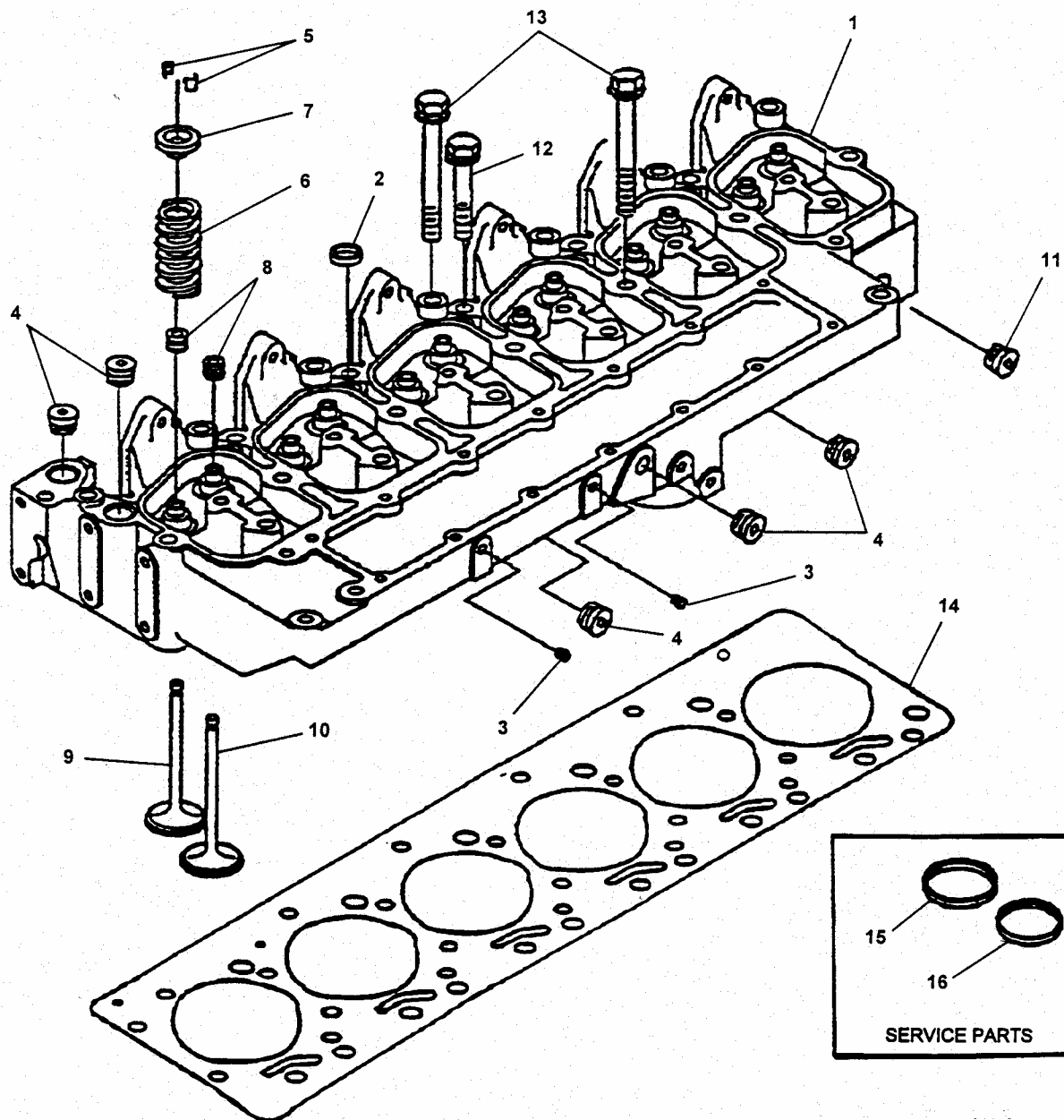
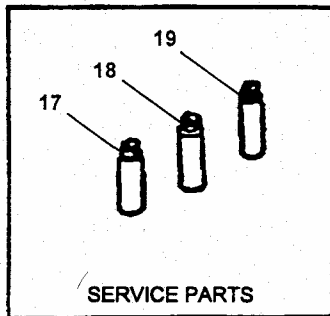
Cylinder Head - Service Tools

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	 3823495

Cylinder Head – Group 2

Exploded View



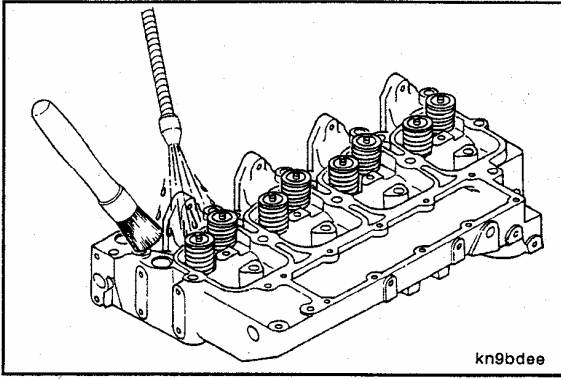
Item	Part Name	Qty.	Remarks
1	Cylinder Head	1	
2	Plug, Expansion	5	
3	Plug, Pipe	2	1/8 NPT
4	Plug, Pipe	5	1/2 NPT
5	Collet, Valve	12	
6	Spring, Valve	12	
7	Retainer, Valve Spring	12	
8	Seal, Valve Stem	12	
9	Valve, Intake	6	
10	Valve, Exhaust	6	
11	Plug, Pipe	1	3/4 NPT
12	Screw, Hex Head Cap	6	M12 x 1.75 x 70
13	Screw, Hex Head Cap	14	M12 x 1.75 x 120
14	Gasket, Cylinder Head	1	Standard
15	Insert, Valve	6	Exhaust
16	Insert, Valve	6	Intake
17	Guide, Valve Stem	6	Thick wall 60.50mm Long intake
18	Guide, Valve Stem	6	Thick wall 51.75mm Long exhaust
19	Guide, Valve Stem	AR	Thin wall can be used on both intake and exhaust

Cylinder Head – 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.

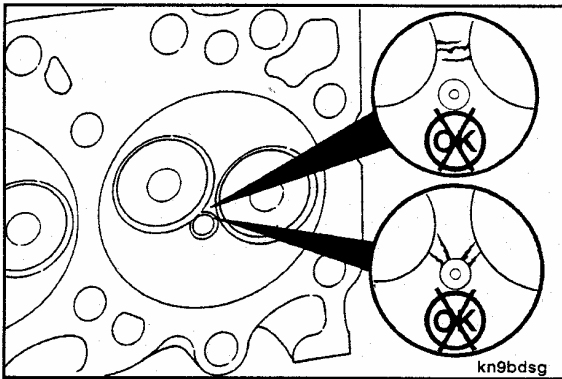
The cylinder head gasket is a composite design with a fire ring to seal the cylinder bores. Orifices in the gasket control coolant flow.

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.

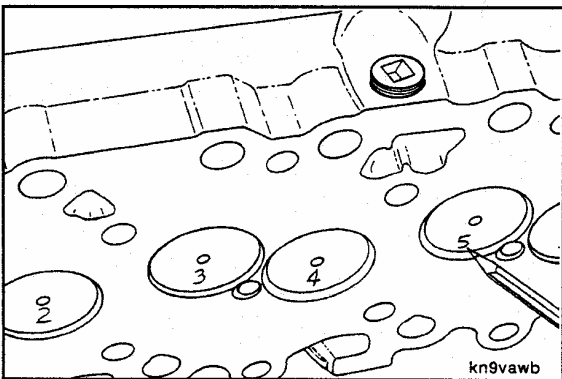


Cylinder Head - Precheck Before Disassembly (2-01)

Clean the cylinder head with solvent.

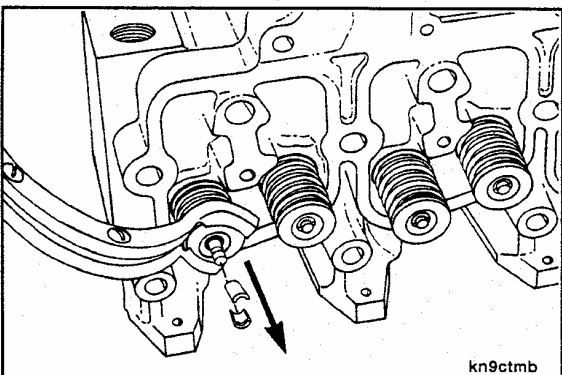


Visually inspect the cylinder head for obvious damage that would prohibit reuse. Check for cracks and damage to the combustion face that would result in loss of sealing.



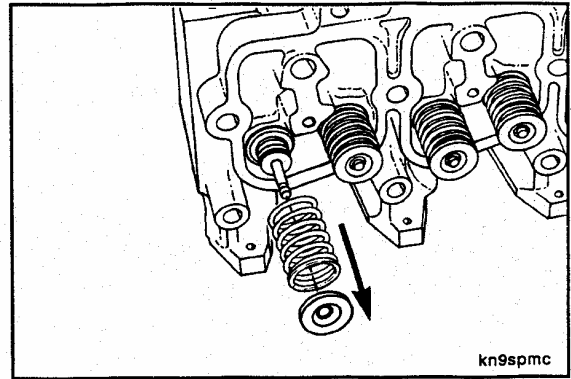
Cylinder Head - Disassembly (2-02)

Mark the valves to identify their position.



Compress the valve spring and remove the valve stem collets.

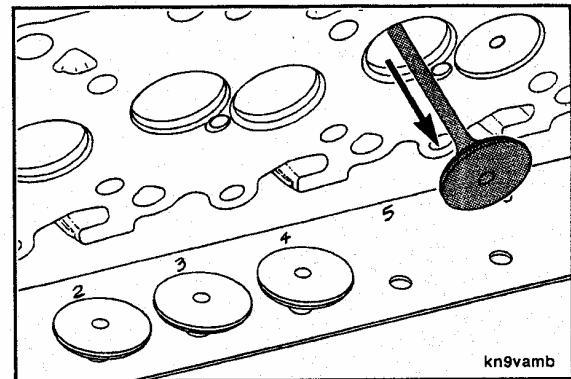
Release valve spring and remove the retainer and spring.



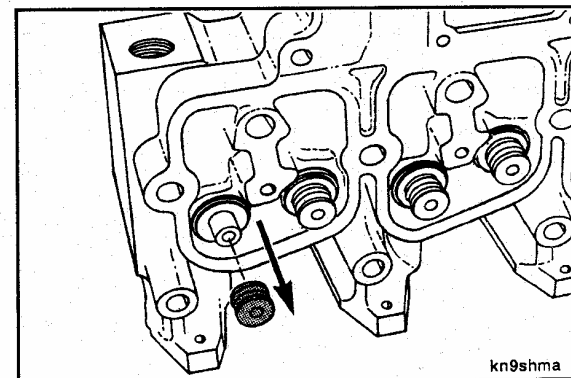
Remove the remaining collets, retainers, springs and valves.

NOTE

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



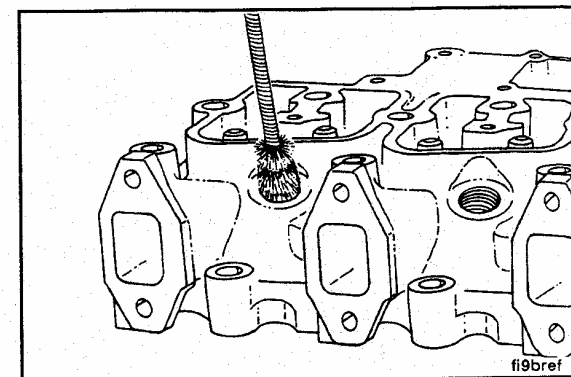
Remove the valve stem seals.

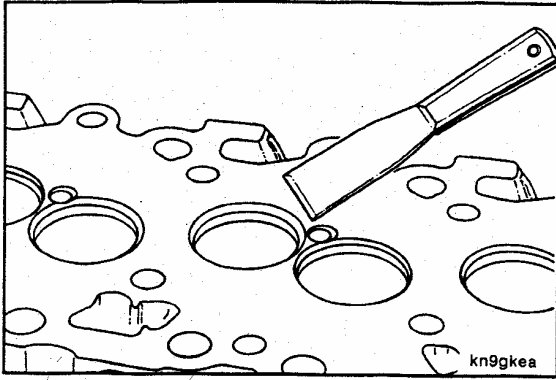


Cylinder Head - Cleaning (2-03)

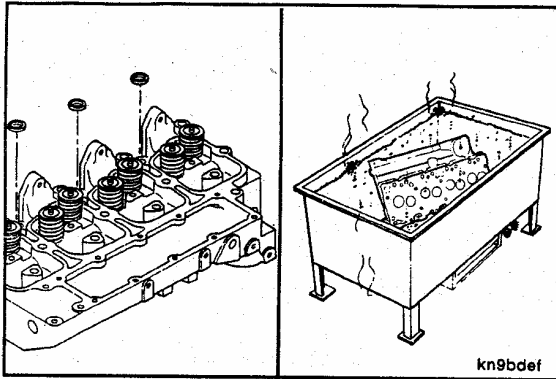
Injector Bore Brush 3822509

Clean the carbon from the injector nozzle seat.

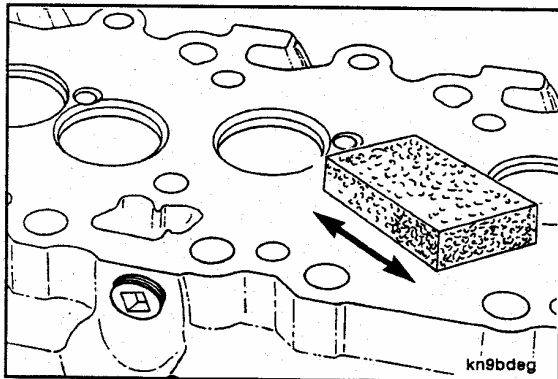




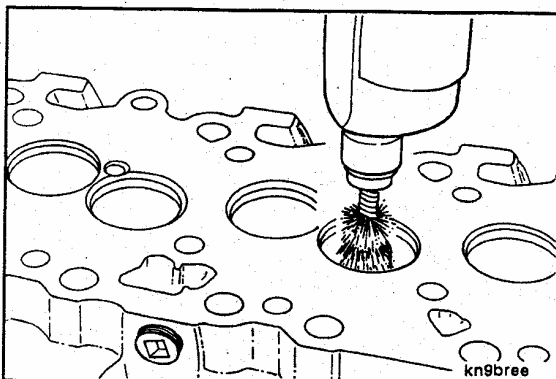
Scrape the gasket material from all gasket surfaces.



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

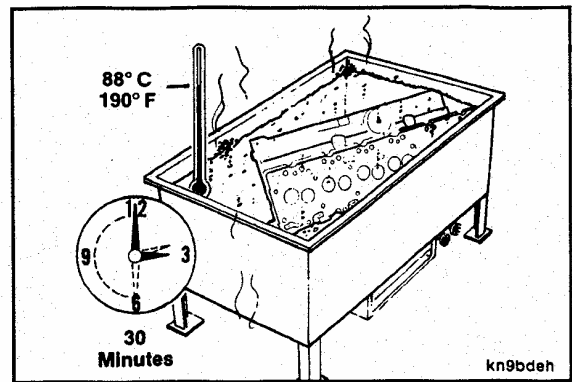
Wear protective eye covering.

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 lose 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.



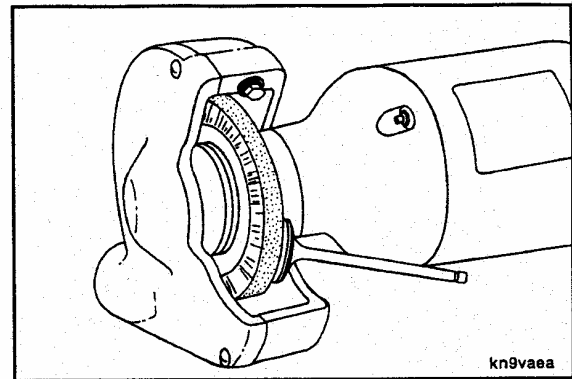
WARNING

Wear protective eye covering.

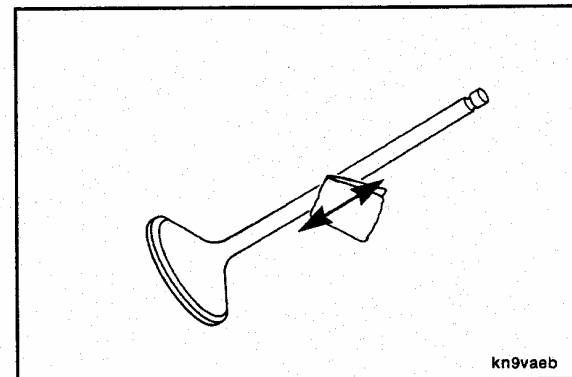
Clean the valve heads with a soft wire wheel.

NOTE

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

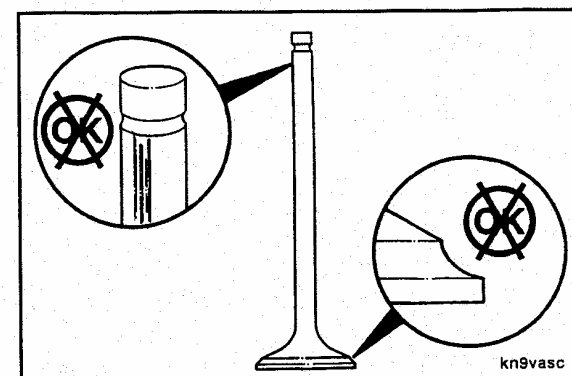


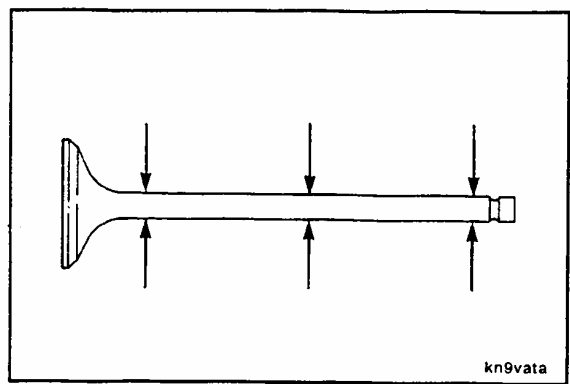
Polish the valve stem with a Scotch-Brite® pad or equivalent cleaning pad and diesel fuel or solvent.



Valve - Inspection (2-04)

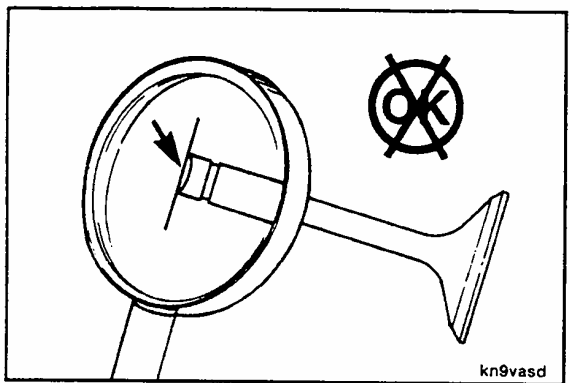
Inspect for abnormal wear on the heads and stems.



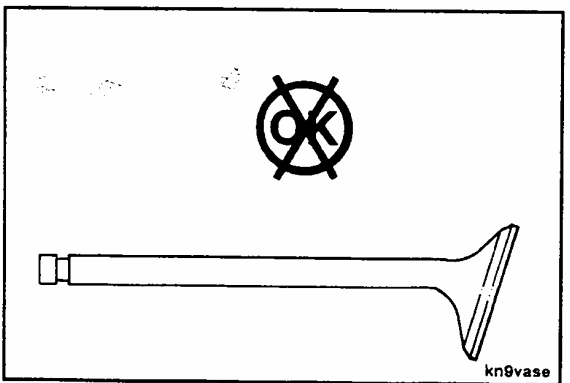


Measure the valve stem diameter.

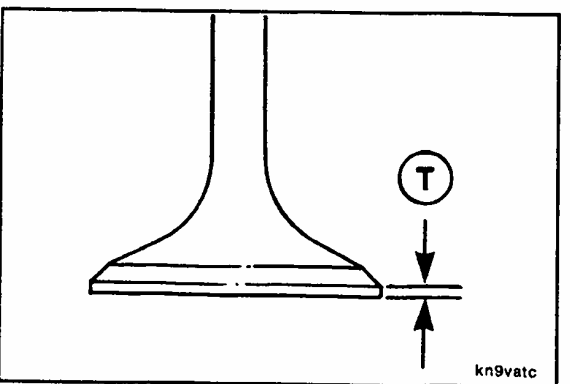
Valve Stem Diameter		
mm		in
7.94	MIN	0.3126
7.98	MAX	0.3142



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 2-15.

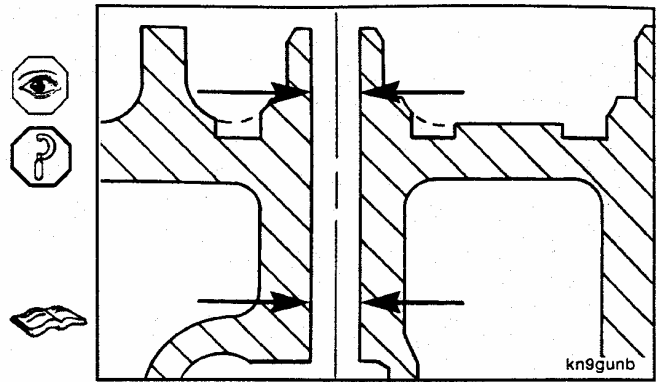
Valve Guide Inspection (2-05)

Inspect the valve guides for scuffing or scoring.

Measure the valve guide bore.

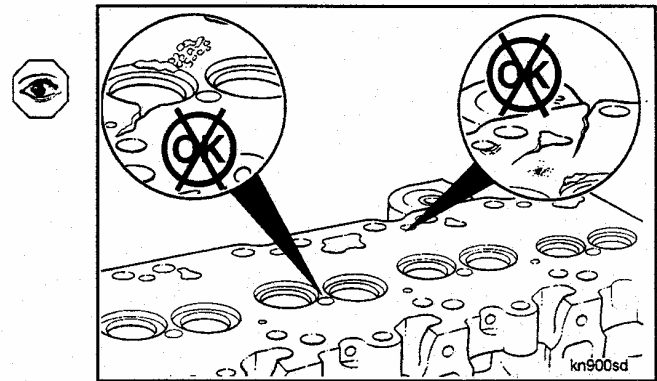
Valve Guide Bore Diameter		
mm		in
8.019	MIN	0.3157
8.090	MAX	0.3185

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.

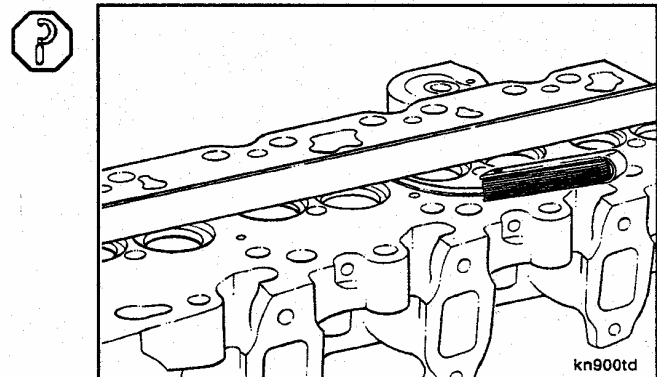


Measure the cylinder head overall flatness:

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]

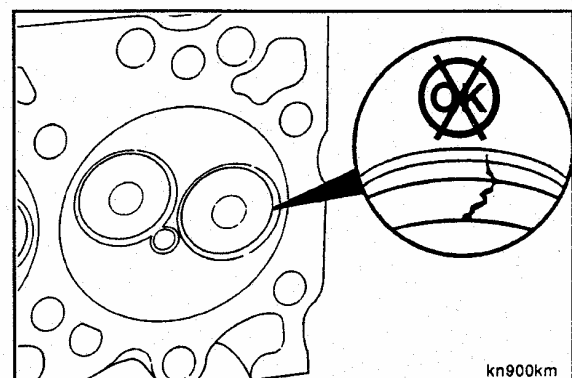
Visually inspect for any localized dips or imperfections. If present, the cylinder head deck must be reground.

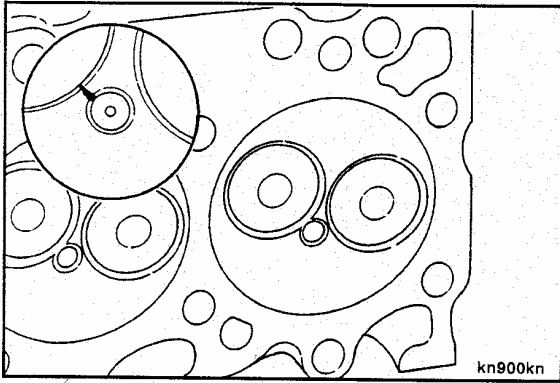


Valve Seat Inspection (2-07)

Inspect the valve seats for cracks or burned spots.

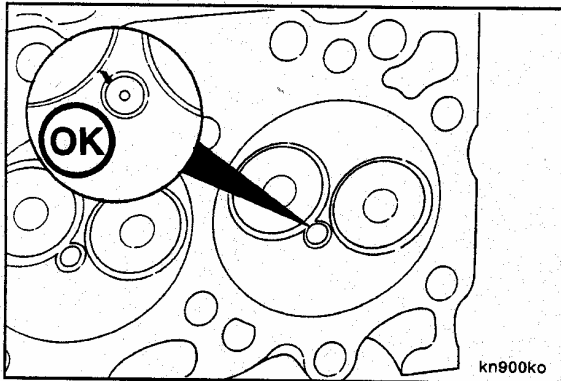
Refer to the following reuse guidelines for any cracks discovered. Service valve seats are available for seats with burned spots that will require more than 0.254 mm [0.010 in] grinding to clean up. Refer to the Alternative Repair Manual, Bulletin No. 3810234, for valve seat installation procedures.





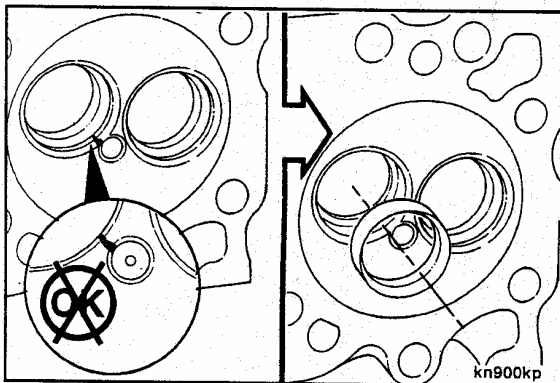
Cylinder Head Cracks - Reuse Guidelines (2-08)

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

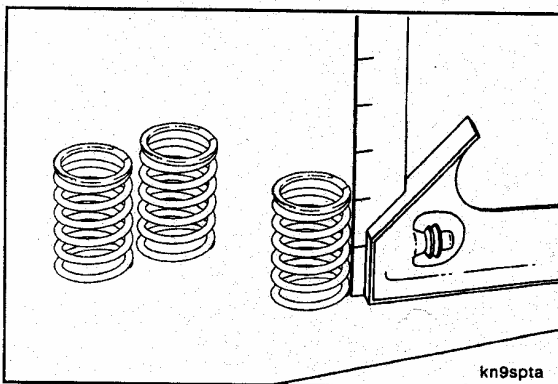


The reuse guidelines for a cylinder head with a crack extending from the injector bore to the valve seat is as follows:

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.

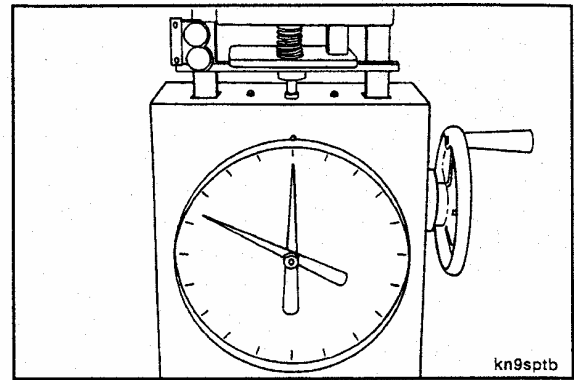
Limits

Approx. Free Length (L): 55.63 mm [2.190 in.]

Maximum Inclination: 1.0 mm [0.039 in.]

Spring Specifications

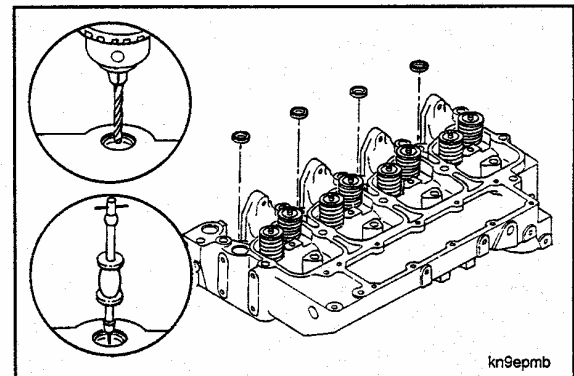
Spring Color	Approximate Free Length	Load at 49.25mm Height
Blue	55.63mm [2.190 in]	289.13 to 321.16 N [65.0 to 72.2 Lbs]
White	70.64mm [2.781 in]	643.2 to 691.2 N [144.6 to 155.4 Lbs]



Cup Plug Replacement (2-10)

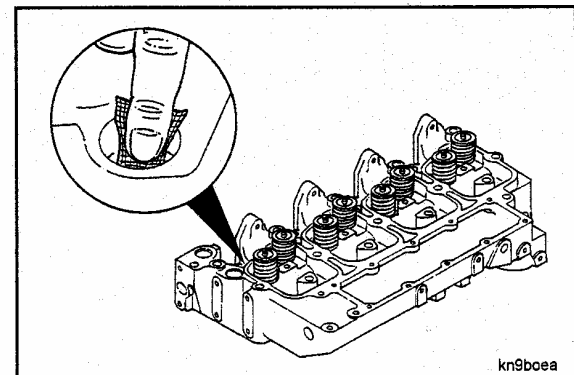
Drill Motor, 3 mm [1/8 inch] drill bit, slide hammer, #10 metal screw.

Remove the cup plugs from the cylinder head.



400 grit sandpaper, Diesel Fuel

Thoroughly clean the cup plug holes.

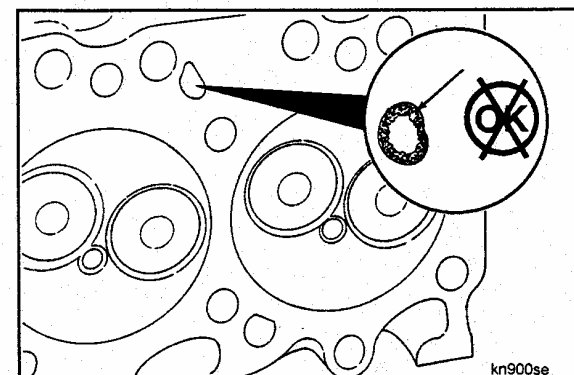
**WARNING**

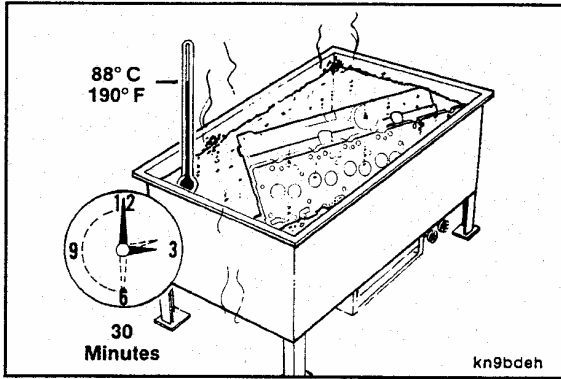
Use protective clothing to prevent personal injury.

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.

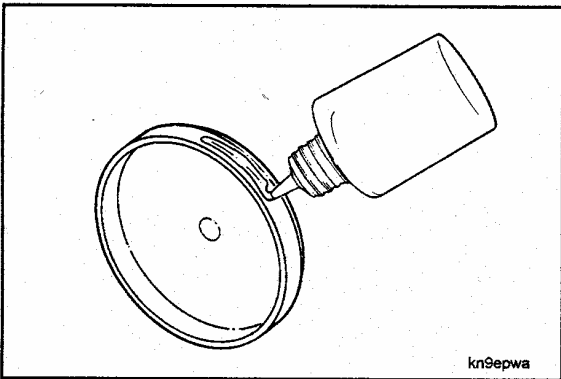




WARNING

Use protective clothing to prevent personal injury.

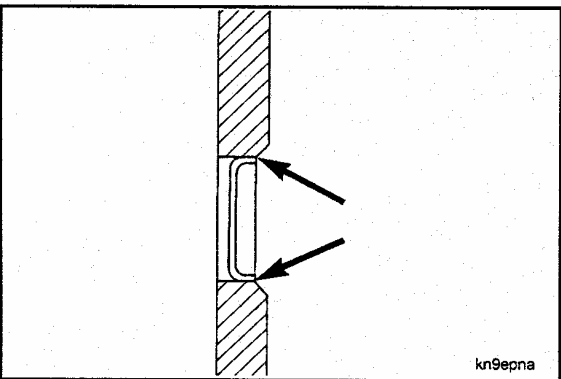
The cylinder head may be cleaned in a hot tank using a soap and water solution.



NOTE

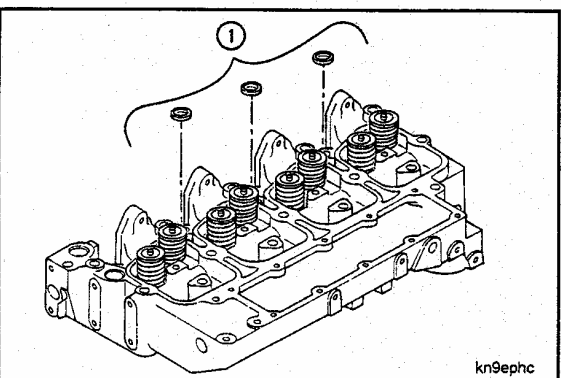
The cup plugs and cup plug holes must be clean and free of oil before installing the cup plugs.

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.

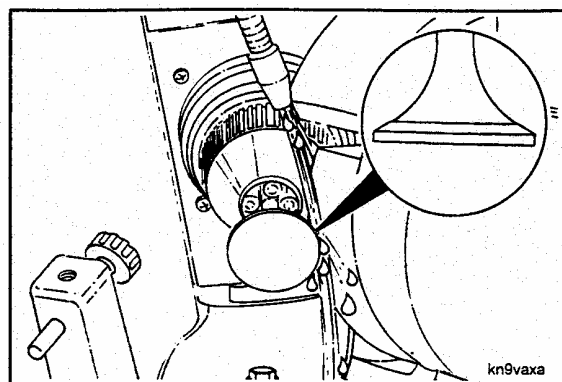


Cup Plug Locations

1. 13/16 inch

Valves - Grinding (2-11)

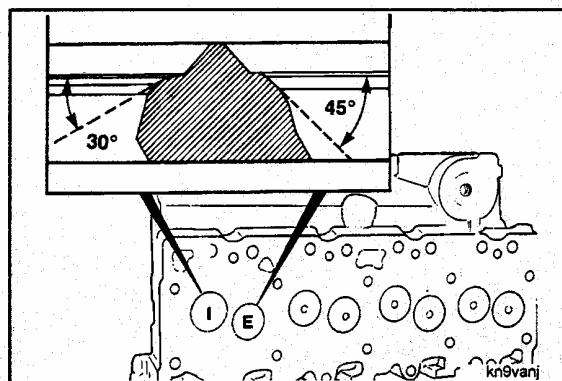
Re-face all reused valves. Check/replace bent valves.



Seat Angle

Intake: 30 Degrees

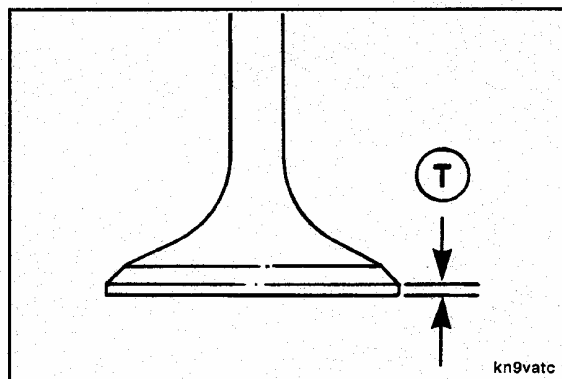
Exhaust: 45 Degrees



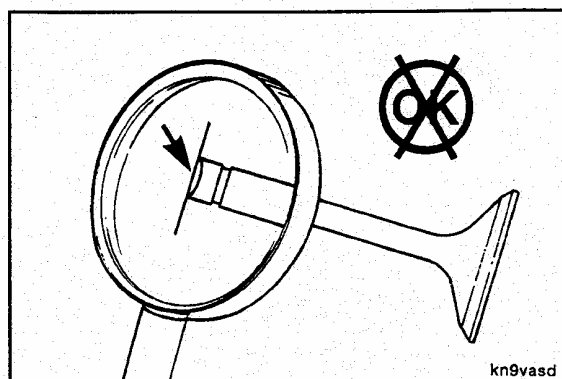
Measure rim thickness.

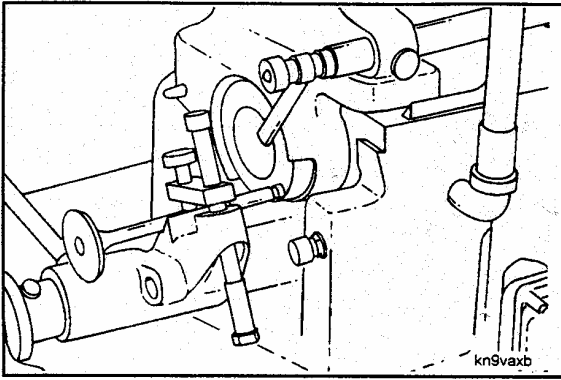
Valve Rim Thickness

Minimum (T): 0.79 mm [0.031 in]

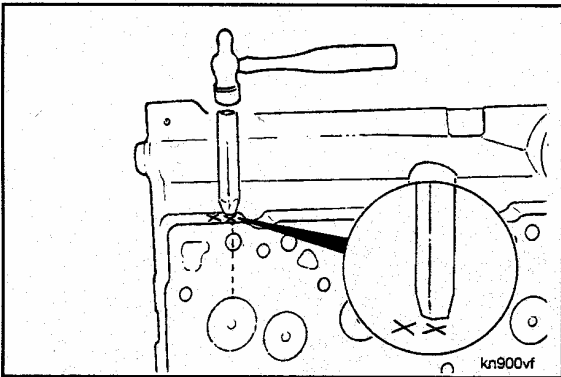


Check the valve stem tip for flatness.





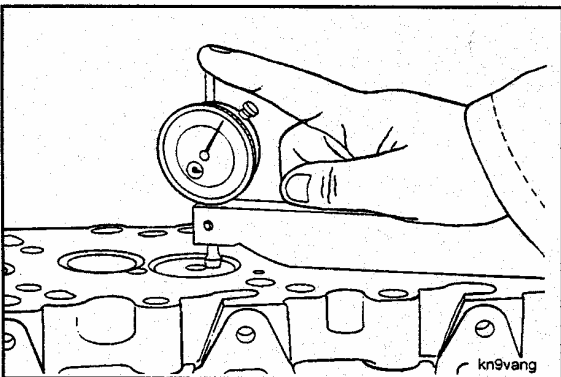
If required, re-surface the tip.



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 with service seats. Refer to the Alternative Repair Manual, Bulletin No. 3810234.

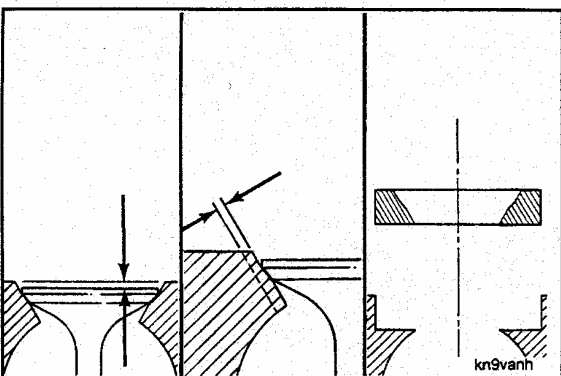


Calculating the Grinding Depth

Measuring the Valve Depth

3823495 Gauge Block

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



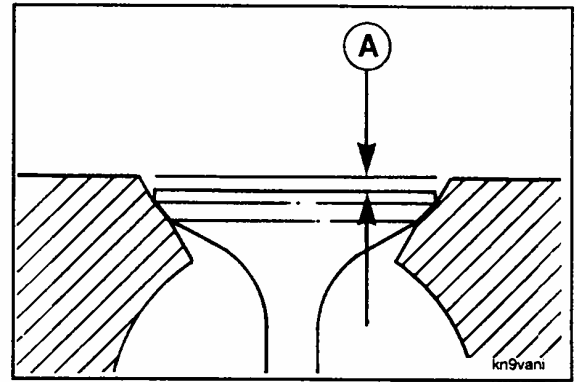
There are two valve seat parameters that are critical to the valve grinding process. The first is to comply with the valve depth limits and the second is to not grind through the hardened layer of the valve seat by observing the grind depth limit. If either of these parameters are out of specification,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

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

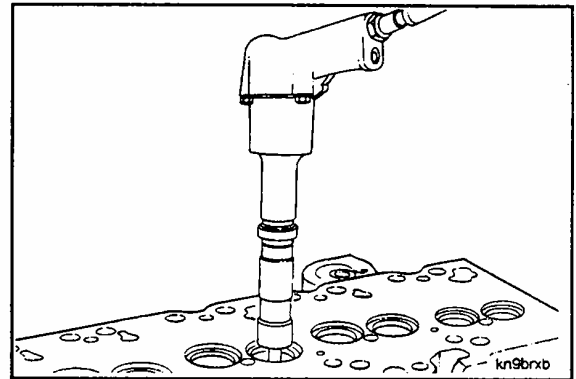
Record the depth of each valve as (A).

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.



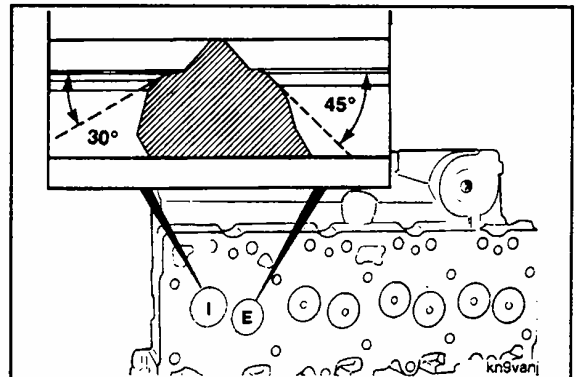
After valves meet initial valve depth criteria, grind the valve seats to remove all scores, scratches and burns.



Seat Angle

Intake: 30 Degrees

Exhaust: 45 Degrees



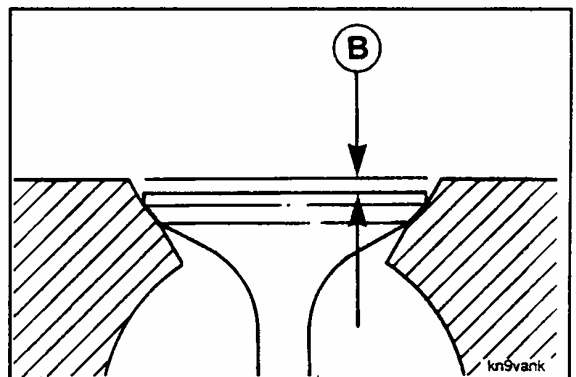
3823495 Gauge Block

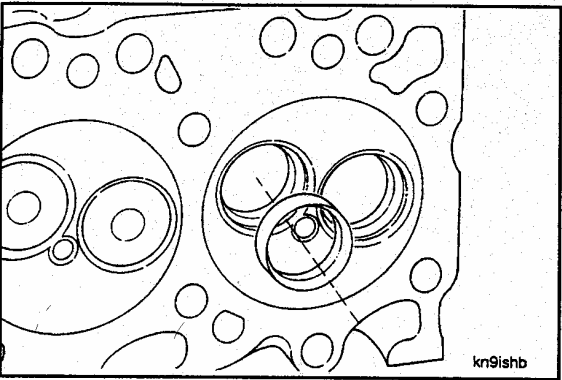
Since the seats have been ground, it is necessary to re-measure the valve depth and to calculate the grinding depth.

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

NOTE

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



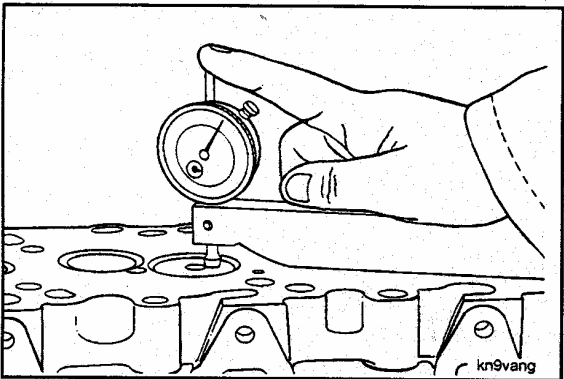


Calculate grinding depth (GD) as follows:
 $GD = (B) - (A)$

Seat Grinding Depth Limit

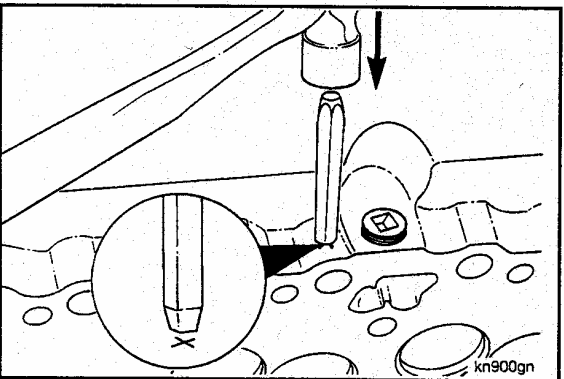
GD: 0.254 mm [0.010 inch]

Service valve seats are available for over the limit seats.

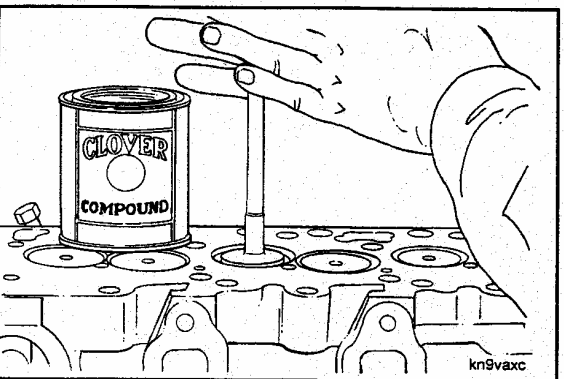


Confirm that the valve depth after grind (B) is still within the original specification.

Valve Depth (A) or (B)		
mm		in
0.99	MIN	0.039
1.52	MAX	0.060

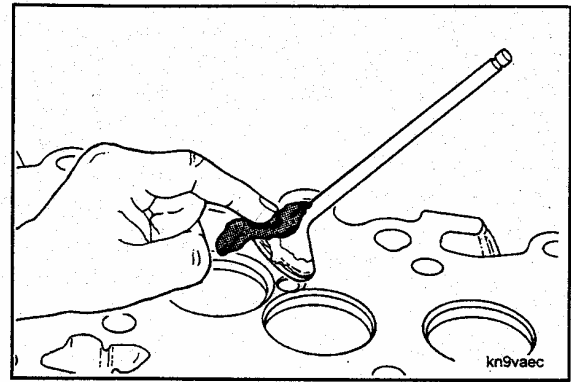


Mark the cylinder head with an (X) to identify each re-ground valve seat.

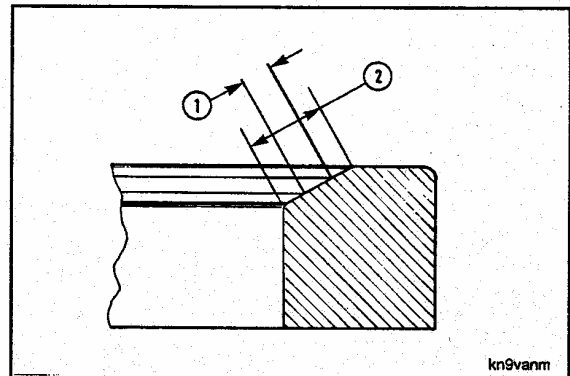


Apply a light coat of valve lapping compound to each valve and lap each valve to its companion seat.

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

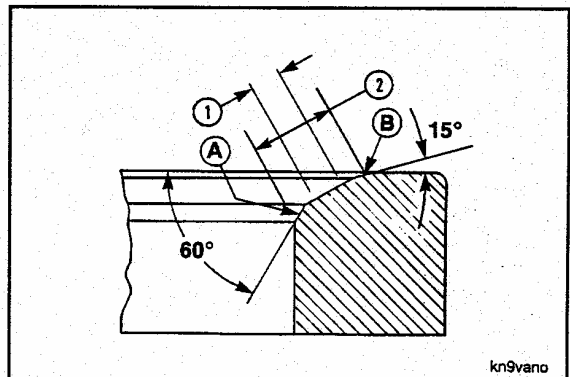


The valve should seat in the center of the valve face. Measure the valve seat width indicated by the lapped surface.



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

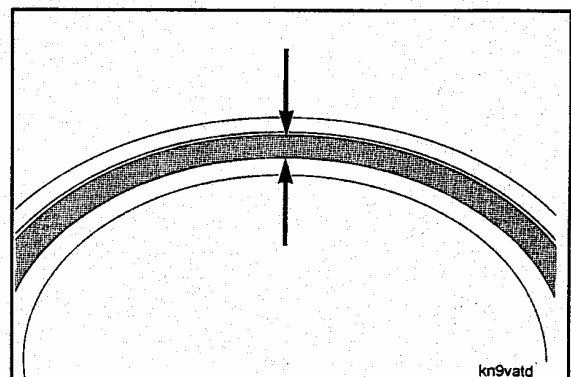
Grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face and obtain the valve seat width limits.

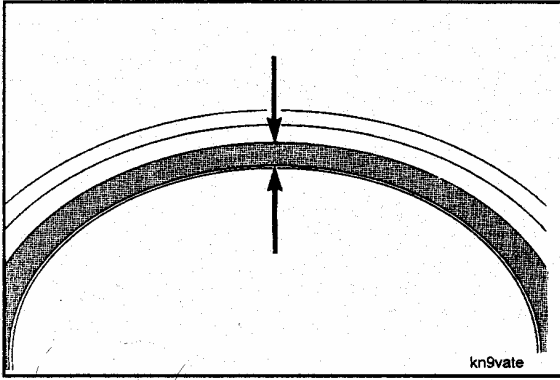


Valve Seat Width Limit		
mm		in
1.5	MIN	0.059
2.0	MAX	0.079

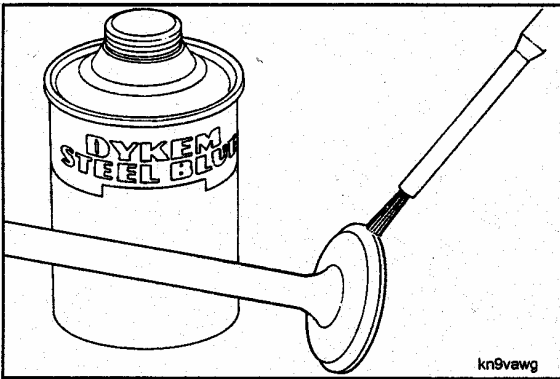
The lapped surface on the valve face is the key to determining how much of each angle to grind.

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.

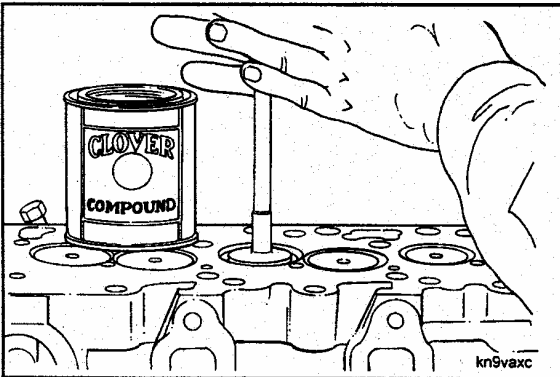




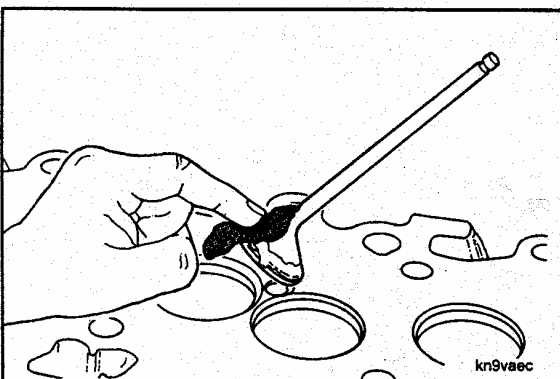
If the lapped surface is at the top of the valve face, the seat will require more grinding with the 15 degree stone than with the 60 degree stone.



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



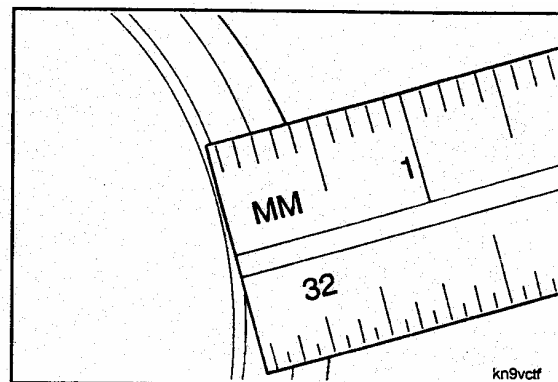
Apply a coat of valve lapping compound to the valve and lap the valve to its companion seat.



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

Valve Seat Width		
mm		in
1.5	MIN	0.059
2.0	MAX	0.079



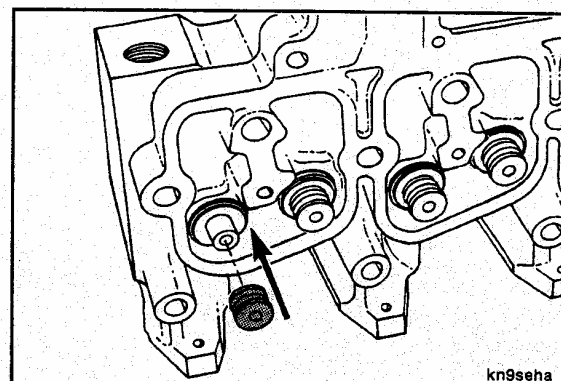
Cylinder Head - Assembly (2-13)

NOTE

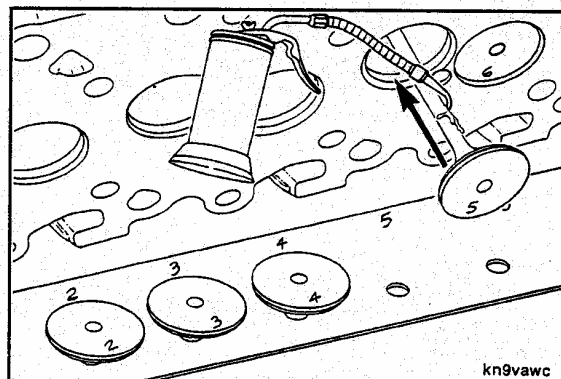
Clean all cylinder head components before assembling.

Install the valve stem seals.

The intake and exhaust seals are the same.

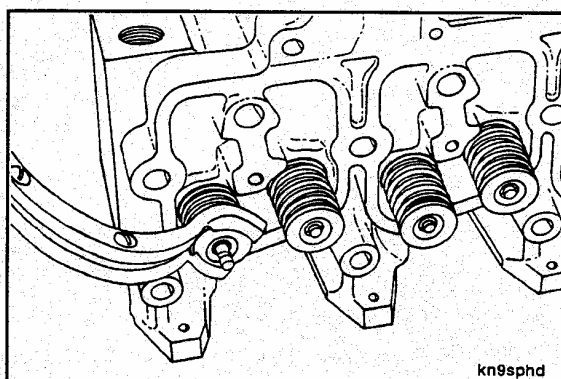


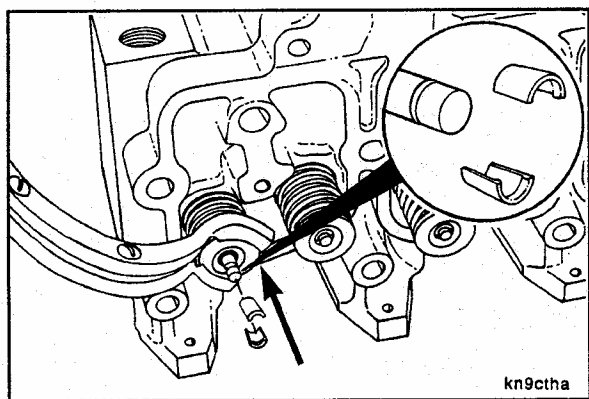
Lubricate the stems with SAE 90W engine oil before installing the valves.



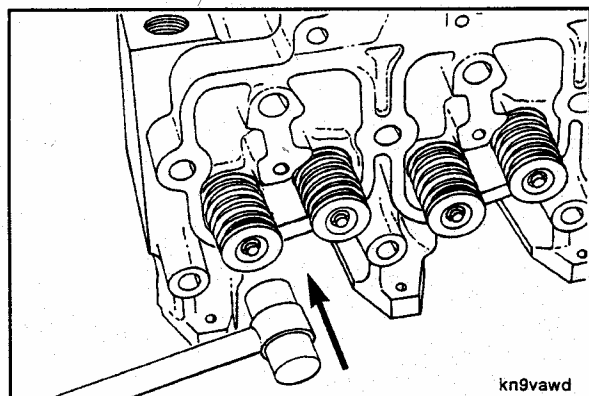
Valve Spring Compressor

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.



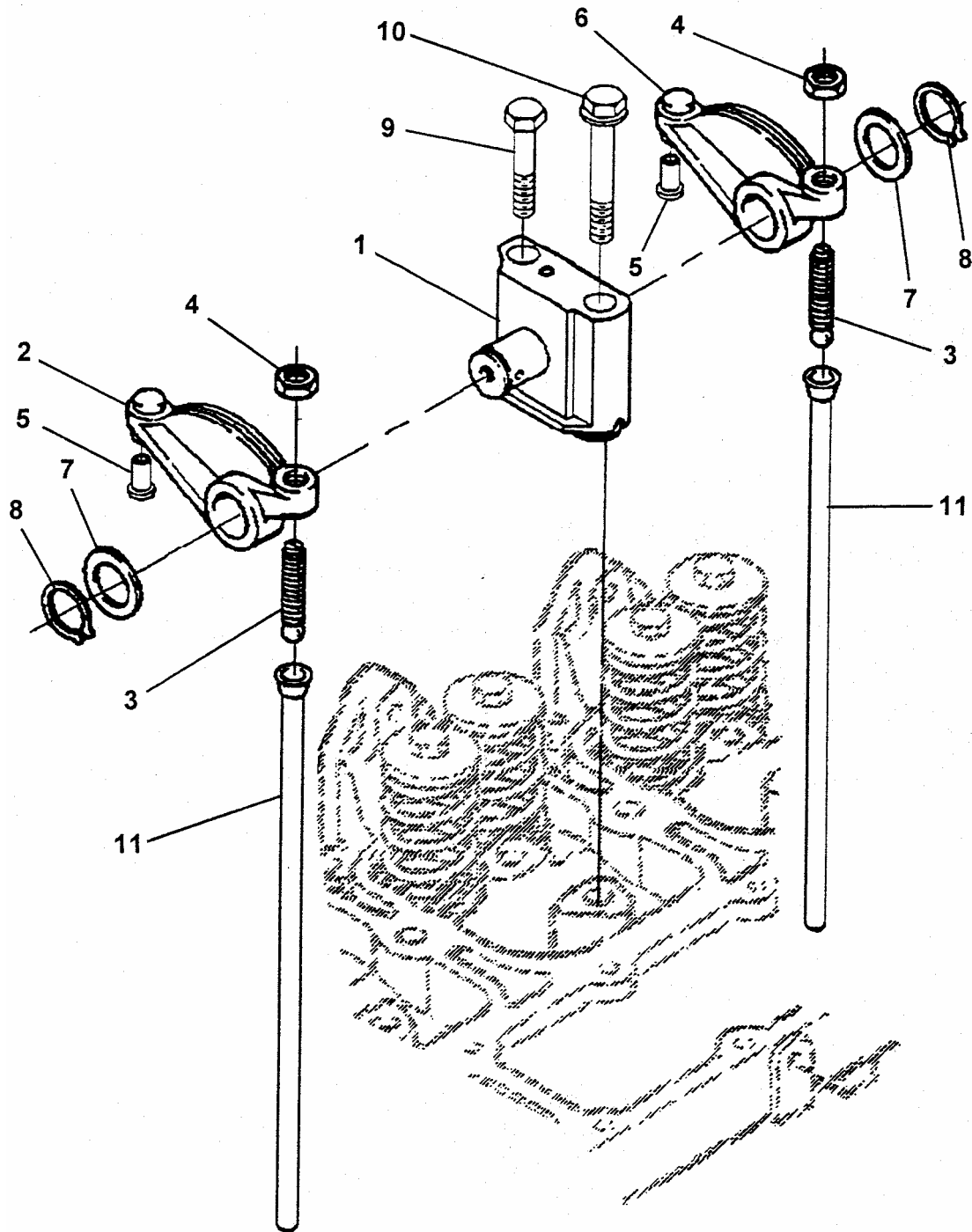
After assembly, hit the valve stems with a plastic hammer to make sure that the collets are seated.

Section 3 – Rocker Levers – Group 03

Section Contents

	Page
Rocker Lever - Inspection	3-6
Rocker Lever Assembly – Exploded View	3-2
Rocker Lever Assembly – General Information	3-4
Rocker Lever Pedestals - Inspection	3-7
Rocker Levers - Assembly	3-7
Rocker Levers – Disassembly	3-5
Rocker Levers and Pedestals – Cleaning	3-6

Rocker Lever Assembly – Exploded View



Ref. No.	Part Name	Qty.	Remarks
1	Support, Rocker Lever	6	Intake
2	Lever, Rocker	6	
3	Screw, Slotted Set	12	
4	Nut, Heavy Hexagon	12	
5	Insert, Rocker Lever	12	
6	Lever, Rocker	6	Exhaust
7	Washer, Plain	12	
8	Ring, Retaining	12	
9	Screw, Hex Head Cap	6	
10	Screw, Hex Head Cap	6	
11	Rod, Push	12	

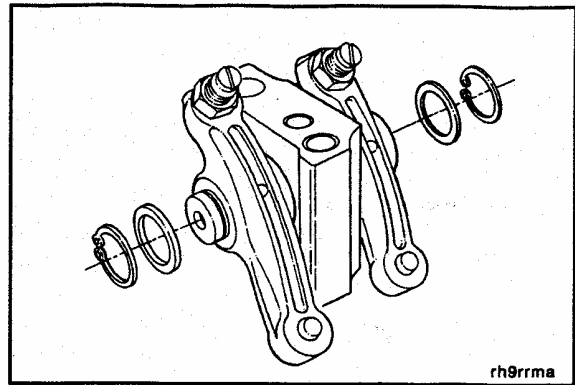
Rocker Lever Assembly - General Information

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.

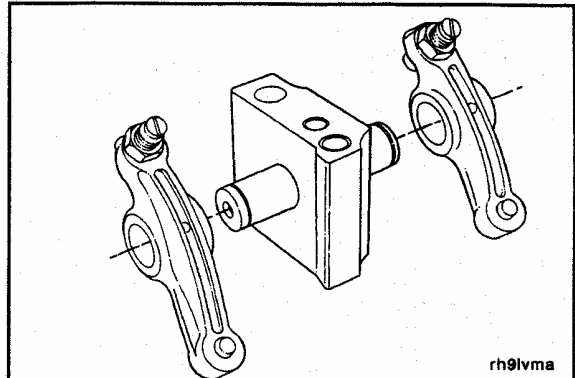
The levers are push rod actuated and use an adjusting screw to control the clearance between the lever and valve stem. The levers do not use a bushing in the bore for the rocker lever shaft. The lever must be replaced if the bore is damaged or worn beyond the limit.

Rocker Levers - Disassembly (3-01)

Remove the retaining rings and thrust washers.

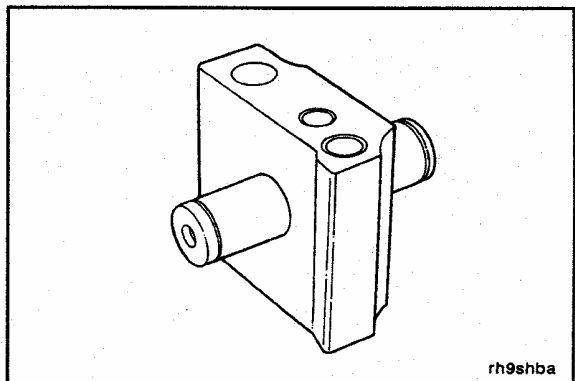


Remove rocker levers

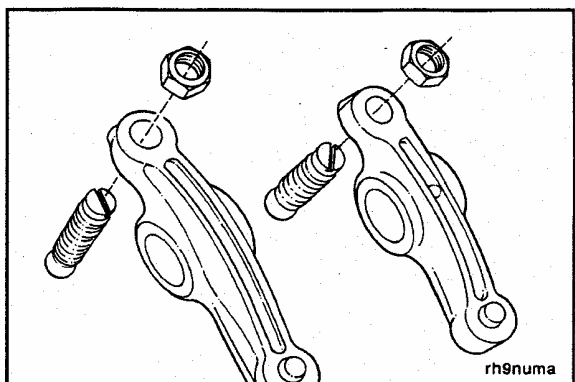


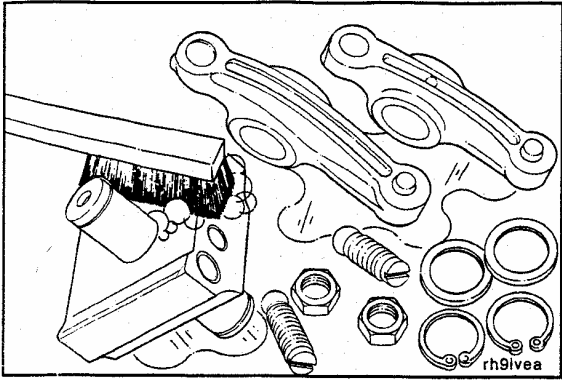
NOTE

The rocker shaft and pedestals are serviced as an assembly. Do not disassemble.



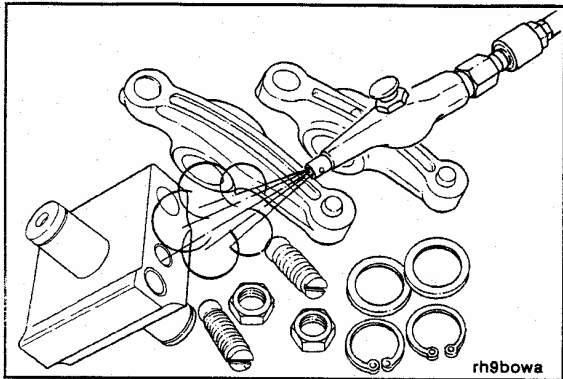
Remove the locknut and adjusting screw.





Rocker Levers and Pedestals - Cleaning (3-02)

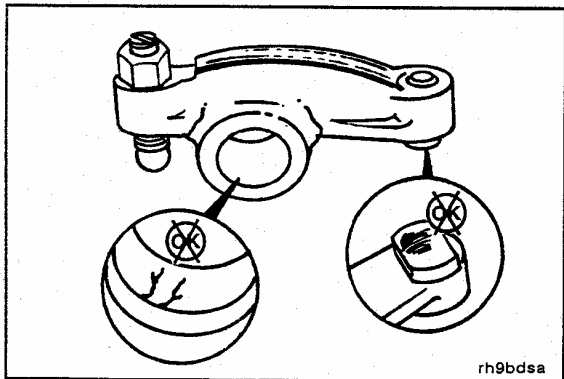
Clean all parts in a strong solution of laundry detergent in hot water.



Use compressed air to dry the parts after rinsing in clean, hot water.

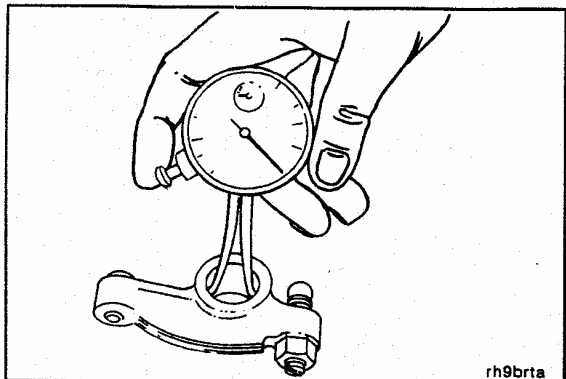
NOTE

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.



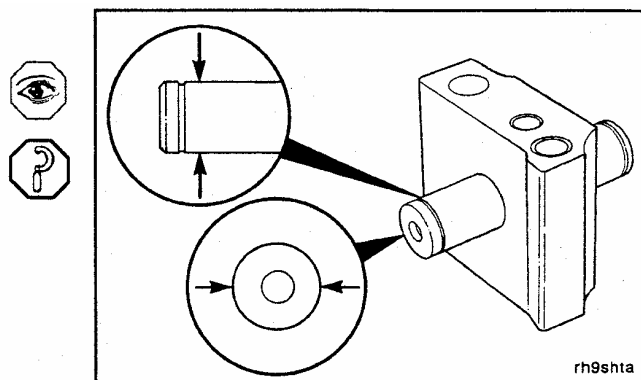
Measure the rocker lever bore.

Diameter		
mm		in
19.000	MIN	[0.7480]
19.051	MAX	[0.7500]

Rocker Lever Pedestals - Inspection (3-04)

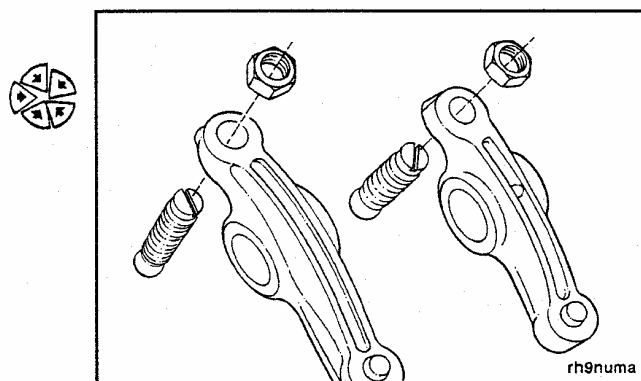
Inspect the pedestal and shaft for obvious damage.
Measure the shaft diameter.

	Diameter	
mm		in
18.938	MIN	[0.7456]
18.975	MAX	[0.7470]

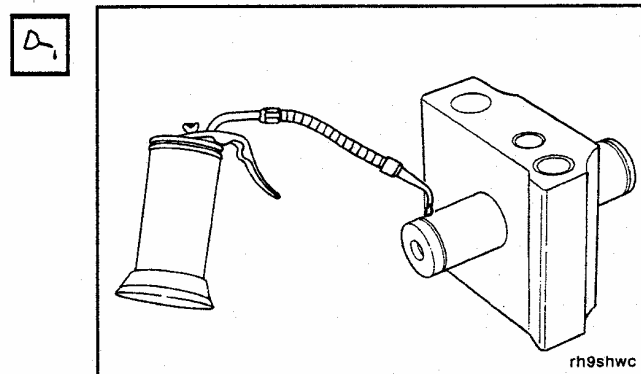


Rocker Levers - Assembly (3-05)

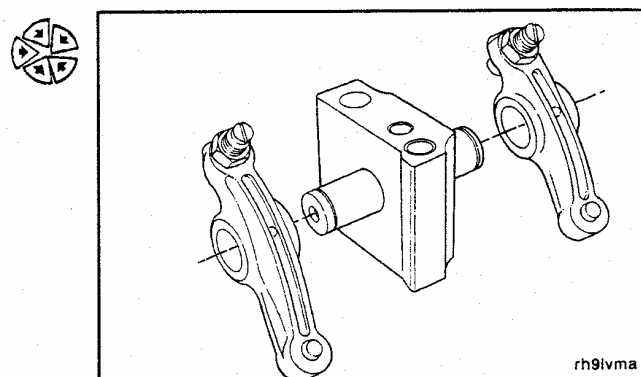
Install the adjusting screw and locknut.

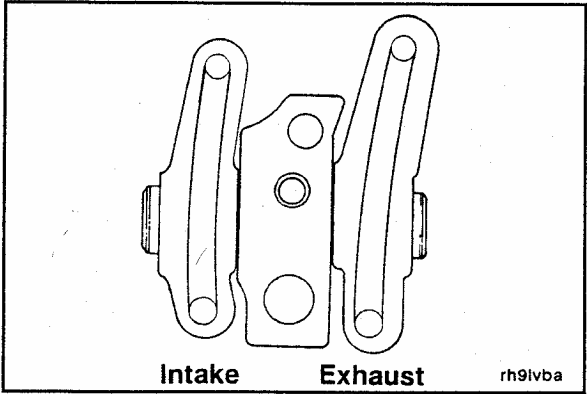


Lubricate the shaft with clean engine oil.



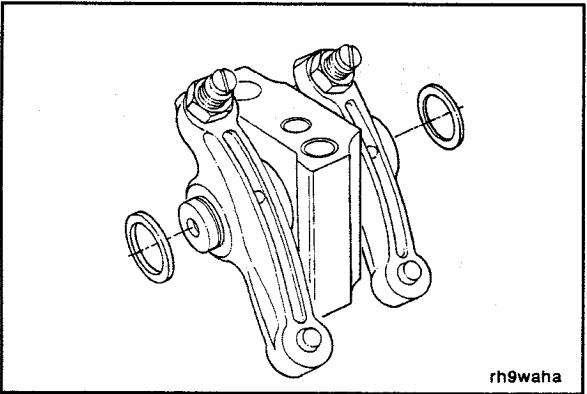
Position the levers on the rocker shaft.



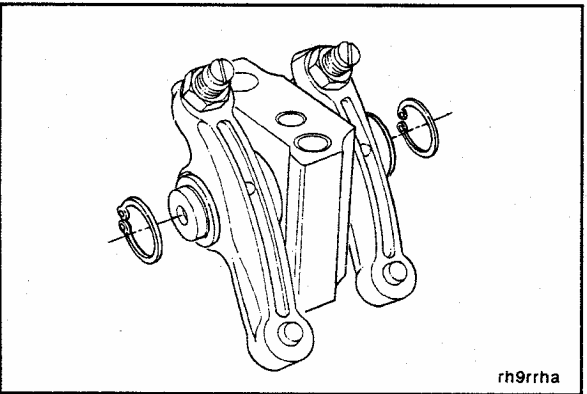


NOTE

Be sure to assemble the intake and exhaust rocker levers in the correct locations.



Install the thrust washers.



Snap Ring Pliers

Install the snap rings.

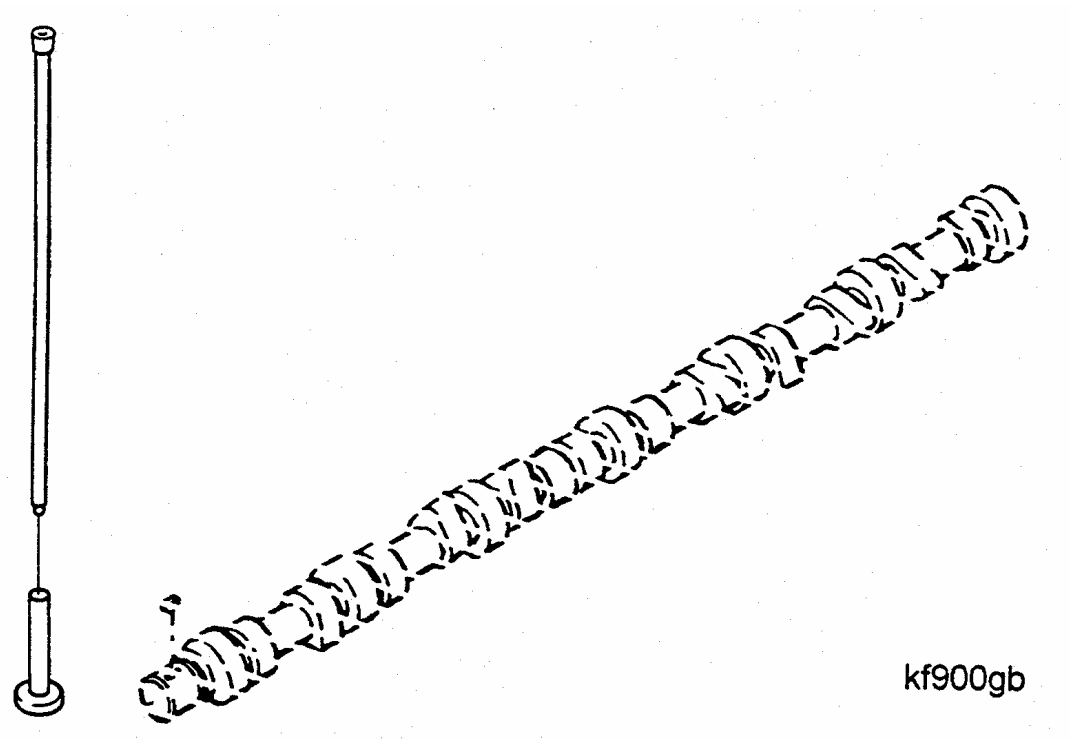


Section 4 – Tappets and Push Rods – Group 04

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Tappets and Push Rods - Exploded View	4-2
General Information	4-3
Tappets and Push Rods - General Information	4-3
Valve Tappets - Inspection.....	4-4

Tappets and Push Rods - Exploded View



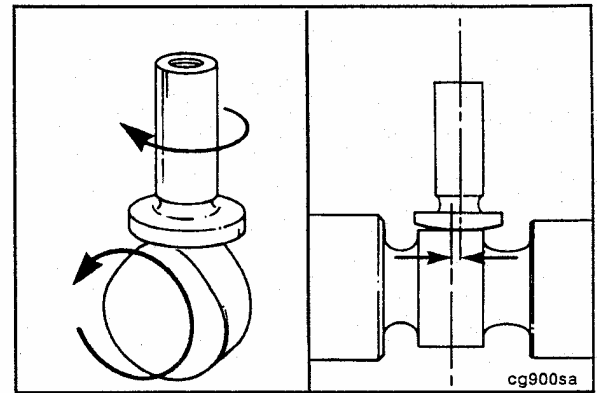
kf900gb

Tappets and Push Rods - General Information

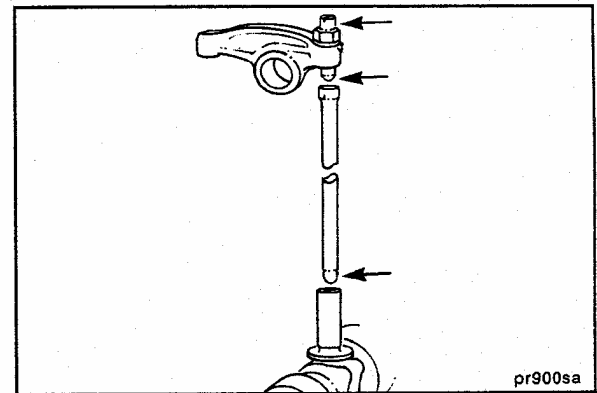
General Information

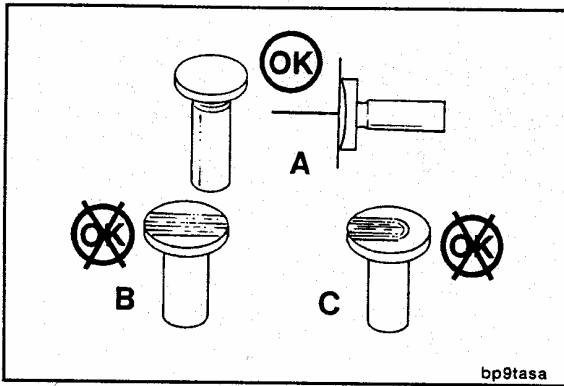
The camshaft has lobes to operate the intake and exhaust valves and a special lobe to drive the lift pump. The valve lobes contact the valve tappets which lift the push rods subsequently opening the valves.

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.





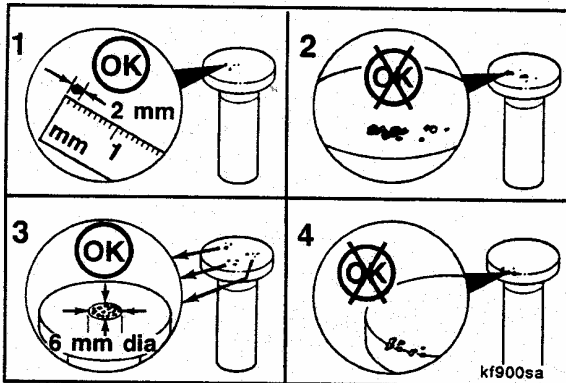
Valve Tappets – Inspection (4-01)

Inspect the socket, stem and face for excessive wear, cracks and other damage.

Visual Limits

(A) - Normal Contact

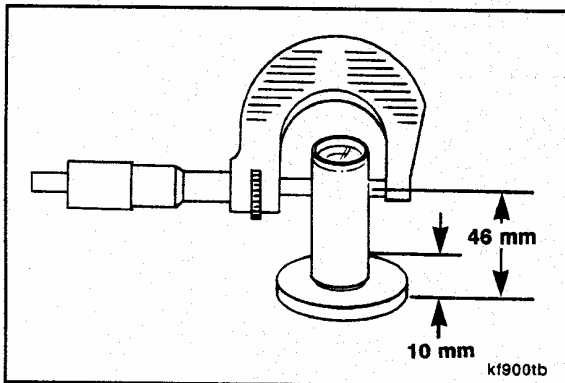
(B) and (C) - Irregular Contact: **Do not reuse.**



Pit marks on the tappet face are acceptable.

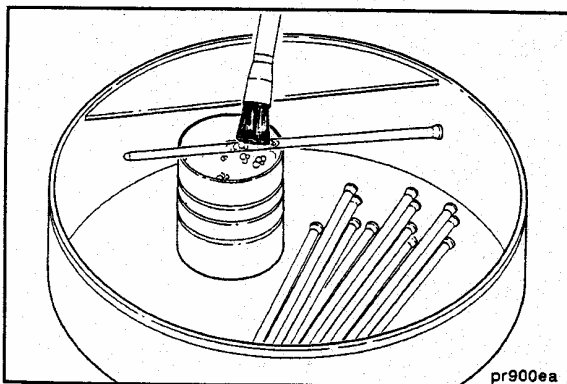
The following criteria define the size of the pits allowed.

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.

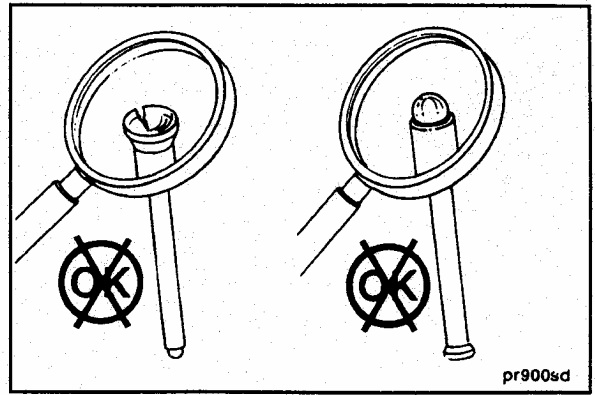
Diameter		
mm		in
15.936	MIN	[0.627]
15.977	MAX	[0.629]



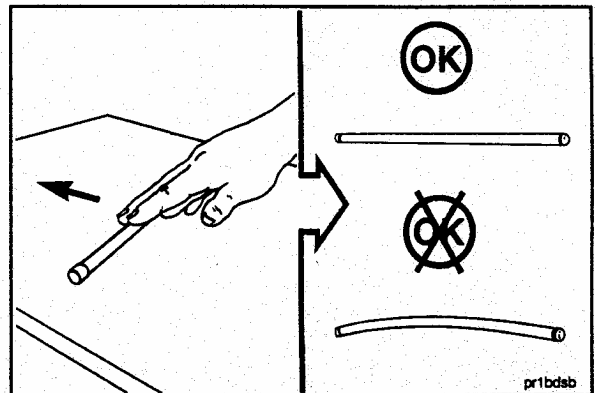
Push Rods - Inspection (4-02)

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.

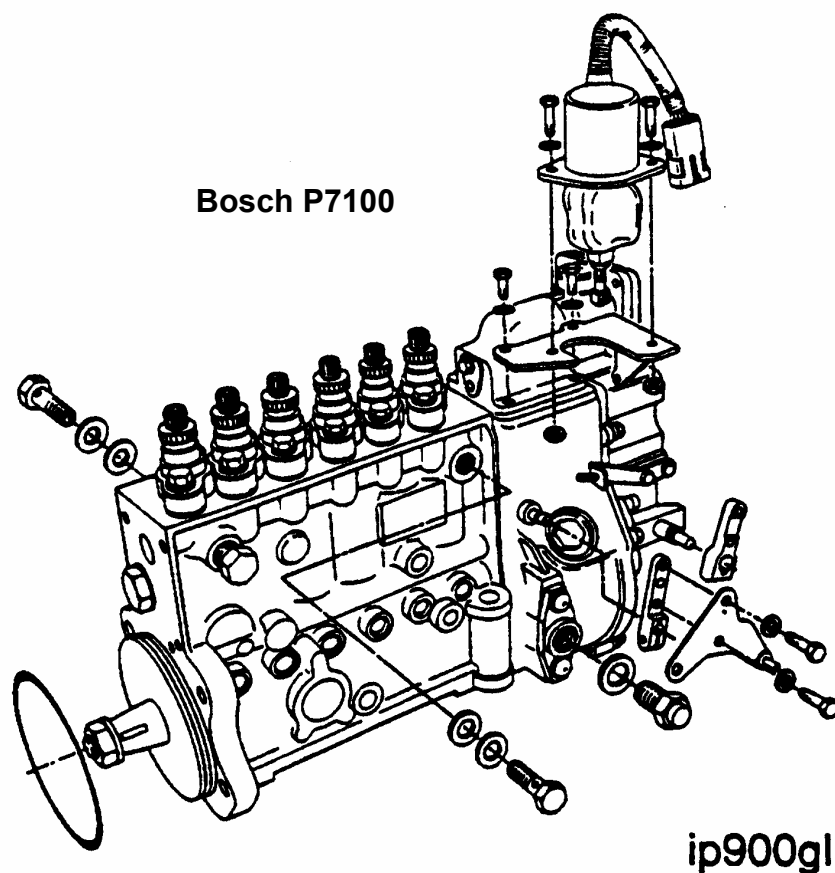


Section 5 – Fuel System – Group 05

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Exploded View – Fuel System



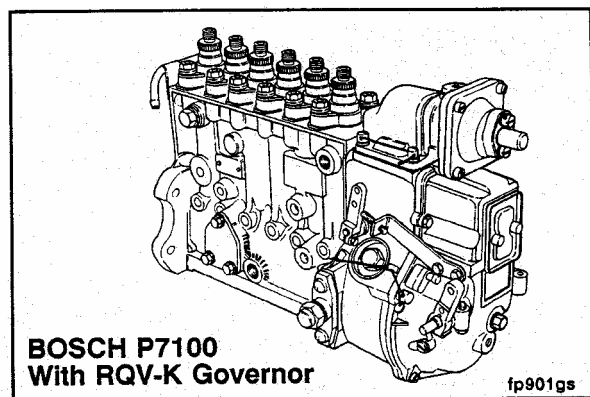
Injection Pump - General Information

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.



The Bosch P7100 in-line fuel injection pump.

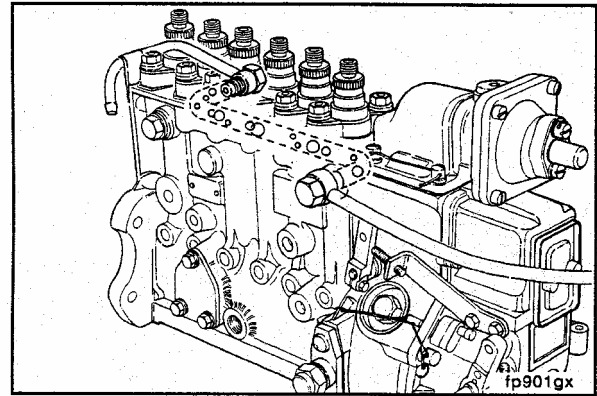
- 1991 high horsepower automotive ratings.
- All 1994 automotive ratings.

Injection Pump Repairs (5-21)

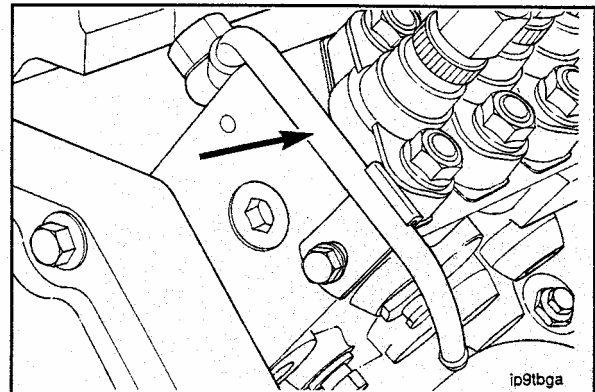
Pressure Relief Valve and Sealing Washer Replacement, Bosch P7100 (5-29)

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.

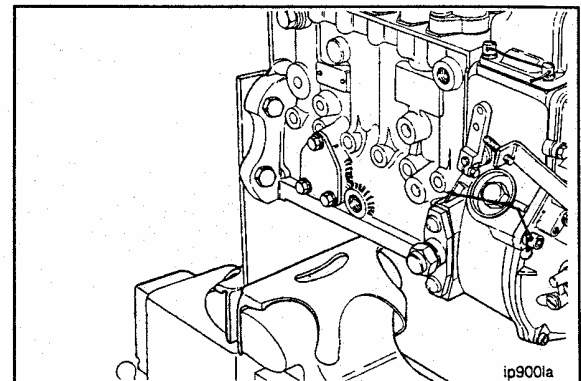
A sticky or malfunctioning relief valve can result in engine miss, low power or hard starting.



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.

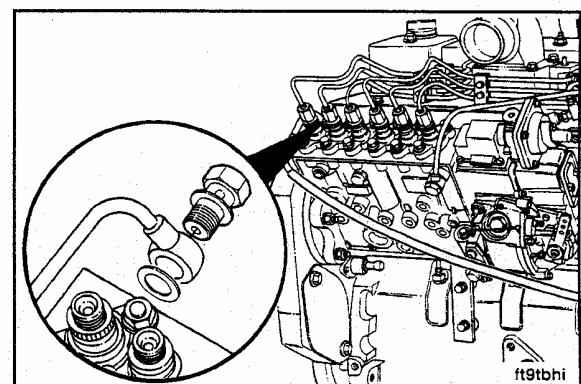


Mount the pump in a suitable bracket and hold pump with a vise.



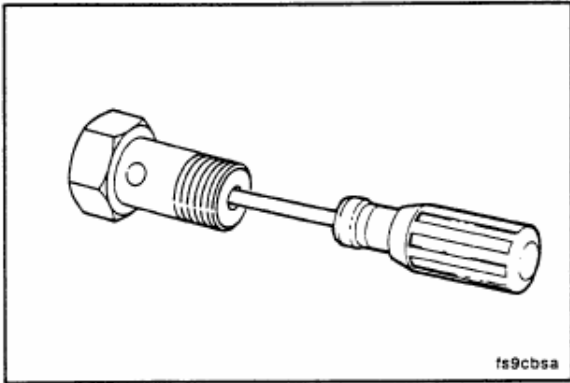
19 mm

Remove the pressure relief valve and sealing washers.
Remove the jump-over tube.





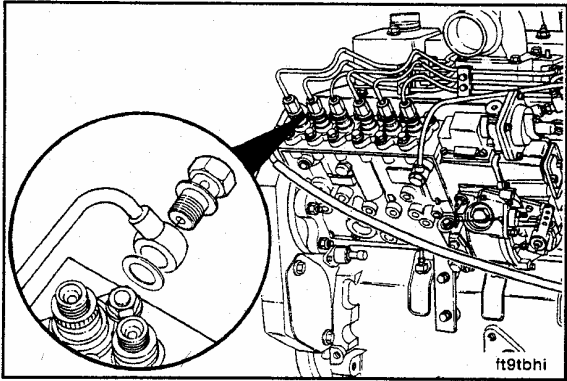
Thoroughly flush the pressure relief valve with a cleaning solution.



Use a small screwdriver to check that the check ball is not sticking in the pressure relief valve assembly.

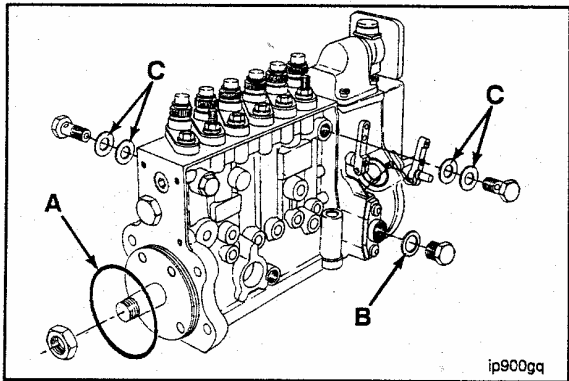
A sticky check ball will result in engine low power and hard starting.

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.



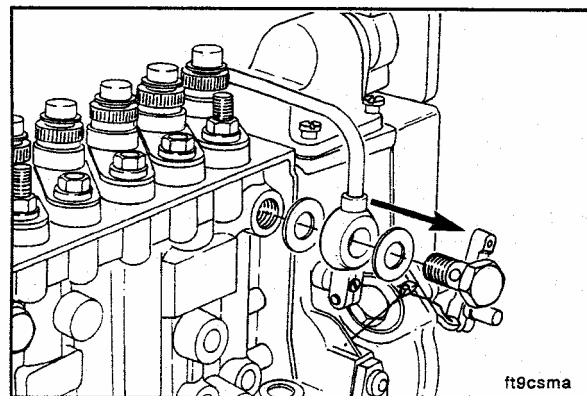
Seal Replacement, Bosch P7100 (5-30)

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)

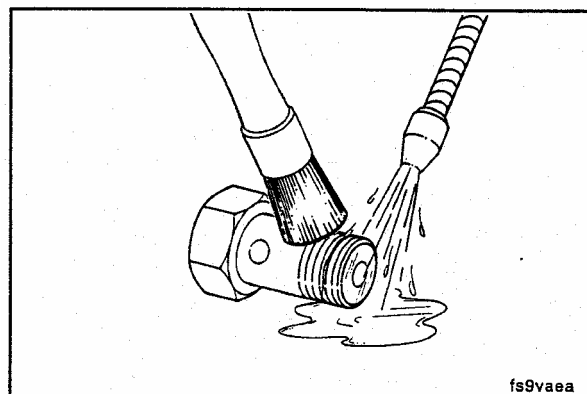
19 mm

Remove the fuel inlet banjo connector and sealing washers.



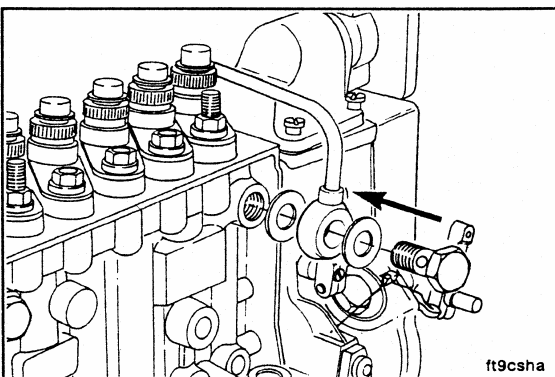
Thoroughly flush the inlet connector with a cleaning solution to ensure it is not blocked with foreign debris.

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.

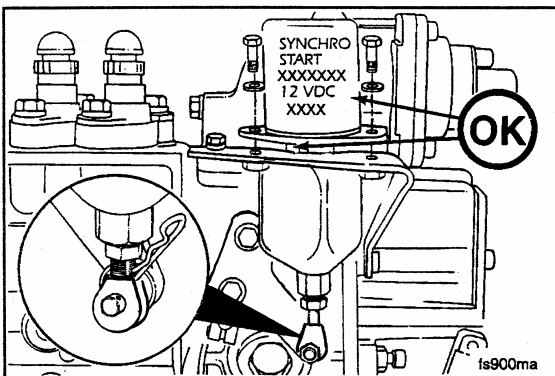


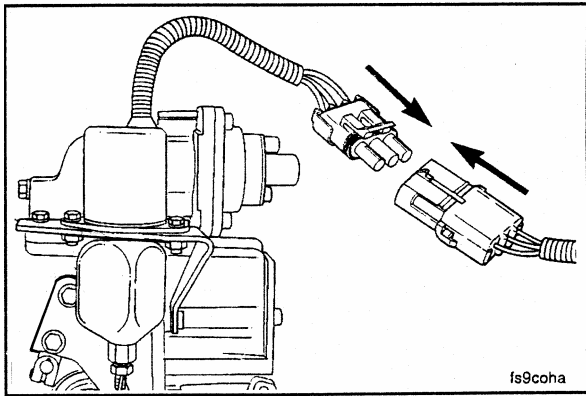
Fuel Shut Off Solenoid Replacement, Bosch P7100 (5-32)

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]



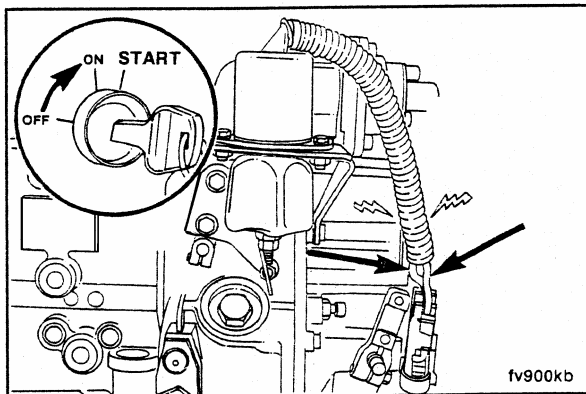


Fuel Shut Off Solenoid Adjustment, Bosch P7100 (5-33)

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.

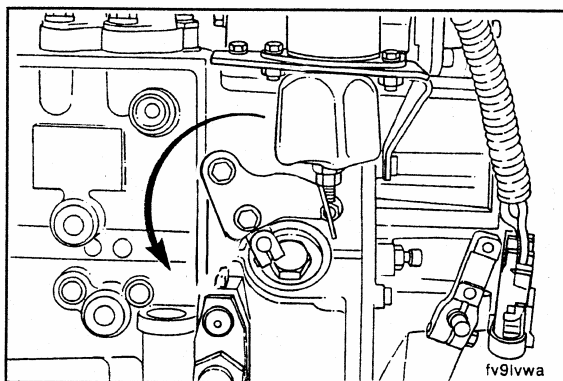


Turn the key to the "ON" position. This will energize the red (hold) wire and black (common) wire.

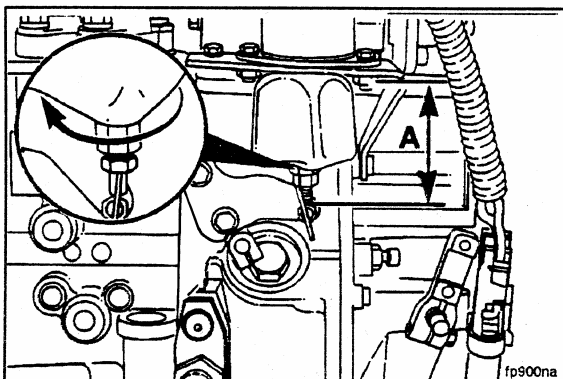
This is the low current hold-in coil and must be energized continuously during this adjustment.

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)

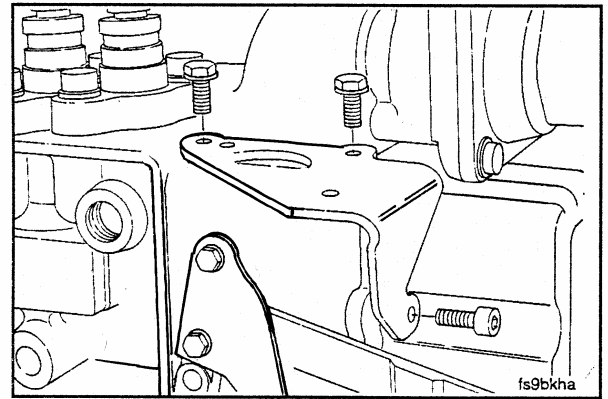
Preparatory Step:

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]



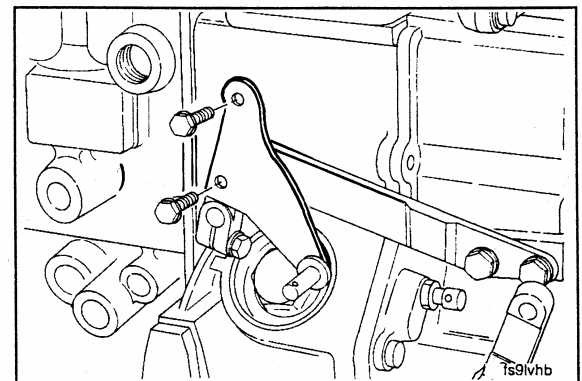
Fuel Pump Shut Off Lever Replacement, Bosch P7100 (5-35)

Preparatory Step:

Remove the shut off solenoid.

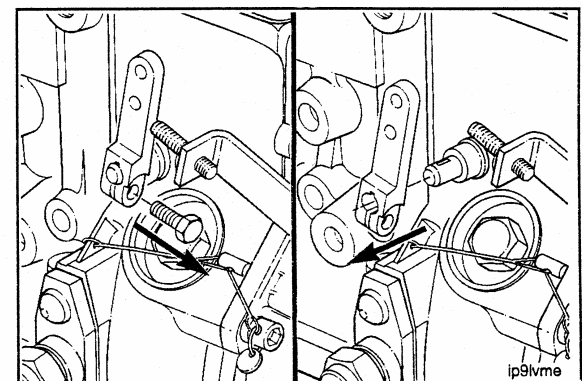
8 mm, 10 mm

Remove the capscrews holding the lever bracket to the lever.



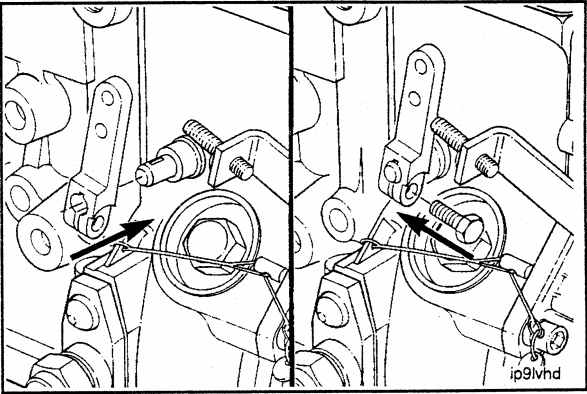
8 mm

Remove the capscrew holding the shut off lever to the shut off shaft.



NOTE

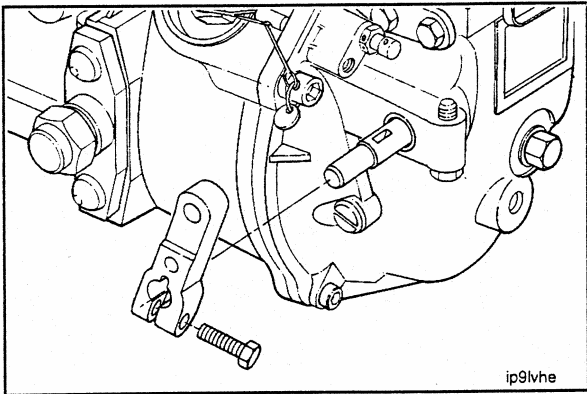
The shut off lever is indexed to the shaft with a Woodruff key.



8 mm, 10 mm

Install in the reverse order of removal.

Adjust the shut off solenoid. Refer to Procedure (5-29).



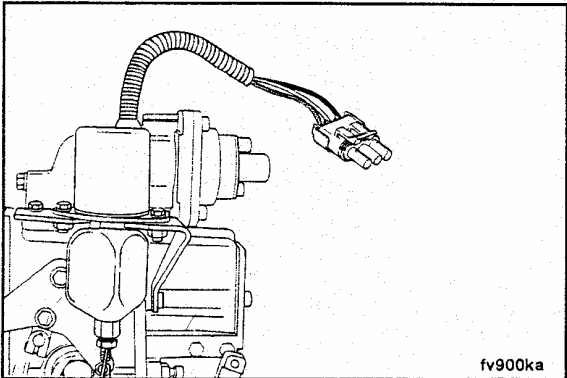
Throttle Lever Replacement, Bosch P7100 (5-36)

8 mm

Remove and replace the throttle lever as illustrated.

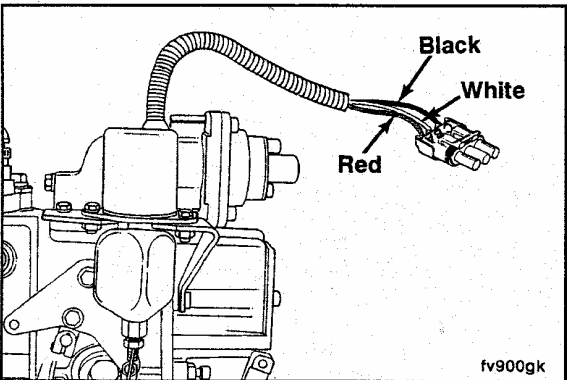
NOTE

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.

<u>Color</u>	<u>Description</u>	<u>Weatherpack Port</u>
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.

Gauge	Length of Wire		
	0-4.5 ft	0-7.0 ft	0-11 ft
	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.

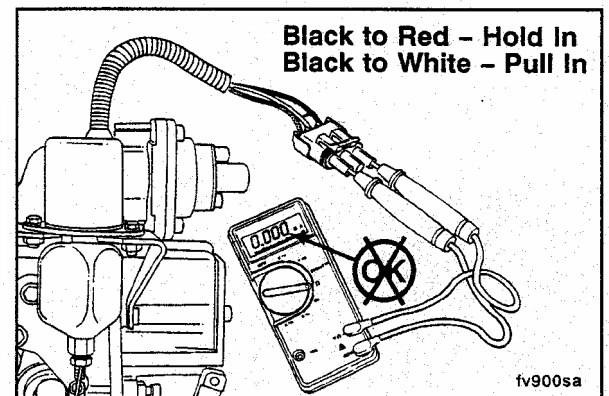
NOTE

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	Hold-In
12	0.22	11.1
24	0.82	41.3



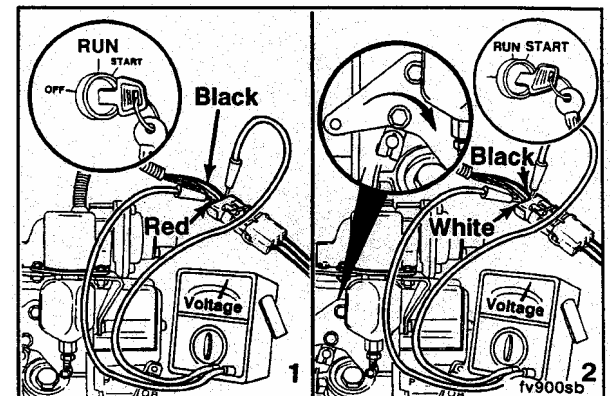
Solenoid Voltage Check

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



NOTES

[illegible]

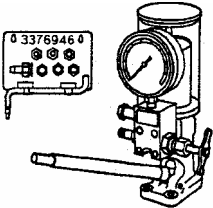
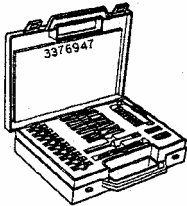
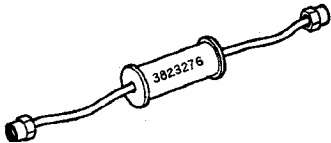
Section 6 – Injectors and Fuel Lines – Group 06

Section Contents

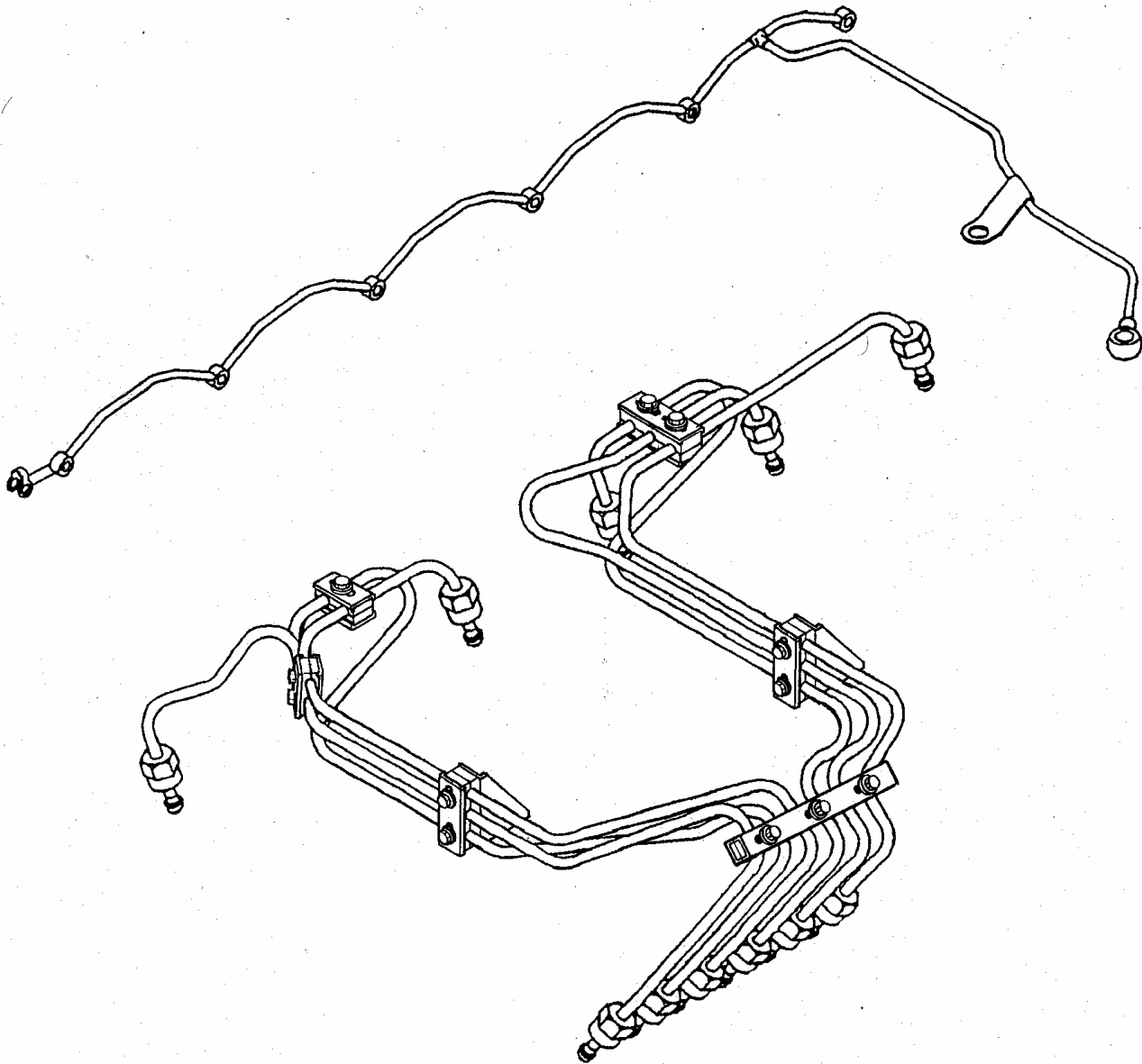
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Injector - Service Tools

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



Injectors – General Information

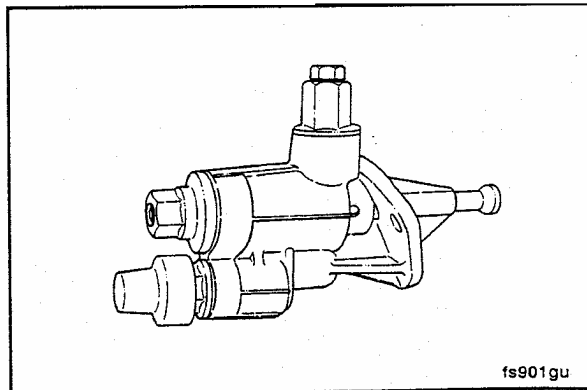
The injector needle valve and the nozzle tip are machined to a very precise tolerance. Never replace only the needle valve. Never mix the needle valves and nozzle tips, they are matched sets.

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

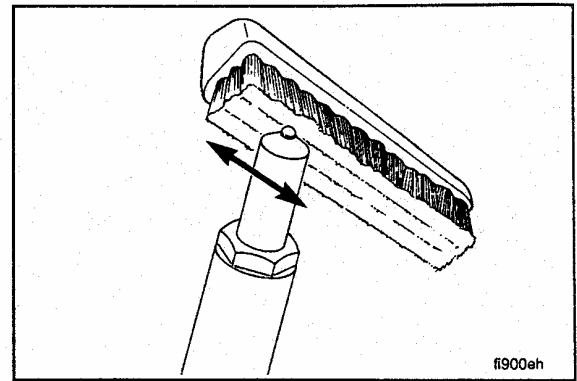
The B series engine uses three different piston style, and one diaphragm style, transfer pumps. The diaphragm style transfer pump cannot be rebuilt.



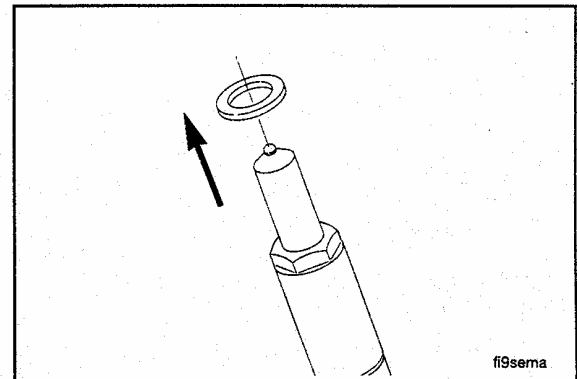
Piston style transfer pump, Part No. 3930134, is used on this model engine.

Injector - Disassembly

Clean the carbon residue from the nozzle. Use a brass wire brush and a piece of hardwood dipped in test oil.

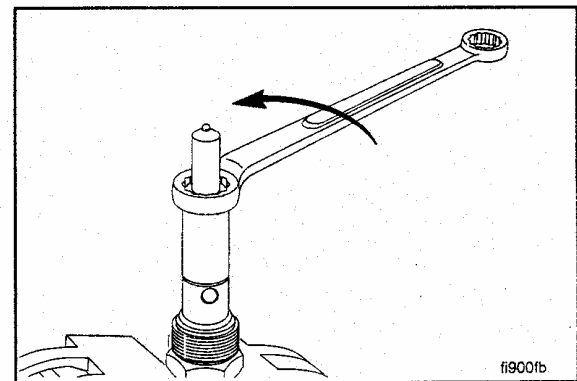


Remove the copper sealing washer and discard.



15 mm

Clamp the nozzle holder in a soft jawed vise and remove the nozzle nut.

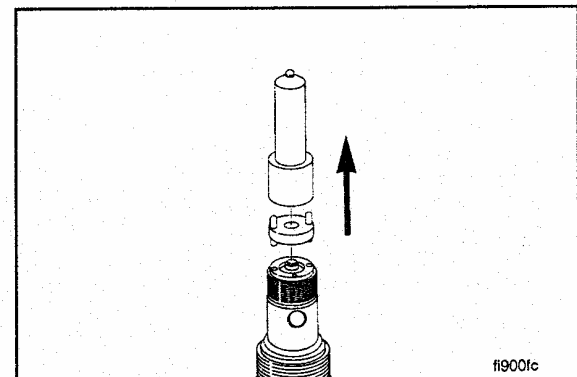


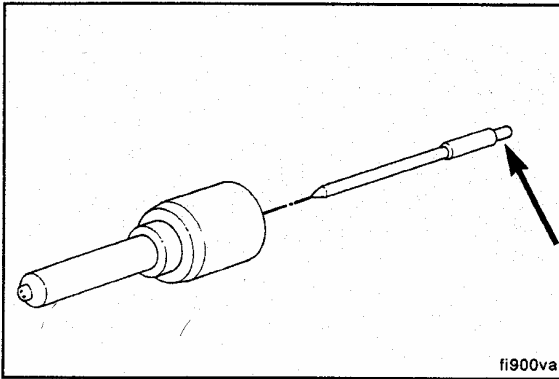
Remove the nozzle needle valve and intermediate plate.



NOTE

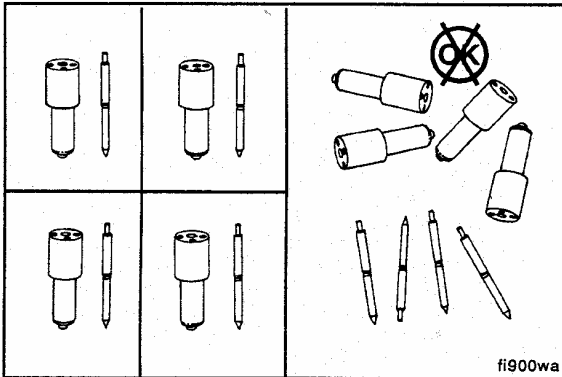
To avoid damage place injector nozzle and needle valve in a suitable bath of clean test oil.





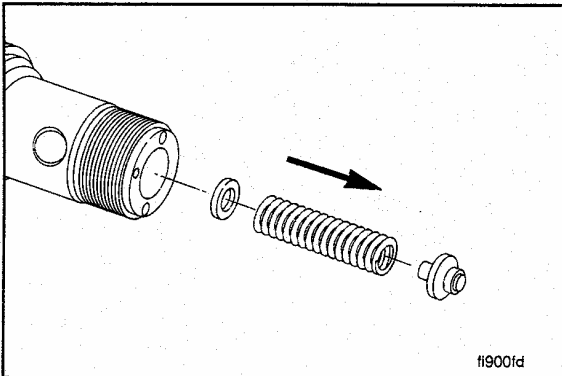
CAUTION

Hold the needle valve by the stem only. Skin oils will corrode the finely lapped surfaces.

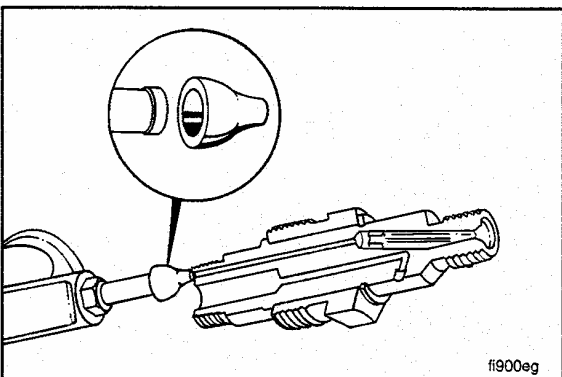


CAUTION

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

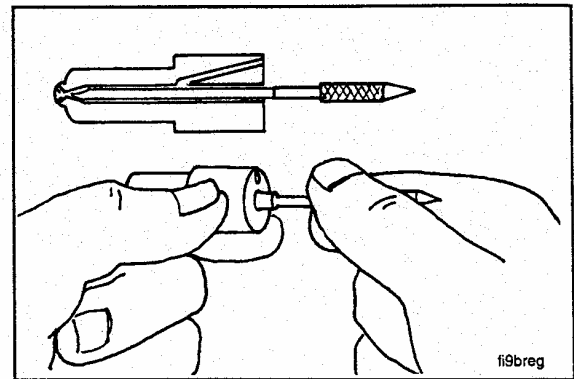
Edge-type filters may be cleaned by applying compressed air to the fuel passage from the nozzle side of the nozzle holder. Edge-type filters are not removable for service.

Rinse new nozzle bodies and needle valves in solvent to thoroughly flush and completely remove all protective coating material.

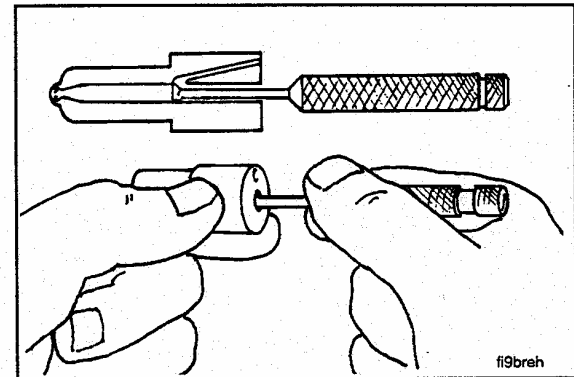
Nozzle Cleaning Kit 3376947**CAUTION**

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.

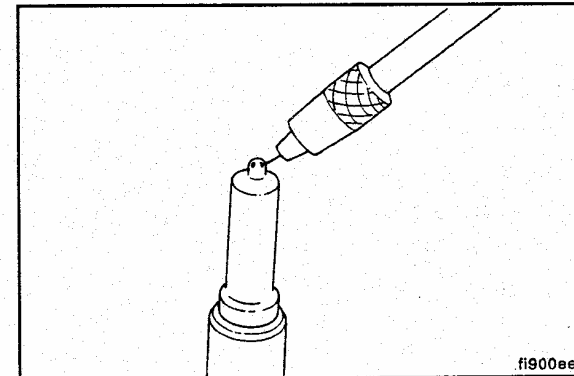


Clean the interior ring groove of the nozzle with the scraper as shown. Rinse in solvent to remove all dirt and carbon residue and dip in clean test oil.



Clean the spray holes of hole-type nozzles as shown with the appropriate size cleaning needle.

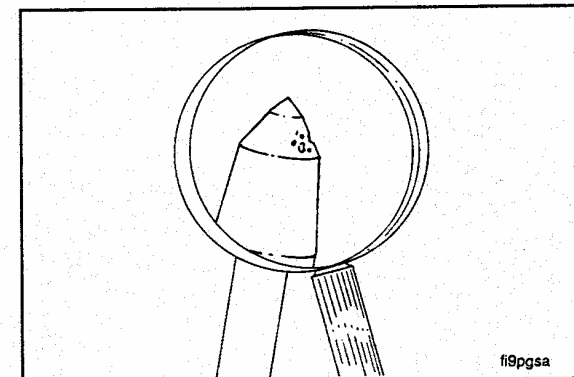
Remove burned-on combustion deposits on all nozzles with a commercially available cleaner. Rinse all parts in clean test oil.

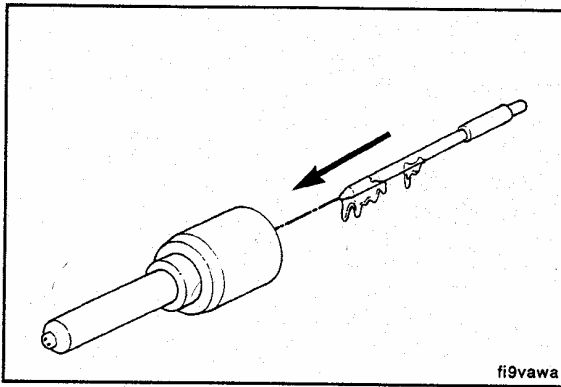


Clean the needle valve tip with a brass brush. Then, inspect for rough surfaces or erosion. The pressure shoulder will normally have a rough machined appearance.

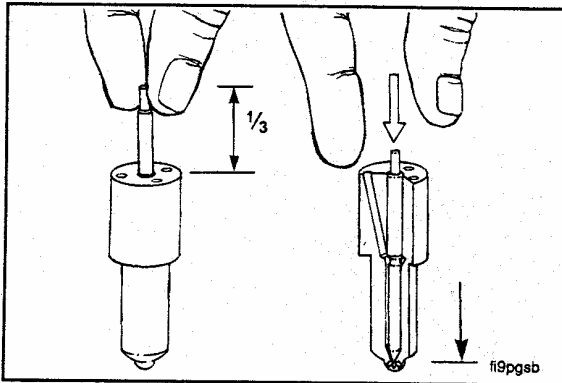
NOTE

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.

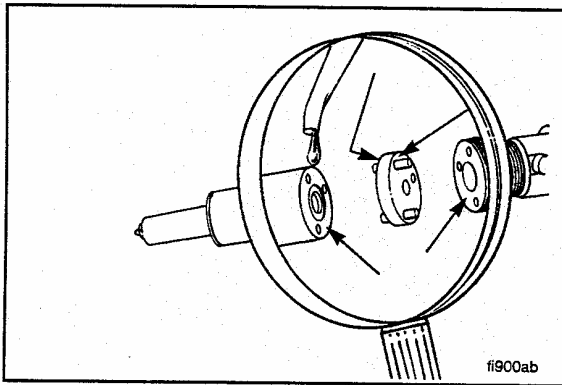


CAUTION

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.

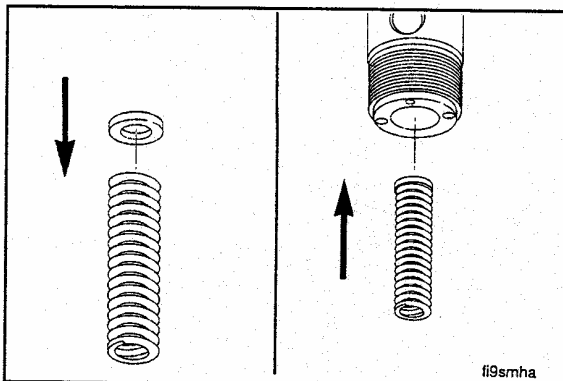
If the nozzle fails the slide test, clean the nozzle again and retest it.



Injector - Assembly

NOTE

Make sure all mating surfaces and pressure faces are absolutely clean and lubricated with fuel oil before assembled.

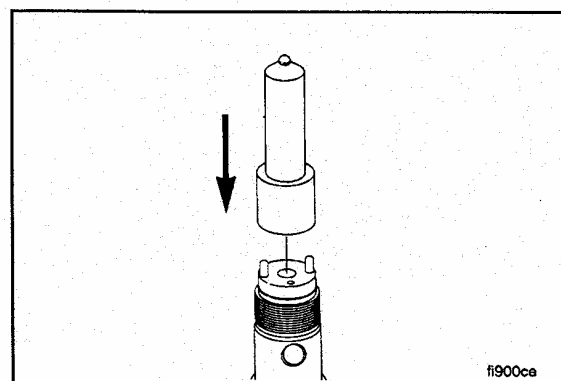


CAUTION

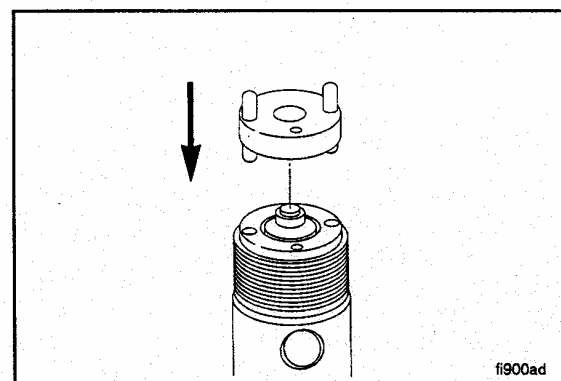
Install the same thickness of shims that were removed in disassembly. Use the pressure spring to make sure the shims are installed flat.

Install the shims.

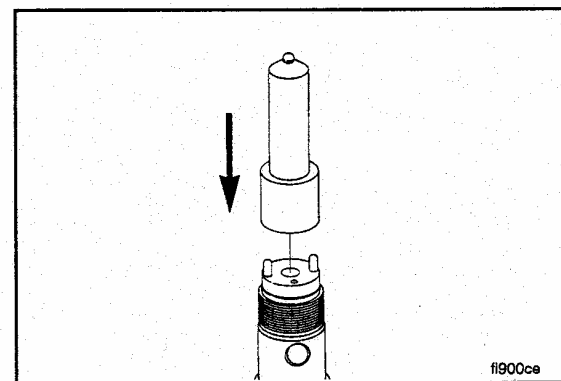
Clamp the nozzle holder in a soft jawed vise and install the spindle.



Install the intermediate plate.



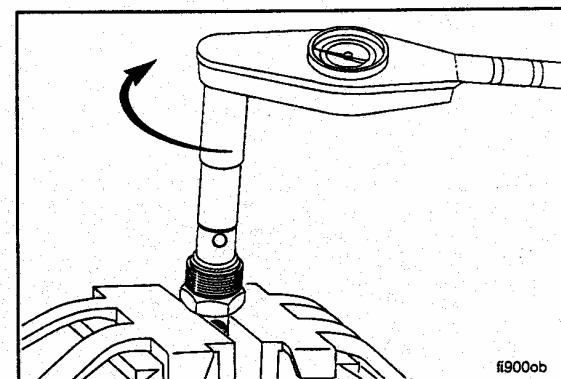
Install the needle valve and nozzle assembly.

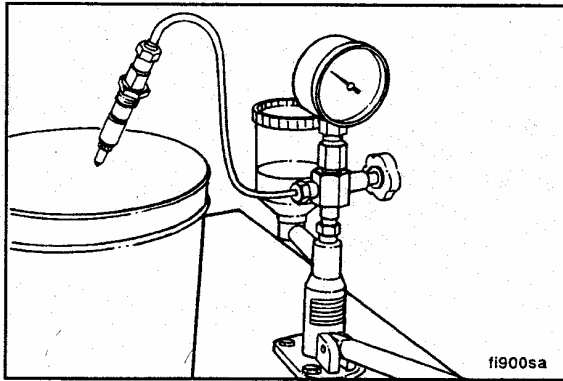


15 mm

Install the nozzle nut.

Torque Value: 30 N•m [22 ft-lb]



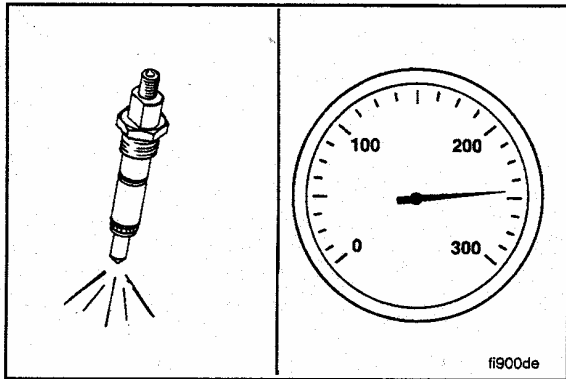


Injector - Testing

WARNING

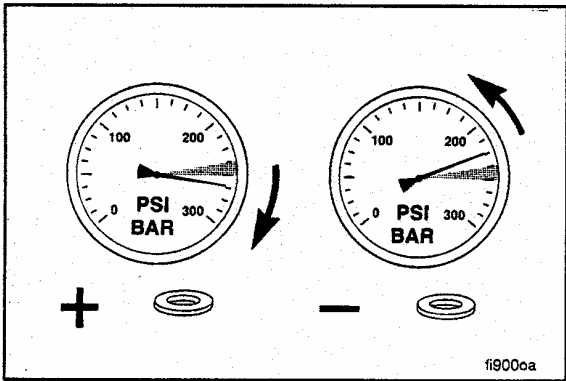
Keep your body clear of test spray. Fluid can be injected into the bloodstream causing blood poisoning and possible death.

All nozzles must be tested for opening pressure, chaffer and spray pattern.

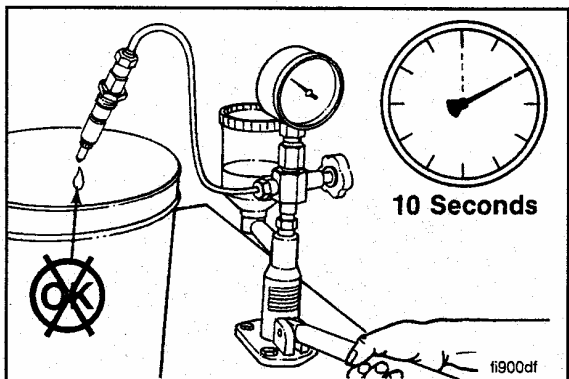


Check the opening pressure.

- Open valve.
- Operate lever at one stroke per second.
- 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:

- Open valve.
- Operate lever to hold pressure 20 bar [290 psi] below opening pressure.
- 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 - Piston Style Rebuild

Preparatory Step:

- Clean debris from the fuel line fittings and the fuel transfer pump.

20 mm, 26 mm Wrench

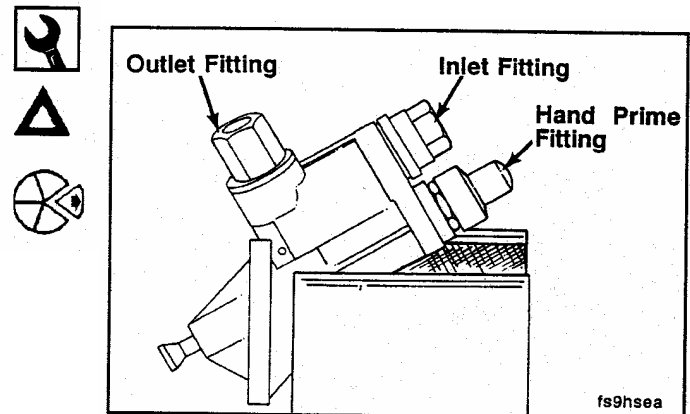
CAUTION

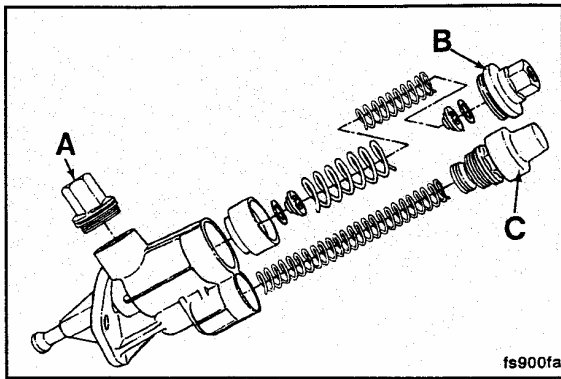
The hand-prime fitting and inlet fitting are spring loaded. Sudden removal of these two fittings can cause personal injury.

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.





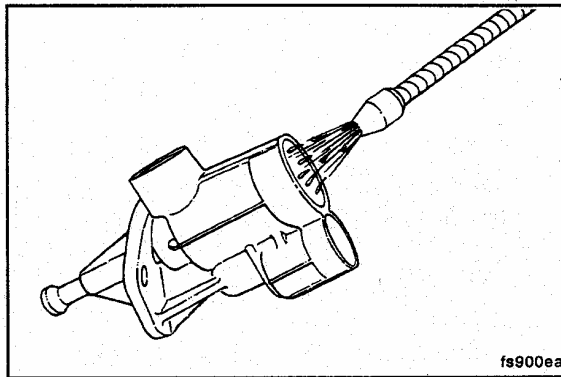
Remove all internal components of the pump.

NOTE

Make sure the check valve gaskets are removed from the inlet fitting.

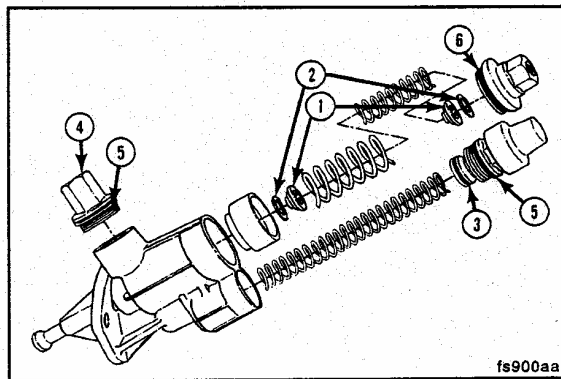


- (A) Outlet Fitting
- (B) Inlet Fitting
- (C) Hand Primer Fitting



Cleaning

Thoroughly flush the pump with a cleaning solution to remove any debris.



Assembly

20 mm, 26 mm Wrench

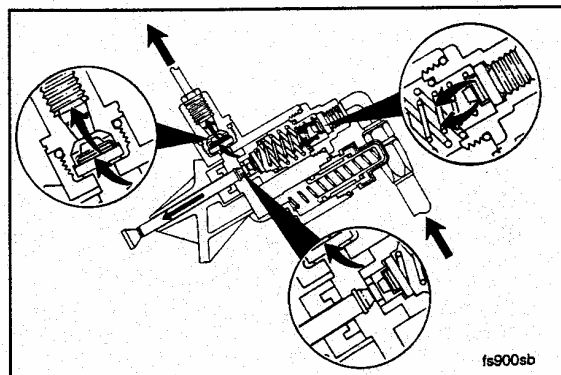
Assemble the pump with the new components supplied in the rebuild kit.

- 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

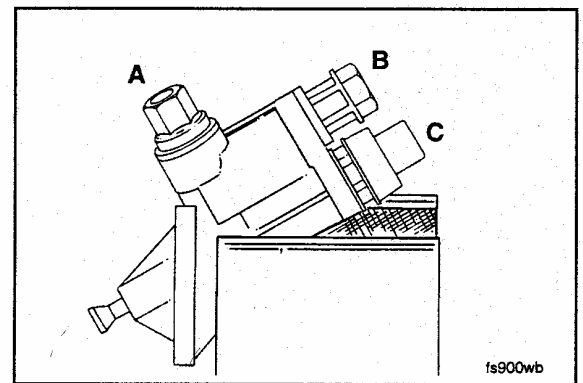
Extreme caution must be used to make sure the check valves are installed to open in the direction of the fuel flow.



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:

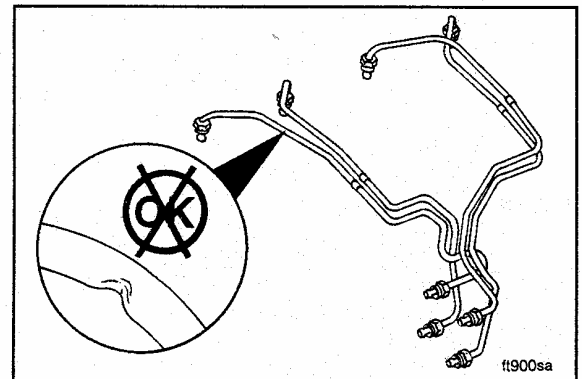
- | | |
|------------------------|-------------------|
| (A) Outlet Fitting | 30 N•m [22 ft-lb] |
| (B) Hand-Prime Fitting | 30 N•m [22 ft-lb] |
| (C) Inlet Fitting | 30 N•m [22 ft-lb] |



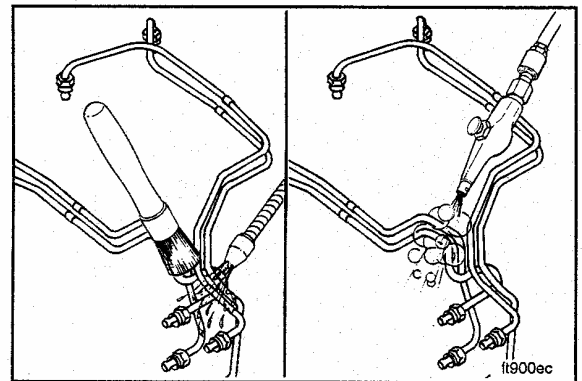
Fuel Lines - Clean and Inspect

High Pressure Fuel Lines

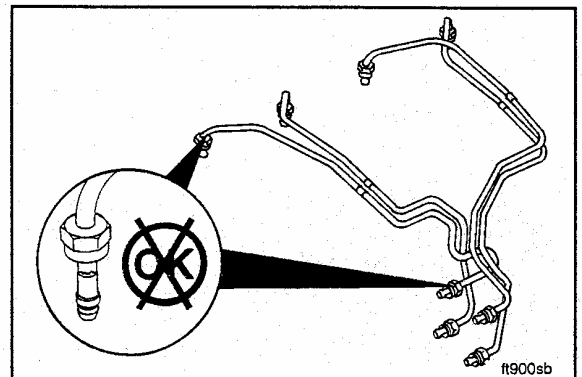
Visually inspect the high pressure fuel lines for obvious damage such as lines that have bent to facilitate injector removal. High pressure pulses expand and contract the injector lines which result in internal flaking at the bent areas. Bent lines should be replaced.

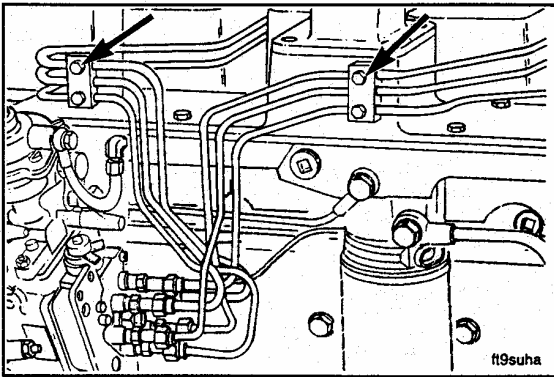


Wash the fuel lines in clean solvent and blow dry with compressed air. Make sure all paint chips are removed.



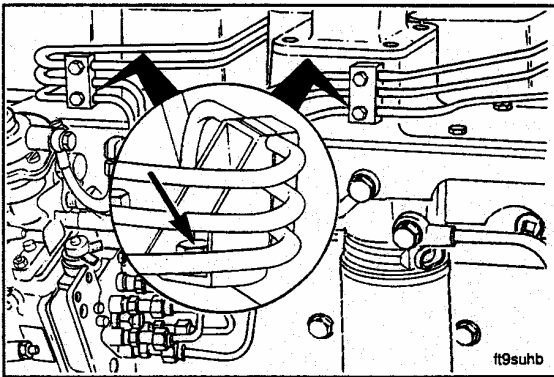
Visually inspect for cracks at both ends of the fuel lines.



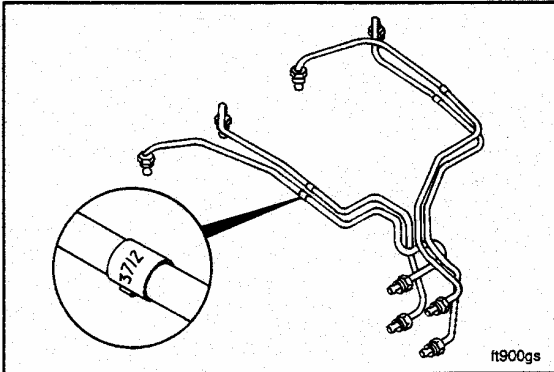


CAUTION

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.



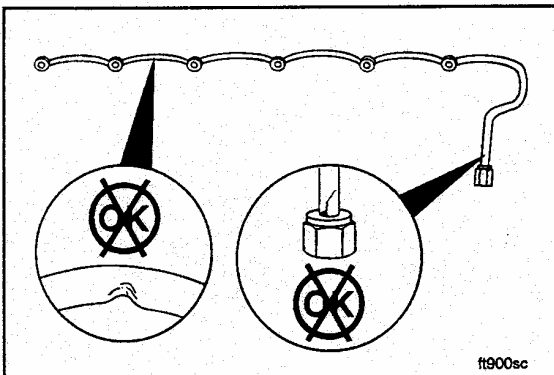
Inspect the vibration isolators (clamps). Make sure all the vibration isolators are positioned and tightened properly. Missing or improperly installed isolators will almost certainly result in fuel line failure.



CAUTION

Do not weld or substitute lines; use only the specified part number for the engine.

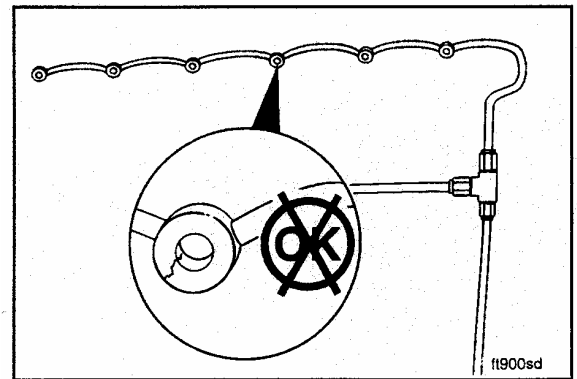
The length, internal size and rigidity of the lines are critical to smooth engine operation. An attached metal tag is used to identify each line with a part number.



Fuel Drain Manifold

Inspect the fuel drain manifold for cracks and obvious damage.

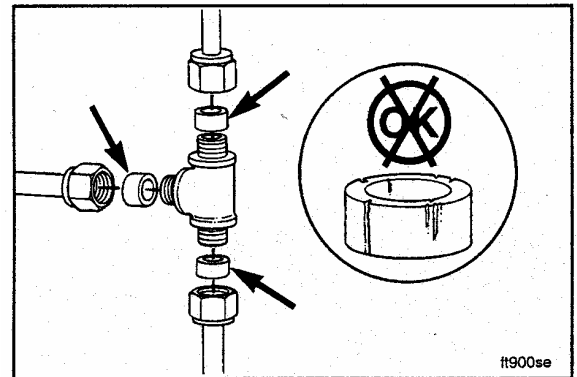
Inspect the sealing surfaces for leak paths.



13 mm

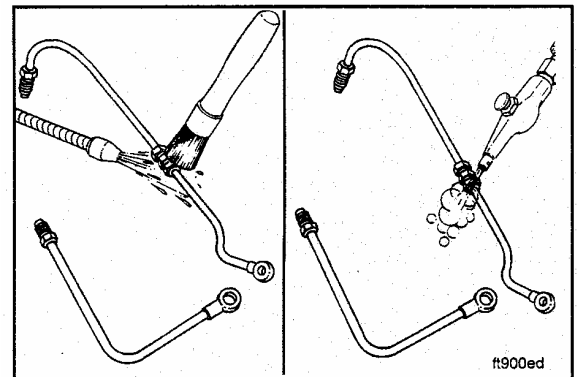
Inspect the rubber seals. Replace any damaged seals or seals that are hard or brittle.

Service Tip: Lubricating the seals with clean engine oil will facilitate the installation.

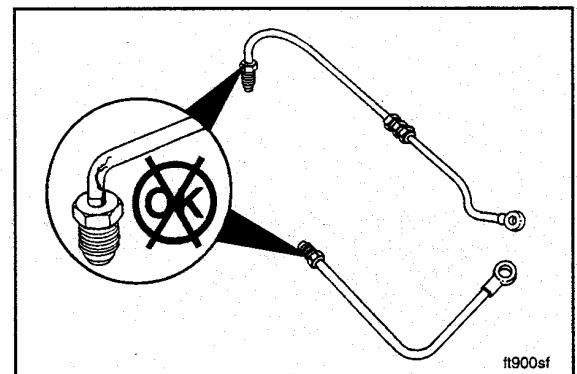


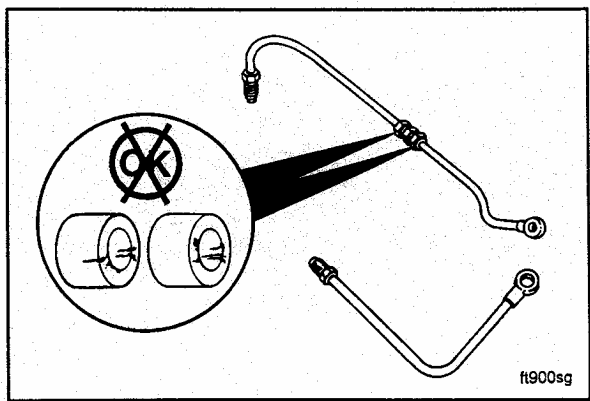
Low Pressure Fuel Lines

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.



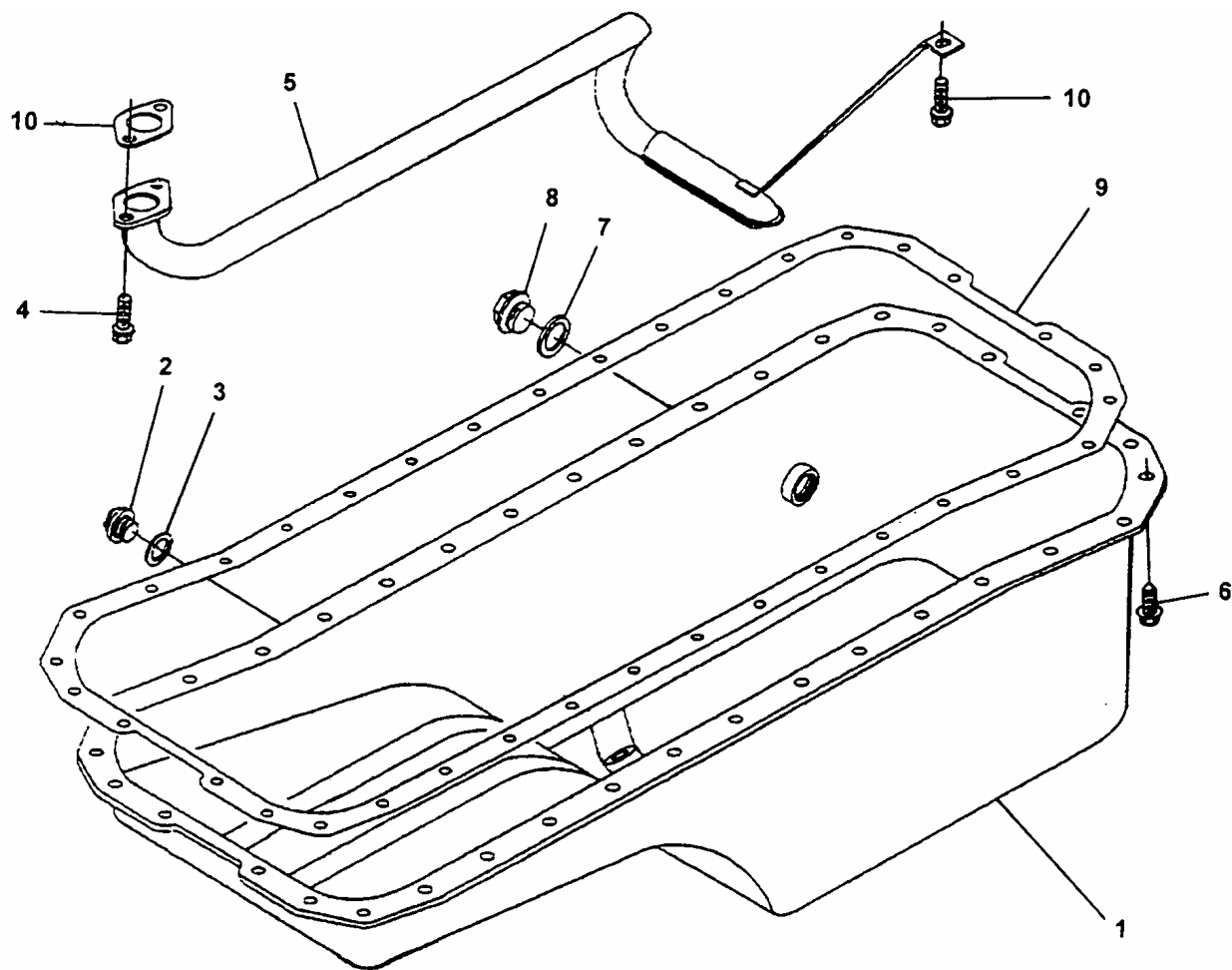
Service Tip: Lubricating the seals with clean engine oil will facilitate the installation.

Section 7 – Lubricating System – Group 7

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Lubricating Oil Cooler - Exploded View	7-5
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Pressure Regulator Valve - Disassembly.....	7-7
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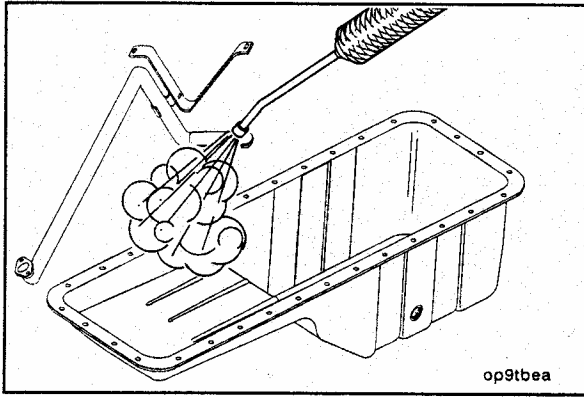
Oil Pan and Suction Tube - Exploded View



Ref. No	Part Name	Qty.	Remarks
1	Pan, Oil	1	
2	Plug, Threaded	1	M18 x 1.50 x 12
3	Washer, Sealing	1	
4	Screw, Hex Flange Head Cap	4	M8 x 1.25 x 16
5	Connection, Oil Suction	1	
6	Screw, Hex Flange Head Cap	36	
7	Washer, Sealing	1	
8	Plug, Threaded	1	M22 x 1.50 x 14
9	Gasket, Oil Pan	1	
10	Gasket, Flange	1	

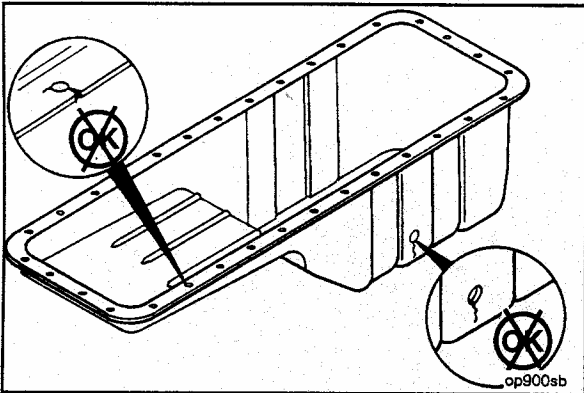
Oil Pan and Suction Tube - General Information

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.

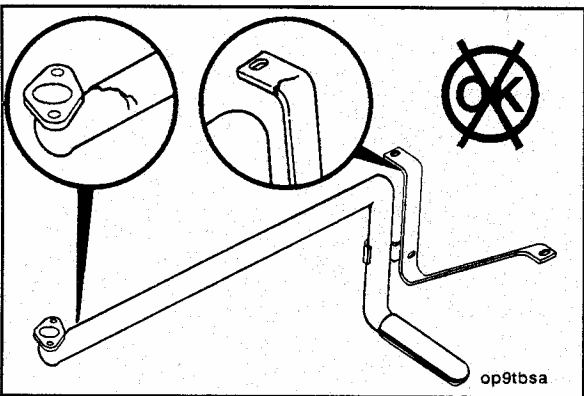


Oil Pan and Suction Tube - Cleaning and Inspection (7-01)

Steam clean the pan and suction tube.



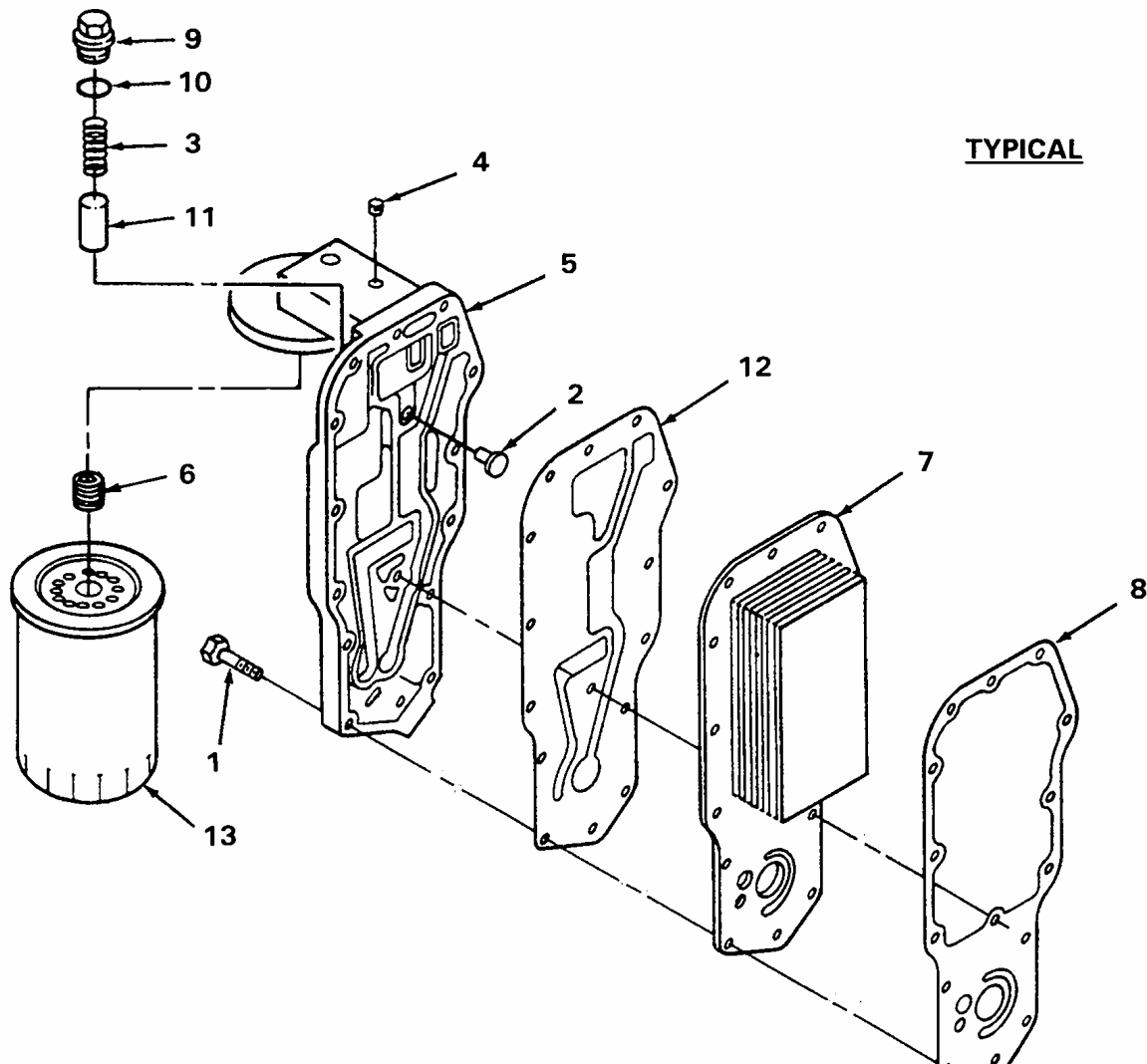
Inspect the pan for cracks and damaged threads.



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, Lube 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, Pressure Regulator	1	
12	Gasket, Oil Cooler Core	1	
13	Cartridge, Lube Oil Filter	1	

Lubrication System - General Information

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 six cylinder engine uses seven plates.

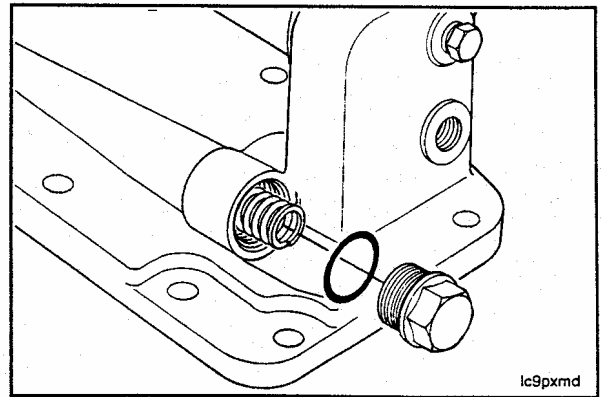
NOTE

Some engines use a jumper plate in place of an oil cooler.

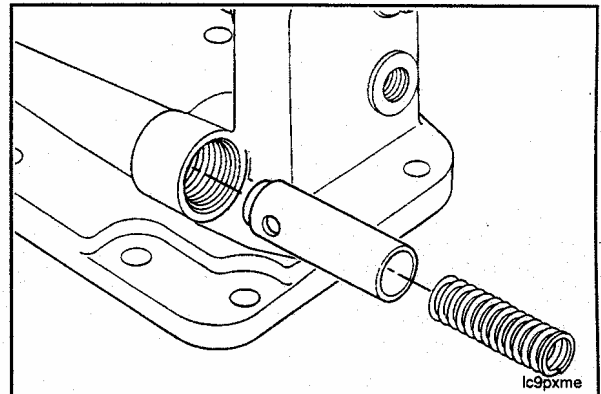
Pressure Regulator Valve - Disassembly (7-02)

19 mm

Remove the plug and sealing washer.



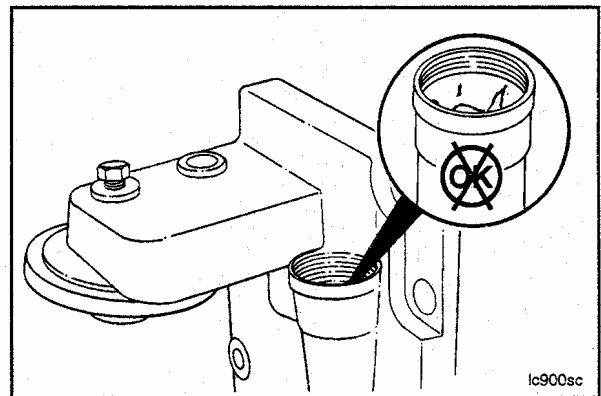
Remove the spring and plunger.

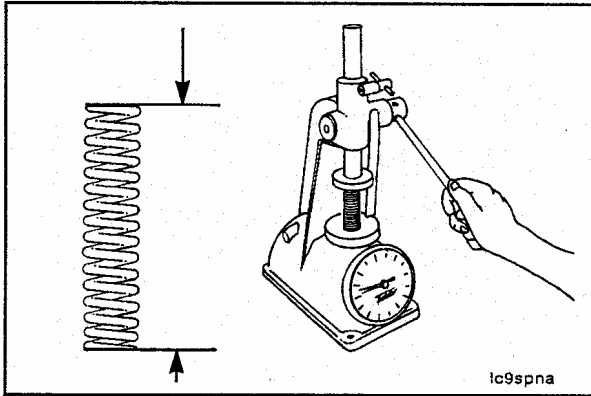


Pressure Regulator Valve – Inspection (7-03)

Inspect the plunger bore for nicks or scratches.

The plunger must move freely in the bore.





Check the pressure regulator spring at the following two heights.

Free Length 60.6 mm [2.38 in]

Limit

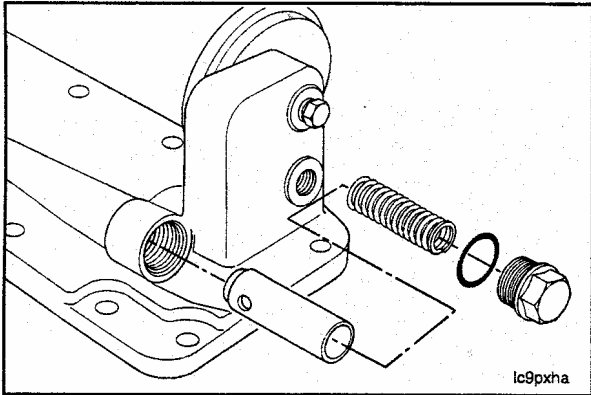
1991

- 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).



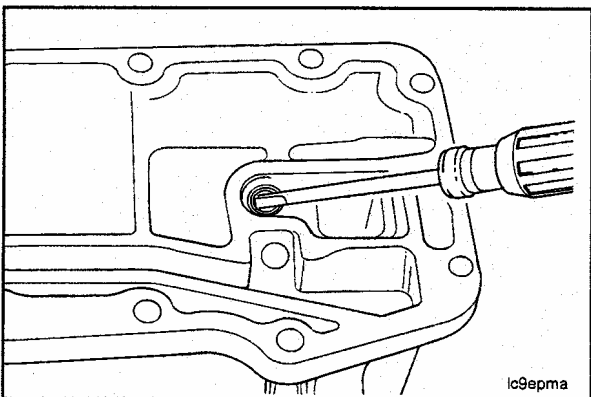
Pressure Regulator Valve – Assembly (7-04)

19 mm

Install the valve.



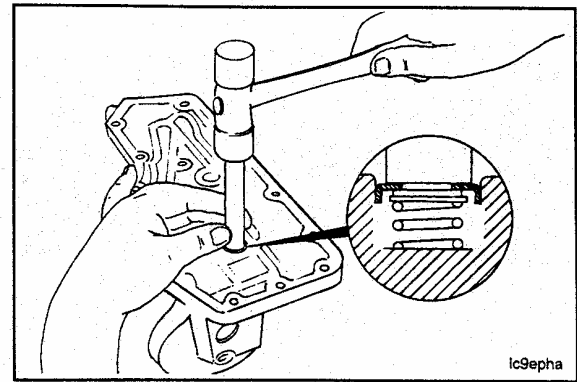
Torque Value: 80 N•m [59 ft-lb]



Filter Bypass Valve - Replace (7-05)

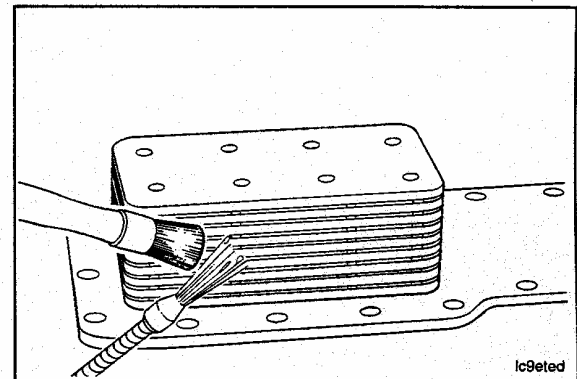
Remove the valve from the cooler cover.

Drive the new valve in until it bottoms against the step in the bore.



Oil Cooler - Cleaning (7-06)

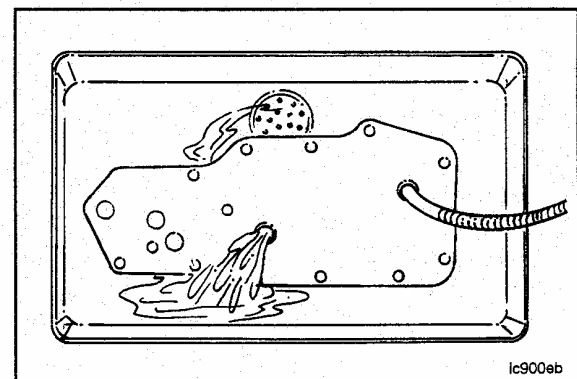
Plug the cooler and soak it in a cleaning solution to remove the coolant deposits.



Remove the plugs and soak the cooler in solvent.

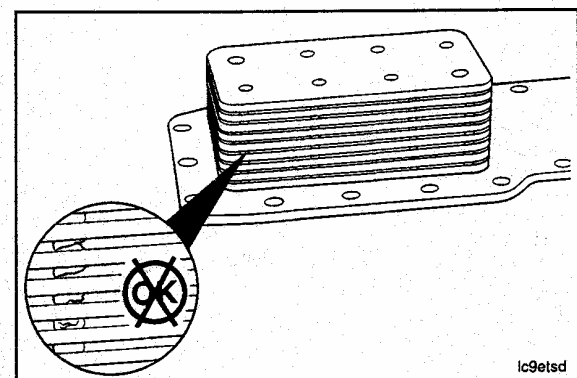
The cooler can be cleaned in a hot tank.

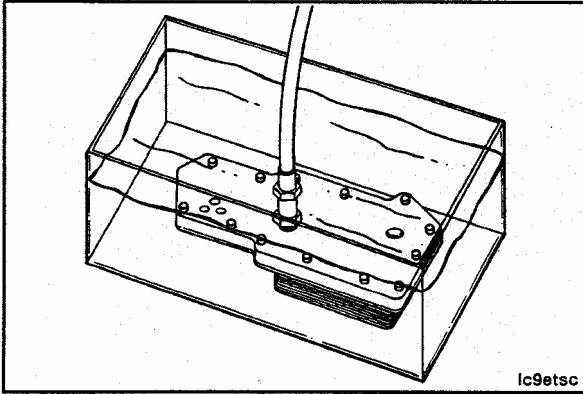
Back flush the oil passages with clean solvent and use compressed air to dry.



Oil Cooler - Inspection (7-07)

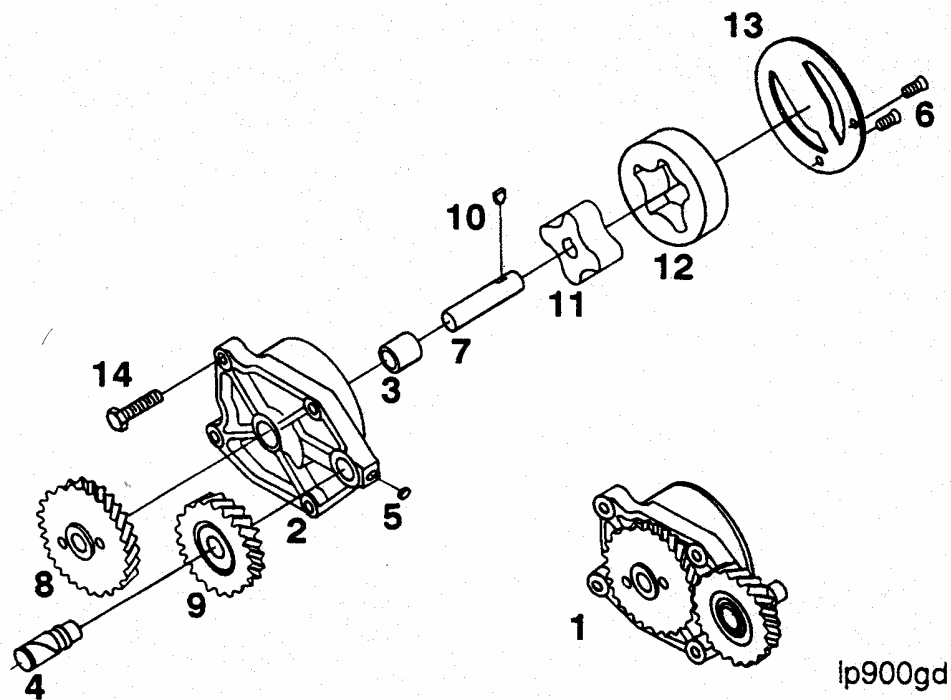
Inspect the soldered joints for corrosion or cracks.





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

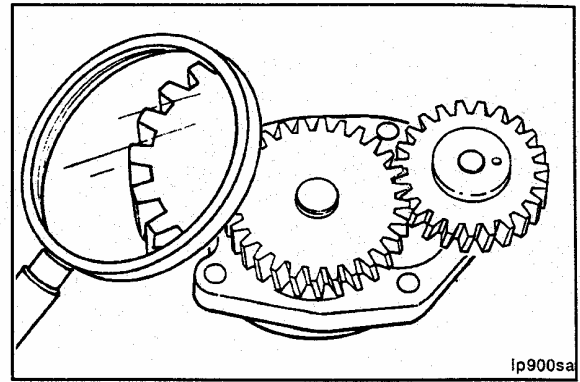
It is not practical to rebuild the gerotor pump. It can be reused if it meets the inspection criteria.

There are two basic B Series lubrication pumps - one for the four cylinder and one for the six cylinder.

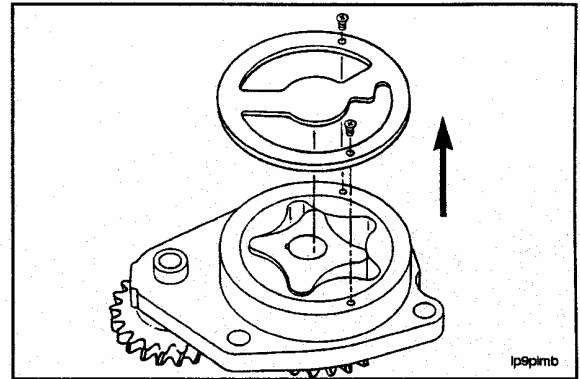
The gerotor width on the four cylinder pumps is narrower than in the six cylinder pumps.

Oil Pump - Inspection (7-08)

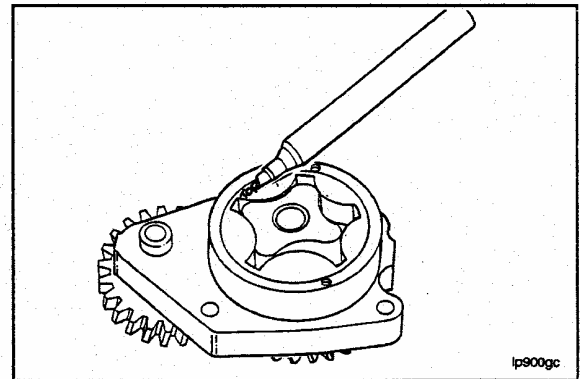
Visually inspect the lube pump gears for chips, cracks, or excessive wear.



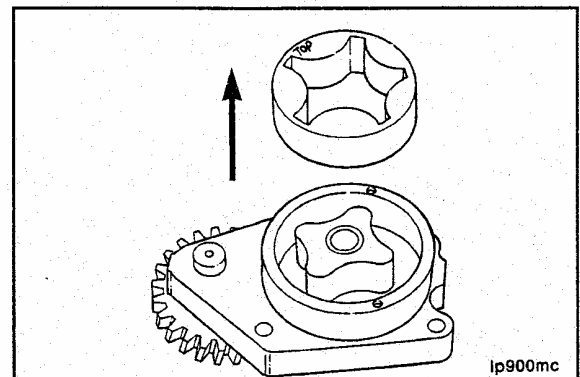
Remove the sealing plate.

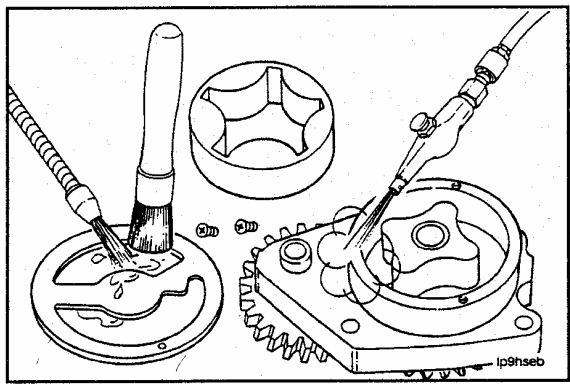


Mark "top" on the gerotor planetary.

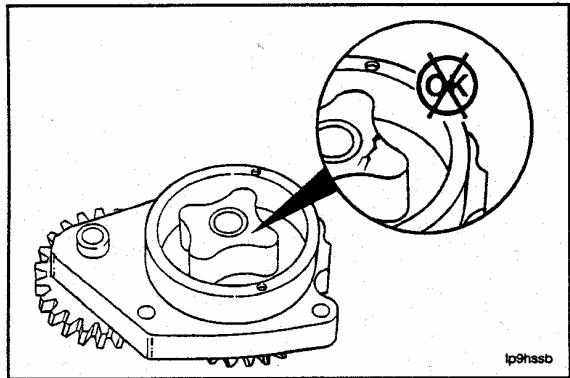


Remove the gerotor planetary.
Inspect for excessive wear or scoring.

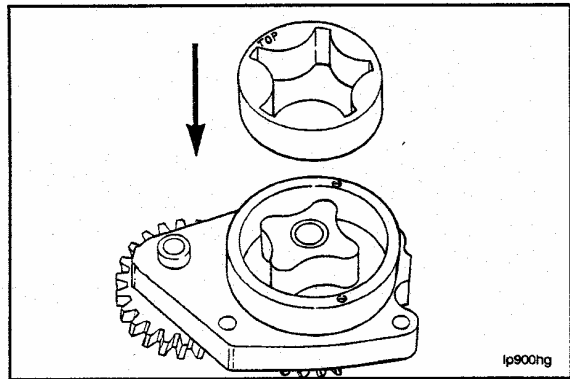




Clean all parts in solvent and use compressed air to dry.

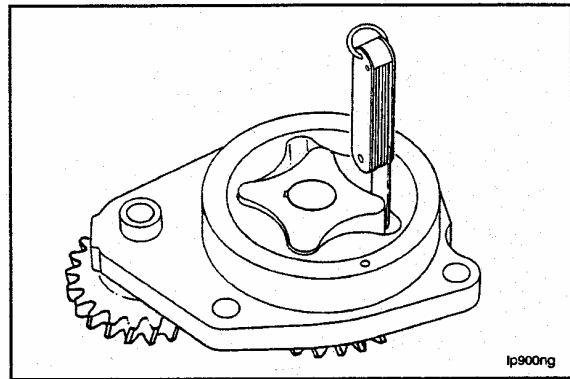


Inspect the pump housing and gerotor drive for damage and excessive wear.



NOTE

Be sure the gerotor planetary is installed in the original position.
Install the gerotor planetary.

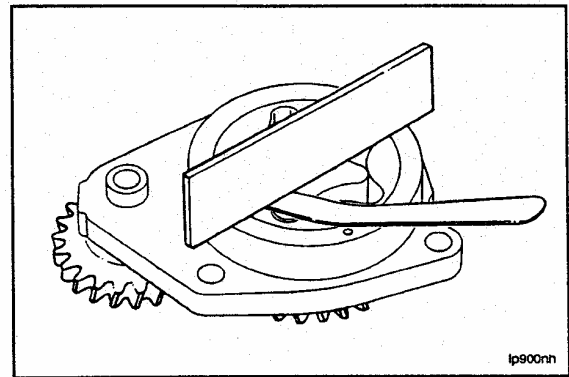


Measure the tip clearance.

Tip Clearance		
mm		in
0.1778	MAX	[0.007]

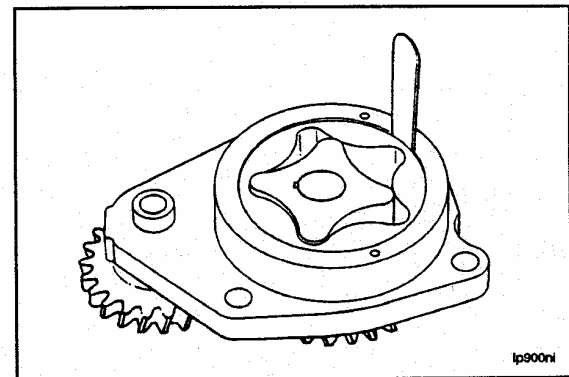
Measure the clearance of the gerotor drive/gerotor planetary to port plate.

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]



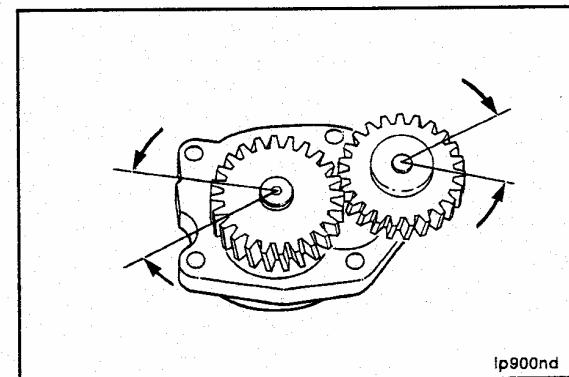
Measure the gears backlash.

Limits for a "Used Pump"

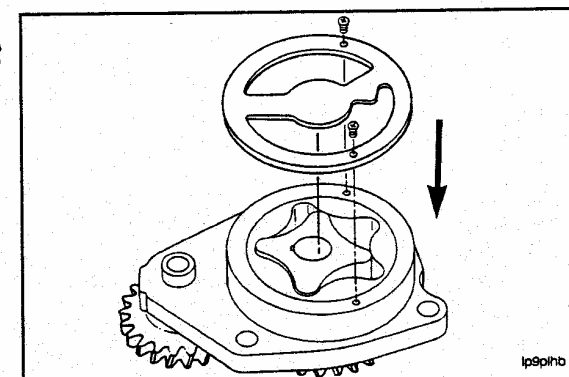
0.076 - 0.33 mm
[0.003 - 0.013 in]

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.



NOTES

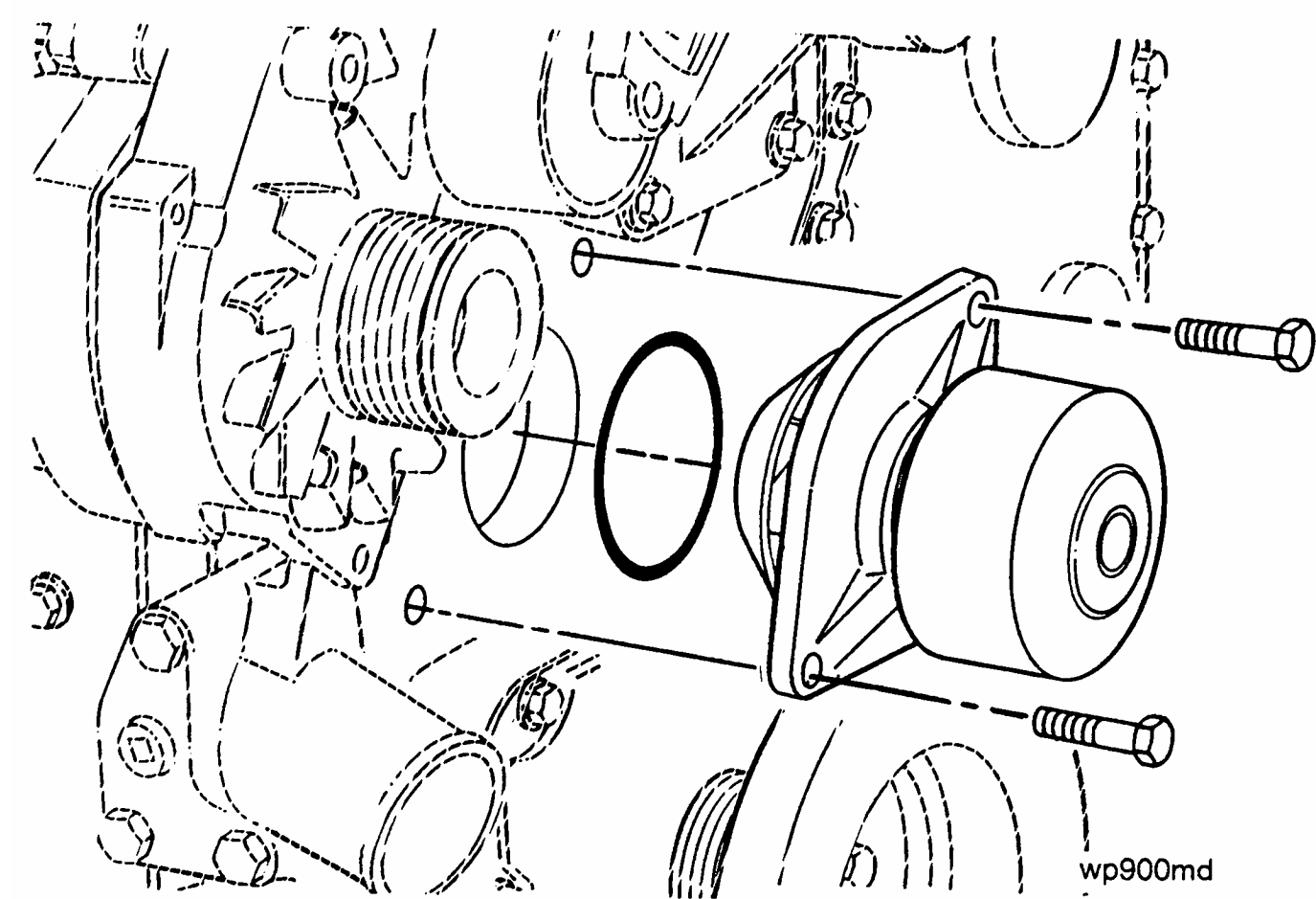
[illegible]

Section 8 – Cooling System – Group 8

Section Contents

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Fans - General Information	8-14
Thermostat - Inspection	8-13
Thermostat Housing Assembly – Exploded View	8-11
Thermostat Housing Assembly – General Information	8-12
Water Pump – Exploded View	8-2
Water Pump – General Information	8-3
Water Pump - Inspection	8-4

Water Pump – Exploded View

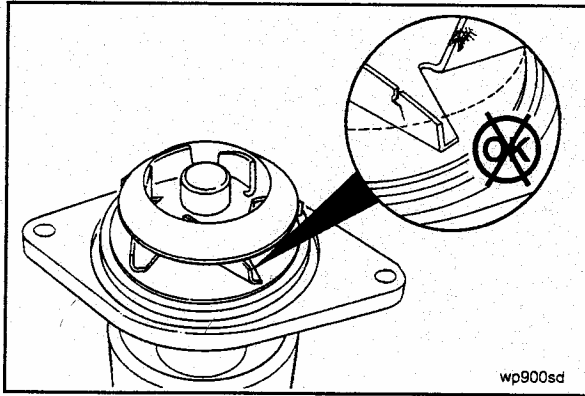


Ref. No.	Part Name	Qty.	Remarks
1	Pump, Water	1	
2	Seal, Rectangular Ring	1	5.16 mm Thick
3	Screw, Hex Hd Cap	2	M8-1.25x22

Water Pump - General Information

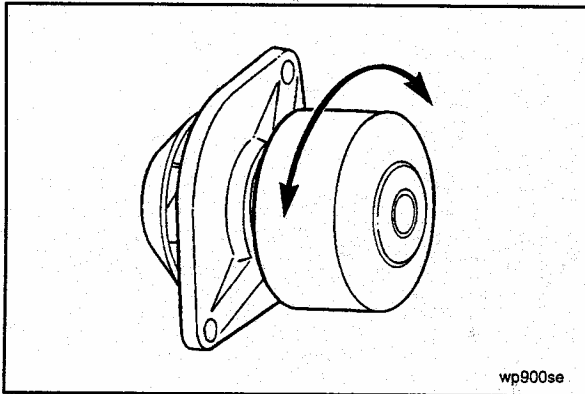
The water pump is a belt driven, centrifugal type pump with the inlet and bypass line as an integral part of the cylinder block.

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.

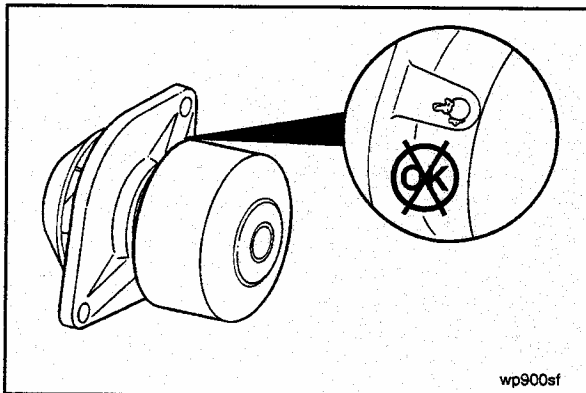


Water Pump - Inspection (8-01)

Inspect the impeller blades for wear or corrosion.



Inspect for free rotation of the pump.

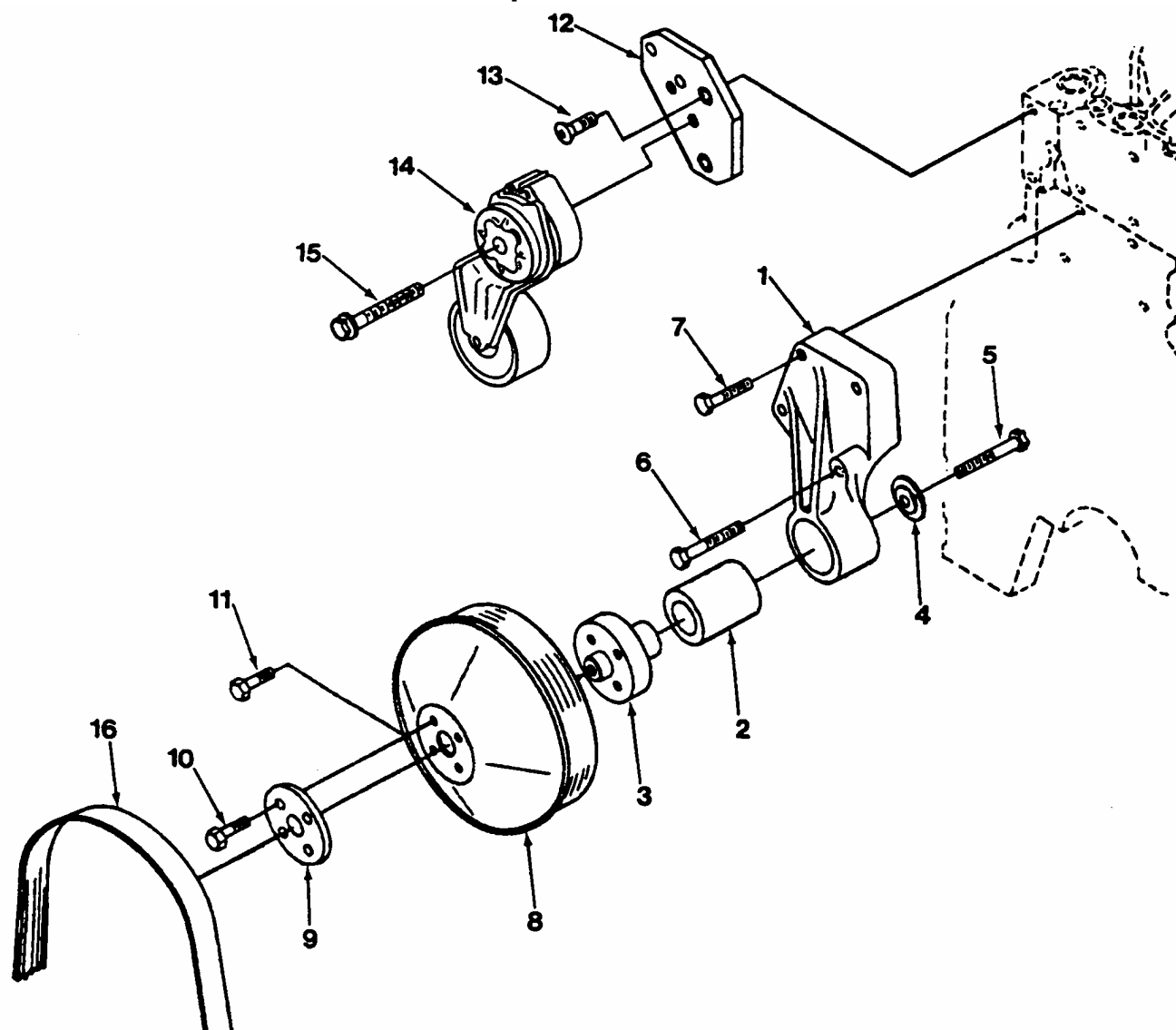


Check the weep hole for evidence that the seal has been leaking.

NOTE

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.

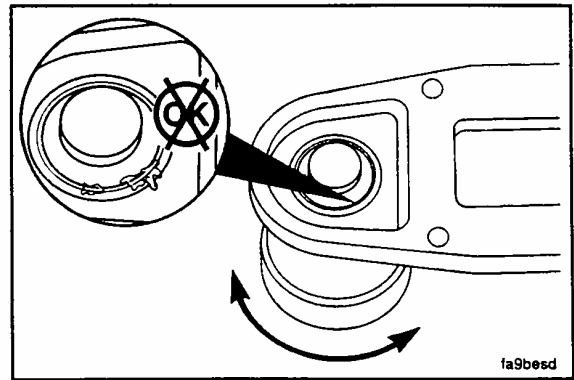
Slight variations exist in the pulley removal and installation for each pulley version.

If the pulley exhibits excessive wear, a special service tensioner is available which features a hardened pulley with increased resistance to wear.

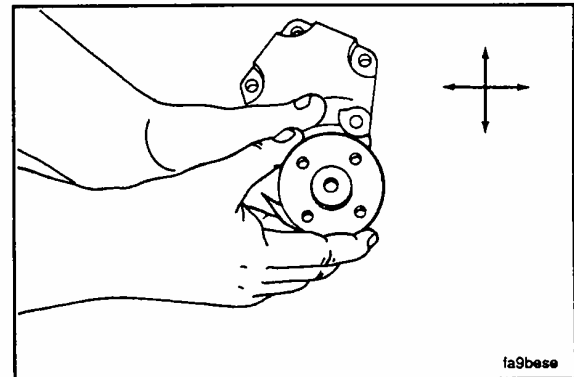
Fan Hub - Inspection (8-02)

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.



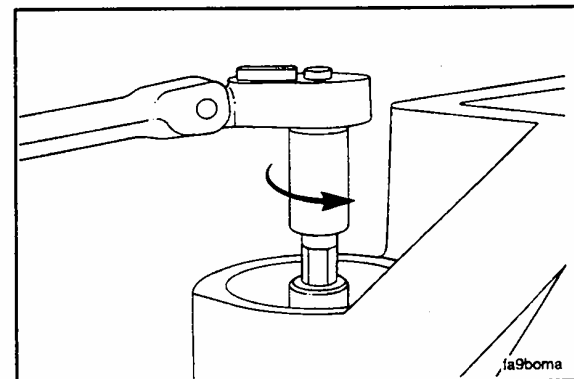
Inspect the fan hub bearing for wear. The bearing should have a minimal amount of side to side or end play movement. Replace the bearings if more than a minimal amount can be felt.



Fan Hub - Disassembly (8-03)

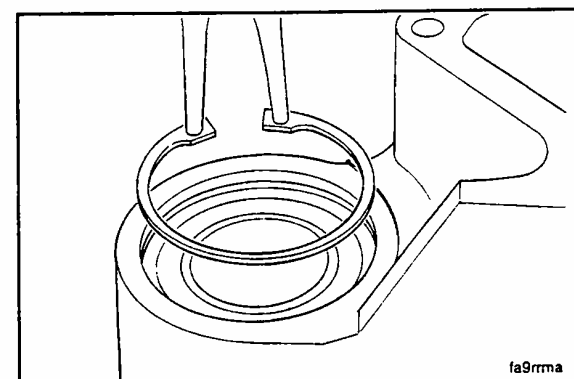
16 mm

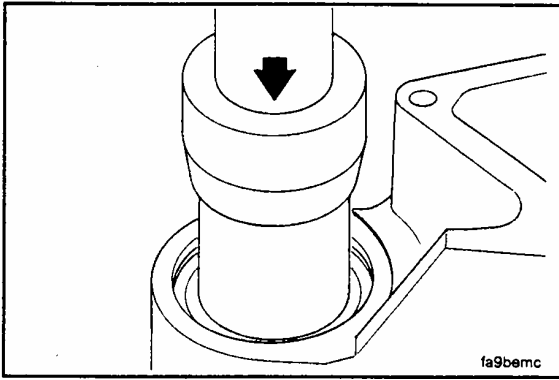
Secure fan hub and remove the center bolt and retainer.



Snap Ring Pliers

If the assembly is equipped with snap rings, remove the snap ring as illustrated.

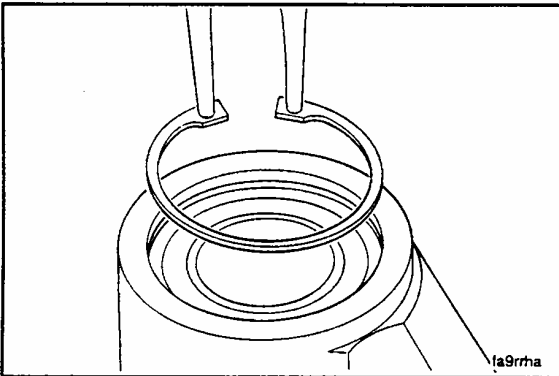




1 inch Drift

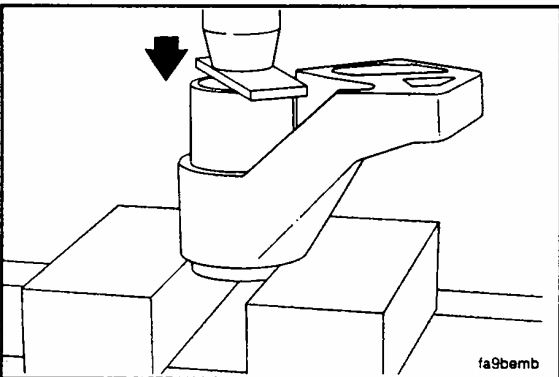
Support the fan hub bracket housing and press out the shaft/hub.

Approximately 6 tons of pressure is required.



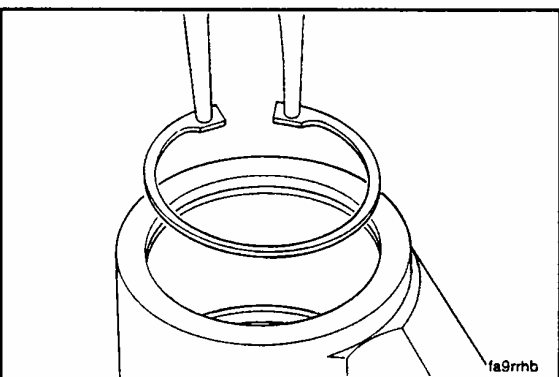
Snap Ring Pliers

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.



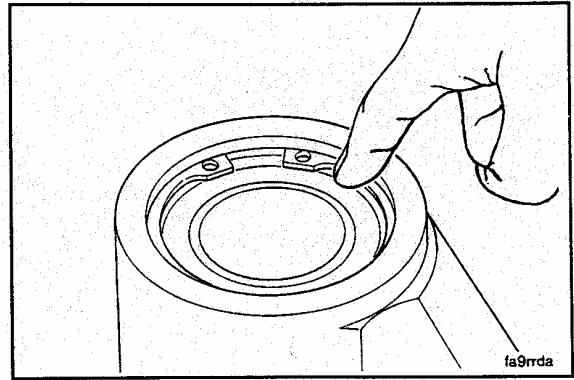
Fan Hub Assembly (8-04)

Snap Ring Pliers

If the bracket housing is equipped for snap rings, install the front snap ring.

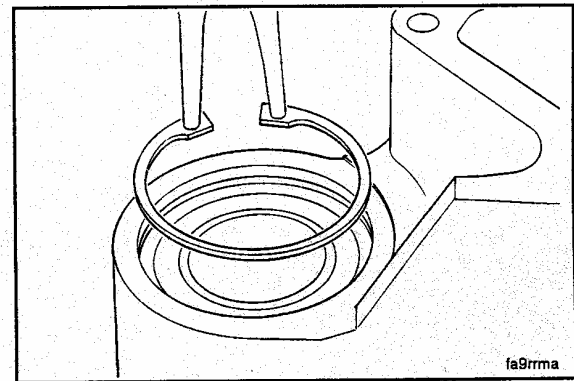
2 Inch Pipe

Press the bearing flush with the front of the housing or to the snap ring.

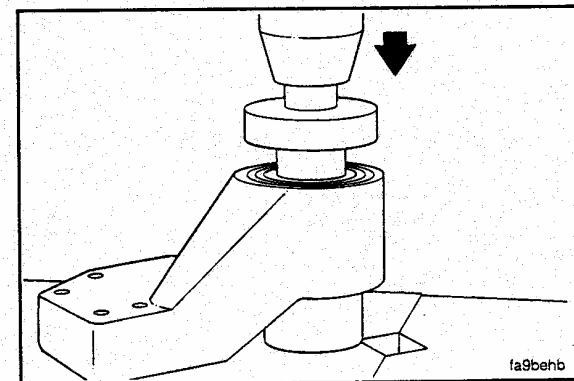


Snap Ring Pliers

Install the second snap ring if so equipped.



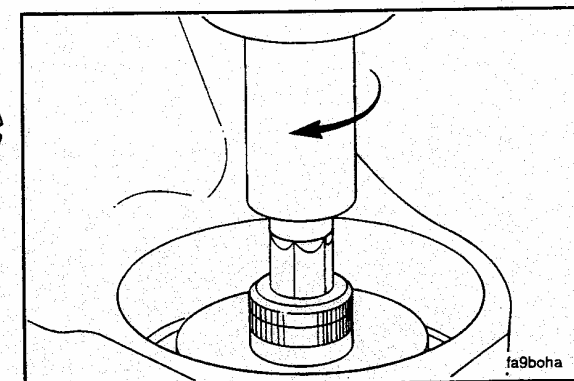
Supporting the bearing inner race with a 1.25 inch pipe coupling, press the hub/shaft in until it bottoms on the bearing.

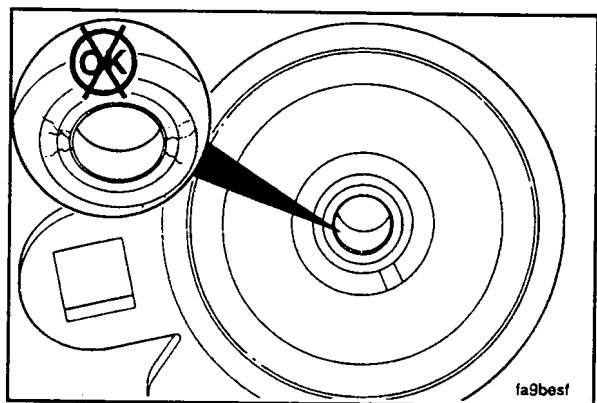


16 mm

Secure the assembly and install the retainer and center bolt.

Tighten to 77 N•m [57 ft-lb].

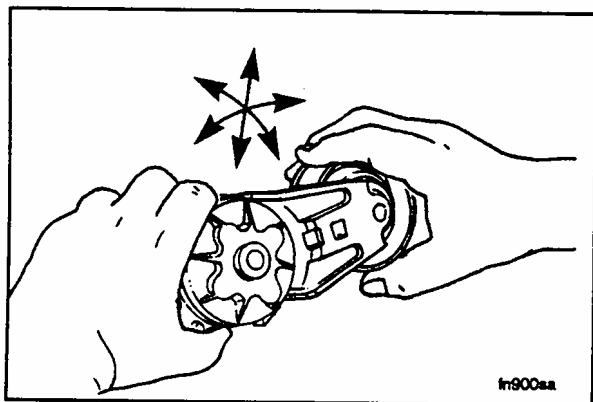




Belt Tensioner - Inspection (8-05)

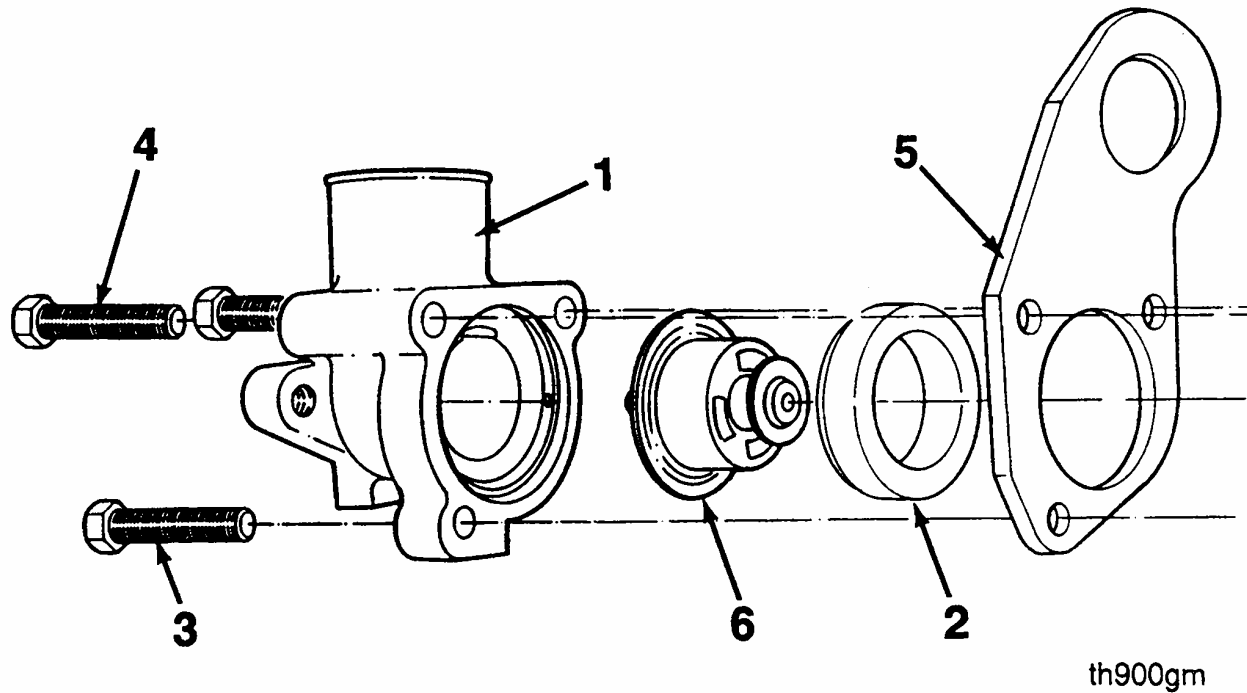


Inspect the pivot tube area of the tensioner for excessive wear evidenced by an elongated hole. If the tensioner exhibits excessive wear, it must be replaced.



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	

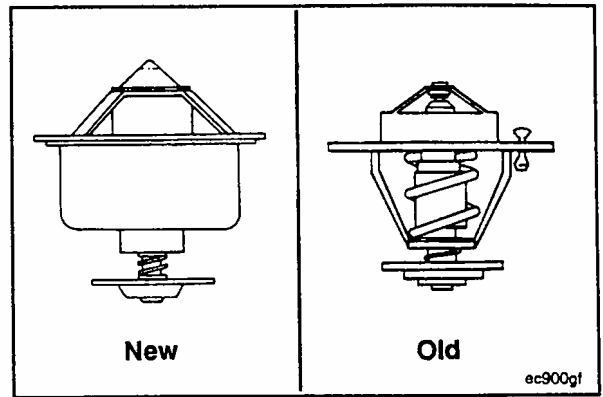
Thermostat Housing Assembly - General Information

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.

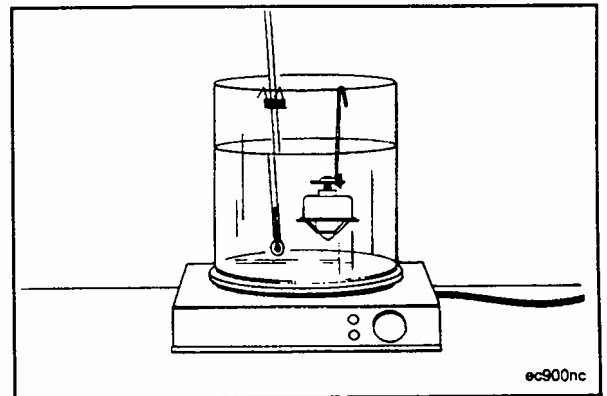


The thermostat can be checked for correct operation.

Requirements

Start to open at 83°C [181°F].

Fully open at 95°C [203°F].



Fans - General Information



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 the conversion of a G-drive engine to a power unit application.

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

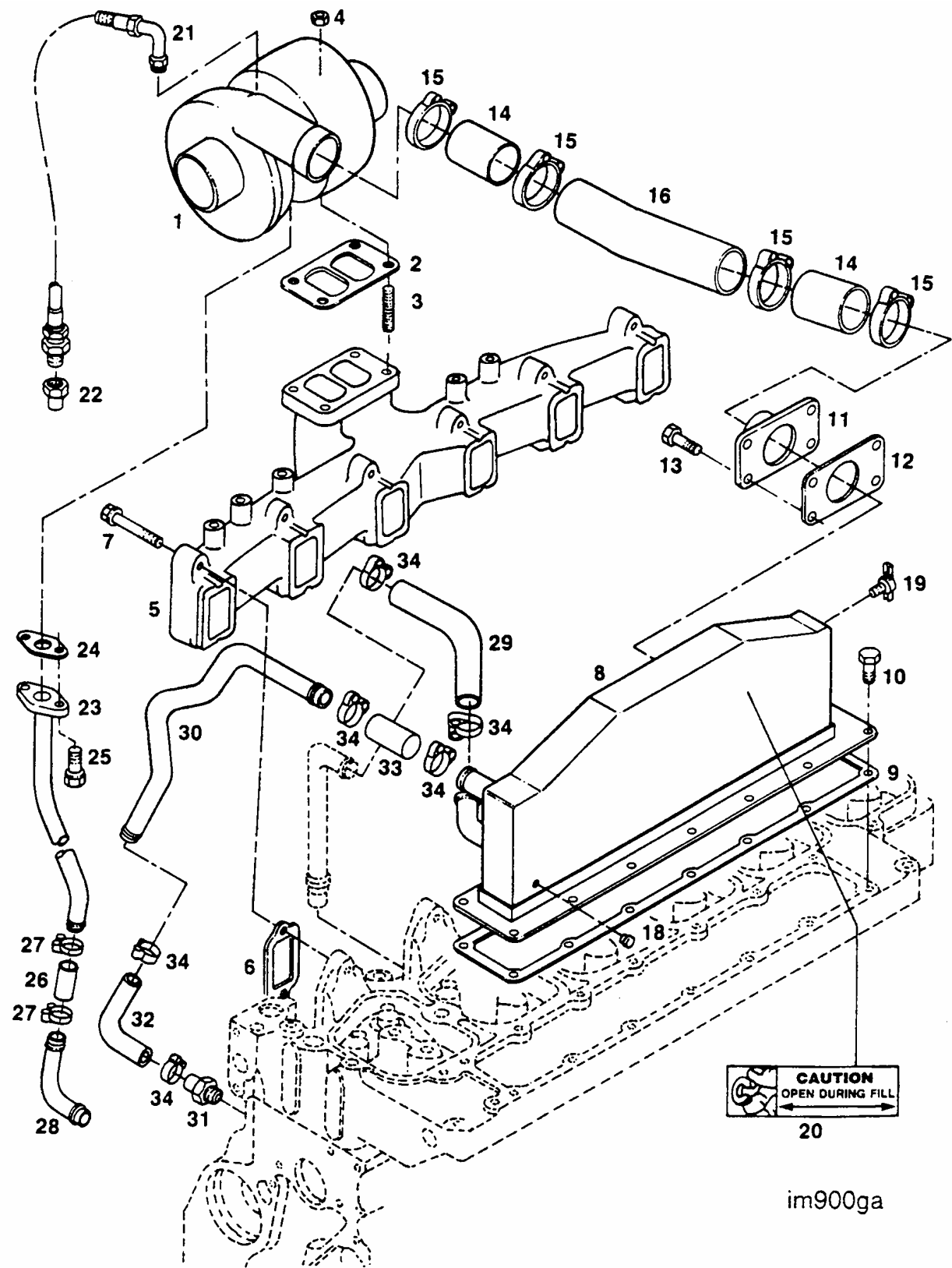
Never repitch (bend) the blades to obtain additional air delivery. Bending the blades or spider creates stress in the material used for the construction of the fan. Repitching (bending) will cause fan failure. The proper diameter fan must be selected. Never modify an existing fan.

Section 10 – Air Intake System – Group 10

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Turbocharger – Cleaning and Inspection for Reuse	10-5
Inspection	10-5

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	M8 - 1.25 x 26mm
9	Gasket, Intake Manifold Cover	1	
10	Screw, Hexagon Head Cap	14	
11	Connection, Air Crossover	1	M8 - 1.25 x 25mm
12	Gasket, Connection	1	
13	Screw, Hexagon Head Cap	4	
14	Hose, Plain	2	
15	Clamp, Hose	4	M8 - 1.25 x 20mm
16	Tube, Air	1	
18	Plug, Pipe	1	
19	Draincock	1	
20	Decal	1	
21	Hose, Flexible	1	
22	Connector, Female	1	
23	Connection, Turbo Oil Drain	1	
24	Gasket, Oil Drain	1	
25	Screw, Hexagon Head Cap	2	
26	Hose, Plain	1	
27	Clamp, Hose	2	
28	Tube, Turbo 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 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 turbocharger is not repairable in accordance with the ATEC Maintenance Allocation Chart (MAC).

NOTE

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.

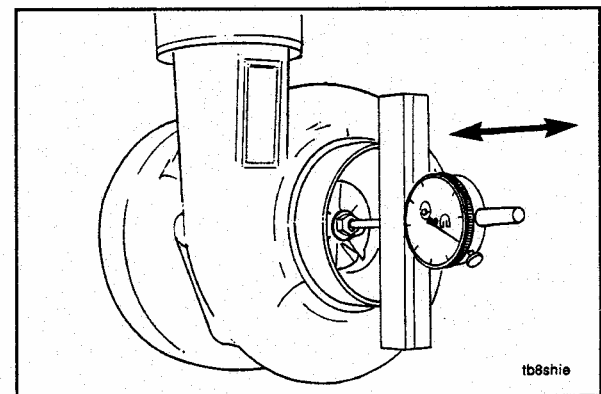
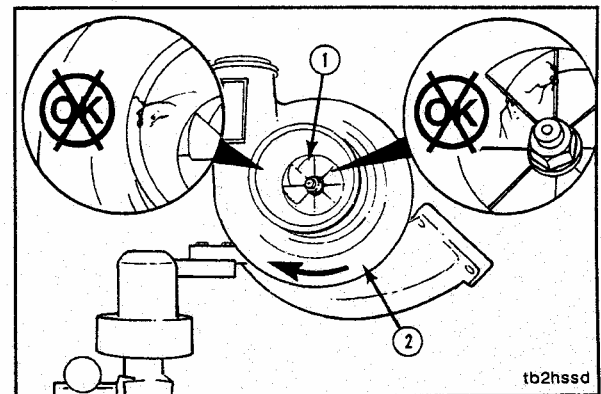
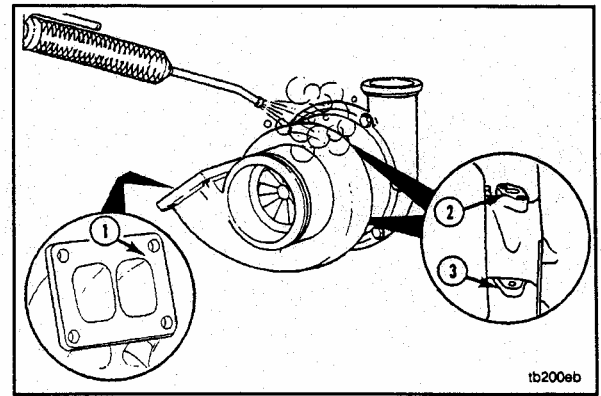
Replace damaged parts.

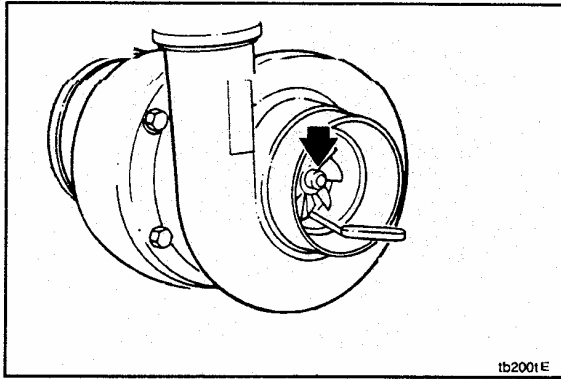
Measure the turbocharger shaft end clearance with the Part No. ST-537 Dial Depth Gauge.

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]

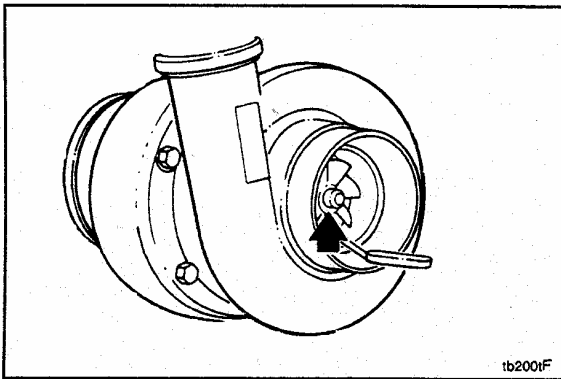




Push the compressor impeller by hand toward the compressor housing.

Install a wire feeler gauge, at the minimum clearance point, between the impeller and the housing to measure the clearance.

Record this clearance.



With the feeler gauge in the same location, push the turbine wheel by hand away from the compressor housing.

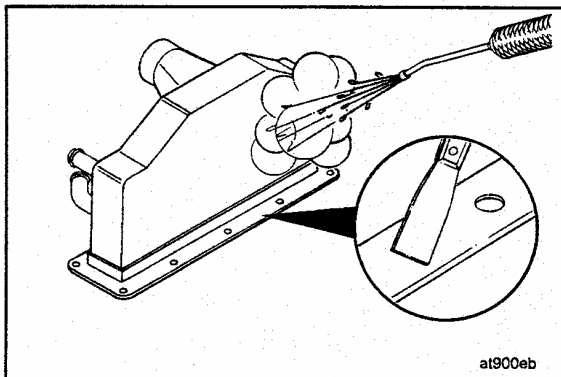
Install a wire feeler gauge, at the same point.

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 replaced.



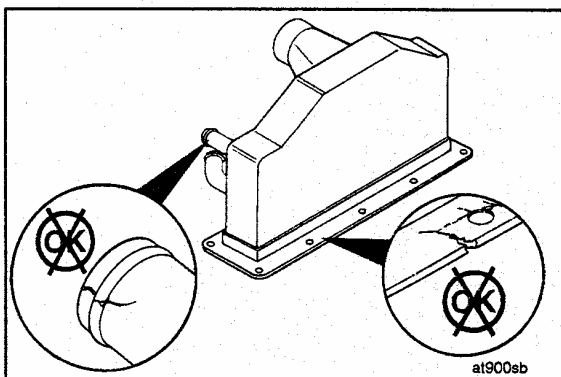
Aftercooler Assembly - Cleaning and Inspection for Reuse (10-02)

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

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.

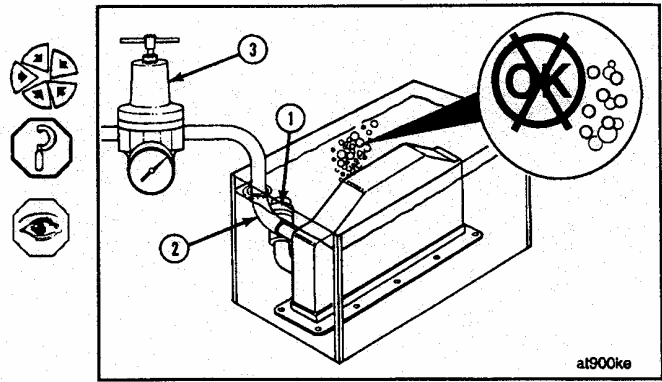
Install the hose and hose clamps (2), and air pressure gauge (3) onto the outlet tube.

Connect the air pressure gauge to a regulated air supply.

Air Pressure: 552 kPa [50 psi]

Submerge the aftercooler in a tank of water.

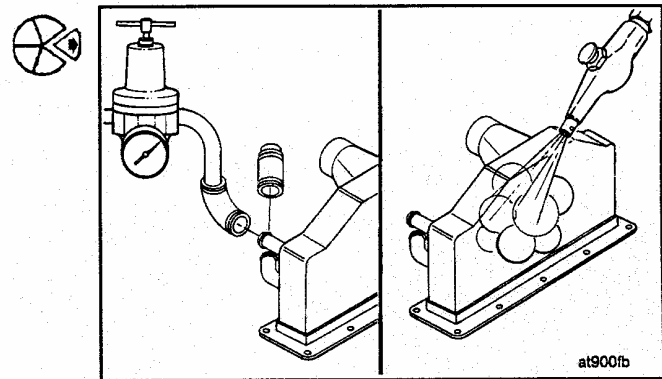
If air bubbles appear, the core is damaged and the aftercooler **must** be replaced.



Remove the aftercooler from the water tank.

Remove the test equipment.

Use compressed air and dry the aftercooler.

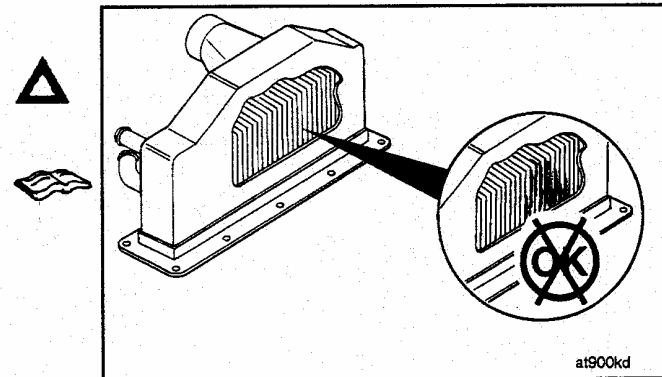


Aftercooler Assembly - Rebuild (10-03)

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).



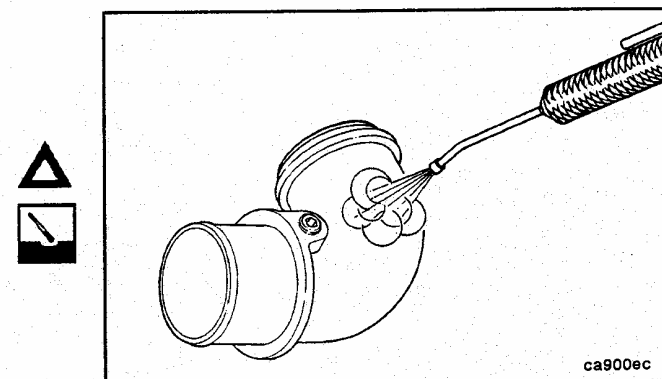
Air Transfer Pipe - Cleaning and Inspection for Reuse (10-04)

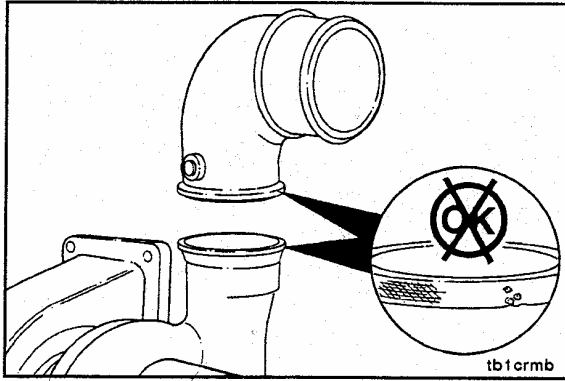
Cleaning

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.

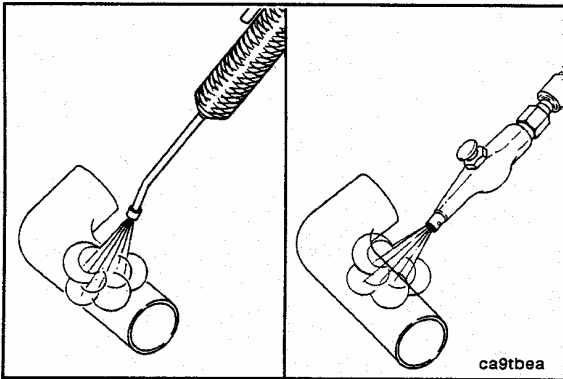




Inspection

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.



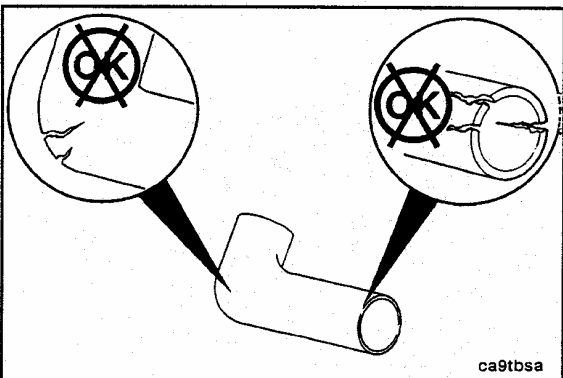
Air Crossover Tube - Cleaning and Inspection for Reuse (10-05)

Cleaning

WARNING

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

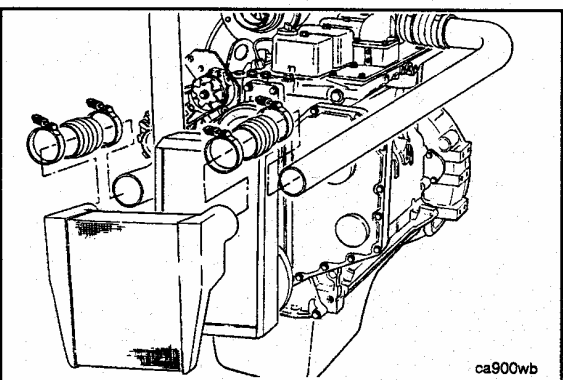
Use solvent or steam to clean the air crossover tube. Dry with compressed air.



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

NOTE

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.

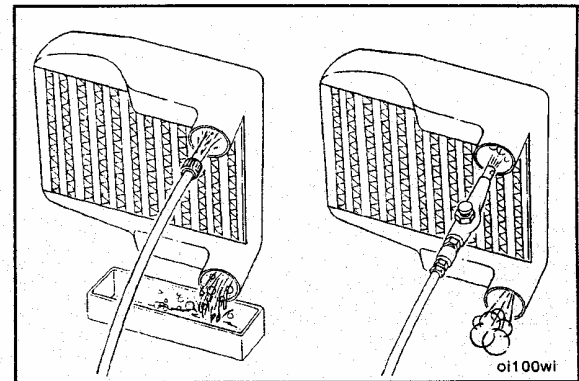
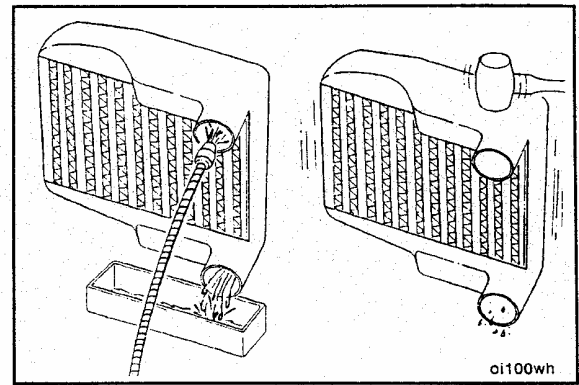
Use a flashlight and mirror to visually inspect the CAC for internal debris.

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

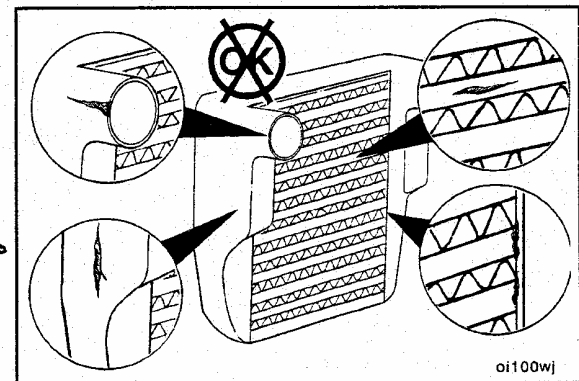
The CAC must be rinsed, dried, and free of solvent, oil, and debris or engine damage will result.

**Inspection**

Visually inspect the CAC for cracks, holes or damage.

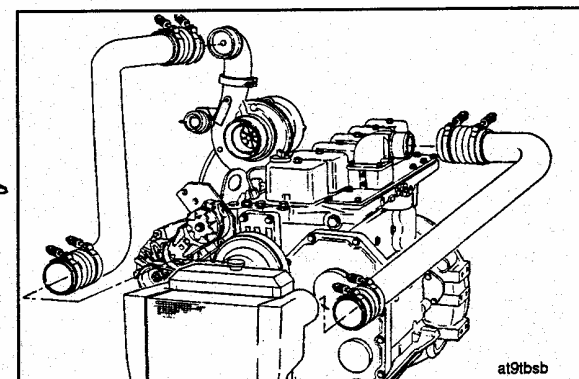
Inspect the tubes, fins and welds for tears, breaks or other damage. If any damage causes the CAC to fail the air leak check mentioned in Procedure (10-07), the CAC must be replaced.

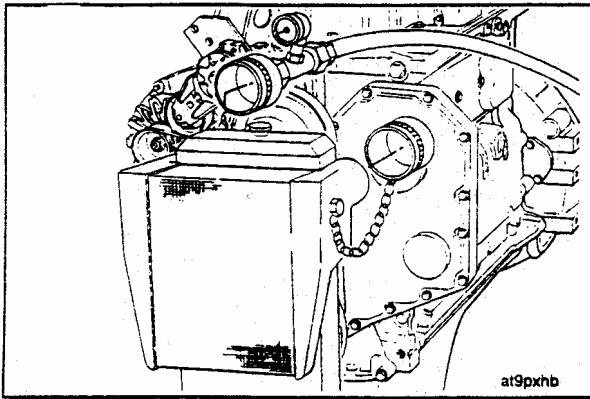
Install the CAC on the vehicle. Refer to the vehicle manufacturer for instructions.

**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.



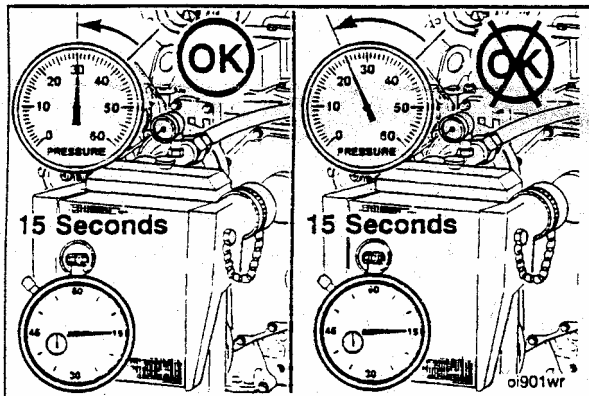


3824556 Test Kit

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.

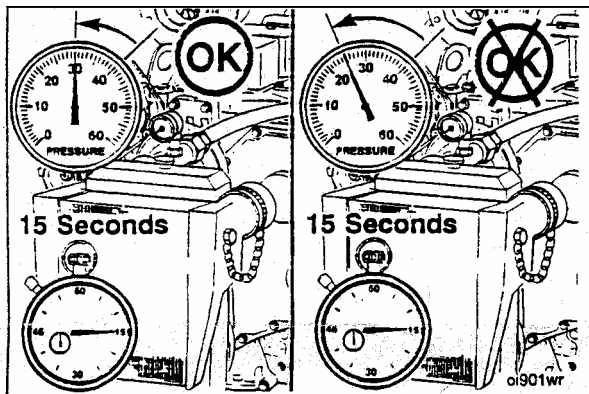


Apply 207 kPa [30 psi] of air pressure to the cooler. Close the air pressure regulator.

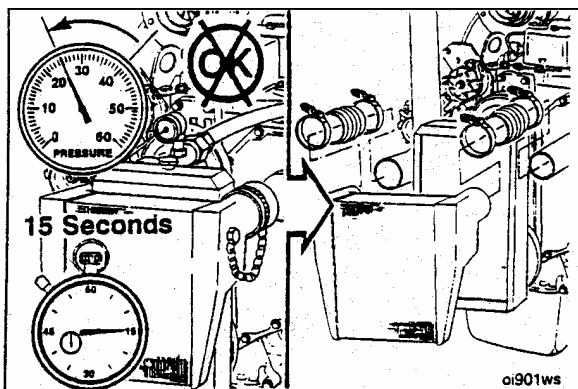
Monitor the pressure gauge and determine the rate of pressure decay with a stop watch.

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 replacement instructions.

NOTE

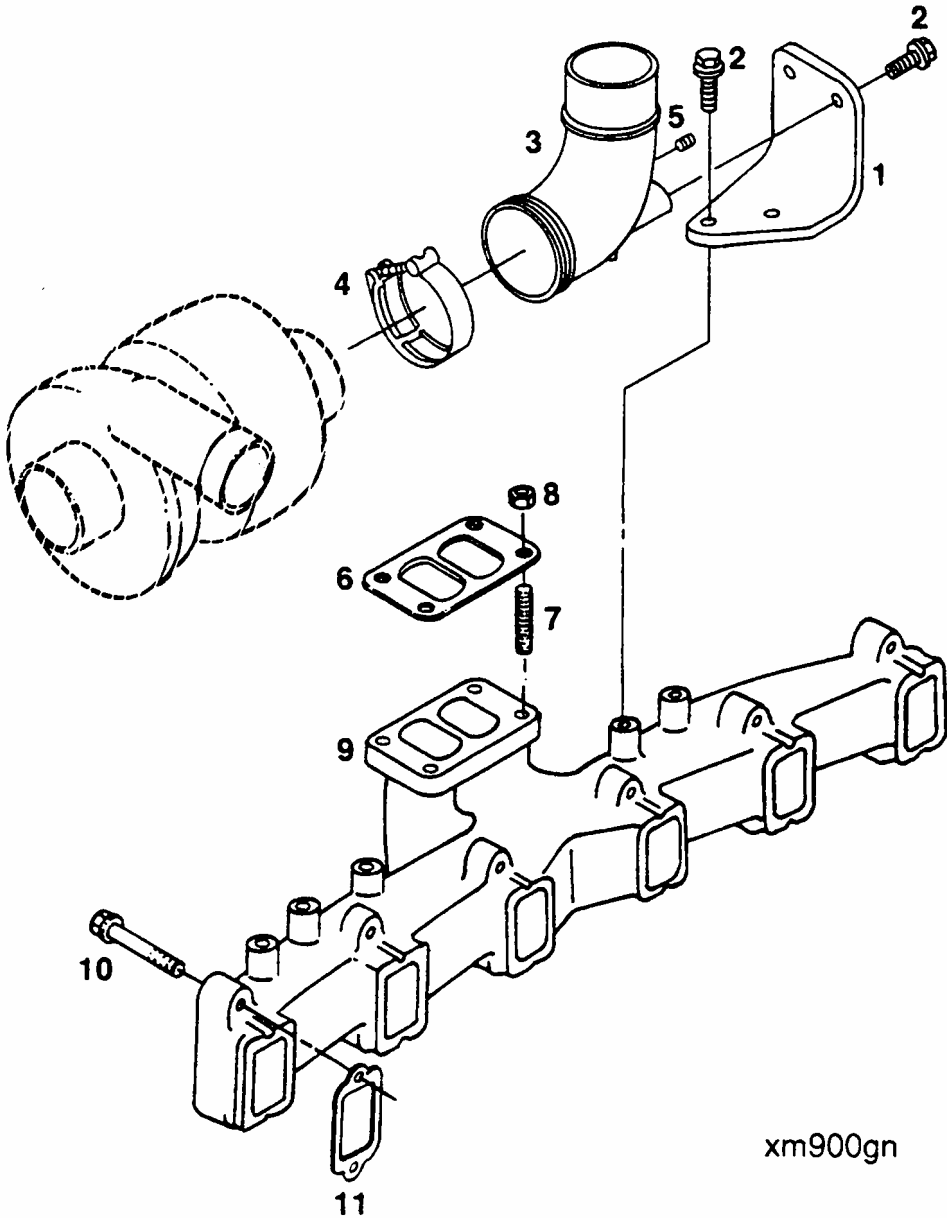
Charge air coolers are **not** designed to be 100% leak free. If the pressure decay is less than 49 kPa [7 psi] in 15 seconds, then the CAC does not need to be replaced.

Section 11 – Exhaust System – Group 11

Section Contents

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Exhaust Manifold	11-3
Turbocharger Mounting Stud Replacement.....	11-4

Exhaust Manifold – Exploded View



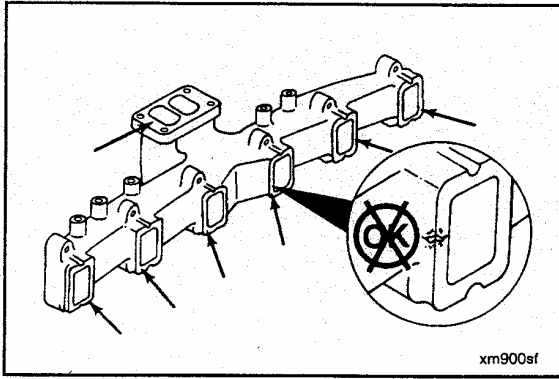
Ref. No.	Part Name	Qty	Remarks
1	Brace, Exhaust Out Conn.	1	
2	Screw, Hex Hd Cap	4	
3	Connection, Exhaust Out	1	90 degree turbo exhaust elbow
4	Clamp, V Band	1	
5	Pipe, plug	1	
6	Gasket, turbocharger	1	
7	Stud	4	
8	Nut	4	
9	Manifold, exhaust	1	
10	Screw, Hex Hd Cap	12	
11	Gasket, manifold	6	

General Information

Exhaust Manifold

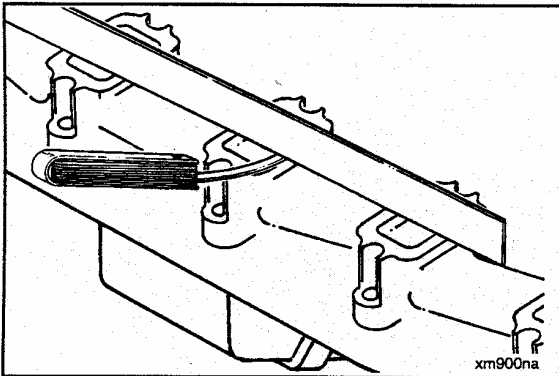
The B series engine uses a pulse-type manifold with a divided turbocharger entry passage (exhaust manifold outlet). Multiple turbocharger locations are available to suit space constraints of various installations. Center, front, rear and high, low turbo mounting locations are offered.

Warping can be corrected by machining or grinding the sealing surfaces to the flatness specification.

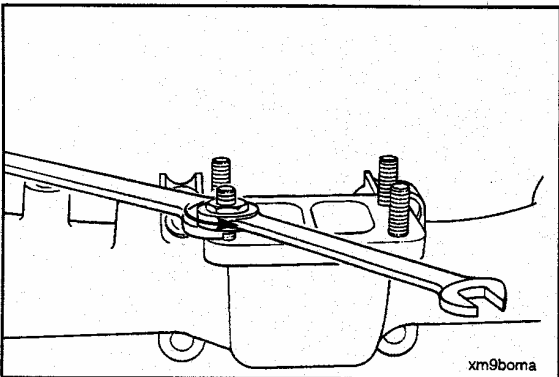


Exhaust Manifold Inspection (11-01)

Inspect the Exhaust Manifold for cracks, burn-out, or damaged threads.



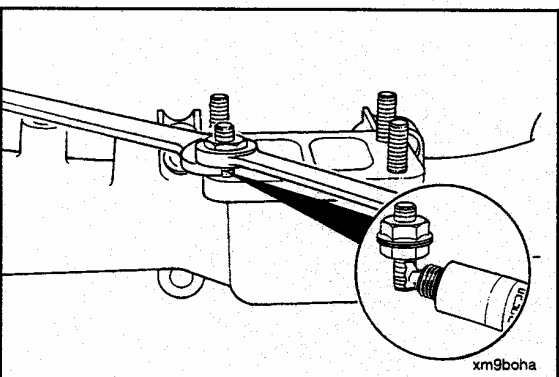
Place straight edge across the exhaust ports. The maximum allowable clearance between the manifold and straight edge is 0.10 mm [0.004 inch].



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-seize compound.

Section 12 – Air Equipment – Group 12

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Inspection	12-3
Air Equipment - General Information	12-2
Air Compressor	12-2

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 55191 -Single Cylinder
8.5 CFM Air Compressor
Rebuild Manual
Bulletin #3810433

Holset SS296 -Single Cylinder
13.2 C.F.M. Air Compressor Bulletin # 3810242

Holset SS338 -Single Cylinder
15.0 CFM 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

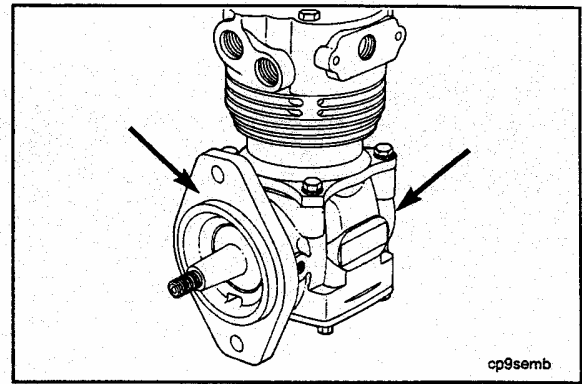
Bendix H.V.S.G.
P.O. Box 5712
1005 Wilton Grove Rd.
London Ontario, Canada N6A458
Attention: Technical Services Dept.

International

Bendix H.V.S.G. Europe Ltd.
66 Grosvenor St.
London, England W1X9OB
Attention: Technical Services Dept.

Air Compressor - Cleaning and Inspection for Reuse (12-01)

Remove all gasket material from the sealing surfaces.



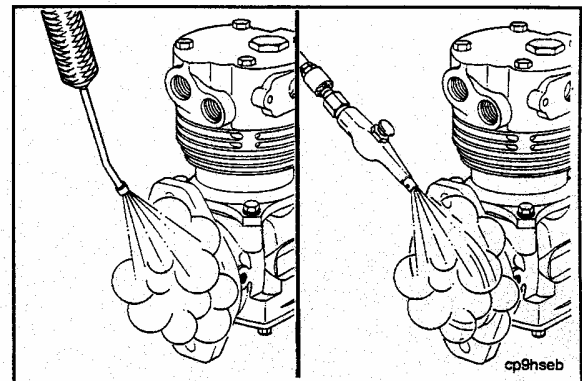
WARNING

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.

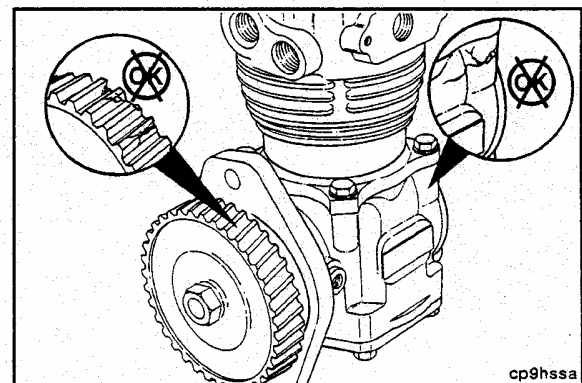


Inspection

Visually inspect the compressor housing for cracks or damage.

Visually inspect the compressor gear drive for cracks or broken teeth.

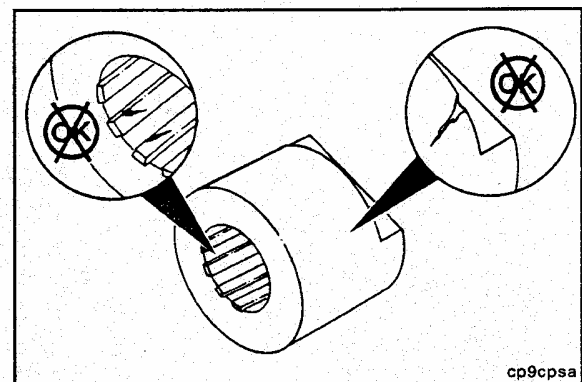
Visually inspect the fuel pump drive hub or spider coupling for wear or damage.

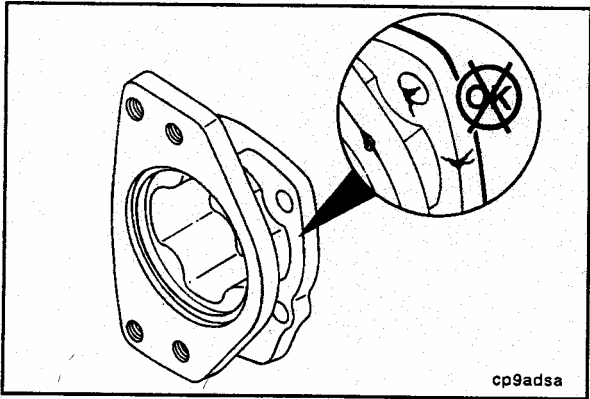


Power Steering Coupling (if Applicable)

Inspect the coupling for wear or cracks.

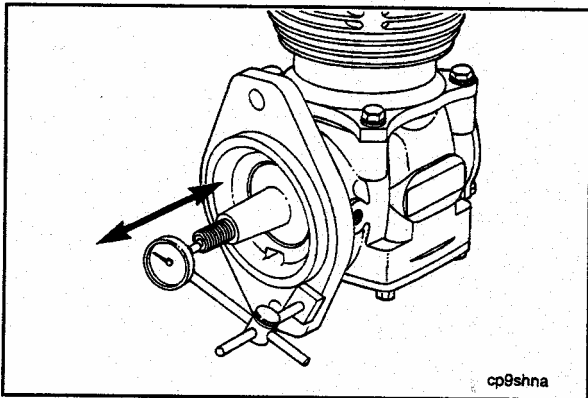
Replace the coupling if damaged.





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

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Alternator - Inspection	13-3
Electrical Equipment - General Information.....	13-2
Starter Inspection.....	13-3

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

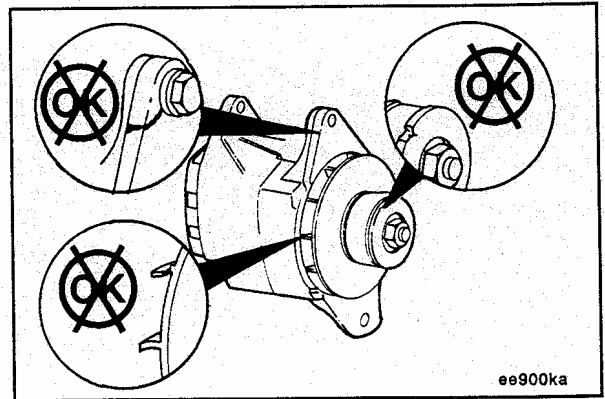
Delco-Remy
P.O. Box 2439
Anderson, IN 46018
U.S.A.
Telephone: (317) 646-7838

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)

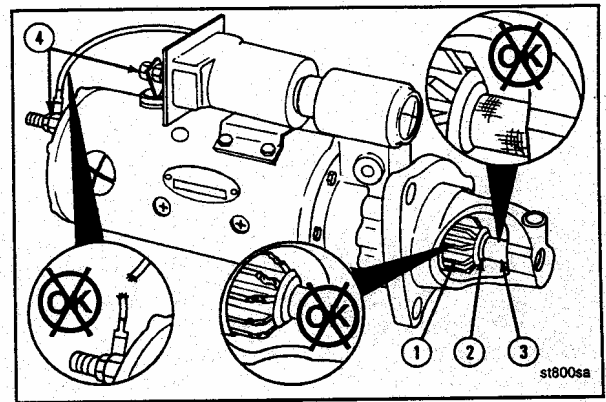
Visually inspect the gear (1) for cracked or broken teeth.

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 electrical equipment manufacturers specifications to rebuild the starting motor.



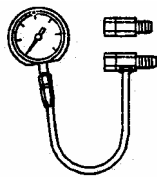
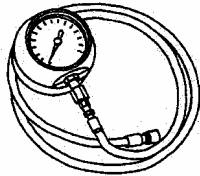
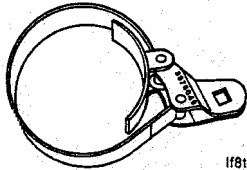
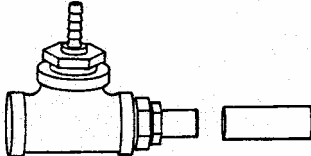
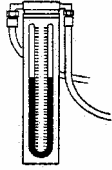
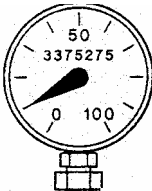
Section 14 – Engine Testing – Group 14

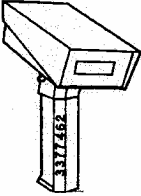
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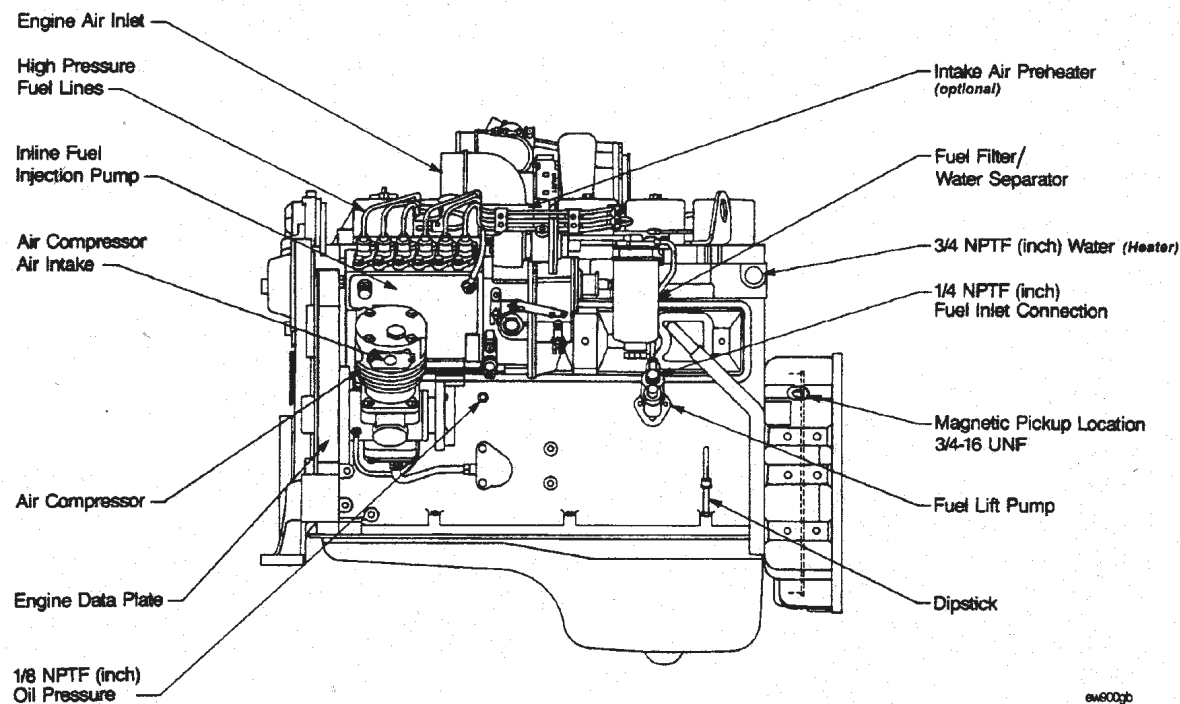
Engine Testing - Service Tools

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-4334-2, and vacuum gauge, Part No. ST-424-12, are used to perform the test.	 eg8tgc
ST-1273	Pressure Gauge Use to measure the engine intake manifold pressure.	 eg8tgi
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.	 eg8tge
ST-1111-3	Water Manometer Used with the blowby check tool to measure engine crankcase pressure.	 eg100a
3375275	Pressure Gauge (0-160 psi) Used to measure lubricating oil pressure.	

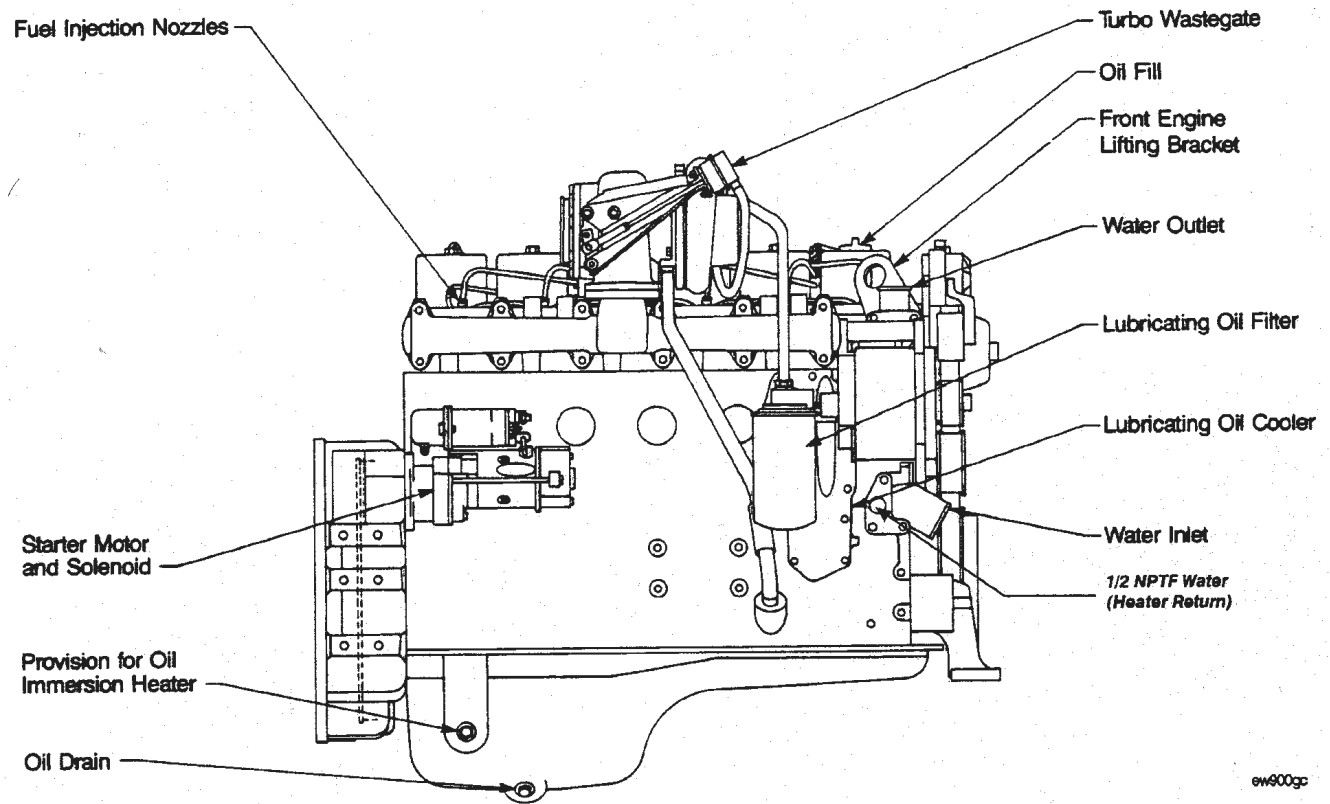
Tool No.	Tool Description	Tool Illustration
3377462	Digital Optical Tachometer Used to measure engine speed (RPM).	 3377462

Engine Testing – Engine Side Views



Fuel Pump Side

Engine Testing – Engine Side Views



Exhaust Side

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 H₂O [10 in. H₂O]
- (medium duty) 305 mm H₂O [12 in. H₂O]
- (heavy duty) 381 mm H₂O [15 in. H₂O]
- 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)
66 @ 2800	34	68
6BT/6BTA/B5.9 @ 2200	63	126
6BT/6BTA/B5.9 @ 2500	76	152
6BT/6BTA/BS.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]

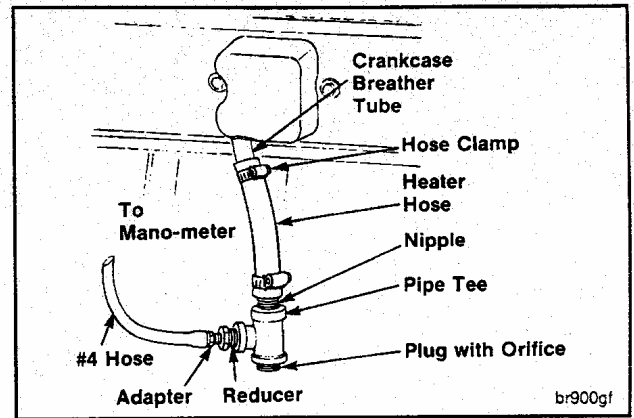
NOTE

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

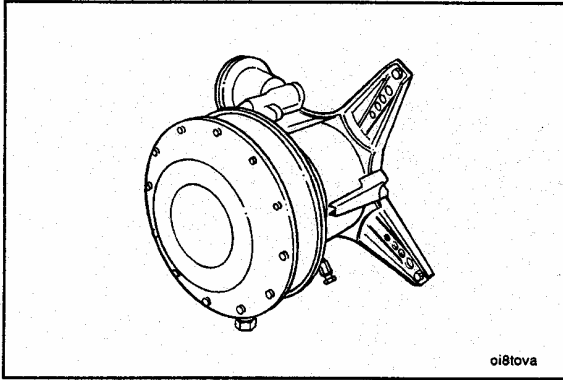
Blowby is generally recorded in liters/minute, but a water manometer may be used to measure blowby from the breather tube after fabricating the following adaptation:

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		

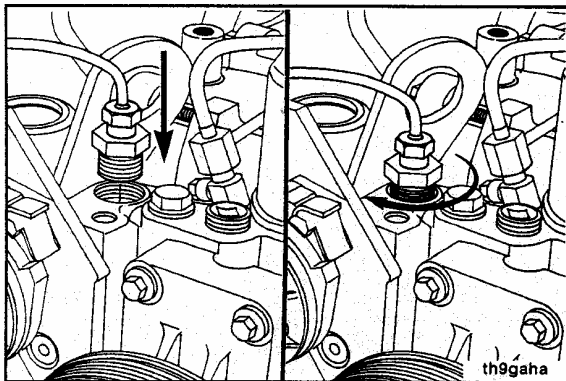


Engine Dynamometer Test - Installation of the Engine (14-01)

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.

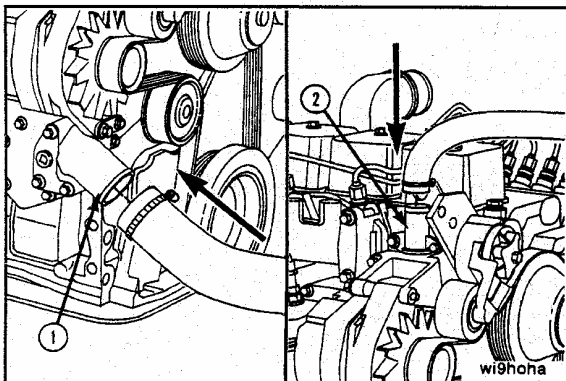
NOTE

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]

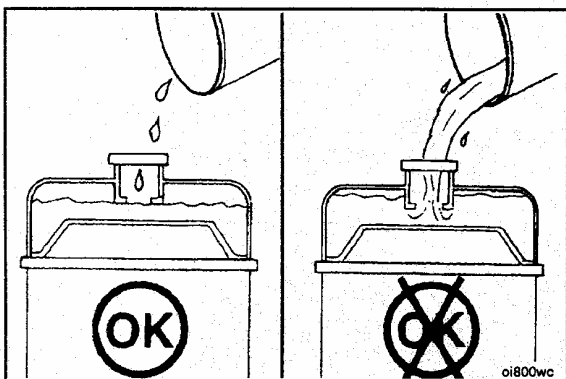


Connect the coolant supply to the water inlet connection (1).

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.

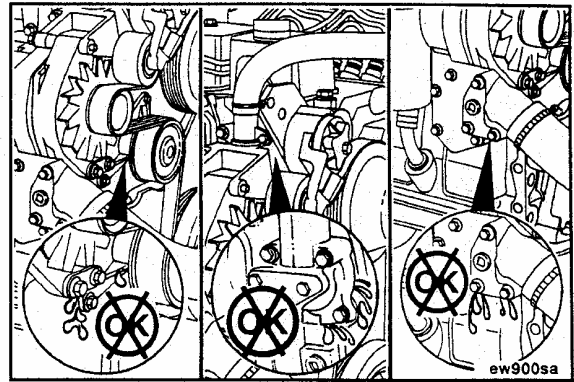


Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill (or expansion) tank.

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.

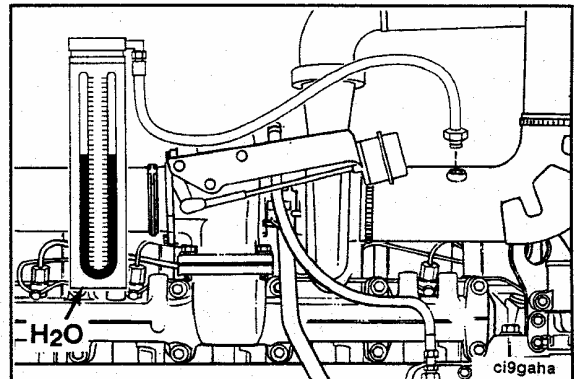
NOTE

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 H₂O [30 in. H₂O]



Connect a mercury manometer to a straight section of the exhaust piping near the turbocharger outlet to check exhaust restriction.

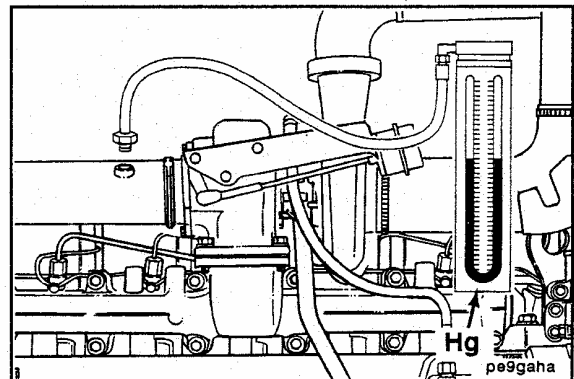
NOTE

A pressure gauge can be used in place of the mercury manometer.

NOTE

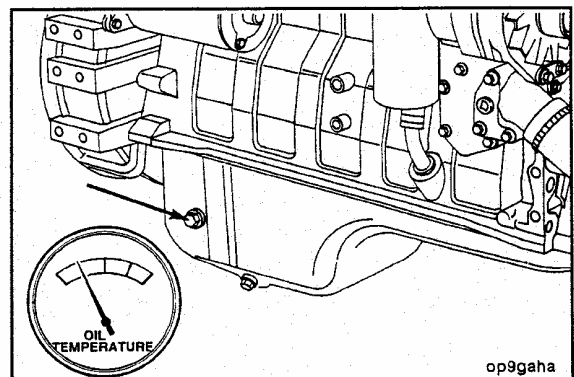
For automotive applications, a tapped hole is provided on the inlet side of the catalyst to check exhaust restriction.

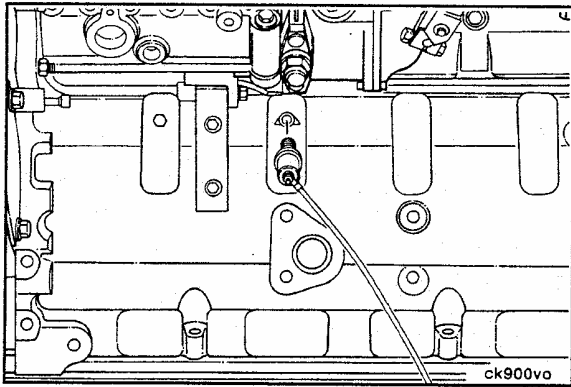
Minimum Gauge Capacity: 254 mm Hg. [10 in. Hg.]



Attach the lubricating oil temperature sensor in one of the locations on the side of the engine as shown.

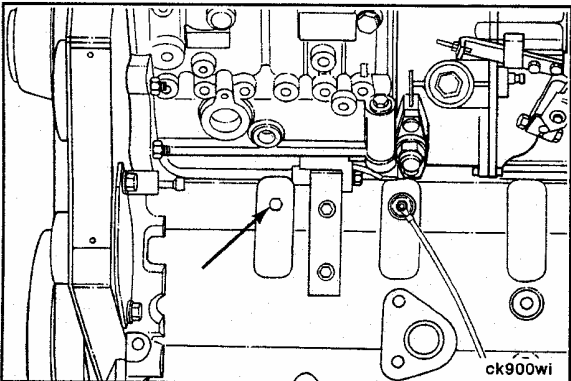
Minimum Gauge Capacity: 150° C [300° F]





Attach the lubricating oil pressure sensor to the main oil rifle drilling in the cylinder block.

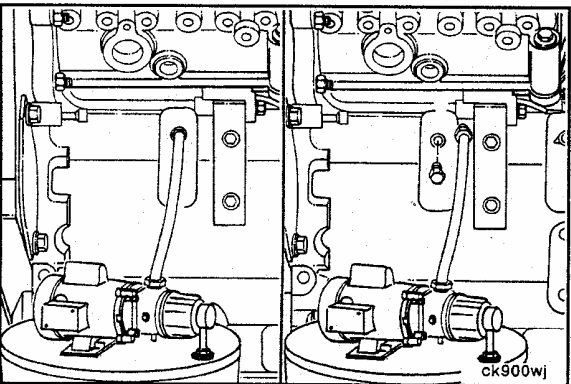
Minimum Gauge Capacity: 1034 kPa [150 psi]



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.

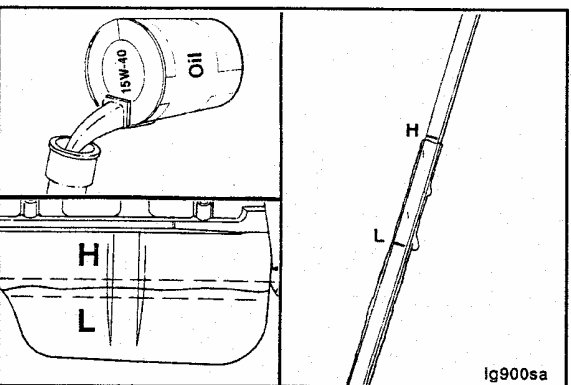
To prime the system using external pressure, connect the supply to the tapped hole in the main oil rifle.



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.

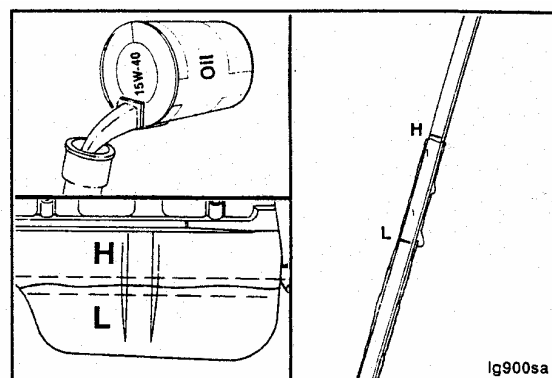
Remove the oil supply tube, and install the plug.



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.

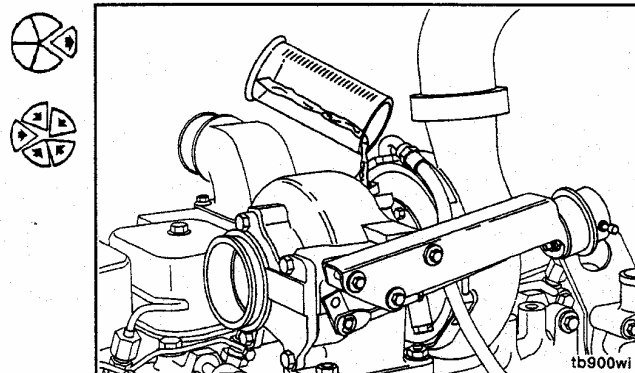
Fill the engine with oil to the high level mark on the dipstick.



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.



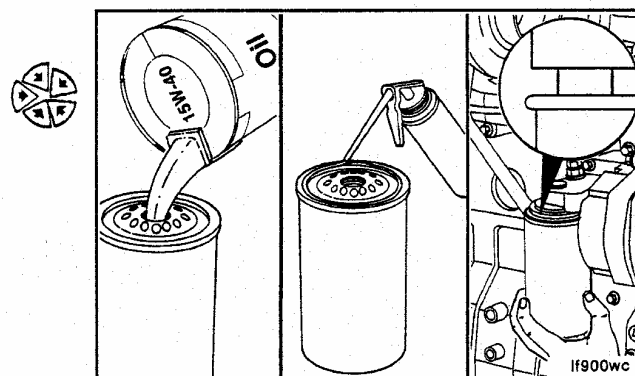
CAUTION

Mechanical over-tightening can distort the threads or damage the filter element seal.

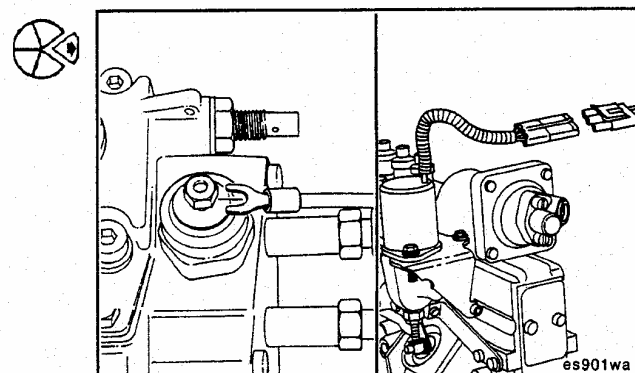
Fill the lubricating oil filter with clean 15W-40 oil.

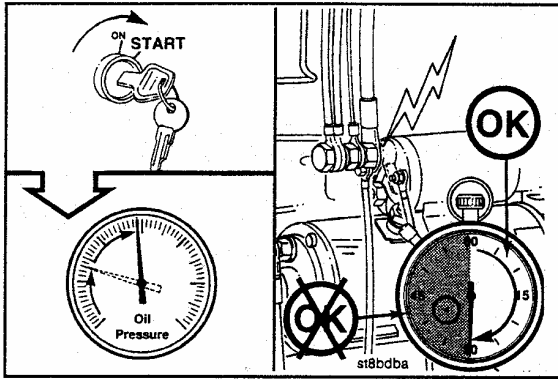
Screw the filter onto the filter head fitting until the gasket contacts the filter head surface.

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.

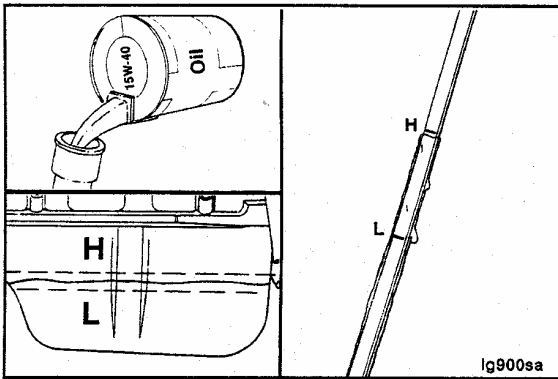
Crank the engine until the oil pressure gauge indicates system pressure.

NOTE

Allow two minutes between the 30-second cranking periods so the starting motor can cool.

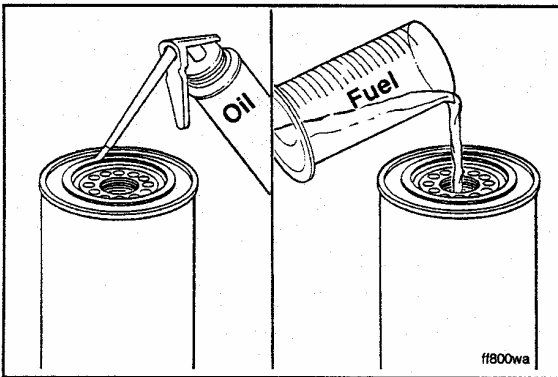
NOTE

If pressure is not indicated, find and correct the problem before continuing.



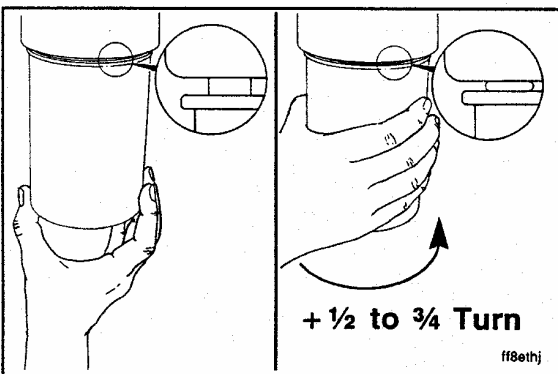
Allow the lubricating oil to drain into the oil pan, and measure the oil level with the dipstick.

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.

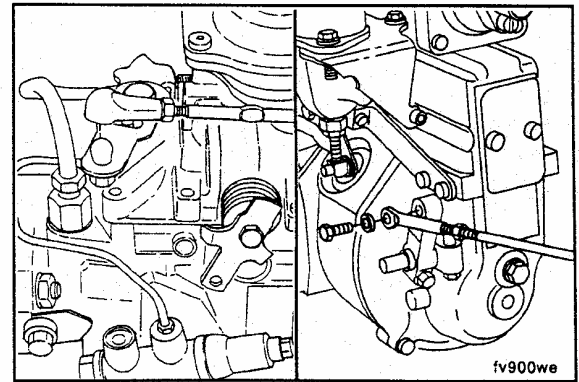


Screw the fuel filter onto the filter head until the gasket contacts the filter head surface.

Tighten the filter an additional 1/2 to 3/4 turn.

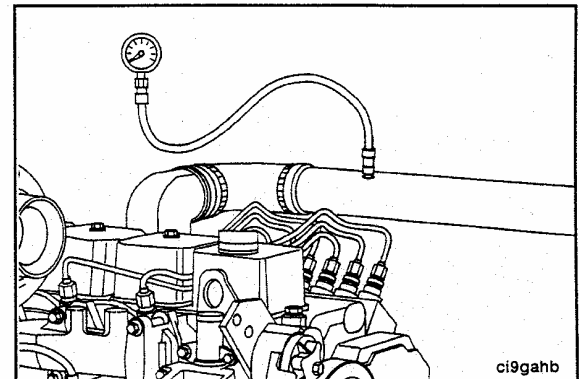
Make sure the voltage supply matches that of the fuel pump solenoid before connecting the electrical wires to it.

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.

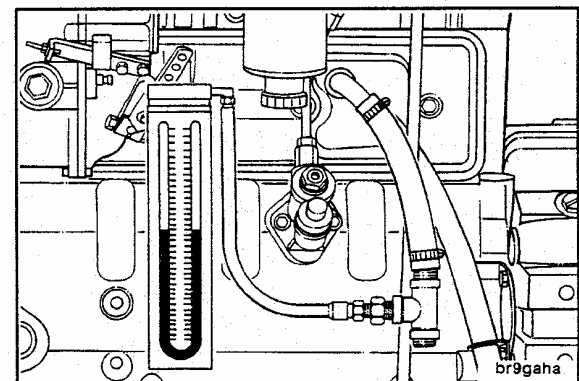


Part No. 3822676

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.

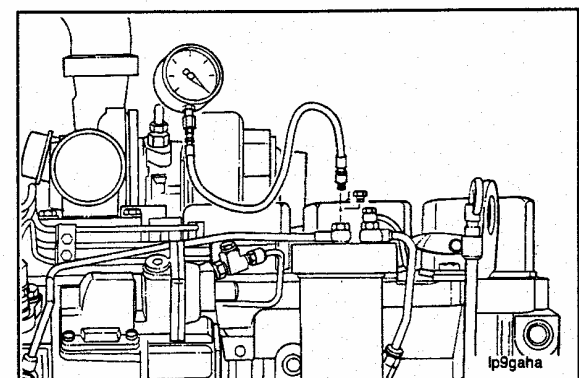
Minimum Gauge Capacity: 1270 mm H₂O [50 in. H₂O]

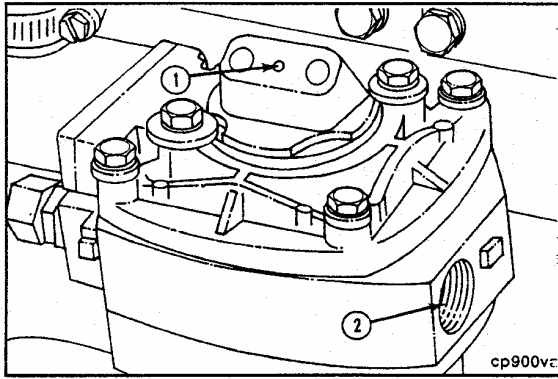


Part No. ST-434

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]





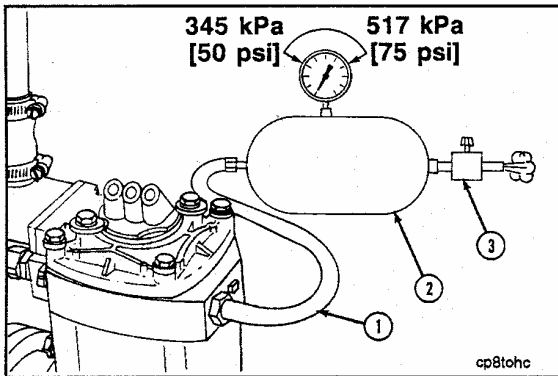
To be able to unload the compressor, connect a source of compressed air to the unloader (1). This air line **must** contain a valve between the source and the unloader.

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

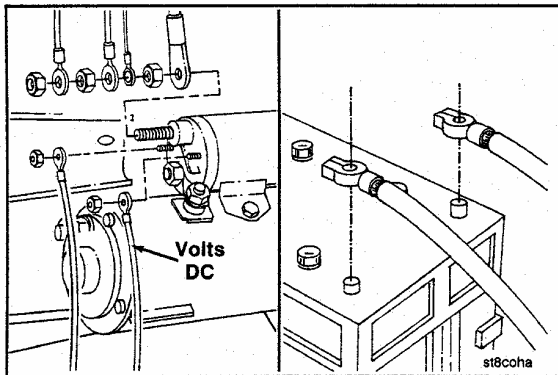
The compressed air load in the accompanying illustration **must** be attached to the air compressor outlet (2).



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]

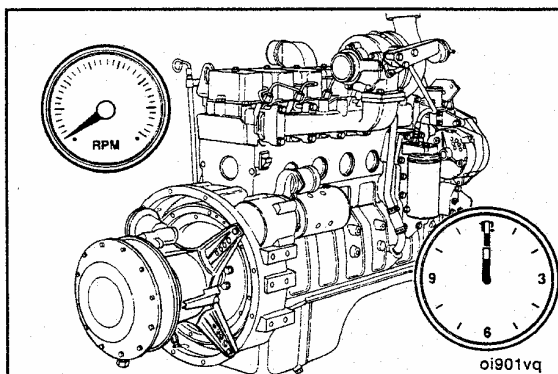


Inspect the voltage rating on the starting motor before installing the electrical wiring.

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.



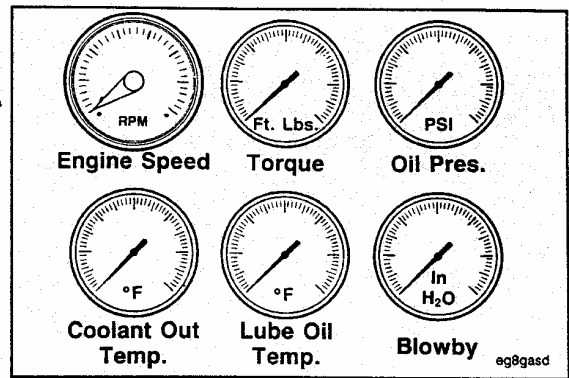
Engine Dynamometer Test - Engine Run-In (14-02)

The engine run-in period allows the tester to detect assembly errors and to make final adjustments needed for performance that meets specifications.

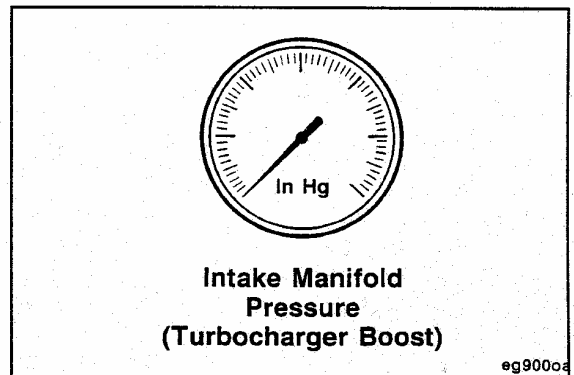
NOTE

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.

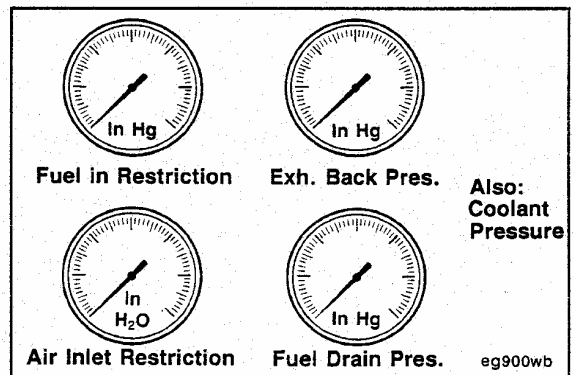
Measurements from these indicators and gauges **must** be observed closely during all phases of the engine run-in period. Refer to page 14-6 for specifications and acceptable readings.



To correctly evaluate the engine performance, this additional measurement must be observed during engine run-in phases.



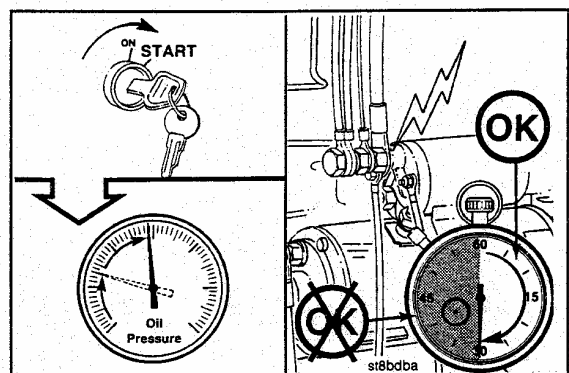
It is good practice to observe these measurements even if engine performance meets specifications. If engine performance does **not** meet specifications, these measurements can indicate possible reasons for under-performance.

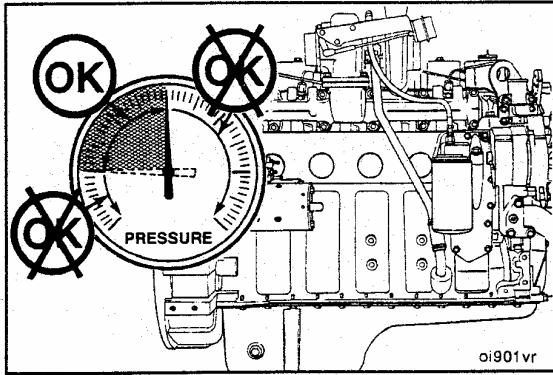


CAUTION

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.



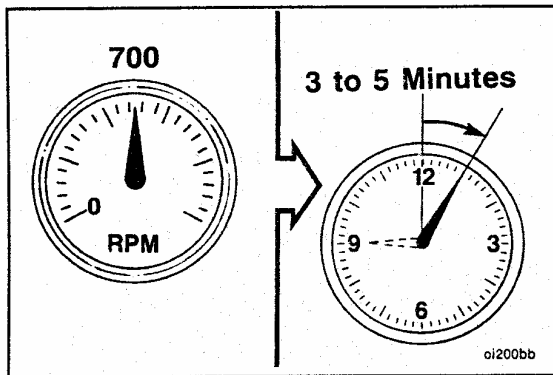


CAUTION

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.

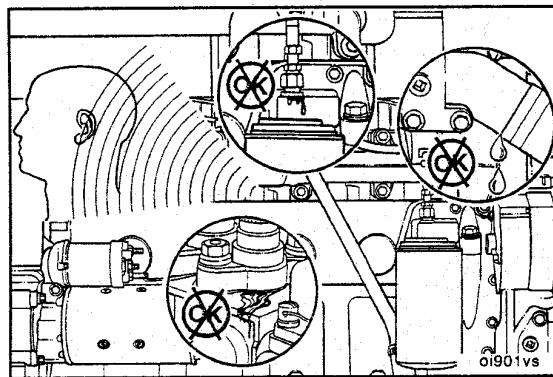
Correct the problem if the oil pressure is not within specifications.



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.

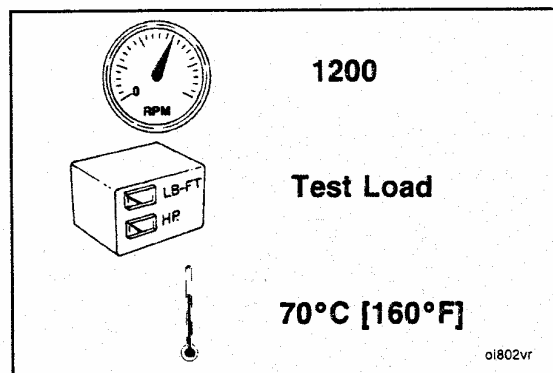
Operate the engine at approximately 700 RPM for 3 to 5 minutes.



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

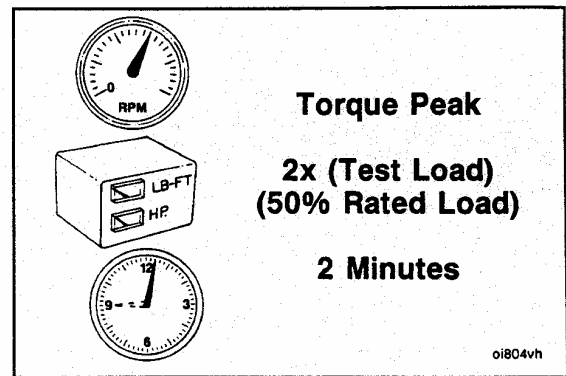
Do **not** proceed to the next step until a steady blowby reading is obtained.

Operate the engine at this speed and load level for 2 minutes.

Check all gauges and record the data.

NOTE

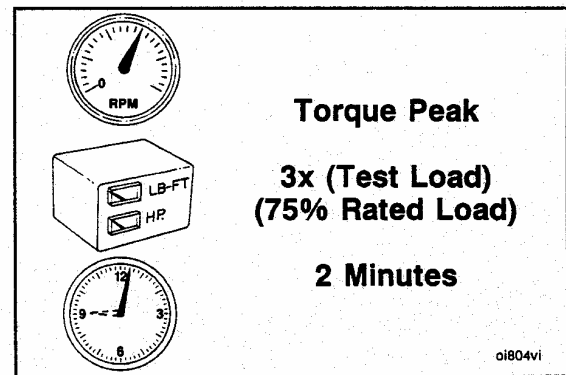
Do **not** proceed to the next step until blowby is stable and within specifications.



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.

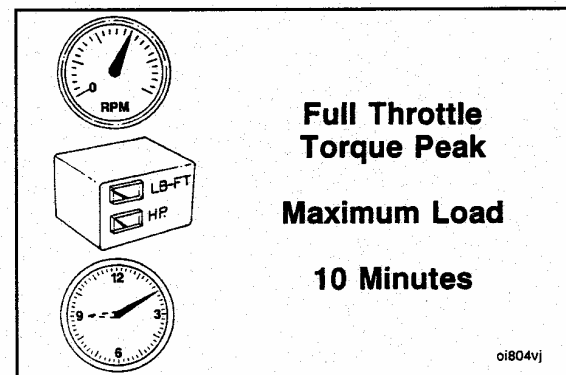
NOTE

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.

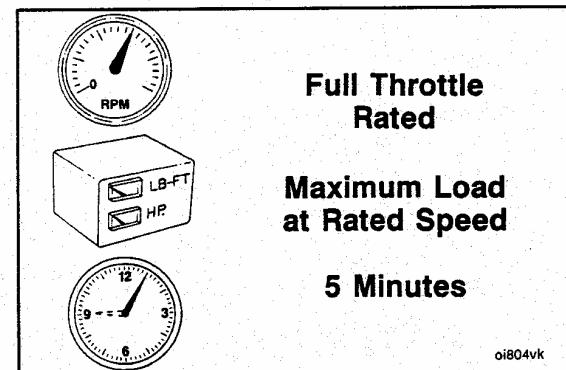
Check all gauges and record the data.

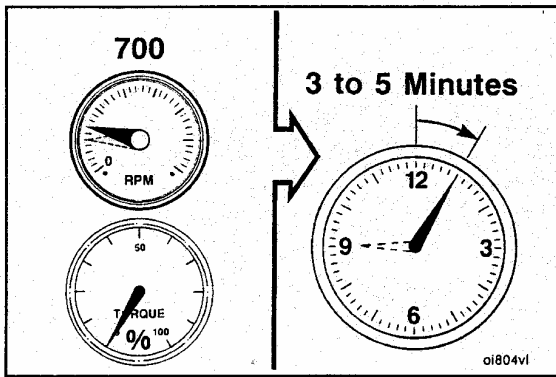


Reduce the dynamometer load until the engine speed increases to the engine's rated RPM.

Operate the engine at rated RPM for 5 minutes.

Check all gauges and record the data.

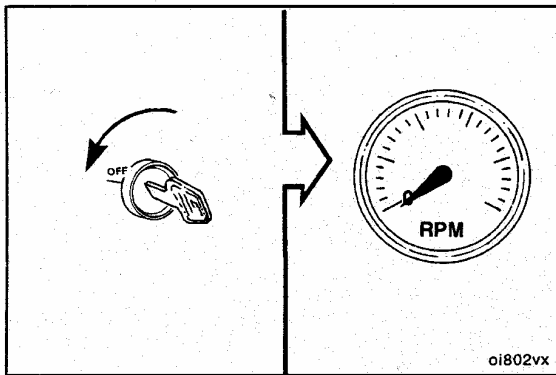




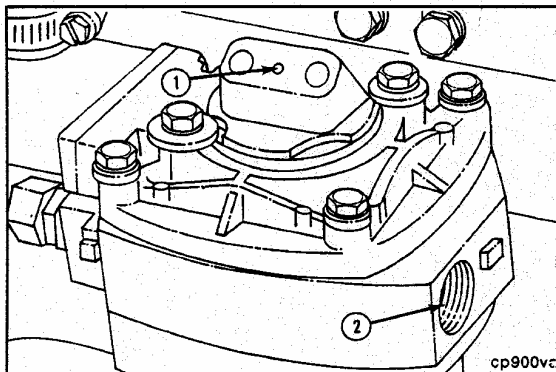
CAUTION

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.



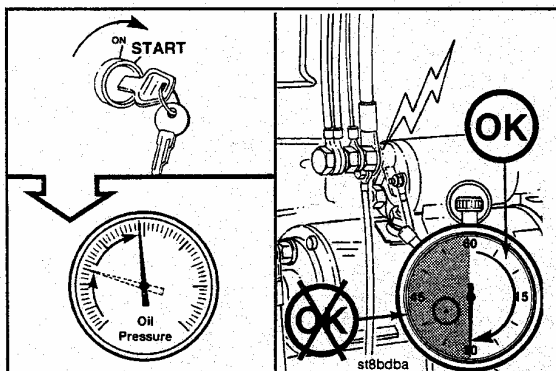
Shut off the engine.



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

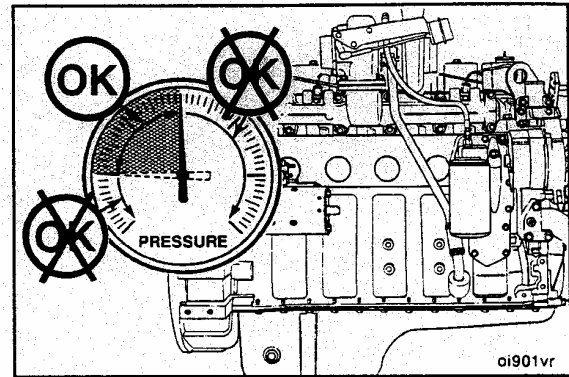
Do not crank the engine for more than 30 seconds. Excessive heat will damage the starting motor.

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.

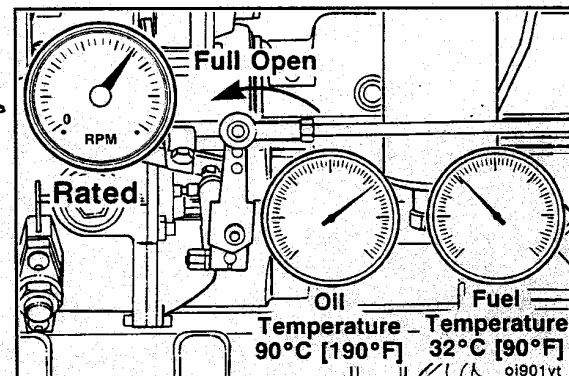
NOTE

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.

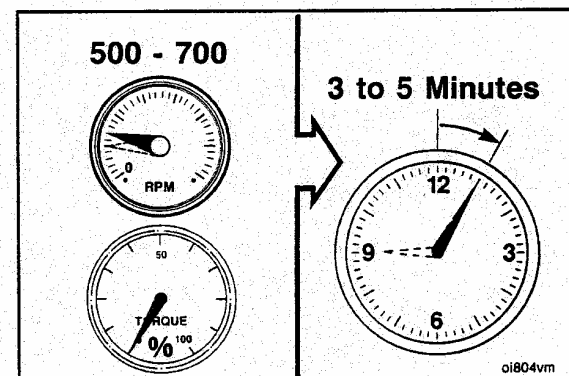
**CAUTION**

Do not shut off the engine immediately after it has been loaded. It must be allowed to sufficiently cool.

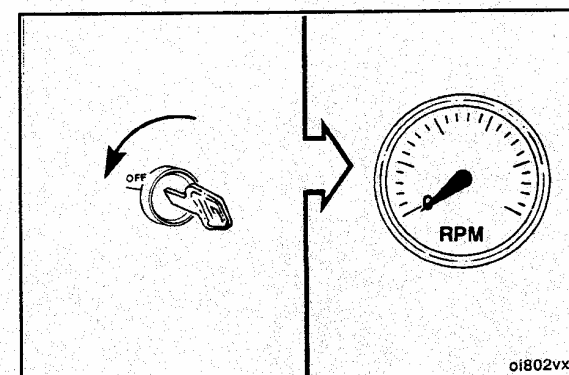
Remove the dynamometer load completely, and operate the engine at idle speed for 3 to 5 minutes. This will allow the turbocharger and other components to cool.

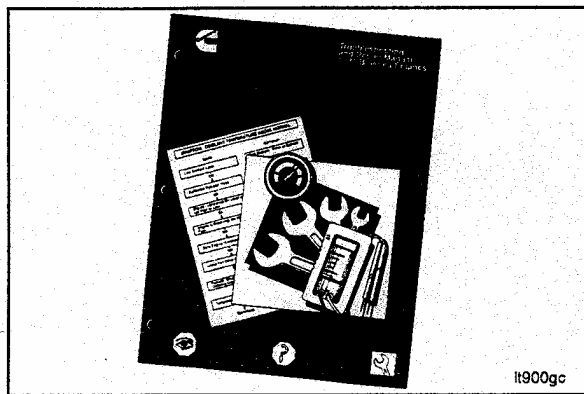
NOTE

Idle periods longer than 5 minutes are to be avoided.

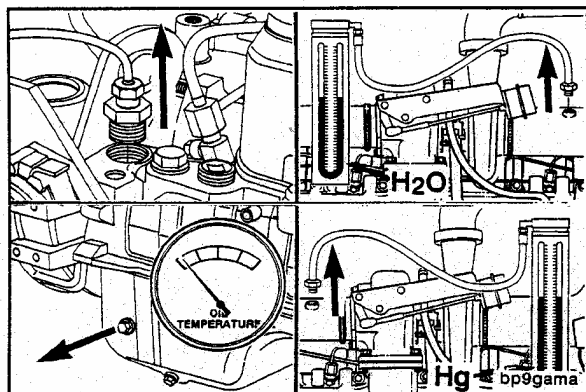


Shut off the engine after the cool-down period.





If power specifications are not met, refer to B Series Troubleshooting and Repair Manual, Bulletin No. 3810486.



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).

Engine Run-In Procedure “In Chassis” - (On- and Off-Highway Vehicles) (14-07)

On-Highway

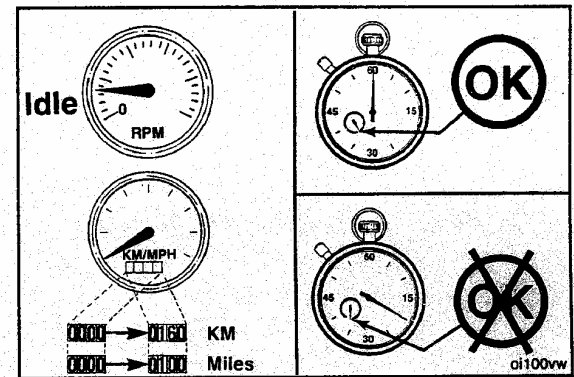
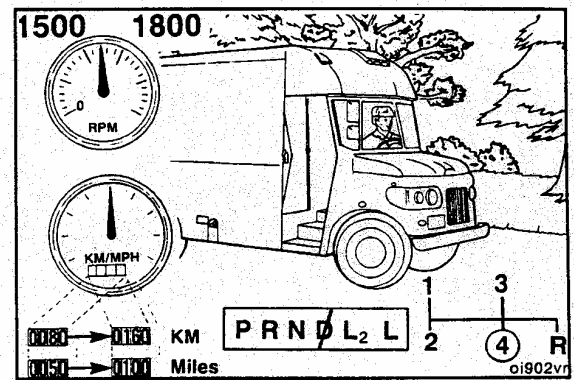
CAUTION

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 five minutes at any one time during the first 160 kilometers [100 miles] of operation.

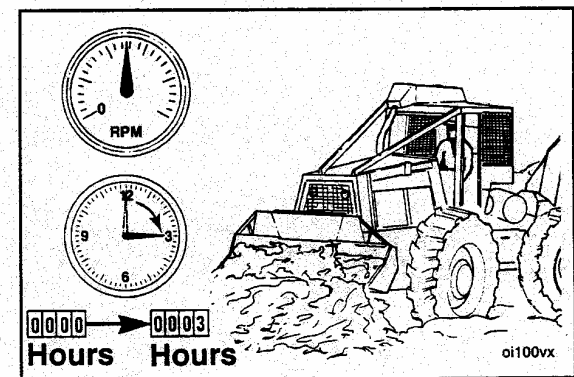


Off-Highway

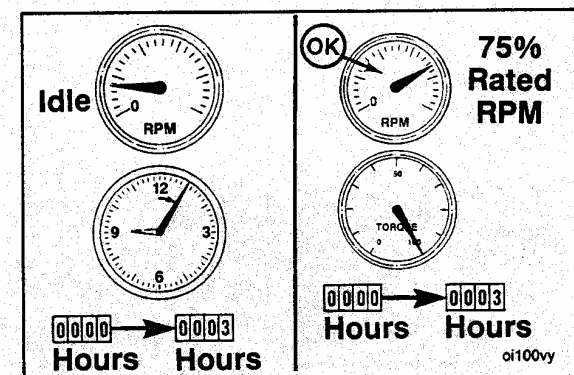
CAUTION

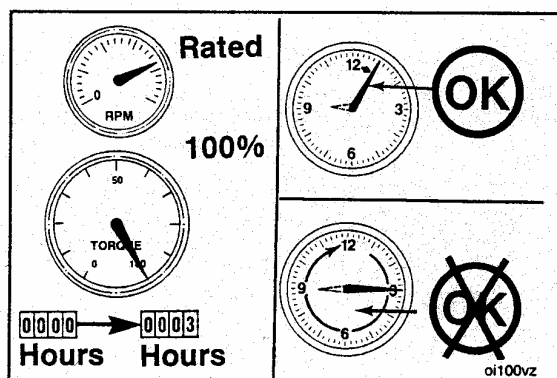
Refer to General Engine Test Procedures - (Chassis Dynamometer) (14-05) before operating the engine to avoid internal component damage.

Operate the engine as follows during the first 3 hours after rebuild:

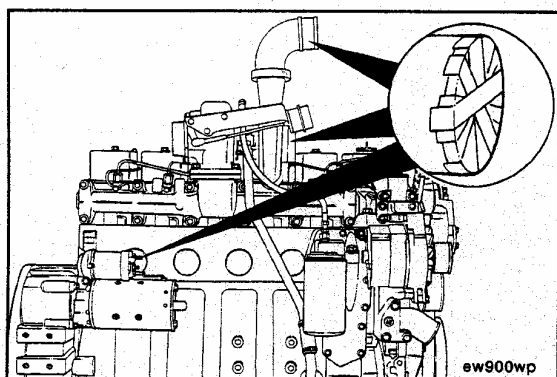


1. Do **not** idle the engine for more than 5 minutes at any one time.
2. Operate the engine at 75 percent throttle while loaded.





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

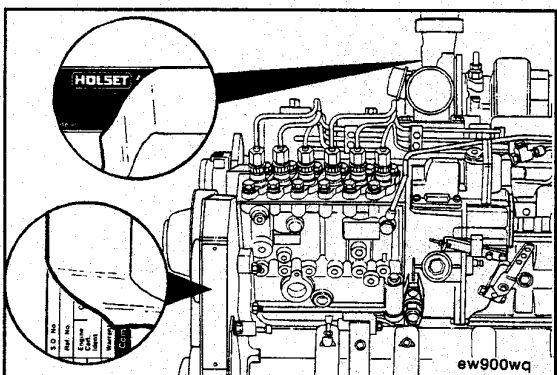
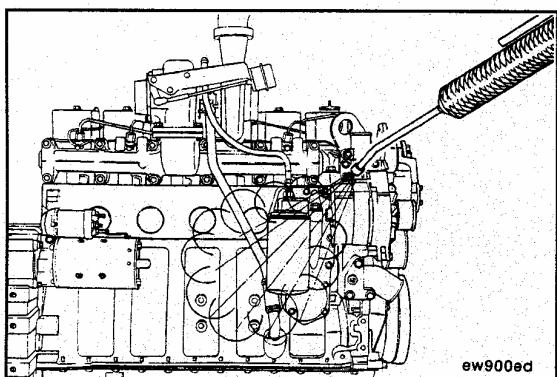
WARNING

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

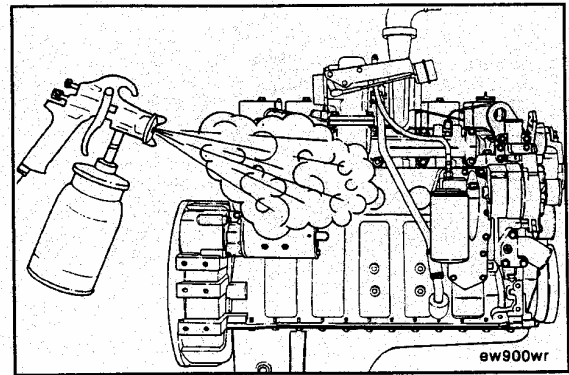
Make sure all engine surfaces are clean and dry before painting the engine.



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.

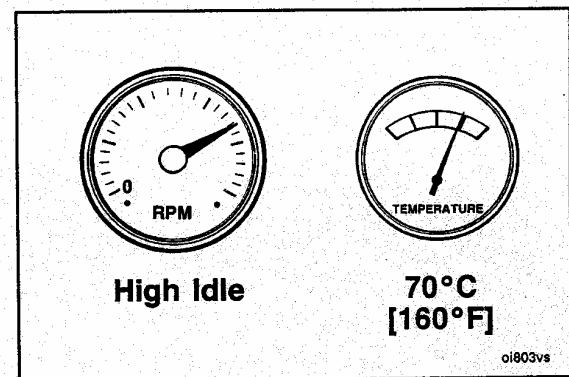


Engine Storage - Short Term (14-09)

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.

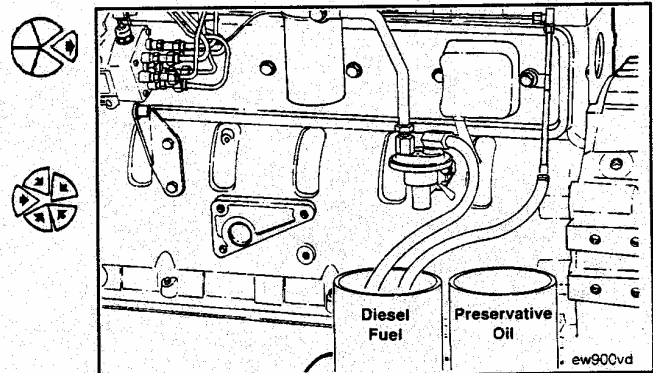


Remove the fuel tube to the engine fuel filter and the injector return tube.

NOTE

Fuel system preservative oil **must** meet Federal Specification VV-L-800C. (Example: Daubert Chemical NoxRust No. 518.)

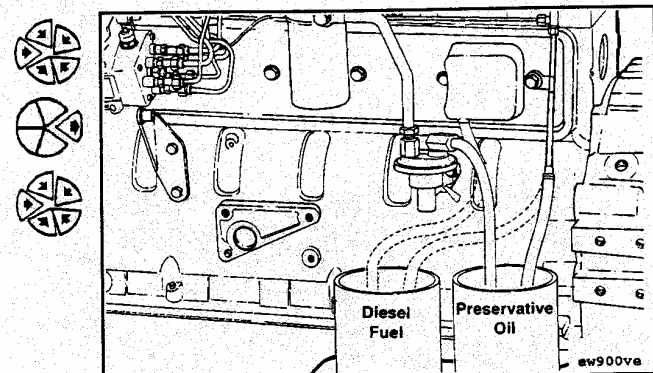
Fill two containers, one with diesel fuel and the other with the preservative oil. Put both fuel tubes into the container of diesel fuel.

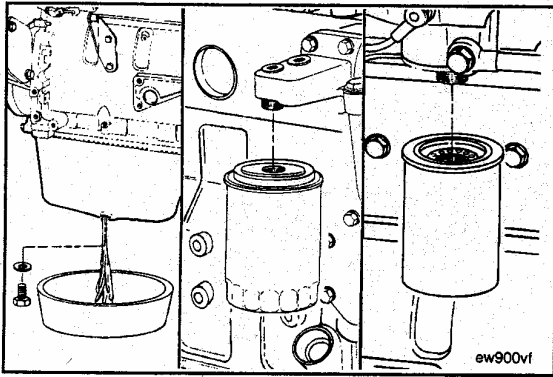


Start the engine. When it is operating smoothly, put the fuel supply tube into the container of preservative oil.

Remove the injector return tube from the diesel fuel container. When preservative oil flows from the tube, shut off the engine.

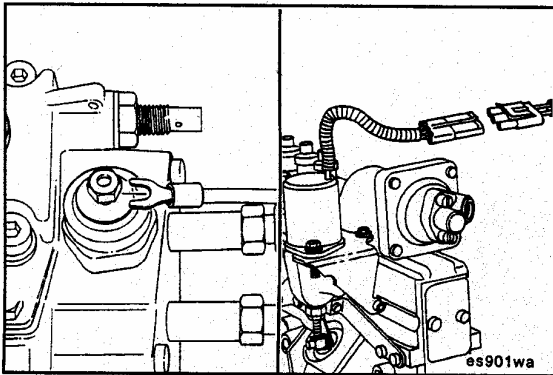
Install the fuel supply tube to the fuel filter, and put a cap on all other fuel tubes.



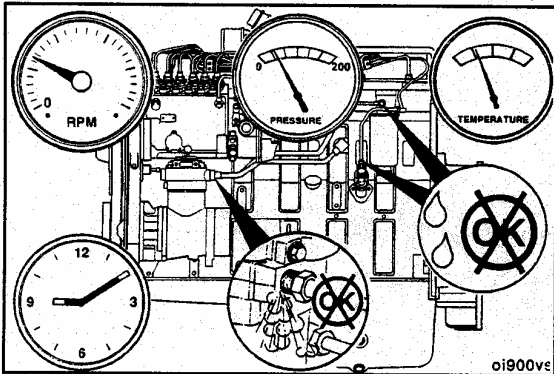


Drain the lubricating oil pan, the oil filters, and the fuel filter.

Install the drain plug into the oil pan, and install the filter cans. Tighten according to specifications.



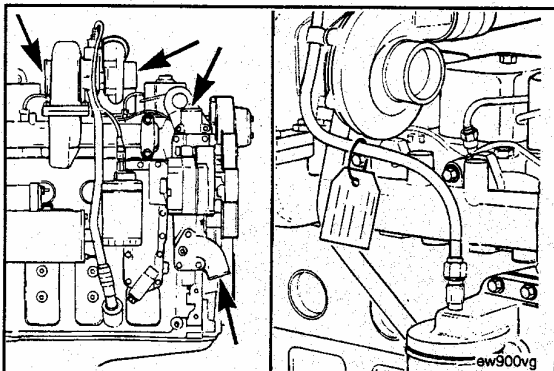
Disconnect the electrical wires from the fuel pump solenoid.



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.

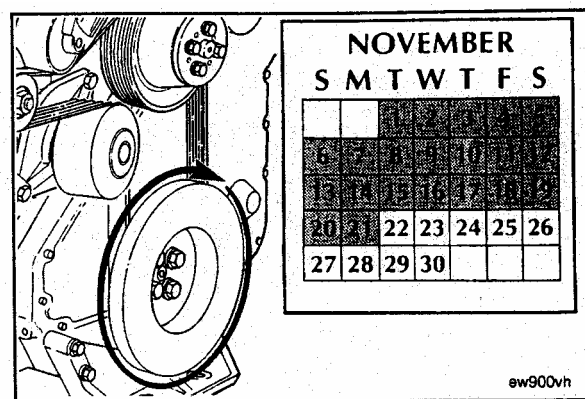


Look the engine over closely, and cover all openings with tape to prevent dirt and moisture from entering.

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.

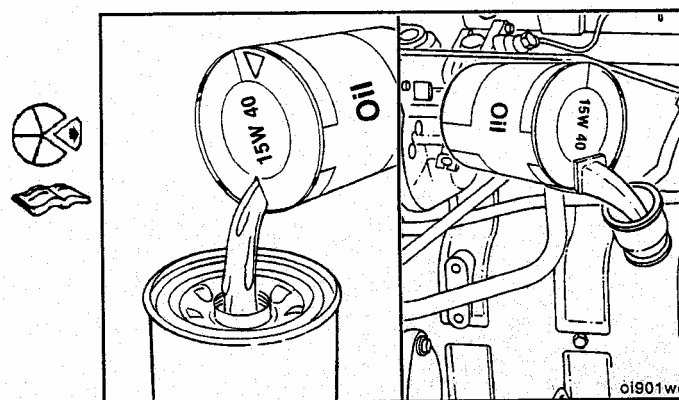


Removing the Engine from Short-Term Storage

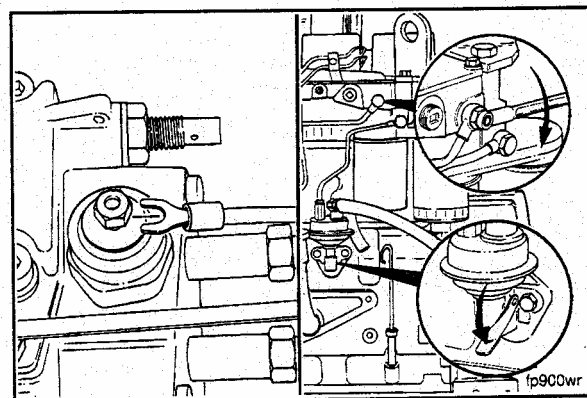
Remove the tape from all openings, and remove the warning tag.

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.

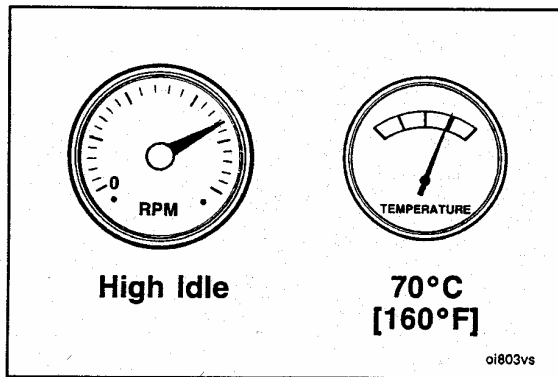


Engine Storage - Long Term (14-10)

This procedure describes the correct method of preparing an engine for long-term (6 to 24 months) storage.

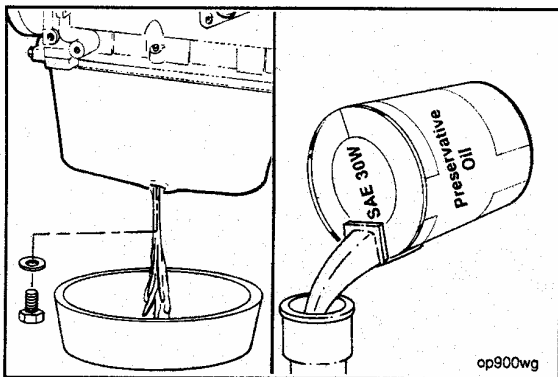
NOTE

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].

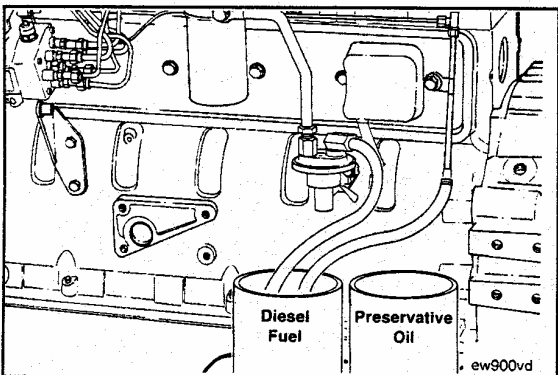
Shut off the engine.



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

Fuel system preservative oil must meet Federal Specification VV-L-800C. (Example: Daubert Chemical NoxRust No. 518.)

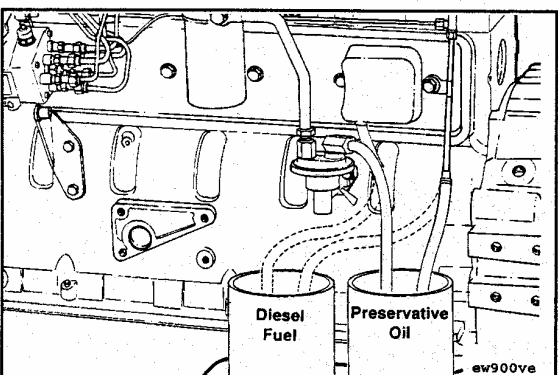


Disconnect the fuel supply tube at the fuel filter and the injector return tube at a convenient place.

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.



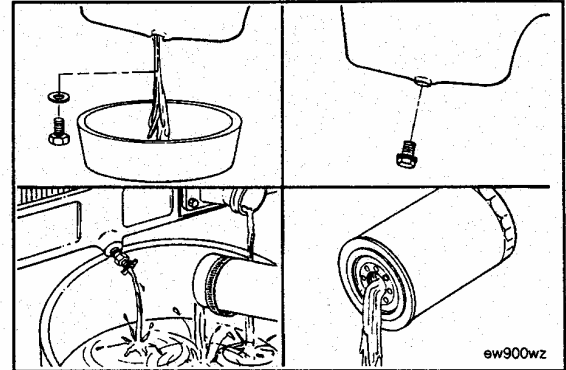
Start the engine and, when operating smoothly, put the fuel supply tube into the container of preservative oil.

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.

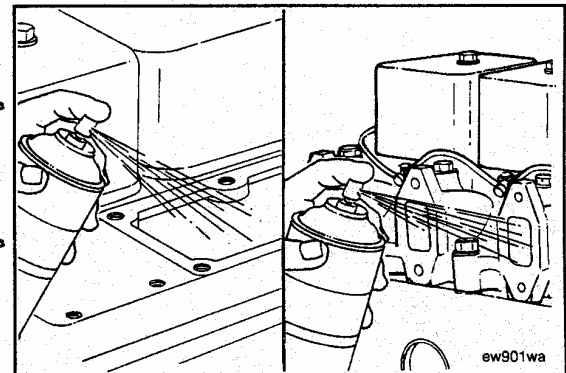


ew900wz

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.

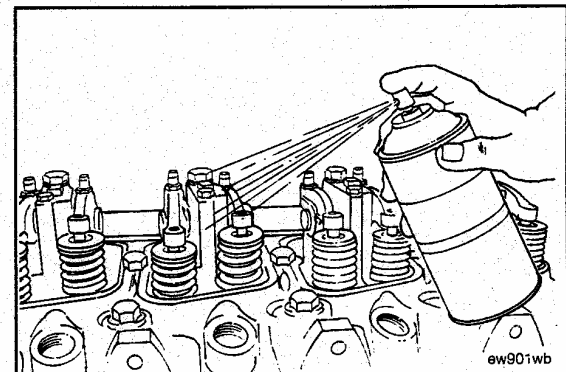
Install the aftercooler assembly and the exhaust manifold. Refer to Engine Assembly.



ew901wa

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.



ew901wb

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:

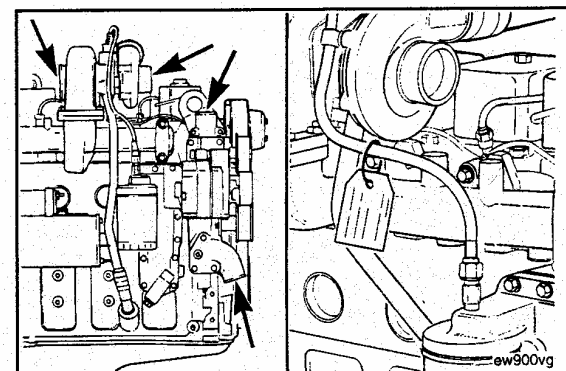
Date the engine was prepared for storage.

Crankshaft **must not** be rotated.

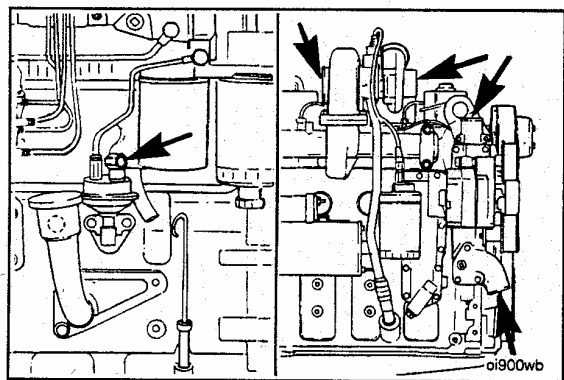
Coolant has been drained.

Engine **must not** be operated.

Store the engine in a dry area of even temperature.

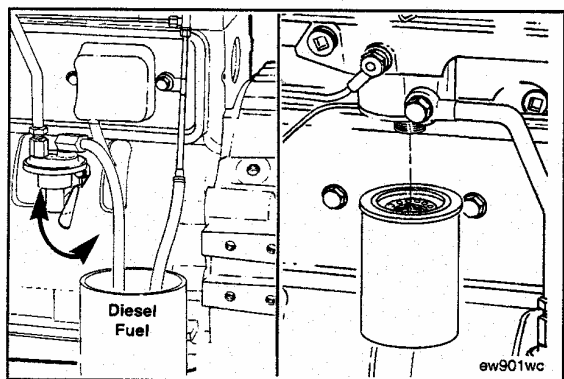


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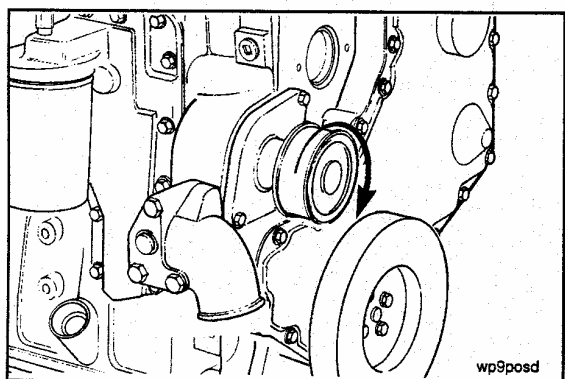


Removing the Engine from Long-Term Storage

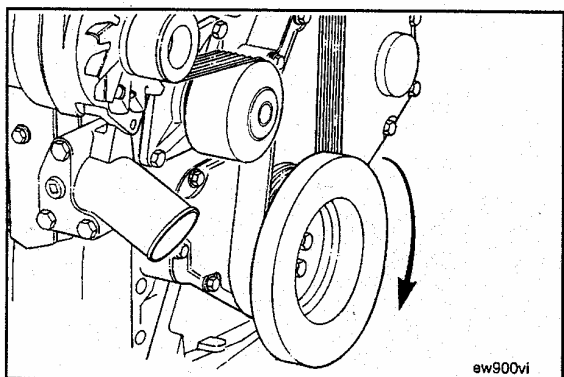
Remove the paper and the tape from all openings. Remove the warning tag.



Flush the fuel system with clean diesel fuel to remove preservative oil.

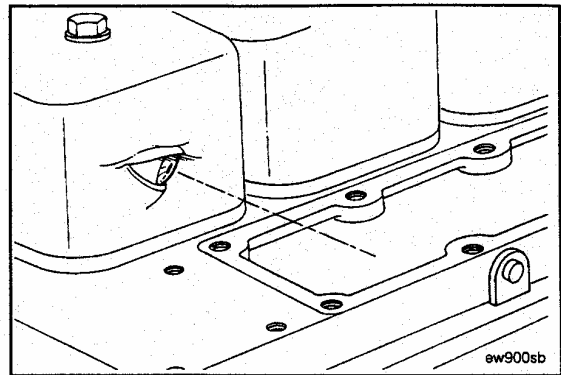


Rotate the water pump to make sure it hasn't rusted in place.

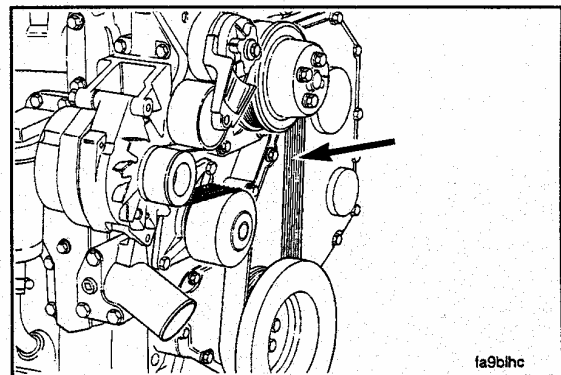


Rotate the crankshaft two complete revolutions to make sure the piston rings are free and no foreign objects are in the engine.

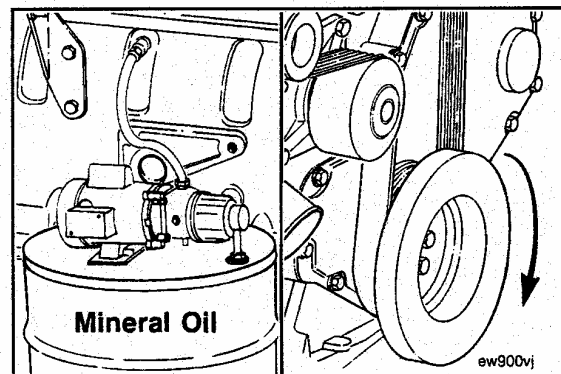
Remove the intake manifold cover or aftercooler and visually inspect the lower valve stem area for presence of rust. An accumulation of rust requires disassembly and rebuild of the cylinder head.



Install the drive belt or belts.

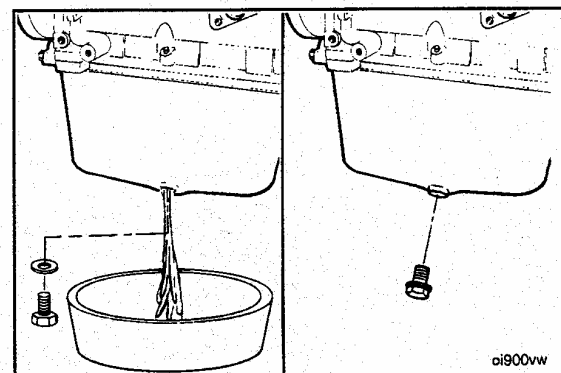


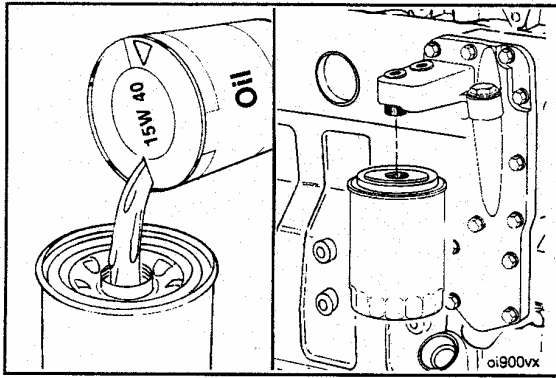
Remove a plug from the main oil rifle drilling and flush the preservative oil from the engine by pumping 4 liters of light mineral oil into the oil rifle. Rotate the crankshaft three or four revolutions as the engine is flushed. Install the plug.



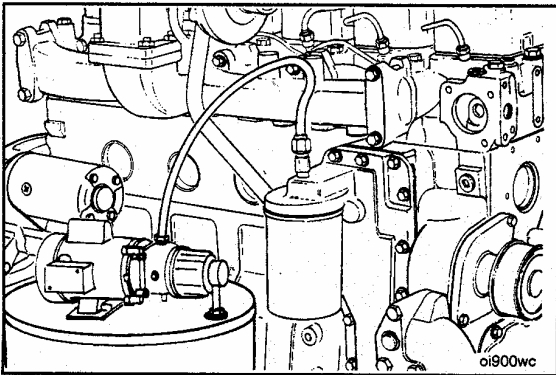
Remove the oil drain plug and allow the mineral oil to drain from the engine.

Install drain plug.

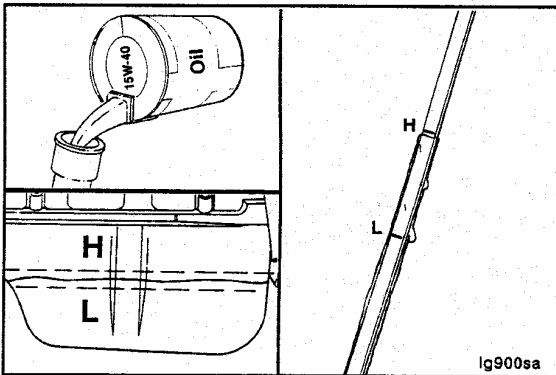




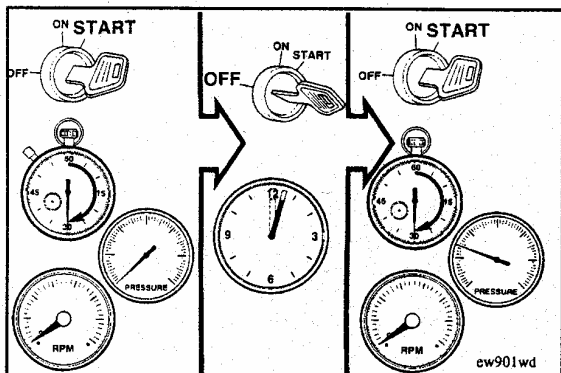
Remove the lubricating oil filter. Install a new filter according to the manufacturer's specifications.



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.

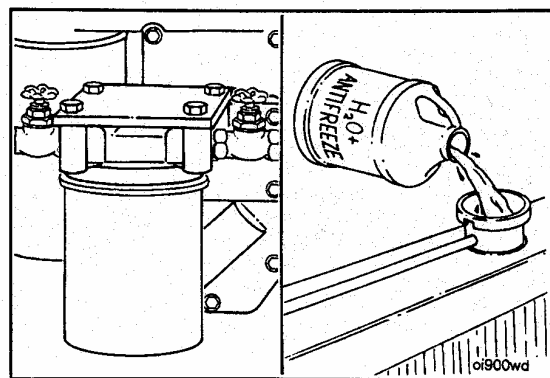


CAUTION

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.

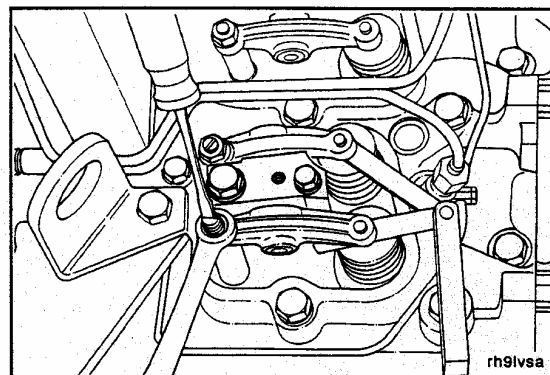
Use the starter to crank the engine for a maximum of 30 seconds, with two minute intervals, until oil pressure registers on the lubricating oil pressure gauge.

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.



NOTES

[illegible]

Section 16 – Mounting Adaptations – Group 16

Section Contents

	Page
Flywheel and Ring Gear Inspection	16-3
Flywheel Housing Assembly.....	16-4
Wet Clutch Application	16-5
Flywheel Housing Inspection	16-4
Front Support - Cleaning and Inspection.....	16-6
General Information	16-2
Flywheel and Ring Gear	16-2
Flywheel Housing.....	16-2
Front Support	16-2
Ring Gear Replacement	16-3

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

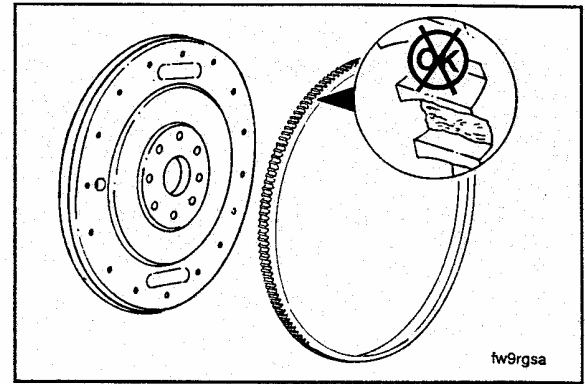
Several different types of front engine mounts are available, depending upon specific applications.

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 damaged, the ring gear must be replaced.



fw9rgsa

Ring Gear Replacement (16-02)

Brass Drift Pin

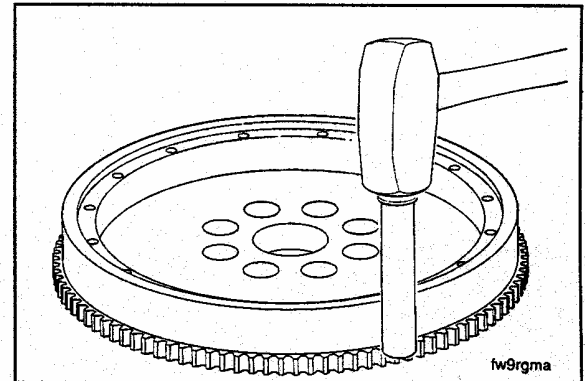
WARNING

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.

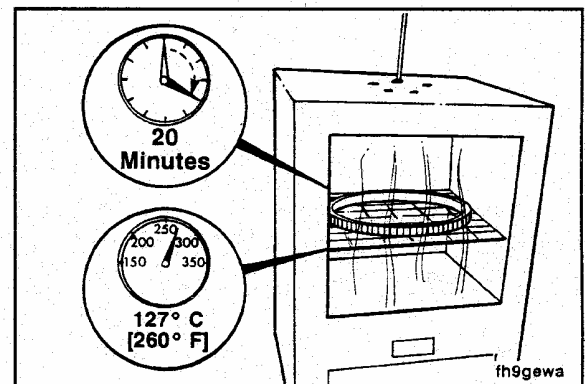
NOTE

The ring gear on flexplate applications cannot be replaced as a separate unit. The entire flexplate assembly must be replaced.



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Heat the new ring gear for 20 minutes in an oven preheated to 127°C [260°F].

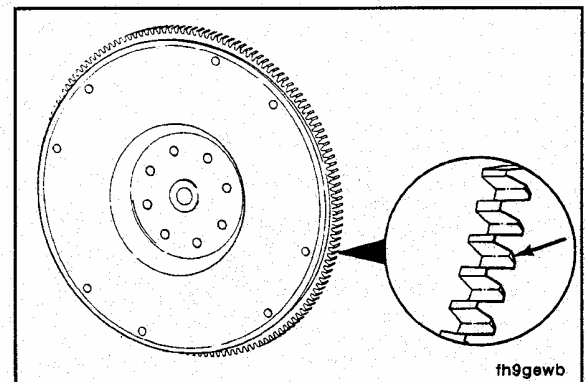


fh9gewa

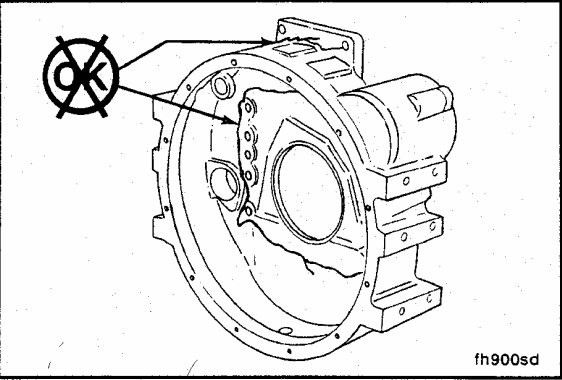
WARNING

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.

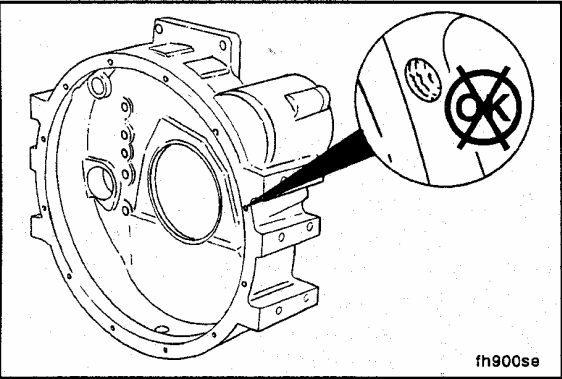


fh9gewb

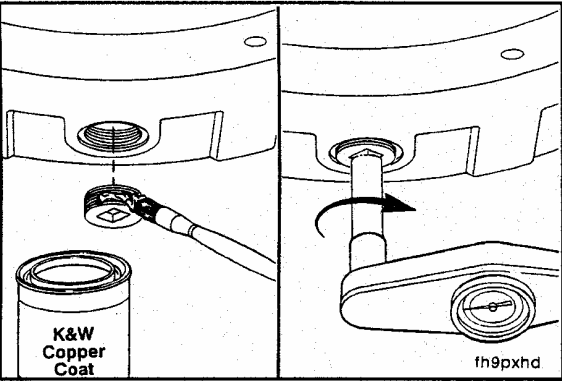


Flywheel Housing Inspection (16-03)

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.

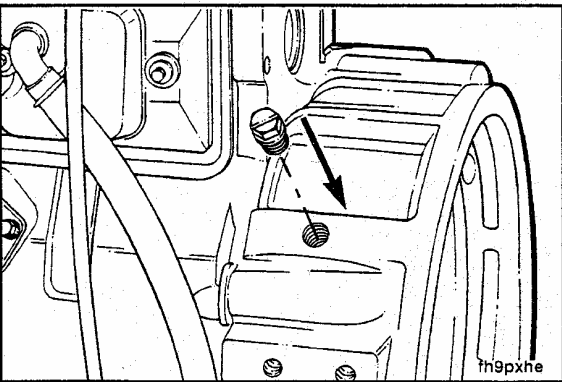


Flywheel Housing Assembly (16-04)

3/8 Inch Square Drive

Coat the drain plug with K&W Copper Coat™ and install.

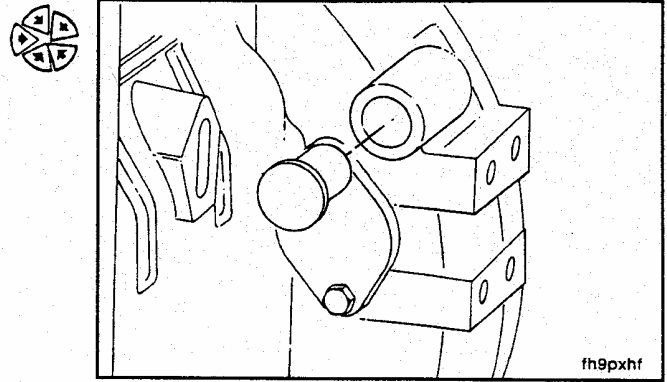
Torque Value		
Cast Iron	55 N•m	[42 ft-lb]
Aluminum	35 N•m	[26 ft-lb]



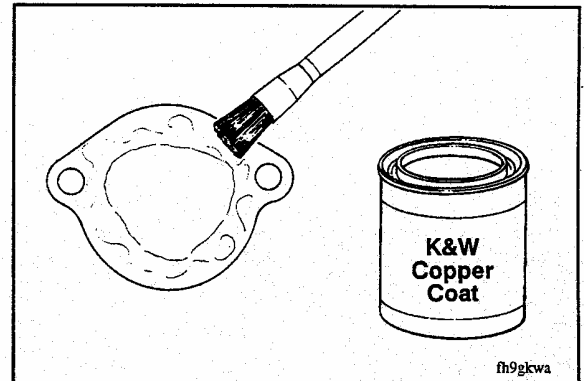
Screwdriver

Install the plastic plug in the tach probe hole.

Install the expanding plug in the barring tool hole.



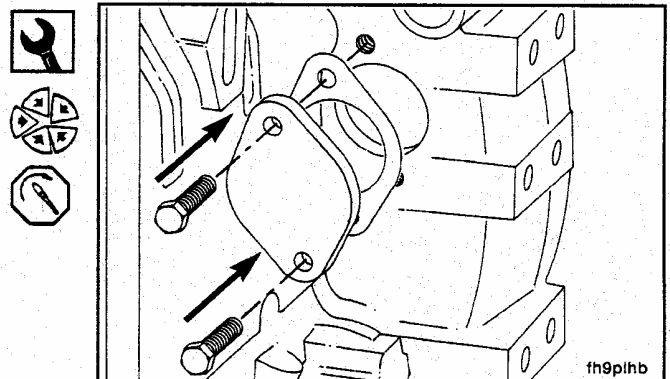
Coat both sides of the inspection plate gasket with K&W Copper Coat™.



13 mm

Install the inspection plate.

Tighten to 24 N•m [18 ft-lbs].



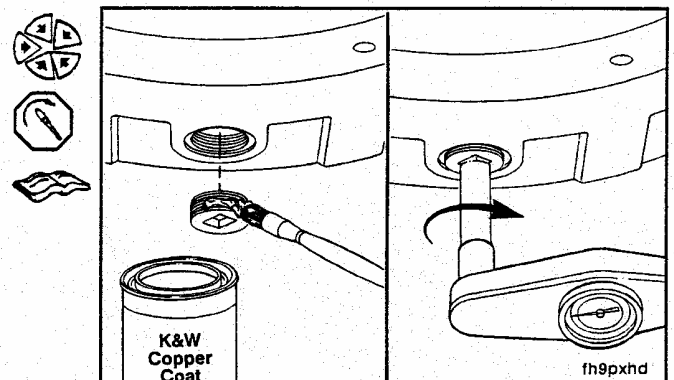
Wet Clutch Application

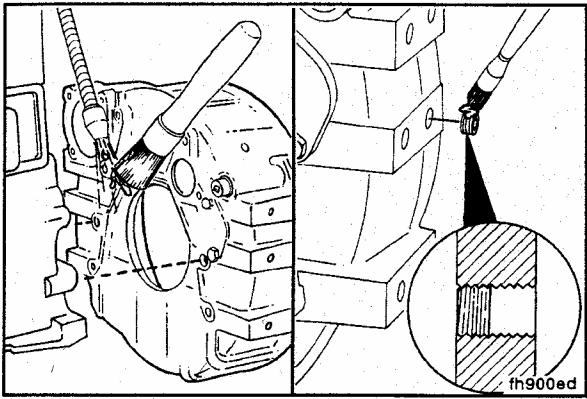
Perform all the steps in the procedure for dry clutch installation in addition to the following:

Coat the flywheel housing drain plug with pipe sealant and install in the hole in the bottom of the flywheel housing.

Tighten the plug.

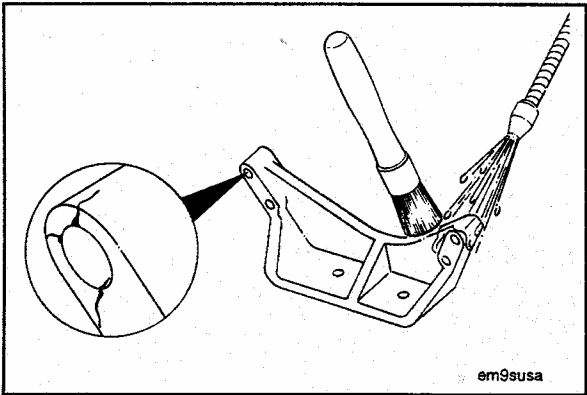
Refer to the pipe plug torque value in Section V – Engine Components Specifications Group 18.





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.

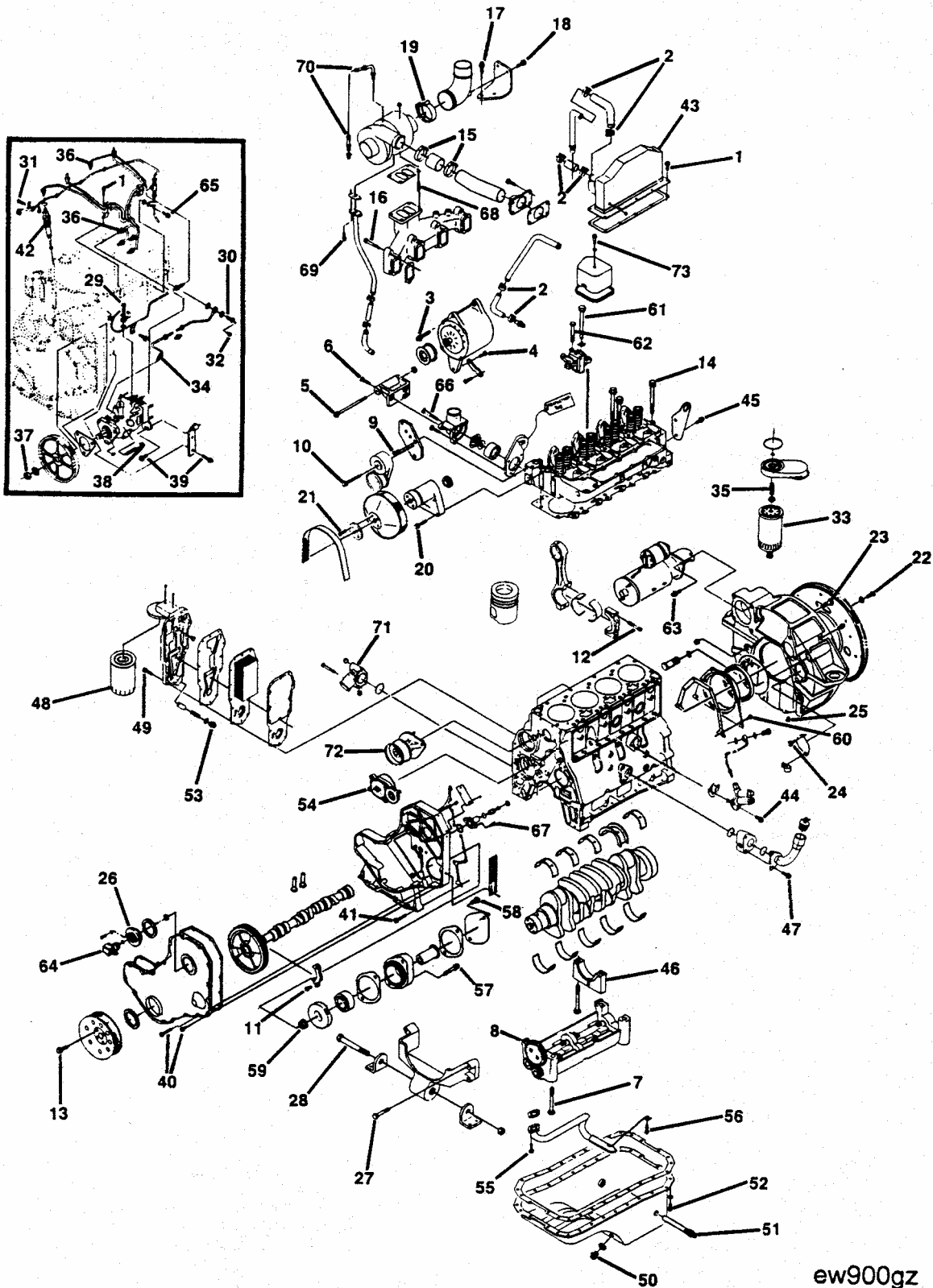
Section V – Engine Component Specifications – Group 18

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	Page
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Component Specifications and Torque Values	V-6
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Combustion Air System	V-31
Compressed Air System Torque Values	V-33
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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.



ew900gz

Engine Component Torque Values

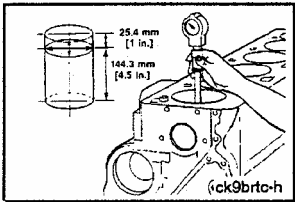
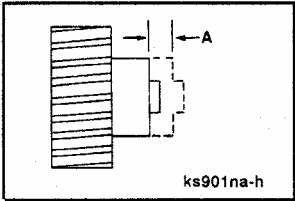
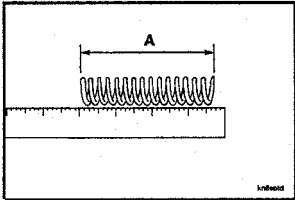
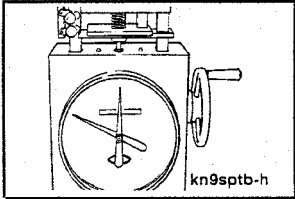
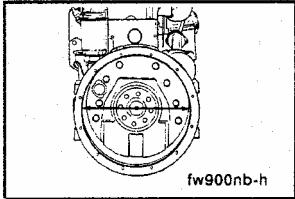
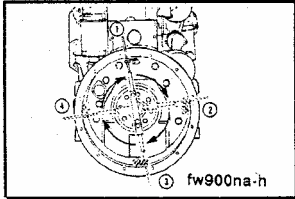
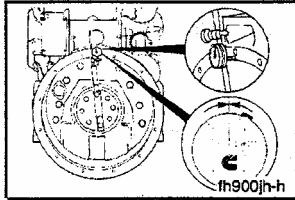
Ref. No.	Socket or Wrench Size MM [Inch]		Torque	
			N•m	[Ft-lb]
1	10	Aftercooler Mounting	24	[18]
2	[5/16]	Aftercooler Water Hose Clamp	5	[4]
3	[15/16]	Alternator Pulley	80	[59]
4	13 or [3/4]	Alternator Link (Delco 15-20-27 SI).....	43	[32]
5	16	Alternator Mounting Bolt 15 SI	43	[32]
5	18	Alternator Mounting Bolt and Nut 20-27 SI	77	[57]
6	13	Alternator Support (Upper)	24	[18]
7	23	Balancer Mounting	50	[36]
		(Alternately Tighten	80	[58]
		in Three Steps)	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	27	[20]
		..... Step 1		
		..... Step 2		
		..... Step 3		
11	13	Cam Thrust Plate	24	[18]
	[3/8]	Coolant Heater	12	[9]
12	12	Connecting Rod Bolt	35	[26]
		(Alternately Tighten	70	[51]
		in Three Steps)	100	[73]
13	15	Crankshaft Damper & Pulley	125	[92]
14	18	Cylinder Head Mounting	90	[66]
		..... Step 1 (All)	90	[66]
		..... Step 2 (All) Recheck to	120	[90]
		..... 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 Bracket 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	43.4	[32]
22	19	Flywheel	137	[101]
23	15	Flywheel Housing	77	[57]
24	13	Flywheel Housing Access Cover	24	[18]
25	[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]

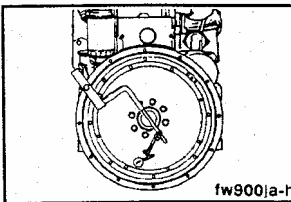
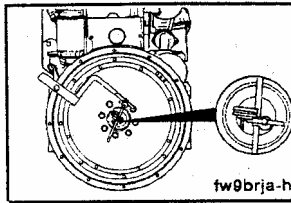
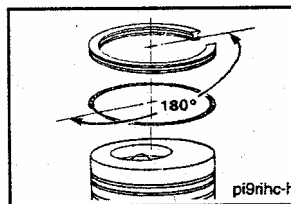
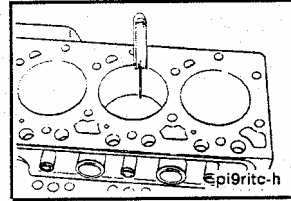
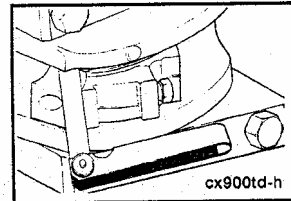
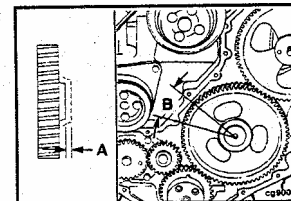
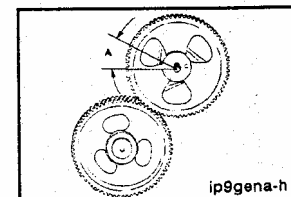
Engine Component Torque Values

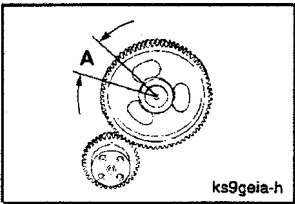
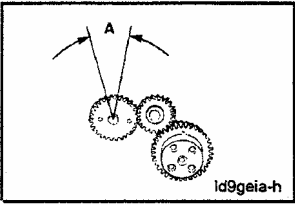
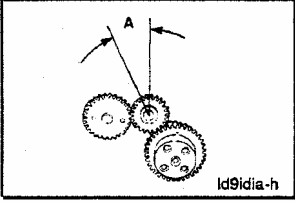
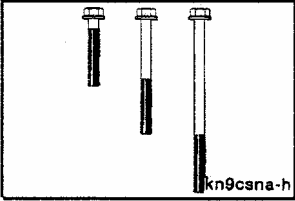
Ref. No.	Socket or Wrench Size MM [Inch]		Torque N•m	[Ft-lb]
37	22	Fuel Pump Drive Gear (With Pump Unlocked)	65	[48]
			123	[92]
		Bosch (P3000, P7100).....	165	[122]
	10	Fuel Pump Lock (Bosch).....	30	[22]
		Fuel Pump UnLock (Bosch).....	13	[10]
		Fuel Pump Mtg. Nut (Bosch In-Line).....	43	[32]
		Fuel 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.....	60	[44]
		..... Step 1		
		..... 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]

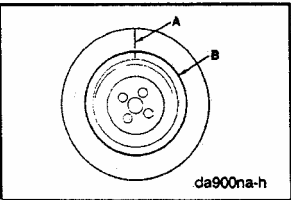
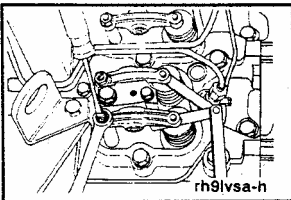
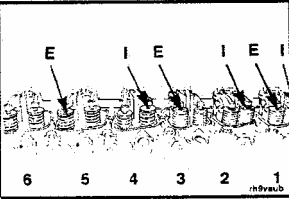
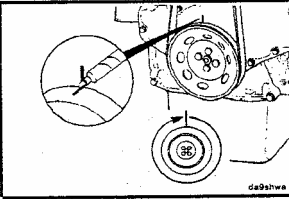
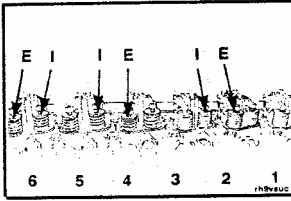
Engine Component Torque Values

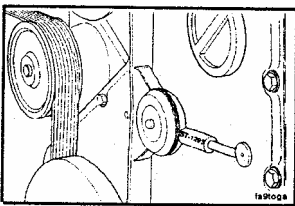
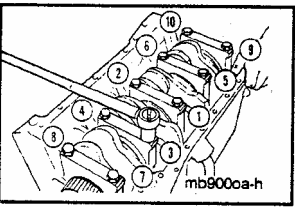
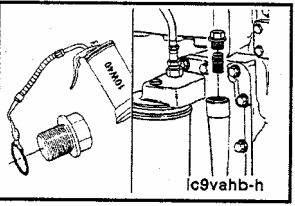
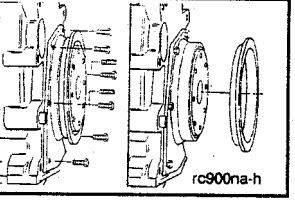
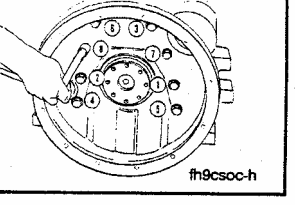
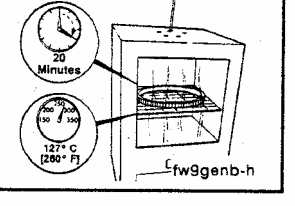
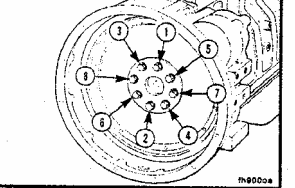
Ref. No.	Socket or Wrench Size MM [Inch]		Torque	
			N•m	[Ft-lb]
69	13	Turbocharger Oil Drain Tube.....	24	[18]
70	[5/8]	Turbocharger Oil Supply (Both Ends)	35	[26]
	13	Turbocharger Turbine Housing	20	[15]
		Water Hose Clamps	4-5	[4]
71	13	Water Inlet Connection.....	43	[32]
	[3/8]	Water Inlet Plugs	24	[18]
72	13	Water Pump Mounting.....	24	[18]
73	15	Valve Cover	24	[18]
	--	Valve Cover Oil Fill.....	Hand Tighten	

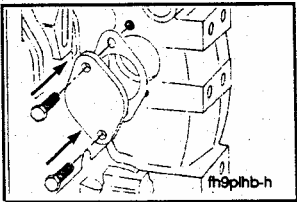
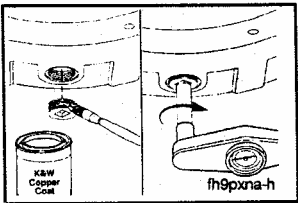
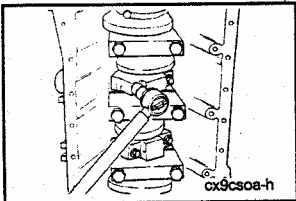
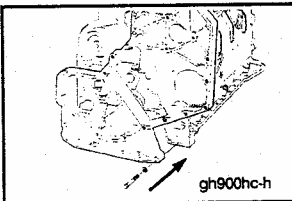
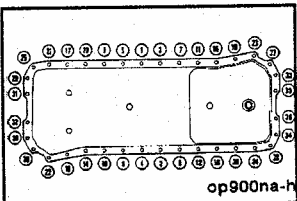
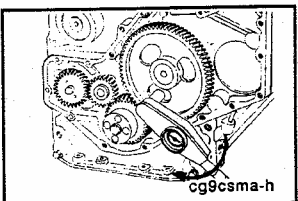
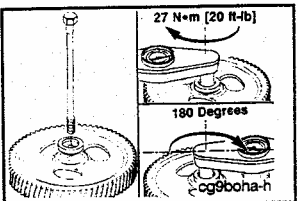
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Component Specifications and Torque Values Engine Assembly - Specifications			
	Cylinder Bores		102.000 mm	MIN 4.0157 in
	Cylinder Bore I.D.		102.116 mm	MAX 4.0203 in
	Cylinder Bore Out of Round		0.035 mm	MAX 0.0014 in
	Cylinder Bore Taper		0.076 mm	MAX 0.003 in
	Crankshaft End Clearance	A	0.102 mm	MIN 0.004 in
			0.432 mm	MAX 0.017 in
	Oil Pressure Regulating Spring	A	60.6 mm	MIN 2.385 in
			66.0 mm	MIN 2.598 in
	<ul style="list-style-type: none"> Spring Free Length 1991 Engines 1994 Engines 		(A) 109.0 N	MIN 24.5 lb
			(B) 141.2 N	MIN 31.7 lb
	Flywheel Housing Bore I.D.	SAE No.		
		2	447.8 mm	MAX 17.63 in
		3	409.7 mm	MAX 16.13 in
	Flywheel Housing Bore Alignment TIR		0.20 mm	MAX 0.008 in
	Flywheel Housing Face Alignment TIR	SAE No.		
		2	0.20 mm	MAX 0.008 in
		3	0.20 mm	MAX 0.008 in

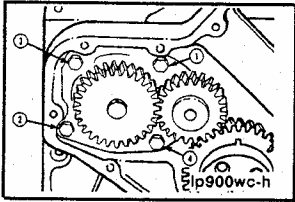
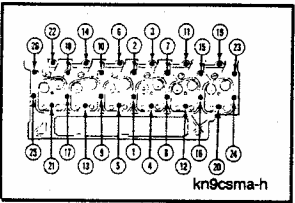
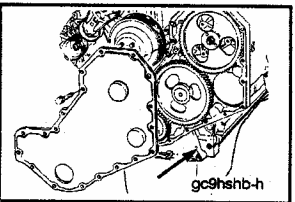
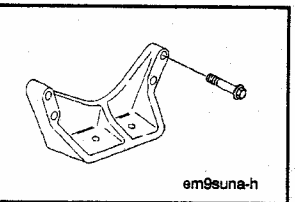
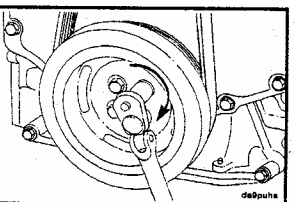
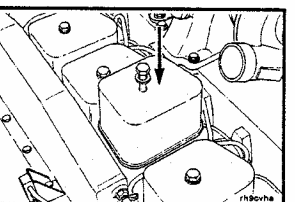
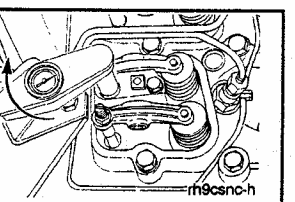
Component or Assembly (Procedure)	Ref. No./Steps	Metric		U.S.			
Flywheel Face Runout TIR		Radius			 fw900ja-h		
		mm	in				
		254	10	0.254		MAX	0.010
		205	8	0.203		MAX	0.008
		181	7	0.152		MAX	0.006
		157	6	0.152		MAX	0.006
		133	5	0.152		MAX	0.006
Flywheel Bore Runout TIR			0.127	MAX	0.0050	 fw9brja-h	
Oil Control Ring End Gap						 pi9rihc-h	
The two-piece oil ring must be installed with the expander gap 180 degrees from the oil ring gap.							
Ring Gap (Feeler Gauge)						 pi9ritc-h	
• 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						 cx900td-h	
		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						 cg900no	
		0.08 mm	MIN	0.003 in			
		0.47 mm	MAX	0.0185 in			
Injection Pump Drive Gear Backlash						 ip9gena-h	
	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.
 ks9geia-h	Camshaft Gear Backlash	A	0.076 mm 0.330 mm	MIN MAX	0.003 in 0.013 in
 ld9geia-h	Lubricating Oil Pump Gear Backlash	A	0.076 mm 0.330 mm	MIN MAX	0.003 in 0.013 in
 ld9idia-h	Lubricating Oil Pump Idler Gear Backlash	A	0.076 mm 0.330 mm	MIN MAX	0.003 in 0.013 in
 kn9cena-h	Cylinder Head Capscrew Free Length (Maximum) Short Medium Long		71.5 mm 122.1 mm 182.9 mm	MAX MAX MAX	2.815 in 4.807 in 7.201 in

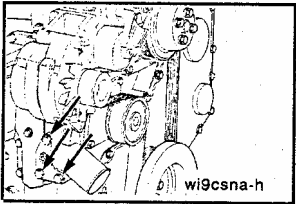
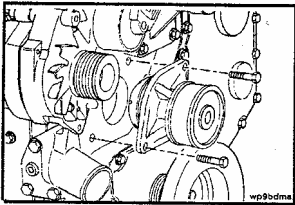
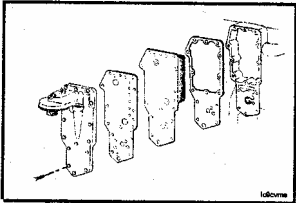
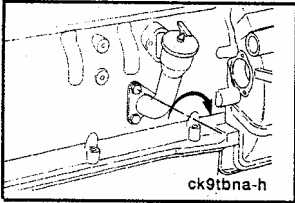
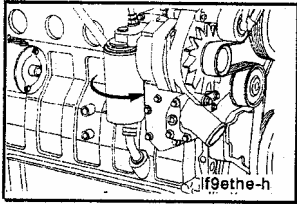
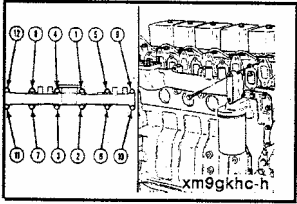
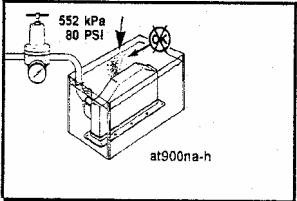
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Vibration Damper Index line out of alignment Missing rubber member chunks	A	1.588 mm	MAX	0.0625 in
	B	3.175 mm	MAX	0.1250 in
				
Valve Stem to Rocker Lever Clearances Intake Exhaust Locknut		0.25 mm		0.010 in
		0.51 mm		0.020 in
		34 Nm		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 - 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 - Six Cylinder				
				
				
				

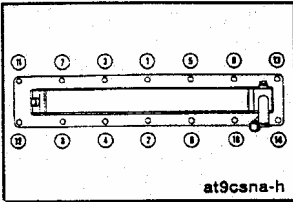
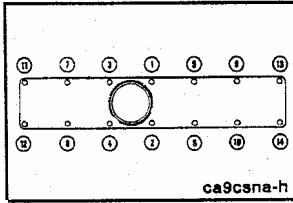
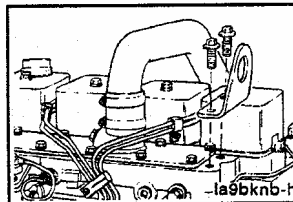
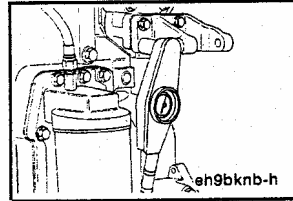
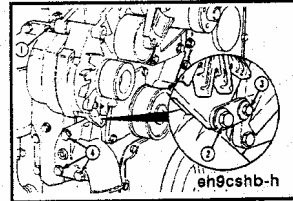
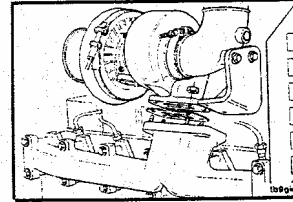
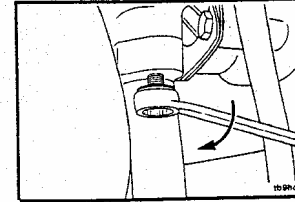
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
	Belt Tension - Fan Drive			
Belt Tension		267 N 578 N	MIN MAX 60 lbf 130 lbf	
	Engine Assembly - Capscrew Torque Values			
Main Bearing Capscrew Torque Value and Sequence	1 2 3	60 N•m 119 N•m 176 N•m	44 ft-lb 88 ft-lb 129 ft-lb	
	Oil Pressure Regulator Retainer Plug	80 N•m	60 ft-lb	
	Rear Seal Cover Mounting	9 N•m	84 ft-lb	
	Flywheel Housing Capscrews	77 N•m	57 ft-lb	
NOTE Tighten the capscrews in the sequence shown.				
	Ring Gear Replacement	Heat the new ring gear for 20 minutes in an oven preheated to 127°C [260°F].		
	Flywheel Mounting Capscrews	137 N•m	101 ft-lb	
Tighten in the sequence shown				

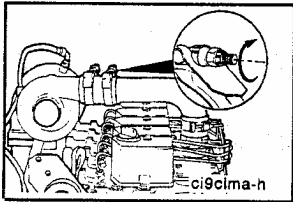
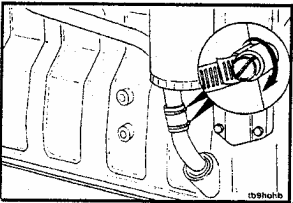
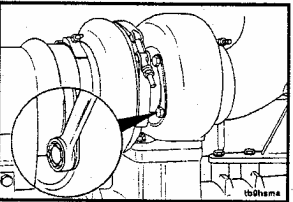
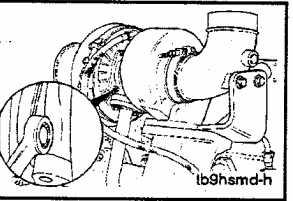
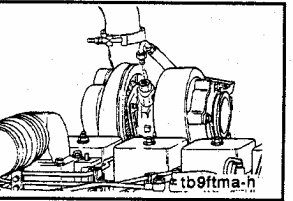
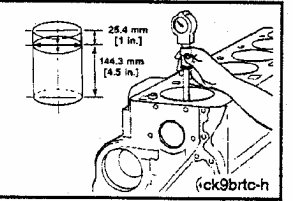
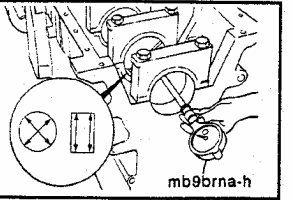
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Flywheel Housing Access Cover		24 N•m	18 ft-lb	
Flywheel Housing Plug		36 N•m	27 ft-lb	
Connecting Rod Bolt	1 2 3	35 N•m 70 N•m 100 N•m	26 ft-lb 52 ft-lb 74 ft-lb	
Gear Housing Mounting Capscrews		24 N•m	18 ft-lb	
Lubricating Oil Pan	NOTE 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	

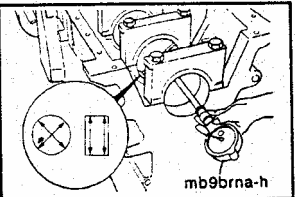
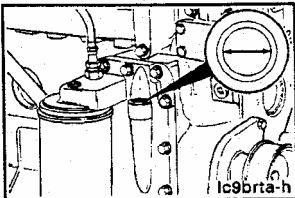
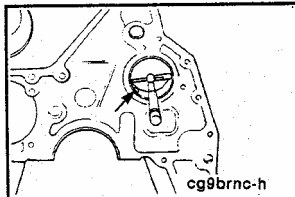
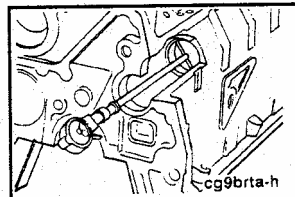
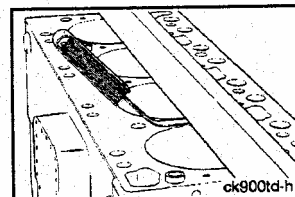
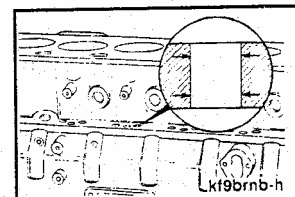
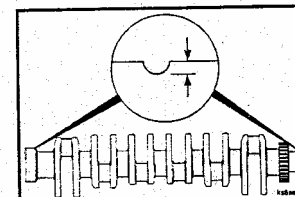
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Oil Pump Mounting Capscrews Tighten in the sequence shown		24 N•m	18 ft-lb
	Cylinder Head Mounting Capscrew (Tighten Capscrews in the Sequence Shown) Step 1 Step 2 - Recheck to Step 3 - (Long capscrews only) Step 4 - (Long capscrews only) - Recheck to Step 5 - Rotate 90 degrees		90 N•m 90 N•m 120 N•m 120 N•m	66 ft-lb 66 ft-lb 90 ft-lb 90 ft-lb
	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 Capscrews (8 mm)		24 N•m	18 ft-lb

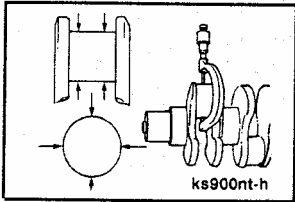
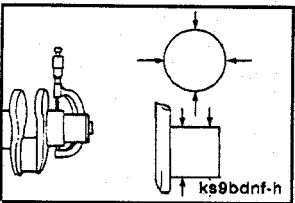
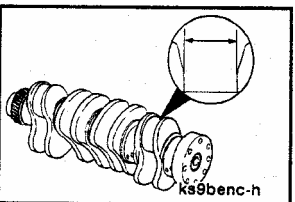
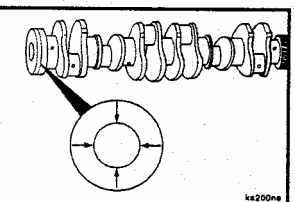
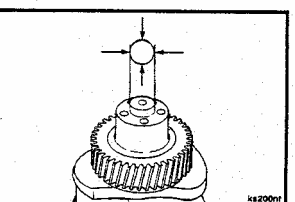
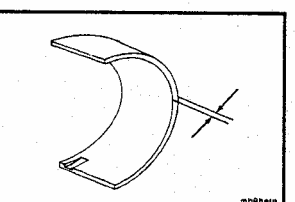
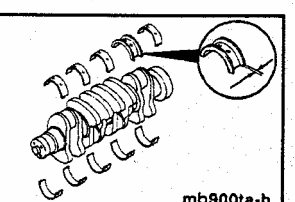
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Starting Motor Mounting Capscrews		43 N•m	32 ft-lb	 st900mc-h
Injection Pump Mounting Nuts				
Bosch (In-Line)		43 N•m	32 ft-lb	
Fuel Transfer Pump Mounting Capscrews		24 N•m	18 ft-lb	
Injection Pump Drive Gear Nut				 fp9nuhe-h
Bosch (P3000, P7100)		165 N•m	122 ft-lb	
Fan Hub Mounting Capscrews		24 N•m	18 ft-lb	 fa900mc-h
Fan Hub Pulley Mounting Capscrews	10 mm	•43 N•m	32 ft-lb	 fa9umb-h
		24 N•m	18 ft-lb	
Thermostat Housing Mounting Capscrews				 th9csoa-h

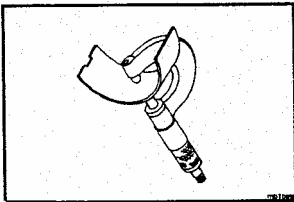
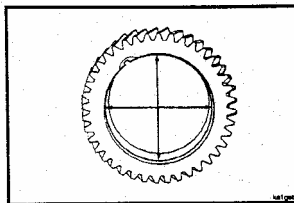
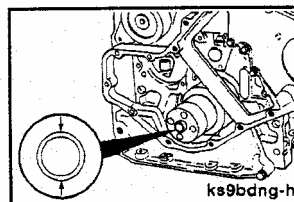
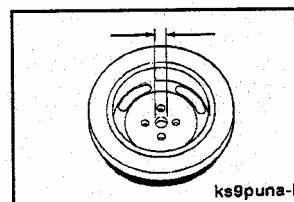
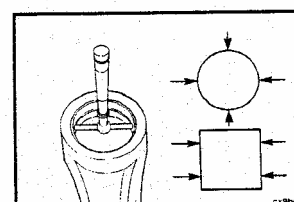
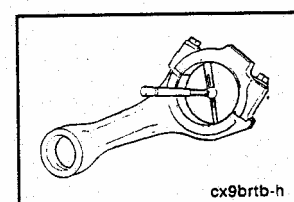
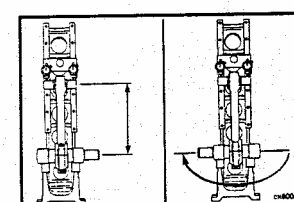
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Coolant Inlet Connection		43 N•m	32 ft-lb
	Water Pump Mounting Capscrews		24 N•m	18 ft-lb
	Oil Cooler Mounting Capscrews		24 N•m	18 ft-lb
	Oil Fill Tube Capscrews		43 N•m	32 ft-lb
	Oil Filter		3/4 Turn after contact	
	Exhaust Manifold Capscrews 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: <ul style="list-style-type: none"> • 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]. 			

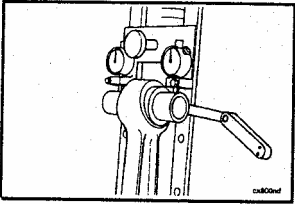
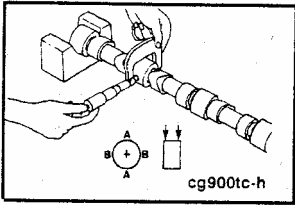
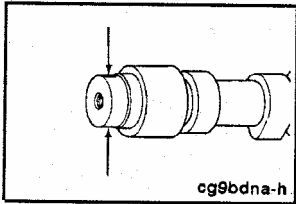
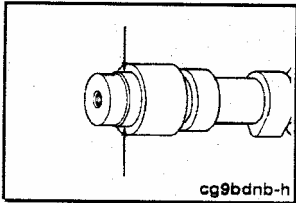
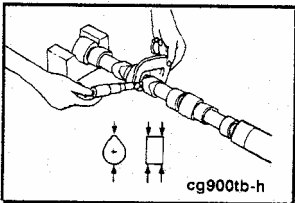
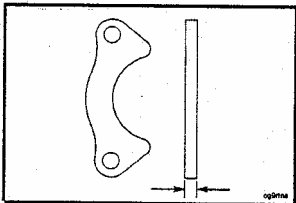
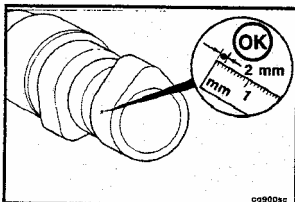
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Aftercooler Capscrews NOTE Tighten the capscrews in the sequence shown.		24 N•m	18 ft-lb	
Air Intake Manifold Capscrews NOTE Tighten the capscrews in the sequence shown.		24 N•m	18 ft-lb	
Lifting Bracket (Rear)		77 N•m	57 ft-lb	
Alternator 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	

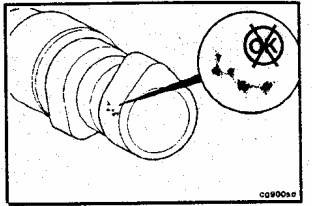
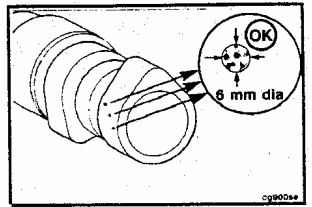
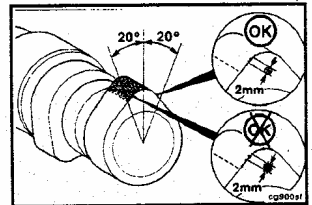
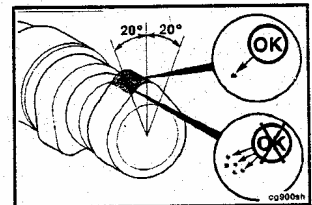
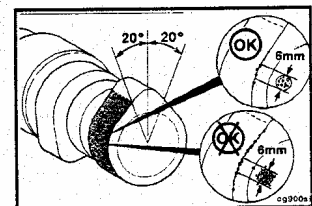
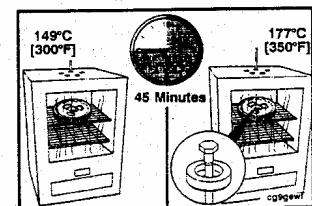
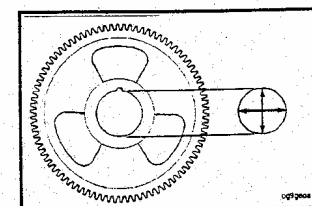
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Turbocharger Air Crossover Hose Clamps		5 N•m	44 ft-lb
	Turbocharger Oil Drain Line Hose Clamps		6 N•m	53 ft-lb
	Turbocharger Turbine Housing Capscrews		20 N•m	15 ft-lb
	Turbocharger Compressor Housing <ul style="list-style-type: none"> Diffuser Plate Capscrews V Band Clamp (Silver Plated Nut) 		8.5 N•m 8.5 N•m	75 ft-lb 75 ft-lb
	Turbocharger Oil Supply Line Connection		35 N•m	26 ft-lb
	Cylinder Block- Rebuild Specifications Cylinder Bore Diameter Out-of-Roundness Taper		102.000 mm 102.116 mm 0.035 mm 0.076 mm	MIN MAX MAX MAX 4.0157 in 4.0203 in 0.0014 in 0.003 in
	Main Bearing Diameter (Bearings Installed) With Capscrews Tightened to 176 N•m [130 ft-lb]		83.106 mm	MAX 3.27720 in

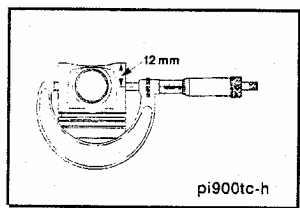
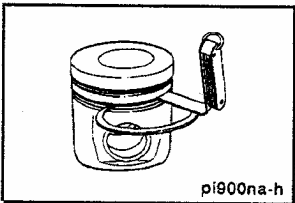
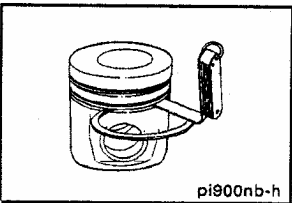
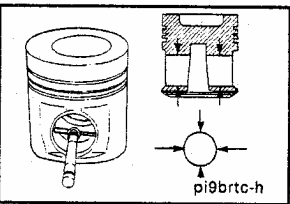
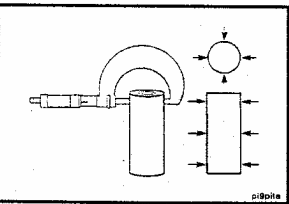
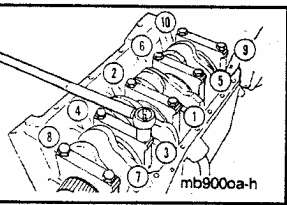
Component or Assembly (Procedure)	Ref. No./Steps	Metric		U.S.	
Main Bearing Bore I.D. (Without Bearings) With Capscrews Tightened to 176 N•m [130 ft-lb]		87.982 mm 88.018 mm	MIN MAX	3.4639 in 3.4653 in	 mb9brna-h
Main Oil Pressure Regulator Valve Bore I.D.		18.30 mm 18.35 mm	MIN MAX	0.7205 in 0.7224 in	 lc9brta-h
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	 cg9brnc-h
Camshaft Bore Diameter All Journals Except No. 1		54.089 mm 54.164 mm	MIN MAX	2.1295 in 2.1324 in	 cg9brta-h
Cylinder Block Overall Flatness <ul style="list-style-type: none"> End-to-end Side-to-side 		0.076 mm 0.051 mm	MAX MAX	0.003 in 0.002 in	 ck900td-h
Valve Tappet Bore Diameter		16.000 mm 16.055 mm	MIN MAX	0.630 in 0.632 in	 kf9brnb-h
Crankshaft Front and Rear Oil Seal Wear Groove		0.25 mm	MAX	0.010 in	 kf9brta-h

	Component or Assembly (Procedure)	Ref. No./Steps	Metric		U.S.
	Crankshaft Connecting Rod Journal O.D. Out of roundness Taper Bearing clearance		68.962 mm 69.013 mm 0.050 mm 0.013 mm 0.114 mm	MIN MAX MAX MAX MAX	2.7150 in 2.7170 in 0.0002 in 0.005 in 0.0045 in
	Crankshaft Main Bearing Journal Diameter Out of roundness Taper Bearing clearance		82.962 mm 83.013 mm 0.050 mm 0.013 mm 0.119 mm	MIN MAX MAX MAX MAX	3.2662 in 3.2682 in 0.002 in 0.005 in 0.0047 in
	Crankshaft Thrust Face Width		37.475 mm 37.602 mm	MIN MAX	1.4754 in. 1.4804 in.
	Crankshaft Rear Oil Seal Flange O.D.		129.975 mm 130.025 mm	MIN MAX	5.1171 in. 5.1191 in.
	Crankshaft Damper Pilot O.D.		18.924 mm 19.000 mm	MIN MAX	0.7450 in. 0.7480 in.
	Main Bearing Shell Thickness (Standard)		2.438 mm 2.464 mm	MIN MAX	0.0960 in. 0.0970 in.
	Crankshaft Thrust Bearing Flange Thickness		2.45 mm 2.55 mm	MIN MAX	0.096 in. 0.100 in.

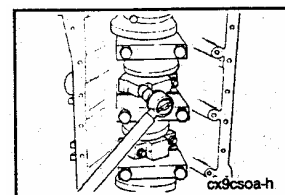
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Connecting Rod Bearing Thickness (Standard)		1.955 mm 1.968 mm	MIN MAX 0.0769 in. 0.0775 in.	
Crankshaft Gear Bore LD.		63.910 mm 63.934 mm	MIN MAX 2.5161 in. 2.5171 in.	
Crankshaft Gear Journal O.D.		63.987 mm 64.006 mm	MIN MAX 2.5192 in. 2.5199 in.	
Crankshaft Pulley Crankshaft Pilot Bore I.D.		19.05 mm 19.15 mm	MIN MAX 0.7500 in. 0.7539 in.	
Connecting Rod Piston Pin Bore I.D. Bushing Removed		42.987 mm 43.013 mm	MIN MAX 1.6924 in. 1.6934 in.	
Bushing Installed (1994 Engines)		40.019 mm 40.042 mm	MIN MAX 1.5756 in. 1.5765 in.	
Connecting Rod Crankshaft Bore LD. (Bearings Installed)		69.051 mm 69.103 mm	MIN MAX 2.7185 in. 2.7205 in.	
(Bearings Removed)		72.987 mm 73.013 mm	MIN MAX 2.8735 in. 2.8745 in.	
Connecting Rod - Length		191.975 mm 192.025 mm	MIN MAX 7.5581 in. 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.
	Connecting Rod - Twist:			
	• (With Bushing)		0.15 mm	MAX 0.006 in.
	Camshaft Bearing Journal Diameter		53.962 mm 54.013 mm	MIN MAX 2.1245 in. 2.1265 in.
	Camshaft Gear Mounting Surface O.D.		41.575 mm 41.593 mm	MIN MAX 1.6368 in. 1.6375 in.
	Camshaft Thrust Bearing Journal O.D.		45.550 mm 45.750 mm	MIN MAX 1.7933 in. 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 Pump	35.50 mm 36.26 mm	MIN MAX 1.398 in. 1.428 in.
	Camshaft Thrust Plate Thickness		9.4 mm 9.6 mm	MIN MAX 0.370 in. 0.378 in.
	Camshaft Pitting Reuse Guidelines		A single pit should not be greater than the area of a 2 mm [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 equivalent 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.
			

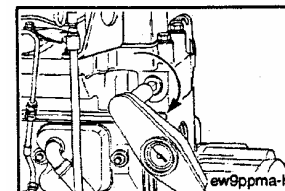
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Piston Skirt O.D. (Worn Limit)		101.823 mm 101.887 mm	MIN MAX 4.0088 in. 4.0113 in.
	Intermediate Ring Side Clearance		0.15 mm	MAX 0.006 in.
	Oil Control Ring Side Clearance		0.13 mm	MAX 0.005 in.
	Piston Pin Bore I.D.		40.006 mm 40.025 mm	MIN MAX 1.5750 in. 1.5758 in.
	Piston Pin O.D.		39.990 mm 40.003 mm	MIN MAX 1.5744 in. 1.5749 in.
	Cylinder Block - Torque Values			
	Main Bearing Capscrew	1		
		2	60 N•m	44 ft-lb
		3	119 N•m	88 ft-lb
			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

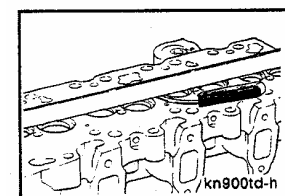
Refer to "Pipe Plug Torque Value Table" at the rear of this section for torque value of various plug sizes.



Cylinder Head - Rebuild Specifications

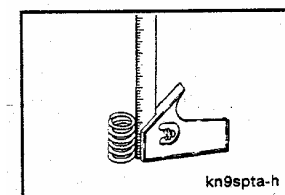
Cylinder Head Flatness

• 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.



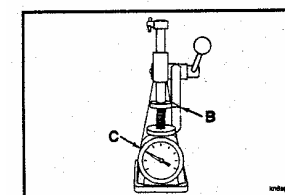
Valve Spring Free Height:

1994	60.00 mm	Nominal	2.362 in.
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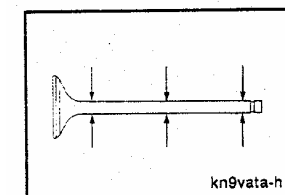


Valve Spring Working Height and Load

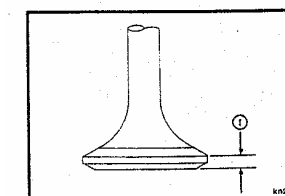
	Working Height (B)	Load For Working Height (C)		
HD Exhaust Brake	48.97 mm	643.2 N	MIN	144.6 lbf
	1.927 in.	691.2 N	MAX	155.4 lbf
Marine With Rotator	47.24 mm	282.7 N	MIN	63.5 lbf
	1.859 in.	323.1 N	MAX	72.6 lbf
1994	49.25 mm	359 N	MIN	80.7 lbf
	1.94 in.	397 N	MAX	89.2 lbf
All Others	49.25 mm	285 N	MIN	64.0 lbf
	1.94 in.	321 N	MAX	72.1 lbf

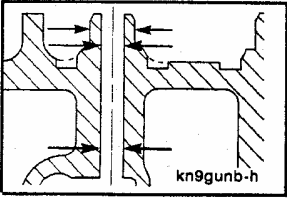
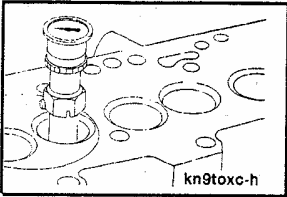
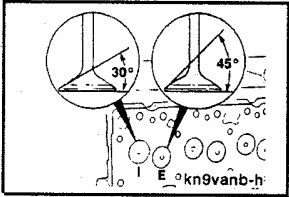
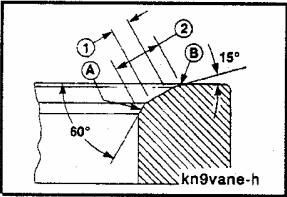
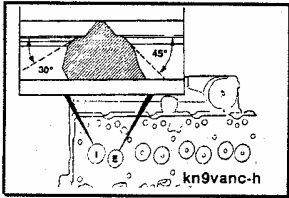
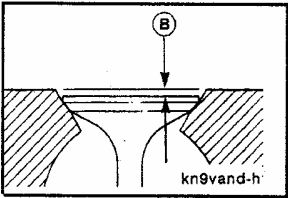
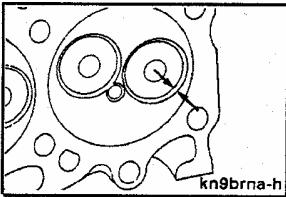


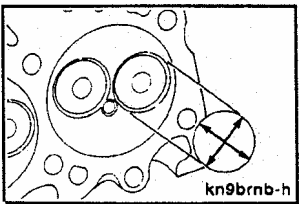
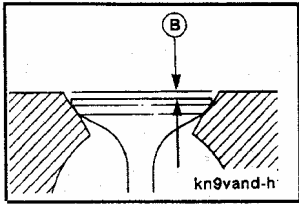
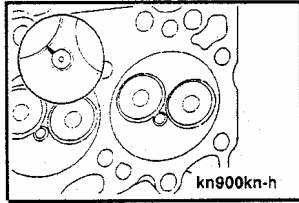
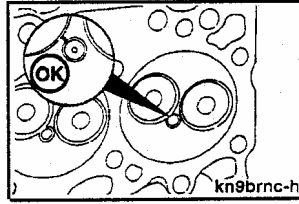
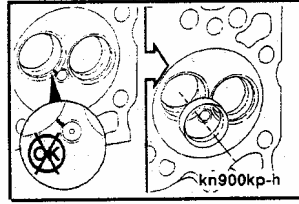
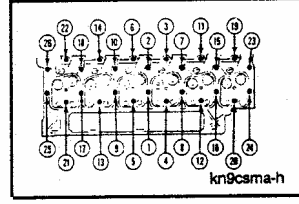
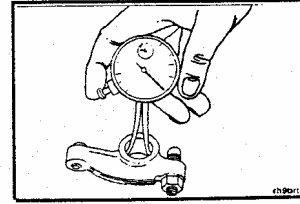
Valve Stem O.D.	7.98 mm	MAX	0.3142 in.
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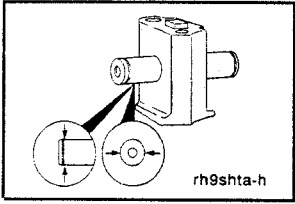
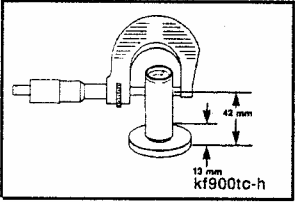
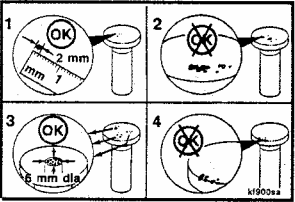
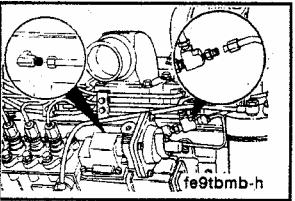
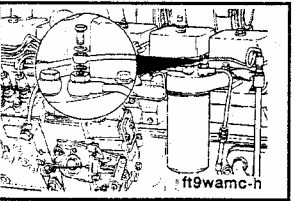
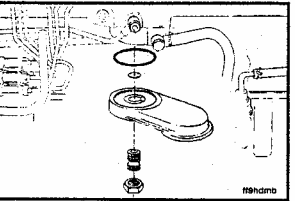


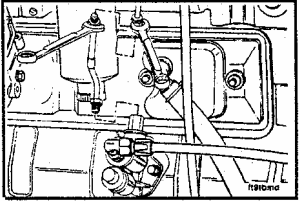
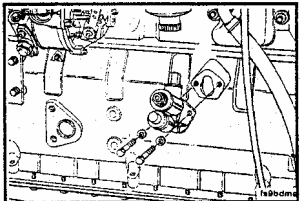
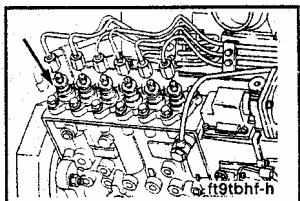
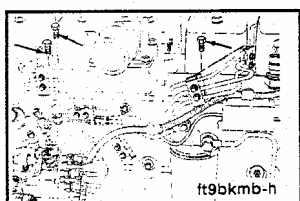
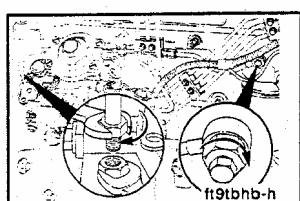
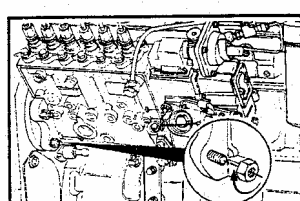
Valve Head Thickness at O.D.	T	0.79 mm	MIN	0.031 in.
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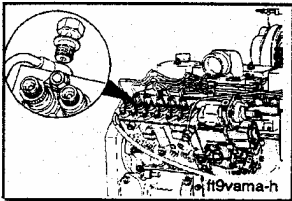
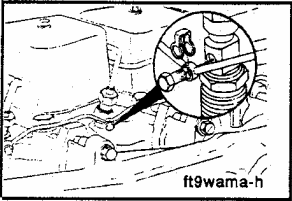
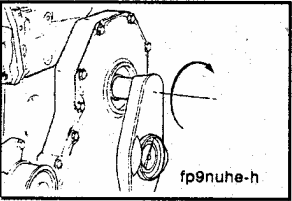
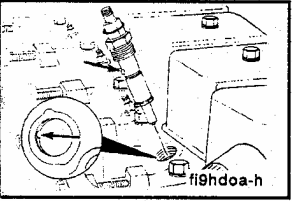
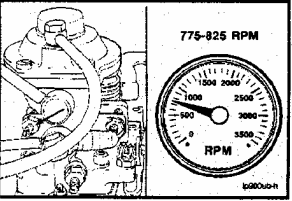
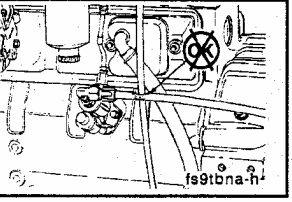
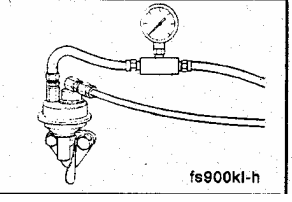


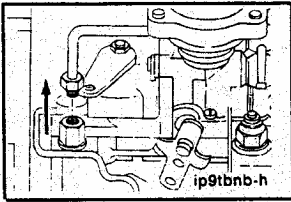
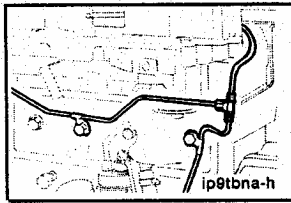
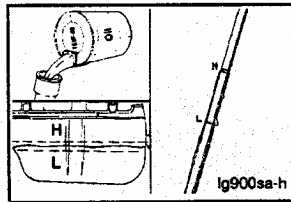
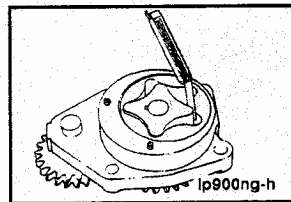
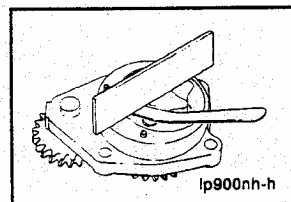
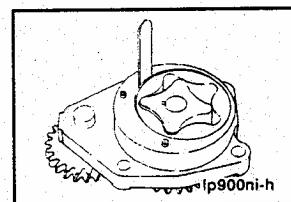
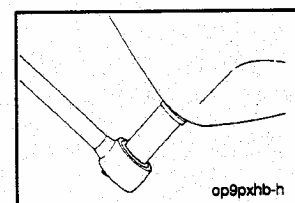
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Valve Guide Bore Diameter		8.019 mm 8.090 mm	MIN MAX 0.3157 in. 0.3185 in.
	Valve Seat-to-Valve Guide Runout 360 Degrees		0.10 mm	MAX 0.004 in.
	Valve Face Grinding Angle Intake: Exhaust:		30 degrees 45 degrees	
	Valve Seat Width Limit Grind 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.

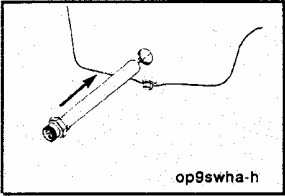
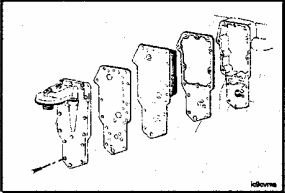
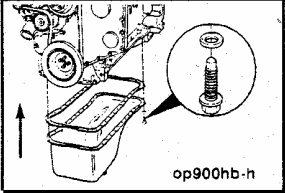
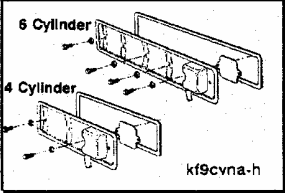
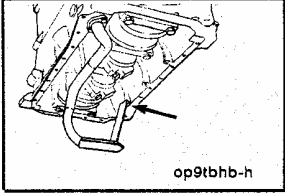
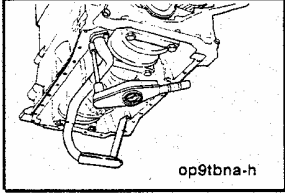
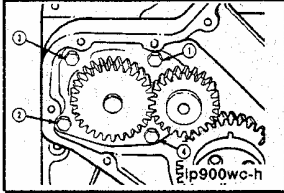
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Valve Insert Bore I.D. (Standard Insert) Note: Refer to Cylinder Head – Oversize Valve Seat Installation for oversize valve insert dimensions.		46.987 mm 47.013 mm	MIN MAX	1.8499 in. 1.8509 in.
				
Valve Seat Grinding Depth Seat grinding depth is the difference in dimension 'B' before and after grinding.	B	0.254 mm	MAX	0.010 in.
				
Cylinder Head Cracks - Reuse Guidelines These guidelines apply only to cracks extending from the injector core to the intake valve seams. 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 Step 2 - Recheck to Step 3 (Long Capscrews Only) Step 4 (Long Capscrews Only) - Recheck to Step 5 - Rotate 90 degrees - All		90 N•m 90 N•m 120 N•m 120 N•m		66 ft-lb 66 ft-lb 90 ft-lb 90 ft-lb
Rocker Levers and Pedestals Rocker Lever Bore Diameter		19.000 19.051	MIN MAX	0.7480 in. 0.7500 in.
				

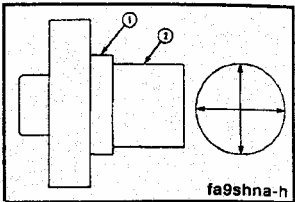
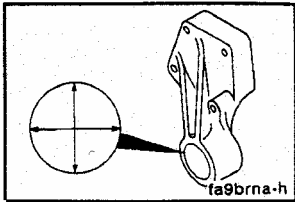
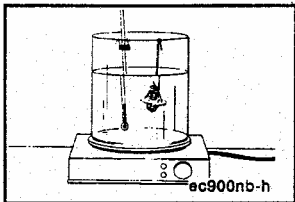
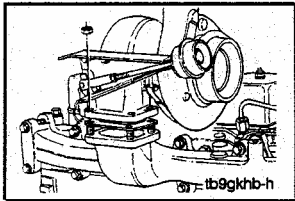
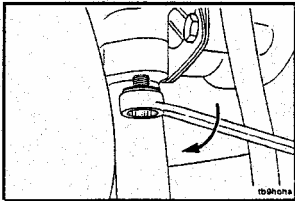
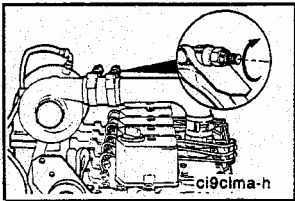
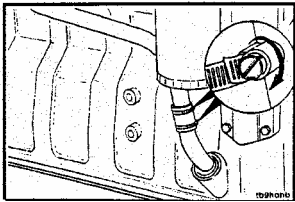
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
 rh9shta-h	Pedestal Shaft Diameter	18.938 mm 18.975 mm	MIN MAX 0.7456 in. 0.7470 in.
 kf900tc-h	Tappet and Push Rods Valve Tappet Stem Diameter	15.936 mm 15.977 mm	MIN MAX 0.627 in. 0.629 in.
 kf900sa	<p>Pit marks on the tappet face are acceptable.</p> <p>The following criteria defines the size of the pits allowed.</p> <ol style="list-style-type: none">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.		
 fe9tbmb-h	Fuel System Air Fuel Control (AFC) Banjo Fitting (In-Line Pump) Pipe Adapter (in cylinder head) Tube Fittings	24 N•m 9 N•m	18 ft-lb 7 ft-lb
 ft9wamc-h	Fuel Filter Banjo Fittings Supply Line Fittings Return Line Fitting Vent Screw	24 N•m 13 N•m 9 N•m	18 ft-lb 10 ft-lb 7 ft-lb
 ft9hdm0	Fuel Filter Head Adapter	32 N•m	24 ft-lb

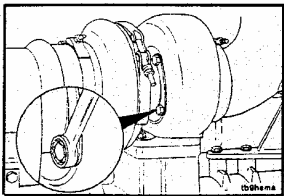
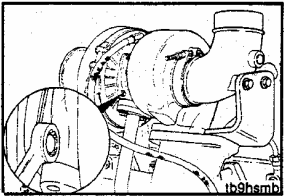
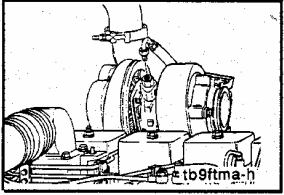
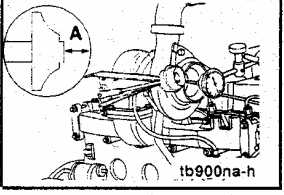
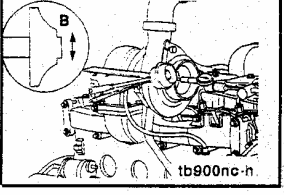
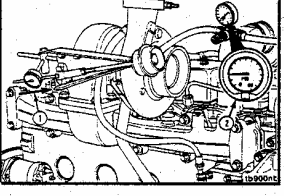
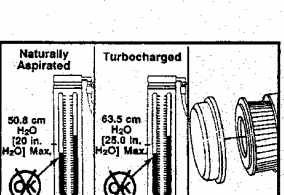

Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Fuel Supply Line (Fuel Transfer Pump Outlet)		24 N•m	18 ft-lb	
Fuel Transfer Pump Mounting Capscrews		24 N•m	18 ft-lb	
High Pressure Fuel Line Fittings		24 N•m	18 ft-lb	
High Pressure Fuel Line Support Clamp Bracket		6 N•m 24 N•m	53 in.-lb 18 ft-lb	
Injection Pump Supply Line Inlet		32 N•m	24 ft-lb	
Injection Pump Mounting Nuts				
Bosch (In-Line)		43 N•m	32 ft-lb	

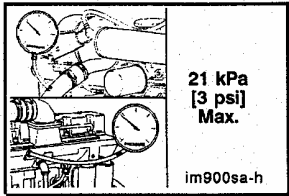
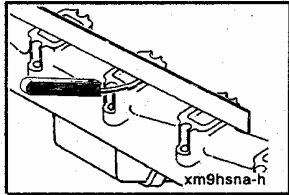
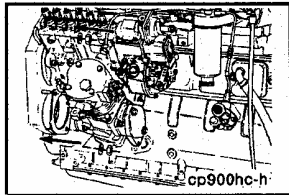
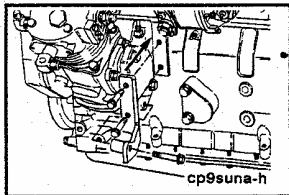
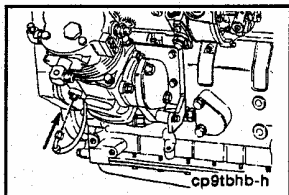
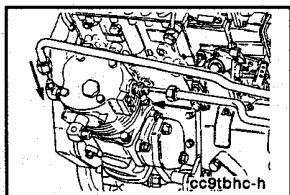
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Injection Pump Fuel Return Banjo Fitting		32 N•m	24 ft-lb
	Injector Drain Manifold			
	Injector Banjo		9 N•m	80 ft-lb
	Filter Head Banjo		13 N•m	10 ft-lb
	Bracket		24 N•m	18 ft-lb
	Injection Pump Drive Gear Nut			
	Bosch (P3000, P7100)		165 N•m	122 ft-lb
	Injector		60 N•m	44 ft-lb
	Engine Low Idle Speed (Typical) (Refer to Engine Data Plate)		700 RPM 800 RPM	MIN 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

Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Fuel Injection Pump Inlet Pressure at Rated Speed				
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				
Oil Pan Capacity				
	6 Cylinder	12.4 liters 14.2 liters	Low High	13 qts. 15 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
				

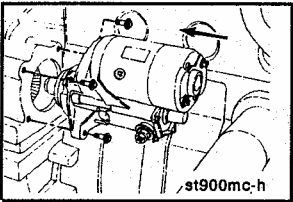
	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
 <p>op8swha-h</p>	Oil Pan Heater Plug		80 N•m	60 ft-lb
 <p>id9vme</p>	Oil Cooler Mounting Capscrews		24 N•m	18 ft-lb
 <p>op900hb-h</p>	Oil Pan Mounting Capscrews		24 N•m	18 ft-lb
 <p>6 Cylinder 4 Cylinder kf9cvna-h</p>	Tappet Cover Mounting Capscrews		24 N•m	18 ft-lb
 <p>op9tbhb-h</p>	Oil Pump Suction Tube Brace Capscrews		24 N•m	18 ft-lb
 <p>op9tbna-h</p>	Oil Pump Suction Tube Mounting Capscrews		24 N•m	18 ft-lb
 <p>mp900wc-h</p>	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 42.25 mm	MIN MAX	1.644 in. 1.663 in.
	2	35.004 mm 35.024 mm	MIN MAX	1.3781 in. 1.3789 in.
				 fa9shna-h
Hub Bearing Bore I.D.		63.938 mm 63.956 mm	MIN MAX	2.5172 in. 2.5179 in.
				 fa9brna-h
Thermostat, Coolant Operating Temperature				
• Initial Opening Temperature		80°C 83°C	MIN MAX	176°F 182°F
• Fully Open Temperature		95°C	MAX	203°F
• Maximum Opening Distance		6.6 mm	MAX	0.260 in.
				 ec900nb-h
Combustion Air System				
Turbocharger Mounting Nuts		43 N•m		32 ft-lb
				 tb9gknb-h
Turbocharger Oil Drain Tube Mounting Capscrew		24 N•m		18 ft-lb
				 tb9shna-h
Turbocharger Air Crossover Hose Clamps		5 N•m		44 in.-lb
				 ci9clma-h
Turbocharger Oil Drain Line Hose Clamps		6 N•m		53 in.-lb
				 tb9shna-h

	Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.
	Turbocharger Turbine Housing Capscrews		20 N•m	15 ft-lb
	Turbocharger Compressor Housing Capscrews			
	<ul style="list-style-type: none"> Diffuser Plate Capscrews V Band Clamp (Silver Plated Nut) 		8.5 N•m 8.5 N•m	75 in.-lb 75 in.-lb
	Turbocharger Oil Supply Line Connection		35 N•m	26 ft-lb
	Air Intake System			
	Turbocharger Axial Clearance		*0.10 mm 0.16 mm	MIN MAX
			**0.03 mm 0.08 mm	MIN MAX
				0.004 in. 0.006 in.
				0.001 in. 0.003 in.
				* For turbochargers with a serial number before 840638. ** For turbochargers with a serial number after and including 840638.
	Turbocharger Radial Clearance		0.30 mm 0.46 mm	MIN MAX
				0.012 in. 0.018 in.
	Wastegate Rod Travel at the Following Wastegate Applied Pressure		0.33 mm 1.3 mm	MIN MAX
				0.013 in. 0.050 in.
	Intake Air Restriction (Rated Speed and Load)			
	<ul style="list-style-type: none"> Turbocharged Engine 		635 mm H ₂ O	MAX 25 in. H ₂ O

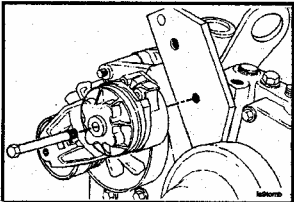
Component or Assembly (Procedure)	Ref. No./Steps	Metric	U.S.	
Charge Air Cooler Differential Pressure Across Cooler		21 kPa	MAX	3 psi
				
Exhaust Manifold Flatness		0.10 mm	MAX	0.004 in.
				
Compressed Air System Torque Values				
Air Compressor Mounting Nuts		77 N•m		57 ft-lb
				
Air Compressor Support Capscrews		24 N•m		18 ft-lb
				
Air Compressor Oil Supply 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.
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Electrical System
Starting Motor Mounting Capscrews

43 N•m 32 ft-lb



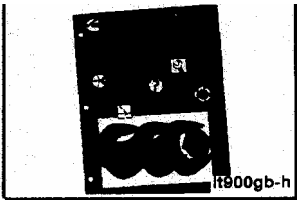
Belt Tensioner Capscrew

43 N•m 32 ft-lb

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

Batteries - State of Charge

Specific Gravity
at 27°C [80°F]
1.260 to 1.280
1.230 to 1.250
1.200 to 1.220
1.170 to 1.190
1.110 to 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				<u>33</u>	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											


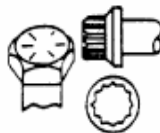

Weight and Measures - Conversion Factors

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	0.001 645
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 H ₂ O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H ₂ O	millimeters of water	mm H ₂ O	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
<p>NOTE</p> <p>To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.</p>					

Capscrew Markings and Torque Values – U.S. Customary

SAE Grade Number			5		8							
Capscrew Head Markings												
These are all SAE Grade 5 (3) line												
												
Capscrew Torque – Grade 5 Capscrew									Capscrew Torque – Grade 8 Capscrew			
Capscrew Body Size		Cast Iron		Aluminum		Cast Iron		Aluminum				
		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			U.S. Customary [5/16 X 18 X 1-1/2]		
M8	1.25	25	5/16	18	1-1/2
Major Thread Diameter in Millimeters	Distance Between Threads in Millimeters	Length in Millimeters	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

Thread	Size		Torque		Torque	
	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		Drill	Tap Size		Drill	Tap Size		Drill	Tap Size		Drill		
60 %	75 %	Size	60 %	75 %	Size	60 %	75 %	Size	60 %	75 %	Size		
3-48	M2.5x.45	48	12-24	M5.5x.9	4.40mm	M9x1.25	M9x1.25	7.50mm	M15x1.5	5/8-11	13.25mm		
		1.95mm			16			19/64			17/32		
		5/64			4.50mm			7.60mm			13.50mm		
		47			15			N			13.75mm		
		2.00mm			4.60mm			7.70mm			35/64		
	M2.6x.45	2.05mm		12-28	14		M9x1	7.75mm		M16x2	14.00mm		
		46			13			7.80mm			14.25mm		
		45			4.70mm			7.90mm			9/16		
		2.10mm			4.75mm			5/16			14.50mm		
		2.15mm			3/16			8.00mm			37/64		
M2.5x.45	M2.6x.45	44	M5.5x.9	M6x1	12	M9x1.25	M9x1	O	M16x1.5	5/8-18	14.75mm		
		2.20mm			4.80mm			8.10mm			15.00mm		
		2.25mm			11			8.20mm			19.32		
		4-36			43			4.90mm			P	15.25mm	
		2.30mm			10			8.25mm			39/64		
4-40	4-48	2.35mm		M6x1	9		3/8-16	M9x1		8.30mm	M17x1.5	M17x1.5	15.50mm
		42			5.00mm					21/64			15.75mm
		3/32			8					8.40mm			5/8
		2.40mm			5.10mm					Q			16.00mm
		41			7					8.50mm			16.25mm
4-48	M3x.6	2.45mm	1/4-20	13/64	M10x1.25	M10x1.25		8.60mm	M18x2	M18x2		41/64	
		40		6				R				16.50mm	
		2.50mm		5.20mm				8.70mm				21/32	
		39		5				11/32				16.75mm	
		38		5.25mm				8.75mm				17.00mm	
M3x.5	5-40	2.60mm	M6x.75	5.30mm		M10x1.5	M10x1.25	8.80mm		M18x1.5	M18x1.5	43/64	
		37		4				S				17.25mm	
		2.70mm		5.40mm				8.90mm				11/16	
		36		3				9.00mm				17.50mm	
		2.75mm		5.50mm				T				17.75mm	
5-44	6-32	7/64	M6x1	7/32	M10x1.25		M10x1	9.10mm	M20x2.5		M20x2	45/64	
		35		5.60mm				23/64				18.00mm	
		2.80mm		2				9.20mm				18.25mm	
		34		5.70mm				9.30mm				23/32	
		33		5.75mm				U				18.50mm	
6-32	M3.5x6	2.90mm		1/4-28		1	M10x1	M11x1.5		9.40mm	M20x1.5	M20x1.5	47/64
		32				5.80mm				9.50mm			18.75mm
		3.00mm				5.90mm				3/8			19.00mm
		31				A				V			3/4
		3.10mm				15/64				9.60mm			19.25mm
M3.5x6	6-40	1/8	M7x1		6.00mm	M11x1.5		M11x1.5	9.70mm	7/8-9		M22x2.5	49/64
		3.20mm			B				9.75mm				19.50mm
		3.25mm			6.10mm				9.80mm				25/32
		30			C				W				19.75mm
		3.30mm			6.20mm				9.90mm				20.00mm
M4x.75	M4x.7	3.40mm		M7x.75	D		7/16-14	7/16-20	25/64		M22x2	7/8-14	51/64
		29			6.25mm				10.00mm				20.25mm
		3.50mm			6.30mm				X				20.50mm
		28			E				10.20mm				13/16
		9/64			1/4				Y				20.75mm
8-32	8-36	3.60mm	M7x.75		6.40mm	M12x1.75		M12x1.5	13/32	M22x1.5		M24x3	21.00mm
		27			6.50mm				Z				53/64
		3.70mm			F				10.50mm				21.25mm
		26			6.60mm				27/64				27/32
		3.75mm			G				10.75mm				21.50mm
M4.5x.75	M4.5x.75	25		M8x1.25	6.70mm		M12x1.5	M12x1.25	11.00mm		M24x3	M24x2	21.75mm
		3.80mm			17/64				7/16				55/64
		24			6.75mm				11.25mm				22.00mm
		3.90mm			H				11.50mm				7/8
		23			6.80mm				29/64				22.25mm
10-24	M5x1	5/32	M8x1.25		6.90mm	M12x1.25		M12x1.5	11.75mm	M24x1.5		M24x1.5	22.50mm
		22			I				11.50mm				57/64
		4.00mm			7.00mm				29/64				22.75mm
		21			J				15/32				23.00mm
		20			7.10mm				12.00mm				29/32
M5x1	M5x.9	4.10mm		M8x1	K		9/16-12	M14x2	12.25mm		M25x2	M25x2	23.25mm
		4.20mm			9/32				31/64				59/64
		19			7.20mm				12.50mm				23.50mm
		4.25mm			7.25mm				1/2				23.75mm
		4.30mm			7.30mm				M14x1.5				15/16
M5x.9	M5x.8	18	M8x1		L	M14x1.5		M14x1.25	12.75mm	M20x1.5		M25x1.5	23.50mm
		11/64			7.40mm				13.00mm				23.75mm
		17			M				33/64				

Section L – Service Literature

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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

Service Literature Ordering Location

Region

United States and Canada

U.K., Europe, Mid-East, Africa,
and Eastern European Countries

South and Central America
(excluding Brazil and Mexico)

Brazil and Mexico

Far East (excluding
Australia and New Zealand

Australia and New Zealand

Ordering Location

Cummins Distributors

or

Cummins Engine Co., Inc.
Publishing Services CMC 95030
Box 3005
Columbus, IN 47202-3005

Cummins Engine Co., Ltd.
Royal Oak Way South
Daventry
Northants, NN11 5NU, England

Cummins Americas, Inc.
16085 N.W. 52nd Avenue
Hialeah, FL 33104

Cummins Engine Co., Inc.
International Parts Order Dept., MC 40931
Box 3005
Columbus, IN 47202-3005

Cummins Diesel Sales Corp.
Literature Center
8 Tanjong Penjuru
Jurong Industrial Estate
Singapore

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).

NOTES

[illegible]

Service Literature Order Form

Use this form for prompt handling of your literature order.

Item	Bulletin Number	Title of Publication	Quantity	U.S. Price Each	Amount
1				\$	\$
2					
3					
4					
5					
6					
Publications Total					\$
Indiana Residents: Add 5% Sales Tax					\$
Handling & Shipping Chg: No. Items X \$1.50 =					\$
Order Total					\$

☐ Payment Enclosed. Make certified check or money order payable to Cummins Engine Co.

☐ Please Ship C.O.D (U.S.A. only)

 Prices subject to change without notice

TM 5-3810-307-24-2-2

For factory orders, mail the Service Publications Order Form along with your ship-to address to:
Cummins Engine Co., Inc. Publishing Services (MC 41407)
Box 3005, Columbus, IN 47202-3005.

FROM:

Name: _____
Street Address: _____
City: _____ State: _____ Zip Code: _____
Country: _____

SHIP TO: (Name and address where literature is to be shipped)

Name: _____
Street Address: _____
City: _____ State: _____ Zip Code: _____
Country: _____

Section C – Component Manufacturers

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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: 0272-671 881

Catching Engineering
2101 Roberts Drive
Broadview, IL 60153
Telephone: (312) 344-2334

Air Heaters

Fleetguard, Inc.
Cookeville, TN 38502
P.O. Box 6001
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

Air Starting Motors

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone: (312) 530-3800

StartMaster
Air Starting Systems
A Division of Sycon Corporation
P.O. Box 491
Marion, OH 43302
Telephone: (614) 382-5771

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 0895-833633

Bute Electric
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21 663

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.
P.O. Box 6001
Cookeville, TN 38502
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

Bute Electric
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
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Telephone: (517) 782-9421

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201 W. Carmel Drive
Carmel, IN 46032
Telephone: (317) 846-3438

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McCordsville, IN 46055
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Aerovent
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Indianapolis, IN 46268
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P.O. Box 80-B
Indianapolis, IN 46206
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England
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Weedon
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England
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Indianapolis, IN 46206
Telephone: (317) 244-1511

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CF8 7XD
England
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TN9 1TB
England
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Potters Bar
Herts
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Bucks
SL1 4DD
England
Telephone: 0753-26835

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Fort Collins, CO 80522
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Strood
Rochester
Kent
ME2 2BD
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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
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Telephone: (313) 280-3000

Z.F.
P.O. Box 1340
Grafvonsoden Strasse
5-9 D7070
Schwaebisch Gmuend
West Germany
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Sunburn on Thames
Middlesex
TW16 7HF
England
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10388 Enterprise Drive
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Telephone: (313) 625-5381

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Chaussee de Namur
Nivelles
Belgium
Telephone: 067-224941

Torque Converters - Contd

Twin Disc Clutch Co.
Racine, WI 53403
Telephone: (414) 634-1981

Rockford Division
Borg-Warner Corporation
1200 Windsor Road
P.O. Box 7007
Rockford, IL 61125-7007
Telephone: (815) 633-7460

Modine
1500 DeKoven Avenue
Racine, WI 53401
Telephone: (414) 636-1640

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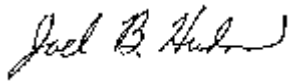
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NOTES

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By order of the Secretary of the Army:

ERIC K. SHINSEKI
General United States Army
Chief of Staff



Official:

JOEL B. HUDSON
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