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# ***SERVICE MANUAL***

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## ***REAR WHEEL DRIVE RAM TRUCK***

***Diesel  
Supplement***



**AUTHENTIC  
RESTORATION™  
PRODUCT**

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# CHRYSLER MOTORS

## 1990 Diesel Supplement Service Manual

### DODGE TRUCKS



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**CHRYSLER  
MOTORS**



**CUMMINS ENGINE  
COMPANY, INC.**

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DODGE Turbo Diesel**

## FOREWORD

The information contained in this service manual has been prepared for the professional automotive technician involved in daily repair operations. Information in this manual is divided into groups. Each group covers a general vehicle system (brakes, steering, body, etc.). Each group is further divided to address individual components or systems within the group.

The Component and System Index will assist you in locating the correct group for the component or system you require.

These groups contain general information, diagnosis, testing, adjustment, removal and installation, assembly and disassembly procedures for the components.

The diagnosis charts in the "Engine Section" are designed to help you locate and correct problems with a systematic approach. The tab locator at the right side of this page will help you to quickly locate the first page of each group. The first page of each group contains an alphabetical index to assist in the location of the component or system.

The information, descriptions, testing procedures and specifications were in effect at the time this manual was released for printing.

Information describing the operation and use of standard and optional equipment is included in the Operating Instructions and Product Information manual located in the glove box.

Navigation Tools: Click on the "Table of Contents" below, or use the Bookmarks to the left.

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## Introduction

### About the Manual

The procedures in this manual were developed for an in-chassis and out-of-chassis environment. The information has been grouped by the main engine systems. The Table of Contents defines the systems. The Index at the beginning of each section subdivides the instructions for the various components of the system. Wrench sizes and special tools are identified in the procedures as needed.

### How to Use the Manual

The organization of this manual is based on the troubleshooting logic presented in Section 9A. To fix a problem, find the logic chart for the particular symptom. Follow the steps specified until the problem is corrected.

The left column of the charts indicate a probable cause. The right column provides a brief description of the corrective action with a reference to the repair procedure or diagnostic discussion when appropriate.

The logic charts reflect three basic considerations:

1. Assumes the engine has provided satisfactory service prior to the problem.
2. Performing the easiest things first.
3. Most logical cause in descending order.

If the problem occurs with a new engine or after repair of the engine, the diagnostics discussion for each major system will provide guidance for sorting out the cause of the problem.

## 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.

## Definition of Terms

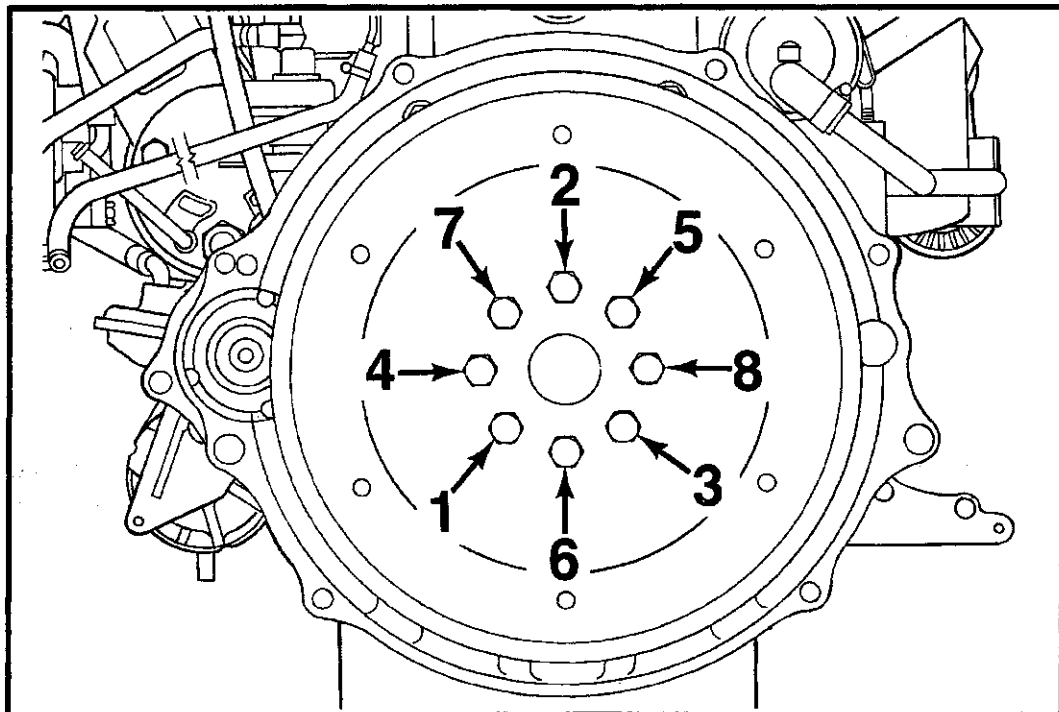
The following is a list of guidelines for each procedure in the "Repair Sections" of the Troubleshooting and Repair Manual. The procedure will be given first; followed by a definition of the step or steps involved.

- **Check** - Examine a component or system for damage, excessive wear, accuracy, safety, or performance.
- **Inspect** - Examine a component or dimension to make sure it meets the required specifications.
- **Test** - Check or compare the performance of a component or system to established specifications.
- **Adjust** - Complete the necessary steps to set or adjust the component, assemblies, or system in the required setting or position.
- **Visually Inspect** - Look for any obvious damage or problem.
- **Remove** - Take off a component or assembly.
- **Clean** - Remove dirt, grease or other contamination.
- **Disassemble** - Take the component or assembly apart.
- **Repair** - Restore a component or assembly to a serviceable condition within the established specifications.

**NOTE:** Only the easiest and simplest repairs will be made to a component or assembly. If a component or assembly must be rebuilt, it must be replaced with a new or reconditioned component or assembly.

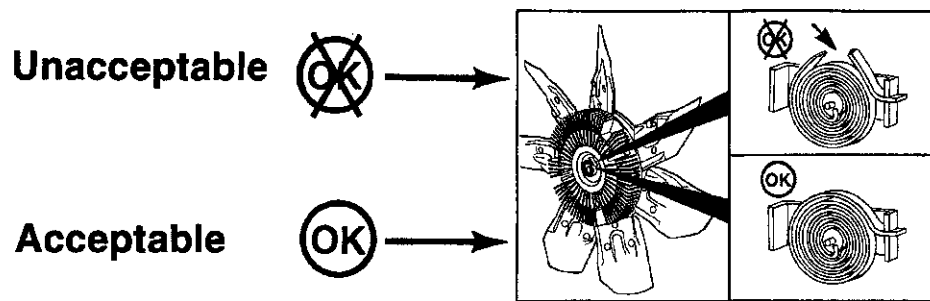
- **Replace** - Install a new, properly rebuilt reconditioned component or assembly in place of one which is removed.
- **Install** - Place a component or assembly in the correct position.

## Star Pattern Torque Sequence



### Illustrations

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



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The illustrations used in the Replacement Sections are intended to show replacement procedures when the engine is installed in a chassis. The illustration may differ from your application, but the procedure given will be the same.

## General Safety Instructions

### Important Safety Notice

Read and understand all safety precautions and warnings before performing repairs.

This symbol appears in the manual when a potential safety hazard exists that can cause personal injury or death. These hazards are not always apparent to a trained mechanic. It is not possible for Chrysler Motors/Cummins Engine Co., Inc. to anticipate every possible circumstance that can involve a potential hazard.

**WARNING: Chrysler Motors/Cummins Engine Company, Inc. does not recommend or authorize any modifications or repairs to engines or components except for those detailed in Chrysler/Cummins Service Information.**

In particular, unauthorized repair to safety-related components can cause personal injury. Below is a partial listing of components classified as safety-related.

- Cooling Fan
- Fan Hub Assembly
- Fan Mounting Bracket(s)
- Fan Mounting Capscrews
- Fan Hub Spindle
- Flywheel
- 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















## General Safety Instructions

### Important Safety Notice







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.

**Warning:** This is the **WARNING SYMBOL**, it appears in the manual when a potential safety hazard exists that can cause personal injury or death. These hazards are not always apparent to a trained mechanic.

**Note:** It is not possible for Chrysler Motors and Cummins Engine Company, Inc. to anticipate every possible circumstance that can involve a potential hazard.

-  Be sure the work area surrounding the product is safe. Be aware of hazardous conditions that can exist.
-  Always wear protective glasses and protective shoes when working.
-  Do not wear loose-fitting or torn clothing. Remove all jewelry such as rings, watches, etc., when working.
-  Disconnect the battery and discharge any capacitors before beginning any repair work. Put a "Do Not Operate" tag in the operator's compartment or on the controls.
-  Use **ONLY** the proper engine barring techniques for manually rotating the engine. Do not attempt to rotate the engine by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s), causing premature fan failure.
-  If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
-  Do not work on anything that is supported **ONLY** by lift jacks or a hoist. Always use blocks or proper stands to support the product before performing any service work.
-  Relieve all pressure in the air, oil, and the cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do not check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
-  To prevent suffocation and frostbite, wear protective clothing and **ONLY** disconnect liquid refrigerant (freon) lines in a well ventilated area.
-  To avoid personal injury, use a hoist or get assistance when lifting components that weigh 23 kg (50 lbs) or more. Be sure all chains, hooks, slings, etc., are in good condition and are of the correct capacity. Be 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.**

### General Safety Instructions

-  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. Be sure you understand how to use them before performing any service work. Use **ONLY** genuine **MOPAR** replacement parts.
-  Always use the same fastener part number (or equivalent) when replacing fasteners. Do not use a fastener of less quality if replacements are necessary.
-  Never spray or pour diesel fuel, flammable liquid, starting fluids (ether) into the air cleaner canister, air intake piping, or turbocharger inlet in an attempt to start the vehicle.
-  Never use gasoline or other flammable materials to clean parts. Always use approved cleaning solvents.
-  Do not use alcohol or gasoline as a fuel blending agent. They can be unstable under certain conditions and be hazardous or explosive when mixed with diesel fuel.

## **General Repair Instructions**

The Dodge Ram/Cummins Turbo 5.9 Liter Diesel engine incorporates the latest diesel technology , yet it is designed to be repaired using existing repair practices performed to quality standards.

### **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. Also, be sure to use good safety practices with tools and equipment.

### **Provide a Clean Environment and Follow the Cleaning Instructions Specified in the Procedures.**

Cleanliness is very important during the repair of a diesel engine. Contamination of the engine during repair will reduce the life of an engine.

### **Perform the Inspections Specified in the Procedures.**

Replacement of worn and damaged parts is also necessary for a successful repair - the engine can not be better than its components.

### **Use Genuine MOPAR Service Parts and Assemblies.**

The assembly instructions have been written for reusing as many parts and assemblies as is practical. When it is necessary to replace a part or assembly, the procedure is based on the use of new or reconditioned parts. All of the repair service described in this manual is available from all Dodge truck dealer locations.


Follow the Specified Disassembly and Assembly Procedures to Avoid Causing Damage to the Parts and to Be Sure That the Components Are Correctly Assembled and Tightened.

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<b>Dodge</b>		<b>Plymouth</b>	
<b>Fargo</b>		<b>De SOTO</b>	
MARCAS REG TMS REG U.S. PAT. OFF.			
MAKE	<input type="text"/>	MODEL	<input type="text"/>
VIN	<input type="text"/>	TON	<input type="text"/>
MAX GVW*	<input type="text"/>		
<small>GROSS VEHICLE WEIGHT (GVW) IS TOTAL WEIGHT OF THE VEHICLE INCLUDING OPTIONS, DRIVER, PASSENGERS, BODY &amp; PAYLOAD. *SEE OPERATORS MANUAL PACKAGE FOR SPECIFIC EQUIPMENT REQUIRED FOR A GIVEN GVW RATING. WARRANTY VOID IF ANY RATINGS ARE EXCEEDED FOR THE ACTUAL GVW &amp; GAWR RATINGS OF THIS VEHICLE. SEE THE SAFETY CERTIFICATION LABEL.</small>			 <small>CHRYSLER CORPORATION</small>
<small>MADE IN U.S.A.</small>			

## VEHICLE AND COMPONENT IDENTIFICATION

**Vehicle Identification Number:** For 1990, (V.I.N.) will consist of 17 elements (numbers and letters) embossed on a plate, located on the upper left corner of the instrument panel, near the windshield. Refer to 1990 "V.I.N. Code Chart", for Alpha/Digit positions and V.I.N. interpretations.

The Vehicle Identification Number is located on the Vehicle Identification Plate, Equipment Identification Plate and on the applicable U. S. Federal Motor Vehicle Safety Standards "Certification Label" and Frame Rail.

**Vehicle Identification Plate** The vehicle identification plate as shown is attached to the rear face of the driver's door, or on the "B" post, on all models.

<small>CHRYSLER CORPORATION</small>		<b>EQUIPMENT IDENTIFICATION</b>		<small>4215966</small>
<small>MODELS</small>		<small>V.I.N.</small>		<small>T.O.N.</small>
<small>CODE NO.</small>	<small>DESCRIPTION</small>	<small>CODE NO.</small>	<small>DESCRIPTION</small>	
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	


## Equipment Identification Plate

The equipment identification plate as shown contains information regarding the vehicle: model, wheel base, V.I.N. (Vehicle Identification Number), T.O.N. (Order Number), and all production or special equipment on the vehicle when it was shipped from the factory. Always refer to this plate when ordering parts. The location of the equipment identification Plate is as follows:

<b>Model</b>	<b>Location</b>
Conventional Cab	Hood Inner Surface

## Vehicle Safety Certification Labels

A vehicle safety certification label is attached to the rear facing of the driver's door on all models. This label reflects the date of manufacture numerically month and year, Gross Vehicle Weight Rating (GVWR), Gross Axle Weight Rating (GAWR) front, Gross Axle Weight Rating (GAWR) rear and Vehicle Identification Number (VIN). A Month-Day-Hour (MDH) number is included on this label and indicates the Month, Day and Hour of manufacture.

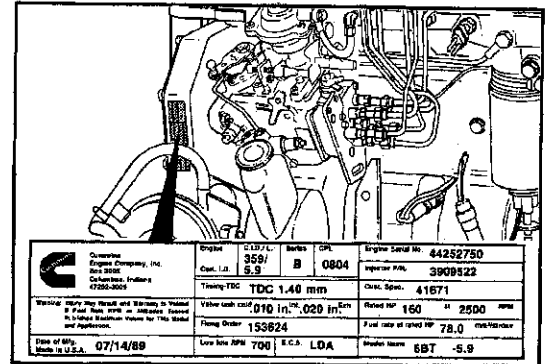
<small>MFD BY</small>				<small>DATE OF MFG. (GVWR)</small>	
<small>GAWR FRONT</small>	<small>WITH TIRES</small>	<small>RIMS AT</small>	<small>PSI CODE</small>		
<small>GAWR REAR</small>	<small>WITH TIRES</small>	<small>RIMS AT</small>	<small>PBI CODE</small>		
<small>THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE.</small>					
<small>VEHICLE NUMBER</small>	<small>VEHICLE TYPE</small>	<small>MDH</small>			
<b>PU834</b>			<small>4038800</small>		

This label when applied, verifies vehicle conformation to all applicable Federal Motor Vehicle Safety Standards in effect on the date of manufacture.

All communications or inquiries regarding the vehicle should include the Month-Day-Hour and Vehicle Identification Number.

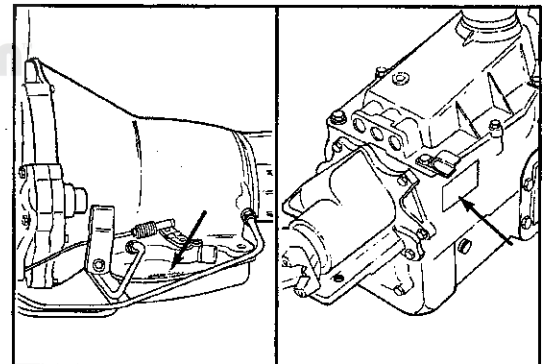
## Engine Serial Number

**Parts Replacement Information** On 5.9 Liter diesel engines, the engine serial number is located on the left front corner of the engine. The engine serial number is stamped into the data plate located on the gear housing.



## Transmission Identification

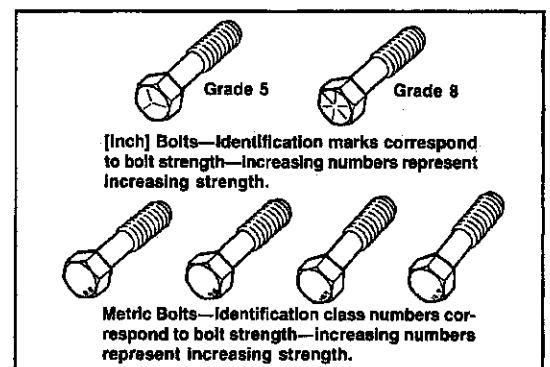
Operation requirements are, in some instances, different for each vehicle and engine combination and some internal parts will be different. Therefore, when replacing parts, refer to the number stamped on left side of the transmission oil pan flange. See Group 21 of this manual for additional information. For manual transmission models, an identification number is permanently stamped into the right side of the transmission case or a metal tag located on the upper right side of the transmission.



## Fastener Classification

**Metric Thread and Grade Identification** Metric and Inch thread notations differ slightly.

Common metric fastener strength property classes are 8.8 and 12.9 with the class identification embossed on the head of each bolt. Inch strength classes range from grade 5 to 8 with line identification embossed on each bolt head as shown. Markings correspond to two lines less than the actual grade (i.e. grade 8 bolt will exhibit 6 embossed lines on the bolt head). Some metric nuts will be marked with single digit strength identification numbers on the nut face.



## **Metric System**

Artwork, specifications, and tightening references in this Service Manual are identified in the metric system and in the [standard-inch] system.

During any maintenance or repair procedures, it is important to salvage metric fasteners (nuts, bolts, etc.) for reassembly. If the fastener is not salvageable, a fastener of equivalent specification should be used.

**Caution: Use of an incorrect fastener may result in component damage or personal injury.**

The metric system is based on quantities of one, ten, one hundred, one thousand, and one million.

### **Metric Prefixes**

Mega - (M) means million

Kilo - (K) means thousand

Deci - (D) means tenth

Centi - (C) means hundredth

Milli - (M) means thousandth

**1990 V.I.N. CODE CHARTS - TRUCKS**

Position	Code Options	Interpretation
1	1=United States	Country of Origin
2	B=Dodge	Make
3	7=Truck	Type of Vehicle
4	K=8001-9000 L=9001-10000 M=10001-14000 W=Hydraulic Brakes	GVWR and Hydraulic Brakes
5	E=Ram Pickup 4 x 2 E=Ram Chassis Cab 4 x 2 M=Power Ram Pickup 4 x 4 M=Power Ram Chassis Cab 4 x 4	Truck Line
6	2=250 3=350	Series
7	6=Conventional Cab	Body
8	8=5.9 Liter Diesel, 160Hp, Cummins	Engine
9	(1 thru 9, 0, or X)	"Check Digit for VIN Verification"
10	L=1990	Model Year
11	S=Dodge City	Assembly Plant
12 thru 17	(6 digits)	Sequence Number

**1990 DODGE Ram Pickup and Chassis Cab  
Model Line-Up and Weights**

Model Name	Vehicle Family	Wheelbase	GVWR	Payload Allowance	Curb Weight
<b>Ram Pick-ups 4 x 2</b>					
D250	D-2	131			3979
					4005
			8510	4163	4347
D350	D-3	131	8700	4395	4305
			10,100	5518	4582
<b>Ram Pick-ups 4 x 4</b>					
W250	D-6	131	8510	3877	4633
W350	D-7	131	8700	3832	4868
<b>Ram Chassis Cab 4 X 2</b>					
D250	D-2	131	8510	4576	3934
D350	D-3	131	8700	4830	3970
		135	10,100	5802	4298
			10,500	6180	4320
		159	10,100	5707	4393
			10,500	6079	4421
<b>Ram Chassis Cab 4 x 4</b>					
W250	D-6	131	8510	4222	4288
		131	8700	4183	4517
W350	D-7	135	10,100	5408	4692
			11,000	6086	4714

**1990 Power Team Availability**  
Conventional Pickup

Vehicle Line	Wheel-base	GVWR	Engine Displacement & Sales Code		Transmission	
			5.9L 360in3 Diesel ETA		5-Sp O.D. Man	3-Sp Auto
<b>Ram Pickup Trucks Two-Wheel Drive</b>						
D250	131	8510	O		S	O
D350	131	8700	O		S	O
		10,100	O		S	O
<b>Ram Pickup Trucks Four Wheel Drive</b>						
W250	131	8510	O		-	O
W350	131	8700	O		-	O
<b>Chassis Cab</b>						
D250	131	8510	O		S	O
D350	131	8700	O		S	O
	135	10,100	O		S	O
	159	10,500	O		S	O
W350	135	8700	O		S	O
	159	10,100	O		S	O
		11,000	O		S	O
S-Standard O-Optional						

**1990 Standard Truck Body Dimensions**

Vehicle Family	Wheelbase Available (inches)	Cab to Axle (inches)	Body Type	Nominal Length(ft.)	Length	Load Space Dimensions		
						Max.Width	Height	Vol. (cu.ft.)
Ram, Power	105.1		Pickup	6	72.0	64.2	15.7	42.0
Ram	116.1			7	88.3	64.2	15.7	51.5
D1,D2,D3, D5,D6,D7	131		Sweptline	8	98	70	19.1	75.8
D2,D3,D7	131	56	Chassis Cab	8				
D3,D7	135	60	Chassis Cab	9.5				
D3	159	84	Chassis Cab	12.5				



**FRACTION, DECIMAL, MILLIMETER, CONVERSIONS**

8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM	8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM
			1	0.0156	0.397				33	0.5156	13.097
		1		0.0313	0.794			17		0.5313	13.494
			3	0.0469	1.191				35	0.5469	13.891
	1			0.0625	1.588		9			0.5625	14.288
			5	0.0781	1.984				37	0.5781	14.684
		3		0.0938	2.381			19		0.5938	15.081
			7	0.1094	2.778				39	0.6094	15.478
1				0.1250	3.175	5				0.6250	15.875
			9	0.1406	3.572				41	0.6406	16.272
		5		0.1563	3.969			21		0.6563	16.669
			11	0.1719	4.366				43	0.6719	17.066
	3			0.1875	4.763		11			0.6875	17.463
			13	0.2031	5.159				45	0.7031	17.859
		7		0.2188	5.556			23		0.7188	18.256
			15	0.2344	5.953				47	0.7344	18.653
1/4				0.2500	6.350	3/4				0.7500	19.050
			17	0.2656	6.747				49	0.7656	19.447
		9		0.2813	7.144			25		0.7813	19.844
			19	0.2969	7.541				51	0.7969	20.241
	5			0.3125	7.938		13			0.8125	20.638
			21	0.3281	8.334				53	0.8281	21.034
		11		0.3438	8.731			27		0.8438	21.431
			23	0.3594	9.128				55	0.8594	21.828
3				0.3750	9.525	7				0.8750	22.225
			25	0.3906	9.922				57	0.8906	22.622
		13		0.4063	10.319			29		0.9063	23.019
			27	0.4219	10.716				59	0.9219	23.416
	7			0.4375	11.113		15			0.9375	23.813
			29	0.4531	11.509				61	0.9531	24.209
		15		0.4688	11.906			31		0.9688	24.606
			31	0.4844	12.303				63	0.9844	25.003
1/2				0.5000	12.700	1 IN.				1.0000	25.400

CONVERSION FACTOR: 1 INCH = 25.4MM



## Lubrication and Maintenance

### Section 0

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## Introduction

### Section 0A

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## General Information

Maintenance and lubrication service recommendations have been compiled to provide maximum protection for the owner's investment against all reasonable types of driving conditions. Since these conditions vary with the individual operator's driving habits, (area in which the vehicle is operated, and type of service to which the vehicle is subject) it is necessary to prescribe lubrication and maintenance service on a time schedule as well as mileage interval basis. The maintenance charts are related to "Heavy Duty Cycle" only.

### Heavy Duty Cycle

Vehicles with a gross vehicle weight rating of 3860 kg [8,501 lbs.] or over must conform to heavy duty emission standards.

The GVWR for each vehicle as manufactured appears on the Safety Certification label, affixed to the lock pillar on the drivers door. Additional information can be found in the Operating Instructions and Product Information Manual provided with the vehicle.

### Severe Service

Vehicles operating under one or more of the following conditions will require more frequent service.

1. In extremely dusty areas.
2. 50 percent or more of the vehicle's operation is in heavy city traffic in high temperature (90 degrees or higher).
3. Prolonged idling.
4. Extremely short run operation.
5. Commercial type operation.
6. Operated in water.

### Noise Control Systems

All vehicles built over 4535 kg [10,000 lbs.] Gross Vehicle Weight Rating and manufactured after 1/1/78 for sale and use in the United States are required to comply with the Federal Government's Exterior Noise Regulations. These vehicles can be identified by the Noise Emissions Control Label located in the operator's compartment.

#### • Required Maintenance for Noise Control Systems

The following maintenance services must be performed every 6 months or 9600 km [6,000 miles] whichever occurs first to assure proper operation of the noise control systems. Inspection and service should be performed anytime a malfunction is observed or suspected. In addition, proper maintenance of the entire vehicle will help the effectiveness of the noise control system.

#### • Exhaust System

Inspect the entire exhaust system for leaks and damage parts. Devices such as hangers, clamps, and U-bolts should be tight and in good condition. Damaged components, burned or blown out mufflers, burned or rusted out exhaust pipes should be replaced according to the procedure and specifications outlined in "Exhaust", Group 11.

#### • Air Cleaner Assembly

Inspect air cleaner housing for proper assembly and fit. Make certain that the air cleaner is properly positioned and the cover is tight. Check all hoses leading to the cleaner for tightness. The air filter element must also be clean and serviced according to the instruction outlined in the Scheduled Maintenance Section of this manual.

- **Tampering with Noise Control System Prohibited**

Federal law prohibits the following acts or the causing thereof: (1) The removal or rendering inoperative by any person other than for purposes of maintenance repair, or replacement of any device or element of design incorporated into any new vehicle for the purpose of noise control prior to its sale or delivery to the ultimate purchaser of while it is in use, (2) the use of the vehicle after such device or element of design has been removed or rendered inoperative by any person.

- **Classification of Lubricants**

Oils, lubricants, and greases are classified and graded according to standards recommended by the Society of Automotive Engineers (SAE), American Petroleum Institute (API) and National Lubricating Greases Institute (NLGI).

- **Engine Oil**

The SAE grade number indicates the viscosity of engine oils. Engines oils are identified by a dual number, for example, SAE 15W-40, which indicates a multi-viscosity oil.

- **Gear Lubricants**

The SAE grade number also indicates the viscosity of Multipurpose Gear Lubricants. The API classification system defines gear lubricants in terms of usage such as API GL-4 API GL-5 etc.

- **Lubricants/Greases**

Semisolid lubricants bear the NLGI designation and are further classified as grades 0,1,2,3 etc.

### **Parts Requiring No Lubrication**

There are many points that should not be lubricated; some because they are permanently lubricated, some because lubricants will be detrimental to their operating characteristics, and some because lubricants will cause component failures. In particular rubber bushings should not be lubricated since this not only will cause them to fail, but will destroy their necessary frictional characteristics. Parts that should not be lubricated are as follows:

Alternator Bearings	Idle Arm Assembly	Suspension Strut Bearing	Water Pump Bearings
Drive Belts	Rubber Bushings	Throttle Control Cable	
Fan Belt Idler Pulley	Starter Bearings	Throttle Linkage	

### **Parts and Lubrication Recommendations**

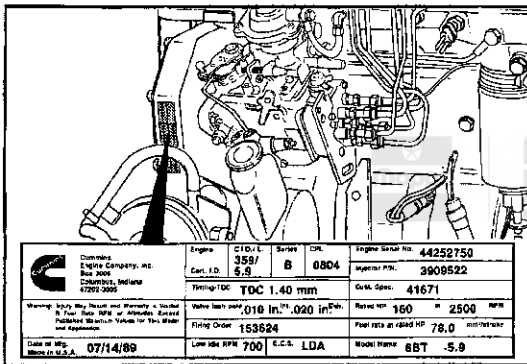
"Your Chrysler Motor vehicle has been engineered to perform for you for years to come. You will occasionally require service and maintenance for your vehicle and Chrysler Motor recommends the use of "MOPAR" brand parts and accessories. Each MOPAR part has been specifically designed to maintain top efficiency and quality by the same team of engineers who designed your vehicle. Only MOPAR can make this claim. Remember, whenever your Dodge requires a new part, always request the brand name MOPAR - it's worth the effort!

## **A Word About Maintenance**

Preventative maintenance is the easiest and least expensive type of maintenance. Follow the maintenance schedule recommendations outlined in Maintenance Guidelines.

Keep records of regularly scheduled maintenance.

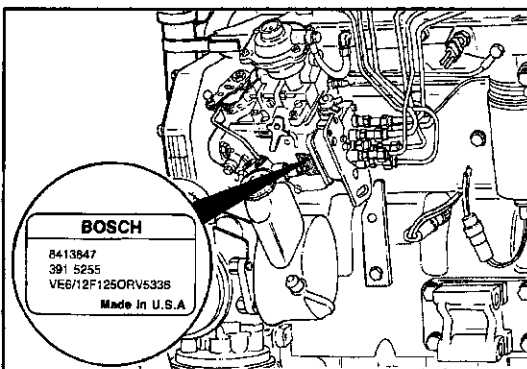
Use the correct fuel, oil, and coolant in your engine as specified in Engine Specifications.



### Engine data plate

Use the information from the engine data plate when discussing service or sourcing parts for the engine.

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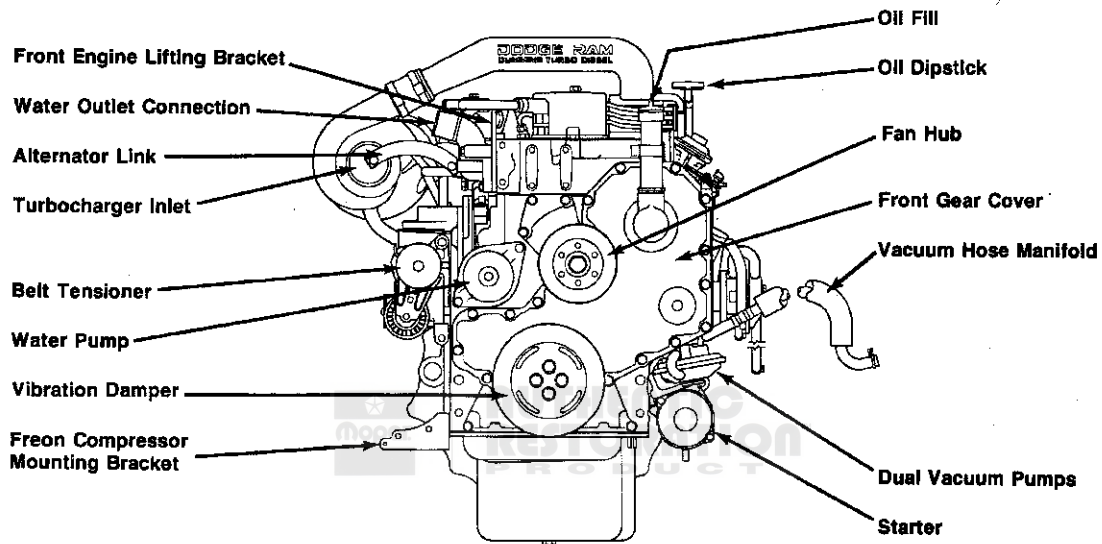
### Fuel pump data plate

Use the information from the fuel pump data plate when discussing service or sourcing parts for the fuel system.

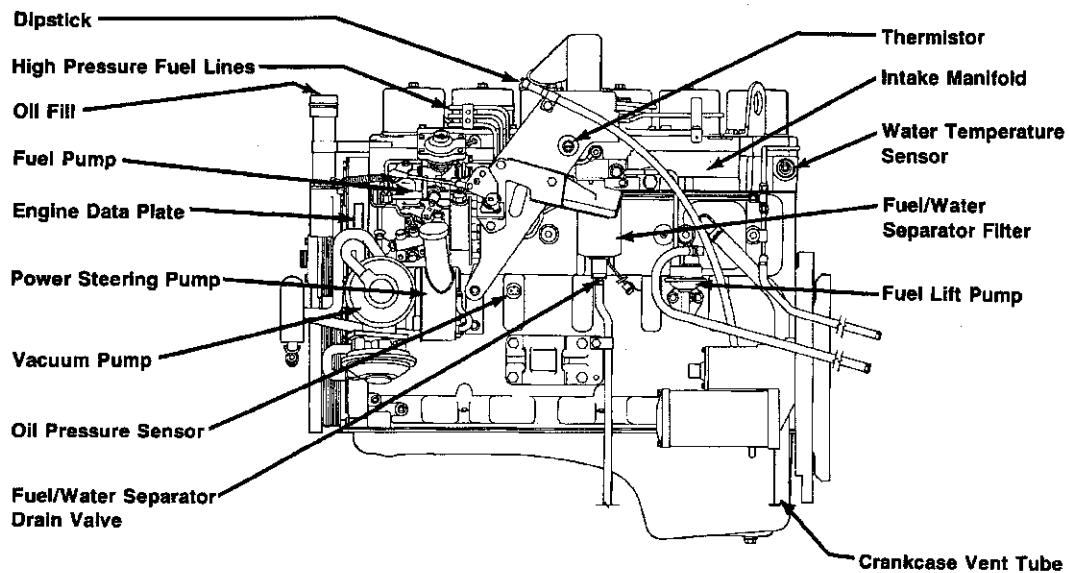
## Identifying Your Engine

The following pictures show the location and name of the major external components, filters, and other service points on your engine.

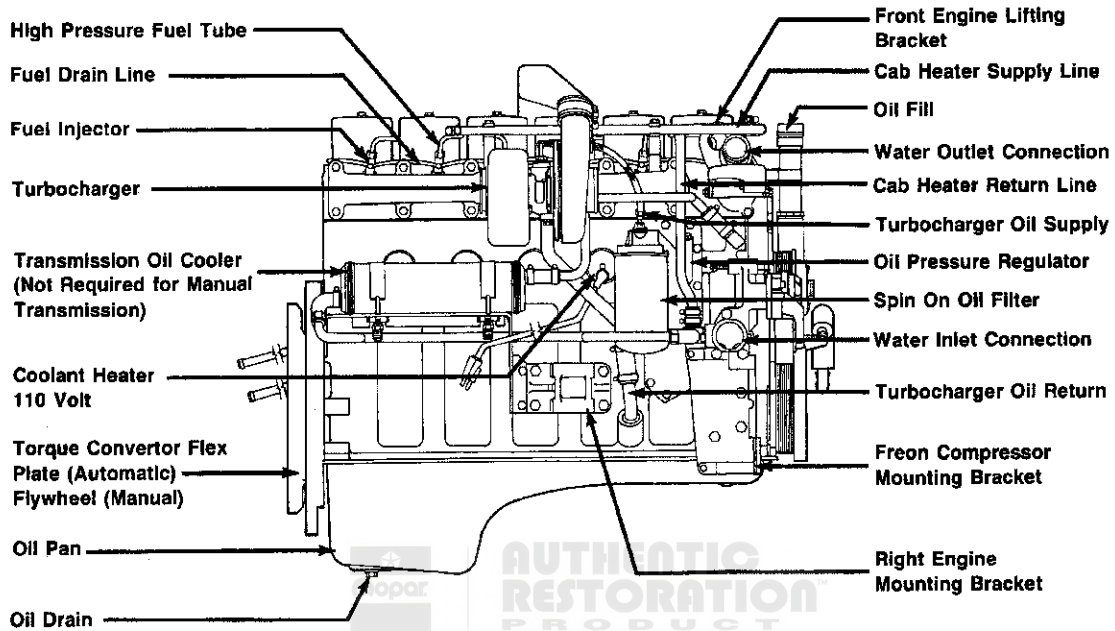
### Front of Engine



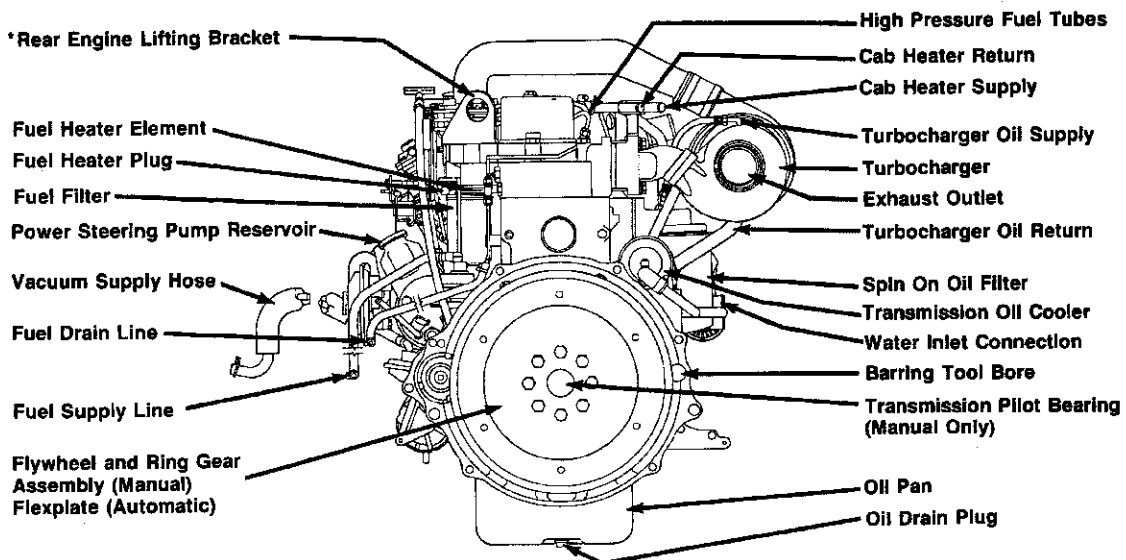
### Fuel Side of Engine



### Exhaust Side of Engine



### Rear of Engine



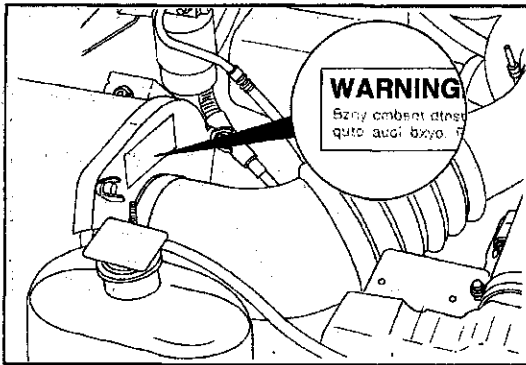
\*Reverse lifting bracket when installed in truck.

## Operating Instructions

### Section 0B

#### Contents

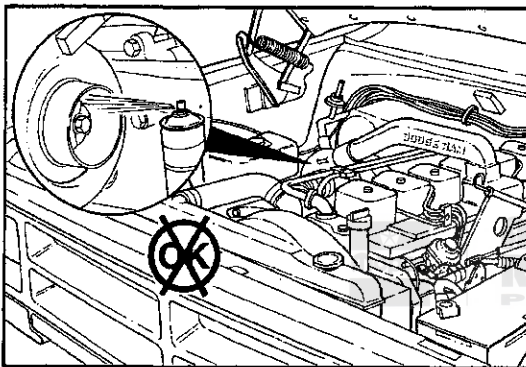
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### Starting Fluids (WARNING)

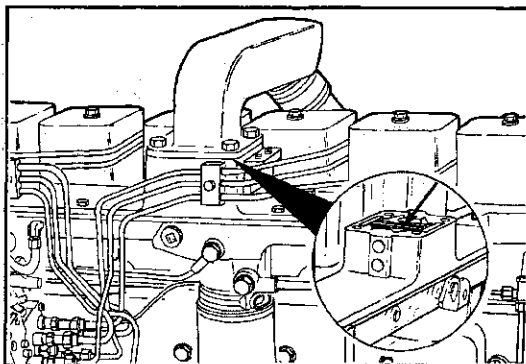


**Warning:** The use of **STARTING FLUIDS** or flammable liquids are **NEVER TO BE USED** in the **DODGE Ram Cummins Turbo Diesel**.



**Warning:** Never pour diesel fuel, flammable liquid, starting fluids (ether) into the air cleaner canister, air intake piping, or turbocharger inlet in an attempt to start the vehicle.

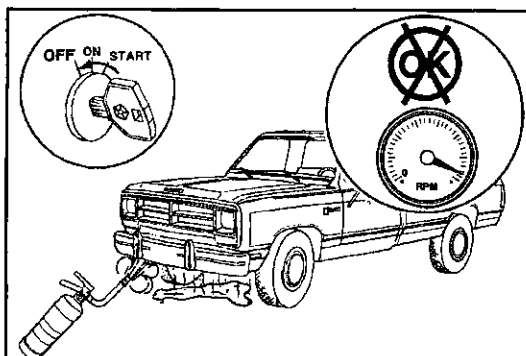
This could result in a flash fire and explosion causing serious personal injury and engine damage.



The engine is equipped with an automatic electric air preheating system. If the instructions in this manual are followed, the engine will start in all conditions unaided.



**Warning:** Never use diesel fuel, flammable liquid, starting fluid (ether) to aid starting or operation of the engine.



### Flammable Fluid Spills

**Warning:** In case of engine runaway due to flammable fumes from gasoline spills being sucked into the engine, use a CO<sub>2</sub> or dry chemical type fire extinguisher and direct the spray under the front bumper to remove oxygen supply. The engine air intake is on the passenger side behind the bumper. The fire extinguisher must be directed at this location for emergency shutdown conditions.






## Maintenance Free Battery

The top of the maintenance free battery is permanently sealed. You will never have to add water, nor is periodic maintenance required.

To determine the battery charge, check the battery test indicator on top of the battery. Refer to the illustration.

**Caution:** It is essential when replacing the cables on the battery that the positive cable is attached to the positive post and the negative cable is attached to the negative post. Battery posts are marked (+) positive and negative (-) and identified on the battery case. Also, if a "fast charger" is used while battery is in vehicle, disconnect both vehicle battery cables before connecting the charger to battery. Do not use a "fast charger" to provide starting voltage.



BATTERY CONDITION INDICATOR	O.K. TO JUMP START	 • DARKENED INDICATOR WITH GREEN DOT • BATTERY CHARGE OK • FLUID LEVEL OK
	DO NOT JUMP START	 • DARKENED INDICATOR NO GREEN DOT • BATTERY CHARGE LOW • FLUID LEVEL OK
		 • LIGHT OR BRIGHT INDICATOR • BATTERY CHARGE UNKNOWN • FLUID LEVEL LOW (CHARGE MAY STILL BE SUFFICIENT TO START YOUR CAR)



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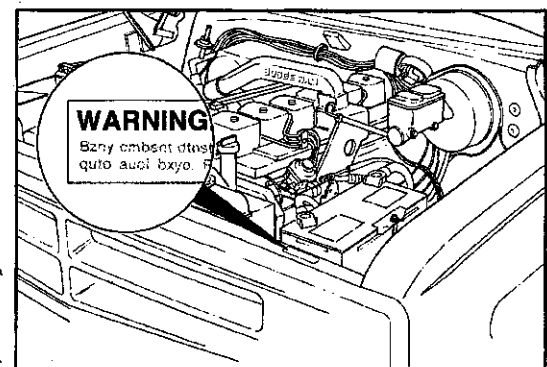
## Assist (Jump) Starting

### With a Booster Battery

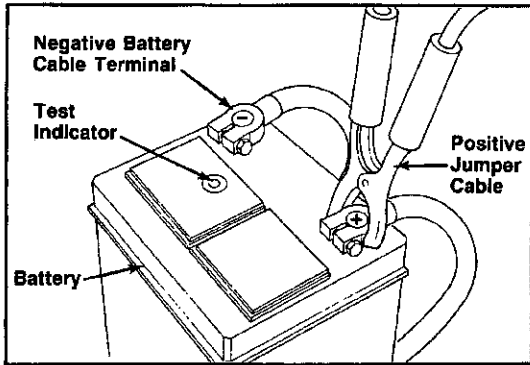
If it becomes necessary to use a booster battery, with jumper cables, to start a vehicle's engine because its battery is discharged, the following procedure should be followed:

**Warning:** To prevent personal injury or damage to clothing, do not allow battery fluid to contact eyes, skin or fabrics. Do not lean over a battery when connecting jumper cables or allow cable clamps to touch each other. Keep open flames or sparks away from battery vent holes. Always wear eye protection when working with batteries.

**Caution:** Do not apply more than 12 Volts D.C. to battery during the jump start procedure. Voltage above 12 Volts D.C. can damage the trucks electrical system.







Set parking brake and place automatic transmission in "Park" (neutral for manual transmission). Turn off lights, heater and other electrical loads. Observe charge indicator. If indicator is light or yellow replace battery.

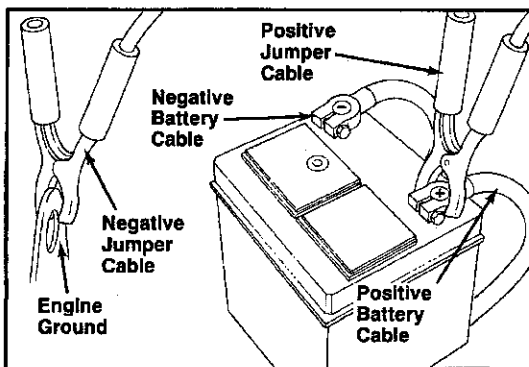


**Caution: Do Not attempt jump starting when indicator is light or yellow. If charge indicator is dark and has a green dot in the center, failure to start is not due to a discharged battery and cranking system should be checked. If charge indicator is dark or red ball appears in center, proceed as follows:**



1. Attach one jumper cable to positive terminal of booster battery and the other end of the same cable to positive terminal of the discharged battery.

**Warning: do not permit vehicles to touch each other as this could establish a ground connection and counteract benefit of this procedure.**

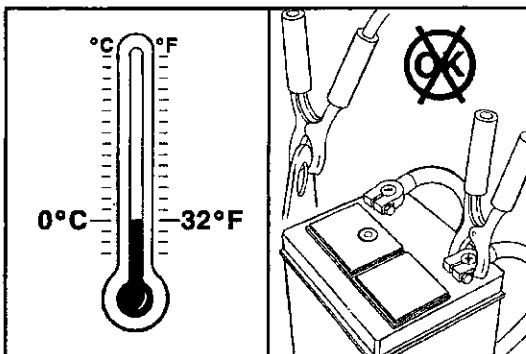


2. Connect one end of the other jumper cable to Negative (-) Post of booster battery. Connect the other end of the jumper cable to a good ground on the vehicle with the discharged battery. Make sure a good connection is made, free of dirt and grease.



**Warning: Do not connect the cable to the negative post of the discharge battery.**

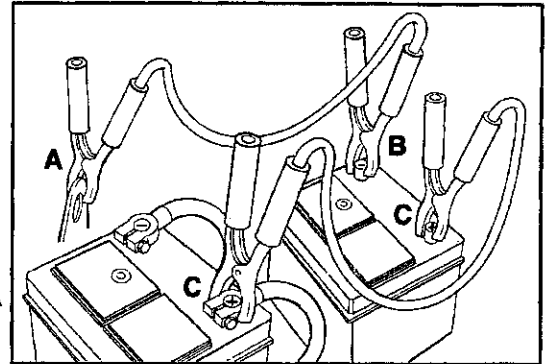
3. Take care that clamps from one cable do not inadvertently touch clamps from the other cable. Do not lean over the battery when making connection. The negative connection must provide good electrical conductivity and current carrying capacity.



**Warning: During cold weather when temperatures are below freezing point, electrolyte in a discharged battery may freeze. Do not attempt jump starting because the battery could rupture or explode. The battery temperature must be brought up above freezing point before attempting jump start.**

4. After engine is started or if engine fails to start, cables must be disconnected in the following order:

- a. Disconnect the negative cable at engine ground.
- b. Disconnect the negative cable at negative post on booster battery.
- c. Disconnect cable between positive post of both batteries.



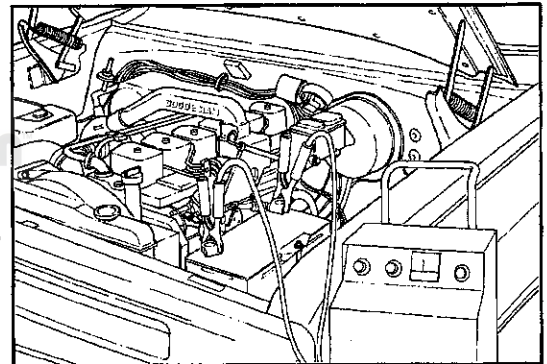
**Warning:** Any procedure other than above could result in: 1) Personal Injury caused by electrolyte squirting out the battery vent, 2) Personal Injury or property damage due to battery explosion, 3) damage to charging system of booster vehicle or of immobilized vehicle.



#### With Portable Starting Unit

There are many types of these units available. Follow instructions of their manufacturer for necessary precautions and operation.

**Caution:** However, it is very important that their operating voltage does not exceed 12 Volts D.C. because damage to battery, starter motor, alternator or electrical system may occur.



#### New Engine Break-In

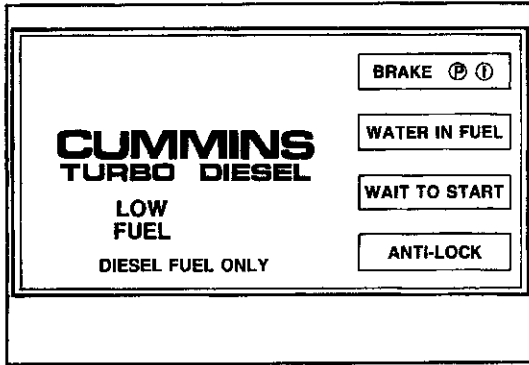
The care given the engine during the 1000 miles of operation can result in longer life, better performance and more economical operation. During this period, follow these recommendations if it is practical to do so:

- Warm up the engine before placing it under load.
- Do not operate the engine at idle or full load for more than 5 minutes.
- Avoid constant speeds.
- Use the appropriate transmission gear to prevent engine lugging.
- Observe vehicle oil pressure and temperature indicators.
- Check the coolant and oil levels frequently.

#### Starting the Engine

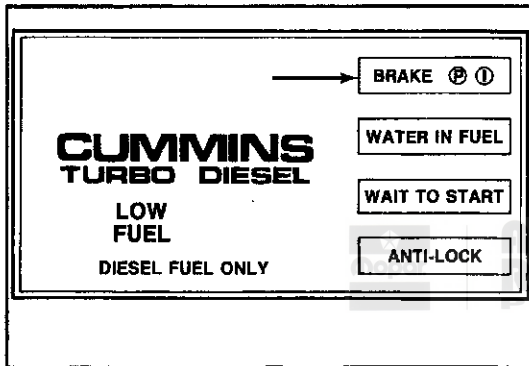
**First Start Up of the Day** - If this is the first start of the day, perform your daily maintenance checks:

- Oil Level - See Page 0C-4.
- Coolant Level - See Page 0C-4.
- If the Water in Fuel light is on, drain water from Fuel/Water Separator Filter - See Page 0C-5.
- Visually check the engine and components - See Page 0C-4, 0C-5.



### Message Center Lights

The engine warning light panel on the dash contains five warning indicator lights: Brake, Water in Fuel, Wait to Start, Anti-Lock, and Low Fuel.



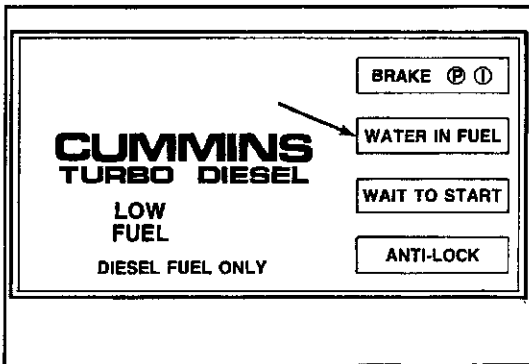
#### Brake Light – Diesel Powered Trucks



The **Brake** light is connected to a sensor that monitors vacuum in the brake booster system. The **Brake** light when lit indicates **LOW VACUUM**. If this light is lit, the brake system must be serviced\*.

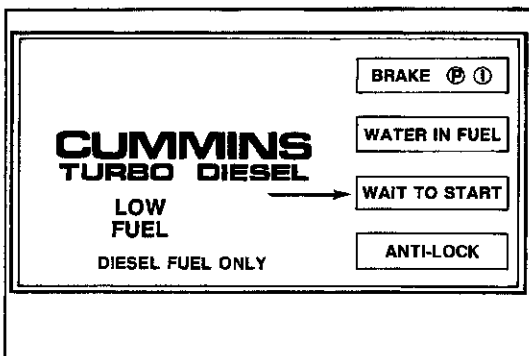
\* **Note:** This maintenance procedure must be performed by a trained service technician.

**Note:** The brake light will be activated when the Park Brake is applied or in the event of a hydraulic brake failure.



#### Water in Fuel

The **Water In Fuel** light is connected to a sensor located in the fuel filter. If water collects in the fuel\water separator filter, the **Water In Fuel** indicator will light. Refer to page 0C-5 to drain the water from the fuel\water separator filter.



#### Wait to Start

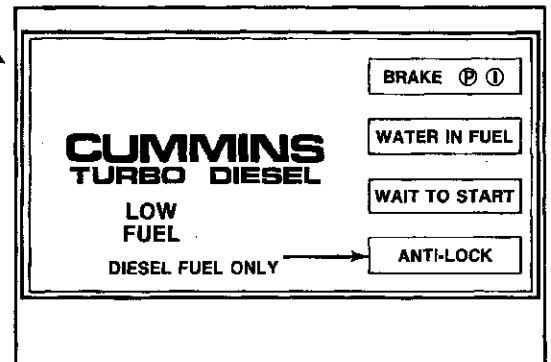
The **Wait to Start** light is connected to a sensor that monitors the intake manifold temperature in the cylinder head. When the intake manifold temperature is below  $-9^{\circ}\text{C}$  [ $15^{\circ}\text{F}$ ] (early module before serial number 0080000A) or  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ] (late module) and the ignition switch is in the ON position, the control module sends power to the intake manifold air heaters and the **Wait to Start** light.

When starting the engine, if the **Wait to Start** light comes on, leave the key in the "ON" position until the light goes out, then start the engine.

### Anti-Lock

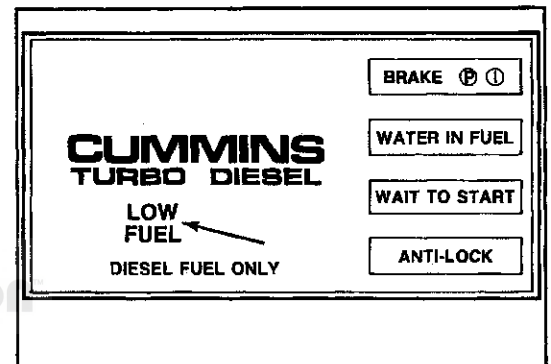
The Anti-Lock light is connected to a sensor that monitors the condition of the truck anti-lock braking system. If this light is lit, the Anti-Lock system must be serviced\*.

**\*Note:** This maintenance procedure must be performed by a trained service technician.



### Low Fuel

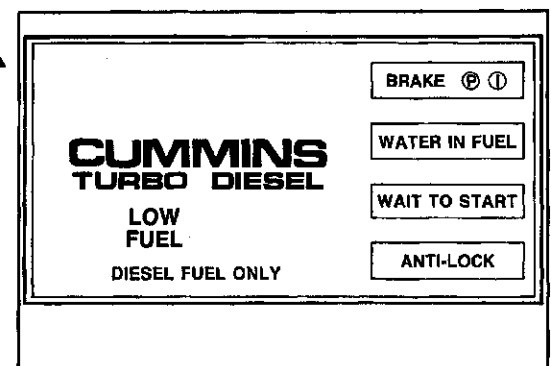
The Low Fuel light is connected to a sensor in the fuel tank. When the fuel level reaches approximately 1/6 of a tank, the words LOW FUEL will illuminate and remain on until fuel is added.



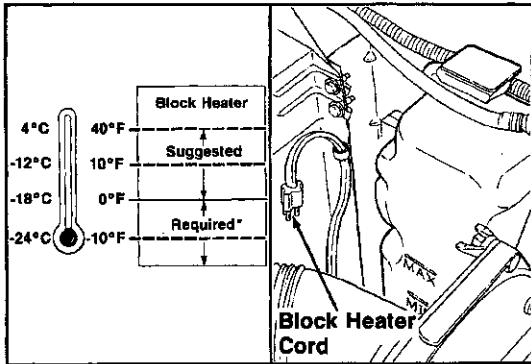
### Normal Starting Procedure

Observe the following when starting the engine:

- **Apply emergency brake**
- **Manual Transmission**
  - Disengage the clutch by depressing the clutch pedal fully.
  - Place the Transmission in Neutral.
  - Turn the key switch to ON and wait for the Wait to Start light to go off.
- **Automatic Transmission**
  - Automatic transmission must be in park.
  - Turn the key switch to ON and wait for the Wait to Start light to go off.
- **Depress the accelerator pedal to one-half of pedal travel.**
- **Turn the key switch to the Start position.**
- **Do not crank the engine (continuously) for longer than 30 seconds.**
- **Wait 2 minutes between unsuccessful starting attempts.**
- **Slow the engine to idle as soon as it starts.**
- **Make sure there is oil pressure within 15 seconds after start up. (Minimum oil pressure of 69 kPa [10 PSI])**



**Caution:** If the Water In Fuel light is lit, do not start the engine until the water has been drained from the filter and the light is out.

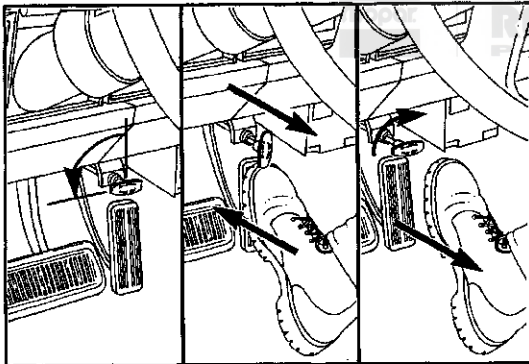


### Cold Weather Starting

Operation in ambient temperature below 0°C [32°F] may require that special considerations be given to engine starting. The following chart suggests these options:

**Note:** At temperatures below 0°C [32°F], operate the engine at moderate speeds for 5 minutes before full loads are applied.

To activate the block heater, install the heater cord into a 110 volt A.C. (6.5 Amp.) outlet.



### Engine Warm-Up



Avoid full throttle operation when the engine is cold. When starting a cold engine, bring the engine up to operating speed slowly to allow the oil pressure to stabilize as the engine warms up.

If temperatures are below 0°C [32°F], operate the engine at moderate speeds for 5 minutes before full loads are applied.

### Hand Throttle

To operate the engine at a moderate speed, the manual transmission trucks have been equipped with a hand throttle.

With the engine running, depress the throttle foot pedal to approximately 1/4 throttle. Turn the hand throttle handle counter clockwise to unlock.

Slowly pull the handle out until you feel resistance. Hold the handle while lifting your foot from the throttle pedal. If the engine speed stays constant, turn the handle clockwise to lock the throttle at this warm-up speed.

**Caution:** Do not operate the truck with the hand throttle activated.

## Engine Idling

Avoid prolonged idling for more than 10 minutes. Long periods of idling may be harmful to your engine because combustion chamber temperatures can drop so low that the fuel may not burn completely. Incomplete combustion allows carbon and varnish to form on piston rings and injector nozzles. Also, the unburned fuel can enter the crankcase, diluting the lubricating oil and causing rapid wear to the engine.

## Stopping the Engine

Idle the engine a few minutes before routine shutdown. After full load operation, idle the engine 3 to 5 minutes before shutting it down. This idle period will allow the lubricating oil and coolant to carry excess heat away from the combustion chamber, bearings and internal components. This is especially important for turbocharged engines, like your Turbo Ram.

## Operating the Engine

### Avoid overheating the engine

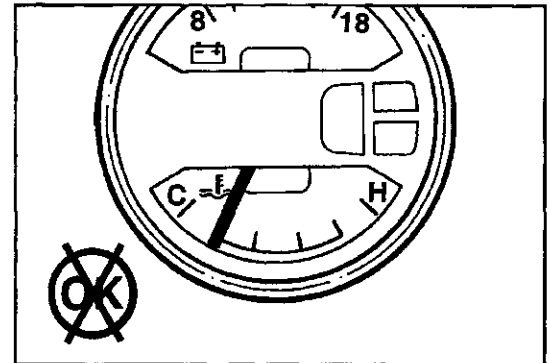
The temperature of the coolant (a mixture of 50% ethylene-glycol and 50% water) must not exceed 110°C [230°F] with a 103 kPa [15 psi] radiator cap.



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### Avoid low coolant temperature operation

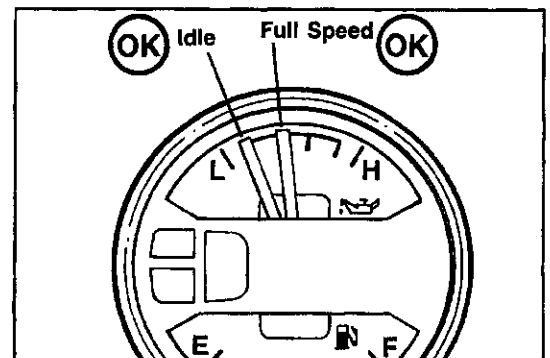
Continual operation at low coolant temperature below 60°C [140°F] can be harmful to the engine. Low coolant temperature can cause incomplete combustion which allows carbon and varnish to form on piston rings and injector nozzles. Also, the unburned fuel can enter the crankcase, diluting the lubricating oil and causing rapid wear to the engine.



### Do not operate the engine with low oil pressure

When the engine is at normal operating temperature, the minimum oil pressures required are:

- Idle 700 to 800 RPM..... 69 kPa [10 PSI]
- Full speed and load..... 207 kPa [30 PSI]
- Turn on dash light..... 41 kPa [6 PSI]



### **Do not operate the engine with failed parts**

Practically all failures give some warning before the parts fail. Be on the alert for changes in performance, sounds and visual evidence that the engine requires service. Some important clues are:

- Engine misfiring or vibrating severely.
- Sudden loss of power.
- Unusual engine noises.
- Fuel, oil or coolant leaks.
- Sudden change in the engine operating temperature.
- Excessive smoke.
- Oil pressure drop.
- Etc.

### **Prevent over-speeding the engine going down hill**

When descending steep grades, use a combination of gears and service brakes to control vehicle/engine speed. Over speed can cause severe engine damage.

### **Fuel Requirement**

**Warning: Do not use alcohol or gasoline as a fuel blending agent. They can be unstable under certain conditions and be hazardous or explosive when mixed with diesel fuel.**

Use only good quality ASTM No. 2 Diesel Fuel.

In extreme cold temperatures, a winter blend of fuel should be used to prevent "waxing" in the fuel filters (See Section 0E - Fuel Specifications).

### **Avoid using contaminated fuel**

Fuel that is contaminated by water, gasoline or dirt can cause severe damage to the engine fuel system. Proper maintenance of the engine fuel filter and fuel tank is essential.

### **Bulk Fuel Storage**

If you store quantities of fuel, good maintenance of the stored fuel is also essential. Fuel contaminated with water will promote the growth of microbes. These microbes form "slime" that will clog fuel filters and lines. Drain condensation from the supply tank and change the line filter on a regular basis.

## Oil Performance Recommendations

Use **CE/SF** or **CE/SG** grade oil (equivalent to MIL-L-45199B) in your Cummins Turbo Diesel Engine.

**Note:** **CC/CD** or **CD/SF** oils can be used in areas where **CE** oil is not yet available.

**Dual Category oils** provide the performance required of each individual category. For example, a **CC/CD** oil is blended to meet both **CC** and **CD** performance levels.

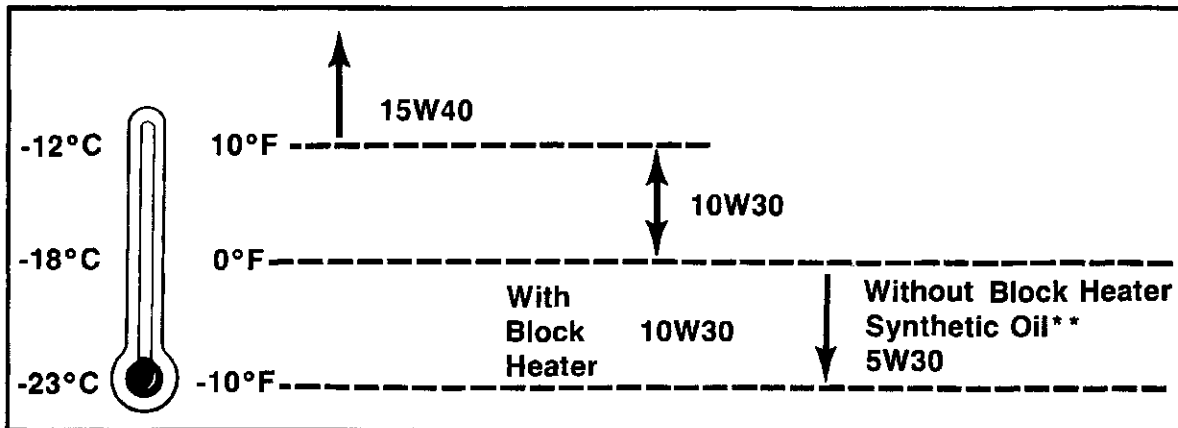
A **Sulfated Ash Limit** is specified for lubricating oil used in the Cummins Turbo Diesel Engine. Past experience has shown that oils with a high ash content may produce deposits on valves that can progress to guttering and valve burning. A maximum sulfated ash content of 1.85 mass % is recommended for all oil used in the engine.

### Break-In oils

**Do not use special "break-in" lubricating oils in the Cummins Turbo Diesel Engine.** Use the lubricating oils specified for normal engine operation. (See Section 0E - Lubricating Oil Specifications for complete details).

### Oil viscosity recommendations

Use a multi-graded\* oil, with the viscosity grades shown below, in the Cummins Turbo Diesel Engine. The use of single grade lubricating oil is not recommended.



- Notes:**
- \* 20W20 is not considered a multi-grade oil.
  - \*\* The same oil change interval is to be followed for synthetic oil as for petroleum based oil. Also, synthetic oil must meet the same performance specifications as petroleum oil. (See Section 0E for Lubricating Oil Specifications)



### Arctic operation

Where there are no provisions to keep the engine warm when it is operating in ambient temperatures consistently below  $-23^{\circ}\text{C}$  [ $-10^{\circ}\text{F}$ ], use a lubricating oil that meets the following requirements (See Section 0E - Lubricating Oil Specifications).

SAE 5W30 viscosity grade synthetic oils may be used provided they meet the minimum viscosity at  $100^{\circ}\text{C}$  [ $212^{\circ}\text{F}$ ].

### Coolant

Use antifreeze during all seasons to protect the cooling system from corrosion as well as freezing damage. The antifreeze should be changed every two years.

A mixture of 50% water and 50% ethylene-glycol base antifreeze is required for operation of the engine in temperature environments above  $-37^{\circ}\text{C}$  [ $-34^{\circ}\text{F}$ ]. A mixture of 40% water and 60% antifreeze is recommended for temperatures below  $-37^{\circ}\text{C}$  [ $-34^{\circ}\text{F}$ ].

**Note:** In tropical climates where antifreeze availability may be limited, use a corrosion inhibitor (Cummins Liquid DCA, or an equivalent) to protect the engine cooling system.

## Maintenance Guidelines

### Section 0C

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### Maintenance Schedules

While specific maintenance periods are given in the following Maintenance Schedule, remember that the actual operating environment of the engine governs the maintenance schedule. If the engine is operating in extreme conditions, you must adopt a shorter maintenance period than indicated. Use the following schedule as a guide in developing a maintenance program to fit your specific operation.

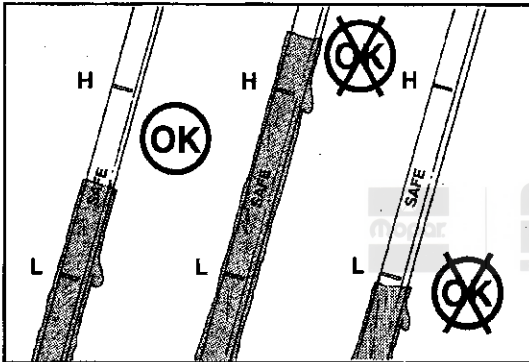
MAINTENANCE SCHEDULE				
Daily or Refueling	Every 6 Months or 9700 Km [6000 Mi.]	Every 12 Months or 19,300 Km [12,000 Mi.]	Every 24 Months or 38,600 Km [24,000 Mi.]	Every 48 Months or 77,200 Km [48,000 Mi.]
<ul style="list-style-type: none"> <li>• Oil Level</li> <li>• Coolant Level</li> <li>• Fuel/Water Separator Filter (if Water-in-Fuel light is lit)</li> <li>• Visual Check of Components</li> </ul>	<b>Change/Replace</b>			
	<ul style="list-style-type: none"> <li>• Lubricating Oil</li> <li>• Lubricating Filter</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricating Oil</li> <li>• Lubricating Filter</li> <li>• Fuel Filter</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricating Oil</li> <li>• Lubricating Filter</li> <li>• Fuel Filter</li> <li>• Air Cleaner</li> <li>• Antifreeze*</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricating Oil</li> <li>• Lubricating Filter</li> <li>• Fuel Filter</li> <li>• Air Cleaner</li> <li>• Antifreeze*</li> </ul>
	<b>Adjust</b>			
			<ul style="list-style-type: none"> <li>• Valve Lash Clearance</li> </ul>	<ul style="list-style-type: none"> <li>• Valve Lash Clearance</li> </ul>
	<b>Check/Inspect</b>			
<ul style="list-style-type: none"> <li>• Air Cleaner</li> <li>• Intake System</li> </ul>	<ul style="list-style-type: none"> <li>• Air Cleaner</li> <li>• Intake System</li> <li>• Antifreeze</li> </ul>	<ul style="list-style-type: none"> <li>• Intake System</li> <li>• Fan Hub</li> <li>• Belt Tensioner Bearing</li> <li>• Belt Tension</li> <li>• Vibration Damper</li> </ul>	<ul style="list-style-type: none"> <li>• Intake System</li> <li>• Fan Hub</li> <li>• Belt Tensioner Bearing</li> <li>• Belt Tension</li> <li>• Vibration Damper</li> </ul>	
<p>* In tropical climates where antifreeze availability may be limited, use a corrosion inhibitor (Cummins Liquid DCA or an equivalent) to protect the engine cooling system.</p>				



## Daily Maintenance

Preventative maintenance is the easiest and least expensive type of maintenance. Preventative maintenance begins with a day-to-day awareness of the condition of your engine and its systems. Each time you re-fuel the truck, check the following:

- Oil level
- Coolant level
- If the **Water in Fuel** light is lit, drain water from the fuel/water separator filter.
- Visually check for leaks, loose parts, frayed belts, etc.

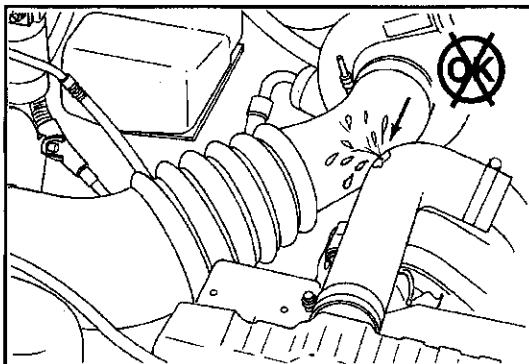


### Oil level - Check



Check the engine oil level. Never operate the engine with the oil level below the "L" (LOW) mark or above the "H" (High) mark.

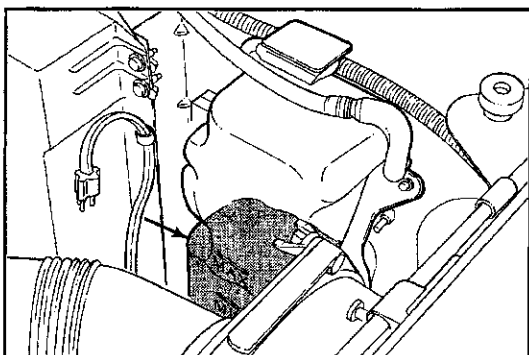
The oil capacity between the low mark and the high mark on the oil dipstick is 1.89 liters [2 U.S. quarts].



### Cooling system - Check



Inspect the cooling system and hoses for leaks or signs of wear. Check the radiator fins for excessive dirt and debris.



### Coolant recovery tank coolant level - Check



Visually check the level of coolant recovery tank. When the engine is running and is at operating temperature, the level should be between the MIN and MAX marks.

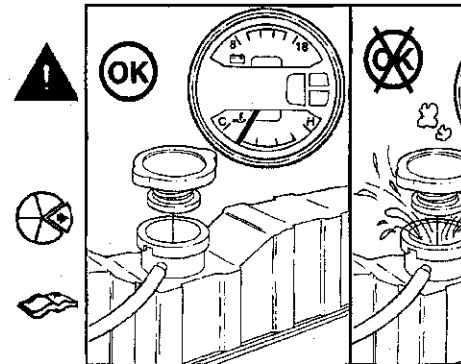
If coolant is required, refer to Cooling Specifications Section 0E.

### Radiator coolant level – Check

**Warning:** Check the radiator coolant level only when the engine is stopped. Wait until the temperature is below 50°C [120°F] before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Remove the filler cap slowly to relieve coolant system pressure. Check the level of the coolant.

If coolant is required, refer to Cooling Specifications Section 0E.



### Draining fuel/water separator filter

**Caution:** Do not drain the fuel/water separator filter when the engine is running.

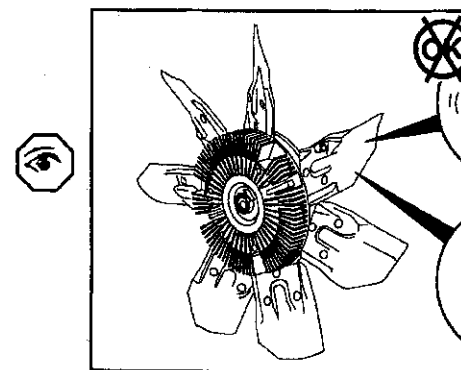
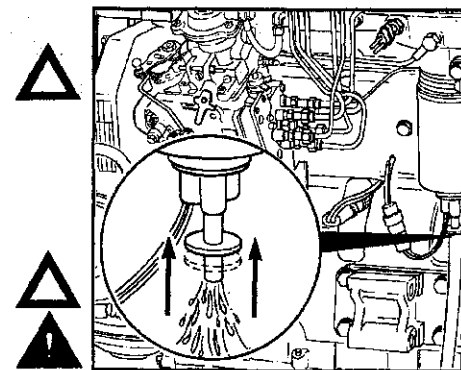
When the dash light **Water In Fuel** is on, drain accumulated water from the fuel/water separator filter. Open the valve on the bottom of the fuel filter (Push Up) to allow any accumulated water to drain. Close (Release Valve) the drain when clean fuel is visible.

**Caution:** Diesel fuel will damage Black Top paving surfaces. Drain the filter into an appropriate container.

**Warning:** Do not use alcohol or gasoline as a fuel blending agent. They can be unstable under certain conditions and be hazardous or explosive when mixed with diesel fuel.

### Fan – Inspection

Check the fan for cracks, loose rivets and bent or loose blades. Make sure it is securely mounted. Tighten the capscrews if loose. Always replace damaged fan.



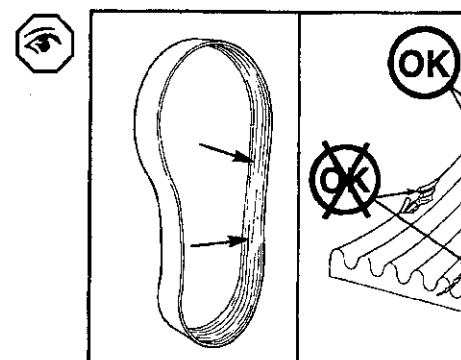
### Drive belt – Inspection

Check the belt for intersecting cracks.

- Transverse (across the belt width) cracks are acceptable.
- Longitudinal (direction of belt length) cracks that intersect with transverse cracks are **NOT** acceptable.

\* Replace the belt if it has unacceptable cracks, is frayed or has pieces of material missing.

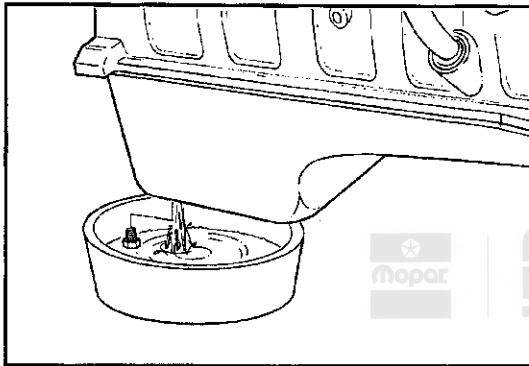
\* **Note:** These maintenance procedures must be performed by a trained service technician.



### Maintenance Every 6 Months or 9,700 Km [6,000 Miles]

Always use the interval (Months or Km [Miles]) that expires first. Perform the Daily Maintenance Procedures and the following:

- Change the lubricating oil and filter.
- Check the air intake system.
- Clean or replace the filter as required.



17mm

Lubricating oil and filter – Change

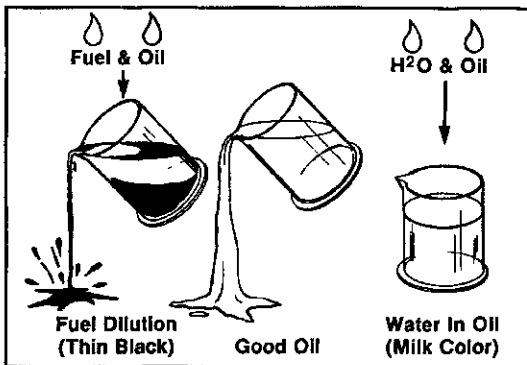


Warning: Hot oil can cause personal injury.



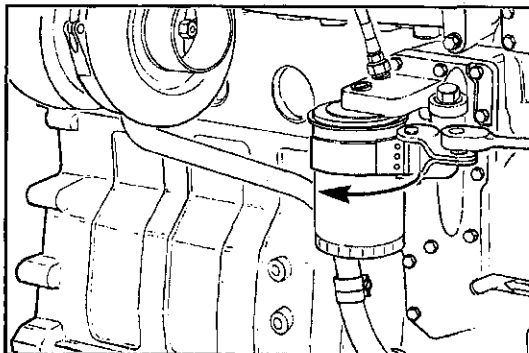
Operate the engine until the water temperature reaches 60°C [140°F]. Shut the engine off. Remove the oil drain plug.

Use a container that can hold at least 14 liters [15 U.S. quarts] to hold the used oil.



Always check the condition of the used oil. This can give you an indication of some engine problems that might exist.

- Thin, black oil indicates fuel dilution.
- Milky discoloration indicates coolant dilution.



Clean the area around the lubricating oil filter head. Remove the filter using a 90-95 mm filter wrench.



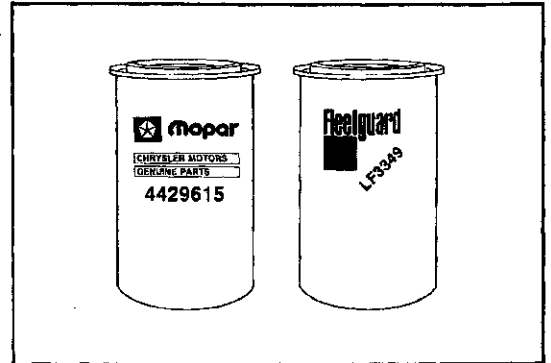
Clean the gasket surface of the filter head. The filter canister o-ring seal can stick on the filter head. Make sure it is removed.



Any one of the following lubricating oil filters can be used on the Cummins Turbo Diesel engine.



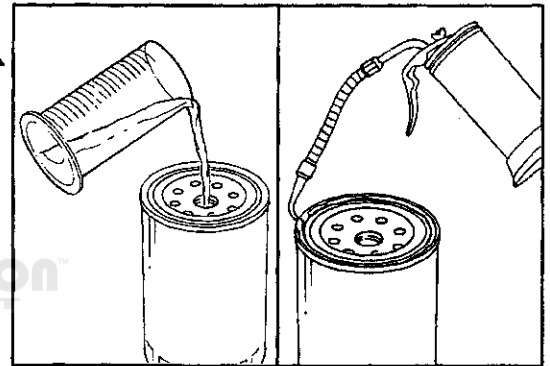
Part No.	Manufacturer
4429615 .....	Chrysler
LF3349 .....	Fleetguard



**Caution:** Fill the oil filter element with clean oil before installation. Use the same type oil that will be used in the engine.



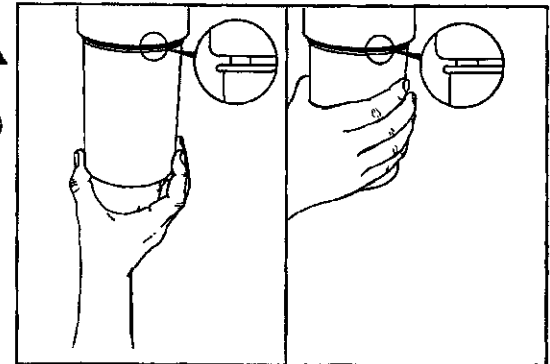
Apply a light film of lubricating oil to the sealing surface before installing the filter.



**Caution:** Mechanical over-tightening may distort the threads or damage the filter element seal.



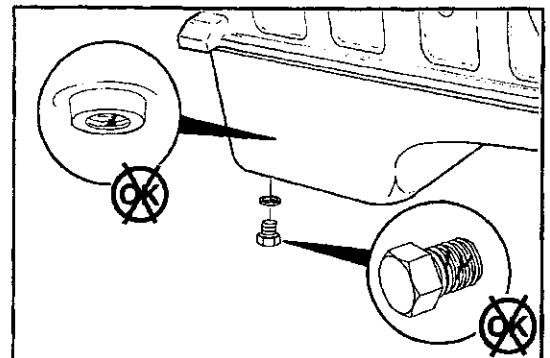
Install the filter as specified by the filter manufacturer.



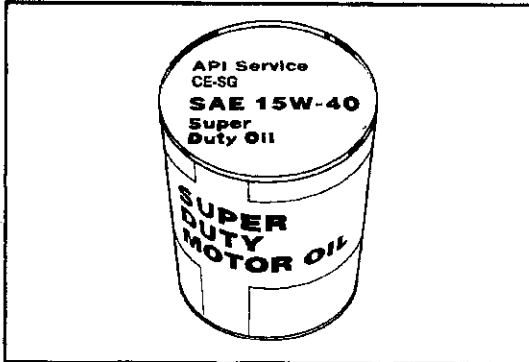
### 17mm


Check the condition of the threads and sealing surface on the oil pan and drain plug.

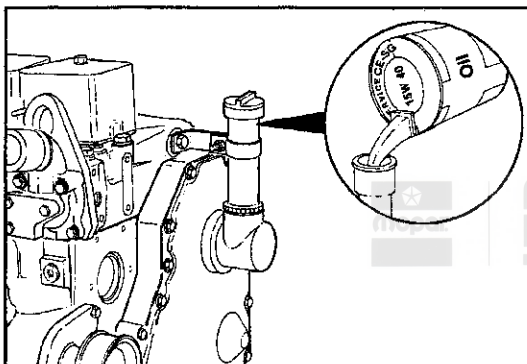
Clean the drain plug and the sealing surface of the pan. Install a new drain plug sealing washer, Chrysler Part #4429216. Install the drain plug and sealing washer. Tighten to 80 N-m [60 ft-lbs].



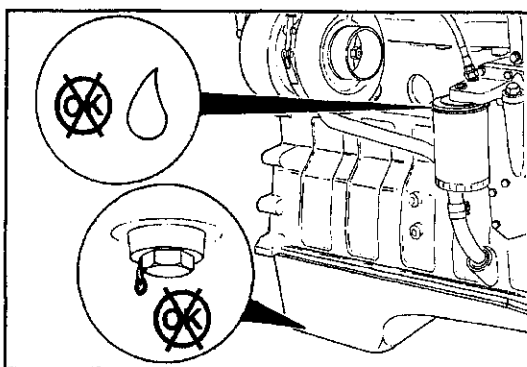





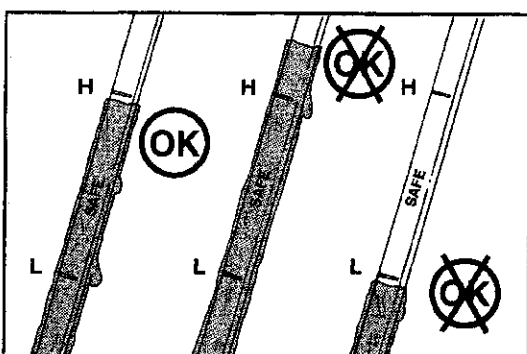
 Use only **High-Quality Multi-Grade** lubricating oil in your Cummins Turbo Diesel Engine. Choose the correct oil for your operating conditions as outlined in the Oil Specifications Section 0E.




Fill the engine with the correct grade of new oil. The engine capacity is 10.4 liters [11 U.S. quarts] in the crankcase and .95 liter [1 U.S. quart] in the lubricating oil filter.



 Start the engine and operate it at idle for several minutes. Check for leaks at the filter and drain plug.



 Stop the engine. Wait approximately 5 minutes to let the oil in the upper parts of the engine drain back to the pan. Check the oil level again.

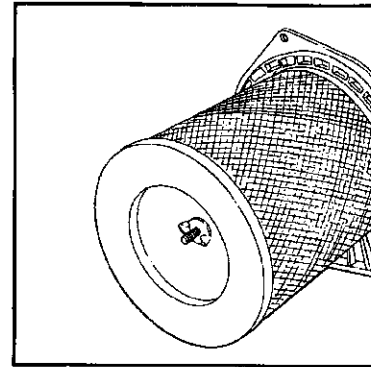
Add oil as necessary to bring the level to the **"H" (High)** mark on the dipstick.

Lubrication and Maintenance  
DODGE Turbo Diesel

Mainten

**Air cleaner element – Inspection**

Check the air cleaner element carefully. If there is even the smallest hole in the element, the element must be replaced. Clean or replace the element as necessary.



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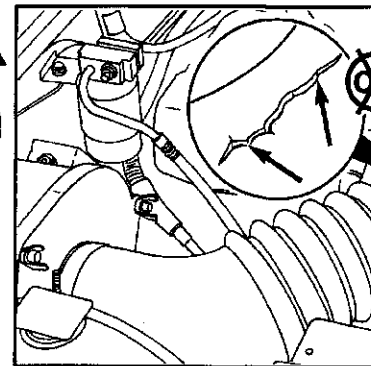
**Caution: All air entering the engine intake must be filtered. The abrasive particles in un-filtered air will cause rapid wear to engine components.**



Inspect the filter housing and air intake piping for cracks, loose clamps, or punctures which would allow un-filtered air to enter the engine.



Tighten or replace parts as necessary to make sure the air intake system does not leak.

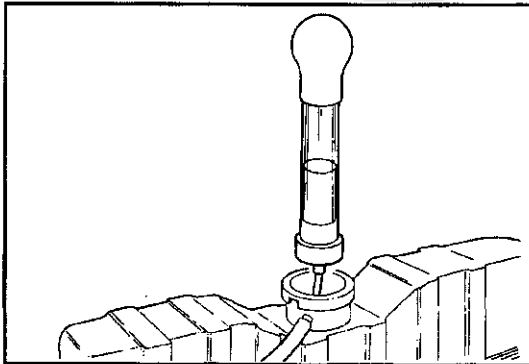


**Maintenance Every 12 Months or 19,300 Km [12,000 Miles]**

Always use the interval (Months, or Km [Miles]) that arrives first. Perform the **6 Month 9,700 Km [6,000 Miles] Maintenance Procedures** and the following:

- Check the antifreeze concentration. Refer to Cooling System (Section 7).
- \* Change the fuel filter. Refer to Fuel System (Section 14).

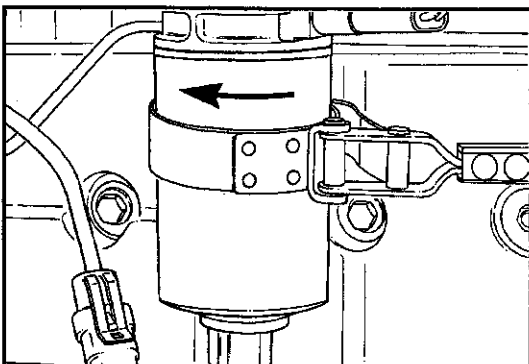
\* **Note:** This maintenance procedure must be performed by a trained service technician.



**Antifreeze concentration – Check**



Check the antifreeze concentration. Refer to Coolant Specifications Section 0E.



**Fuel Filter – Change**

Change the fuel filter. Refer to Fuel System (Section 14).

## Maintenance Every 24 Months or 38,600 Km [24,000 Miles]

Always use the interval (Months, or Km [Miles]) that arrives first. Perform the 12 Month or 19,300 Km [12,000 Miles] Maintenance Procedures and the following:

- Replace air filter (See section 11)
- Change coolant and flush system (See Sections 0C, 0G, 0H, and 7)
- \* Adjust the valves (See section 9F)
- \* Check the fan hub (See section 7)
- \* Check the belt tensioner bearing (See section 7)
- \* Check the belt tension (See section 7)
- Check the vibration damper (See Section 9E)

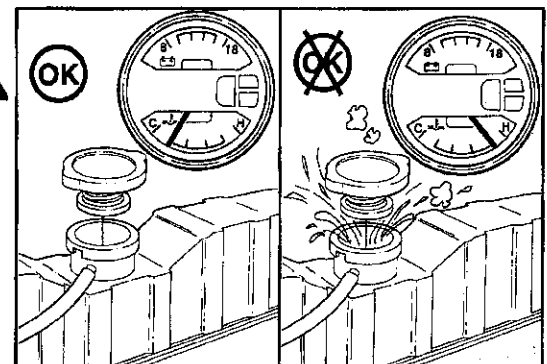
\* **Note:** These maintenance procedures must be performed by a trained service technician.



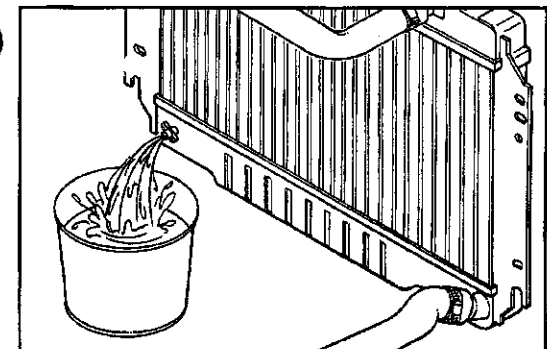
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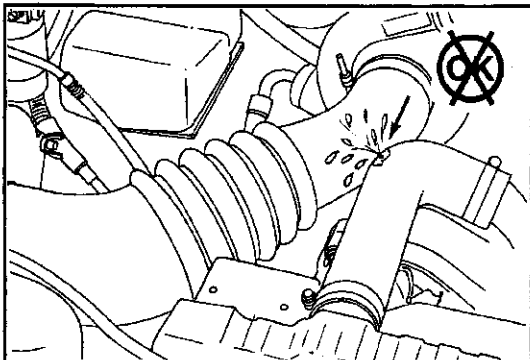
### Coolant – Drain

**Warning:** Wait until the temperature is below 50°C [120°F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

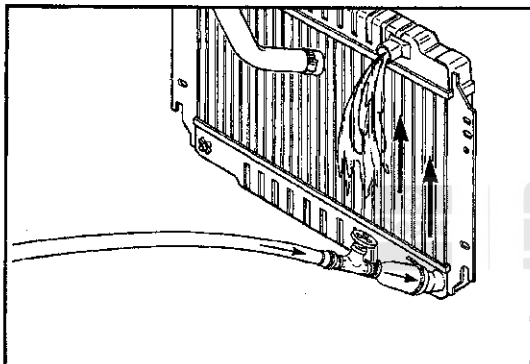


Drain the cooling system by opening the drain valve on the radiator. A drain pan with a capacity of 20 liters [5 U.S. gallons] will be adequate to hold the coolant.





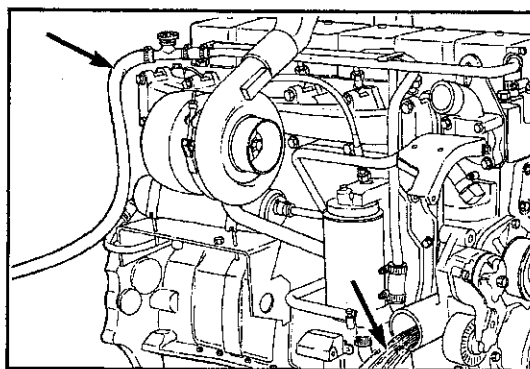
Check for damaged hoses and loose or damaged hose clamps. Replace as required. Check the radiator for leaks, damage or dirt build-up. Clean and repair as required.



### Cooling System - Flush

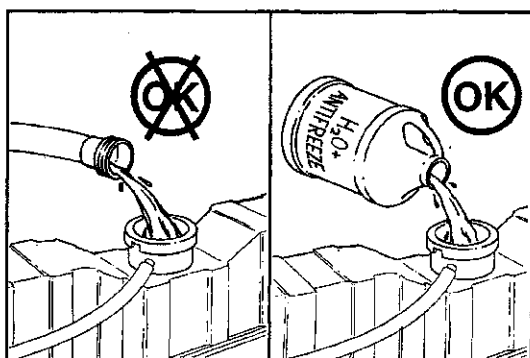
To clean the cooling system, back flush the radiator and engine with clean water.

Remove both radiator hoses from the engine. Attach the water supply to the lower radiator connection and back flush the radiator. If the radiator shows mineral build-up, scale, rust or oil, use a heavy duty radiator cleaner and follow the manufacturer's directions.



Remove the top heater hose. Attach the water supply to the heater line and back flush the engine.

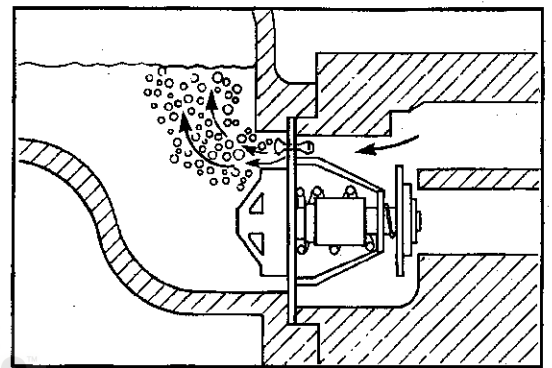
If the engine shows mineral build-up, scale, rust or oil, use a heavy duty radiator cleaner and follow the manufacturer's directions.



Re-fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze. Refer to the Coolant Specifications in Section 0E.

During filling, air must be vented from the engine coolant passages. The air vents through the "jiggle pin" openings in the thermostat out the top radiator hose and fill opening.

The system has a maximum fill rate of 14 liters/minute [3.5 U.S. gallons/minute]. Do not exceed this fill rate.

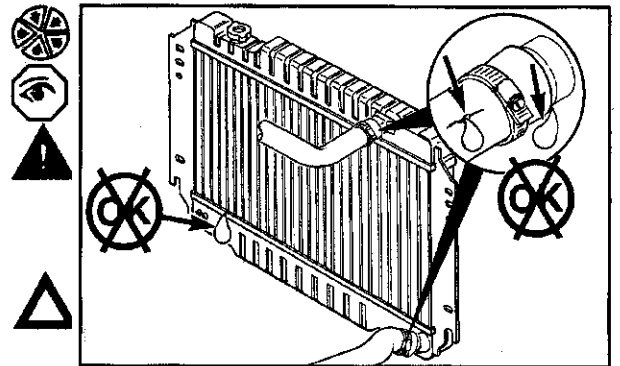


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Install the pressure cap. Start the engine and operate it until it reaches a temperature of 80°C [180°F]. Check the system for leaks.

**Warning:** If the engine has been operating and the coolant is hot, wait until the temperature is below 50°C [120°F] before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

**Caution:** Re-check the cooling system to insure total system is full of coolant.



### Maintenance Every 48 Months or 77,200 Km [48,000 Miles]

Always use the interval (Months, or Km [Miles]) that arrives first. Perform the 24 Month or 38,600 Km [24,000 Miles] Maintenance Procedures.



## Engine Systems - Flow Diagrams

### Section 0D

### Contents

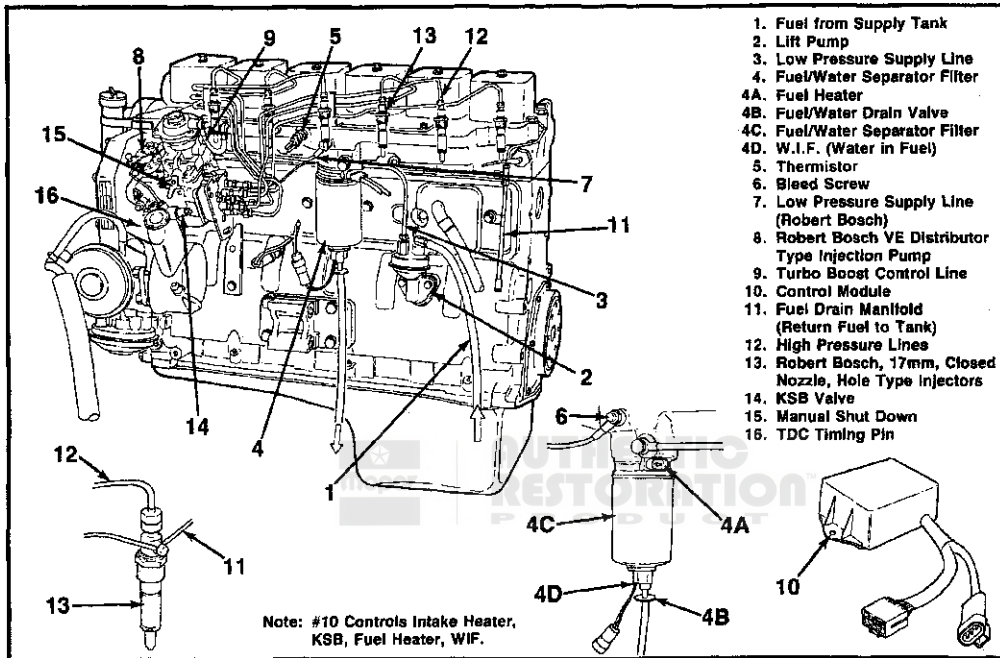
<b>Subject</b>	<b>Page</b>
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Fuel System .....	0D-2
Air System .....	0D-2
Cooling System .....	0D-3
Lubricating Oil System .....	0D-3
Lubrication for the Turbocharger .....	0D-4
Lubrication for the Power Components .....	0D-4
Lubrication for the Overhead .....	0D-5



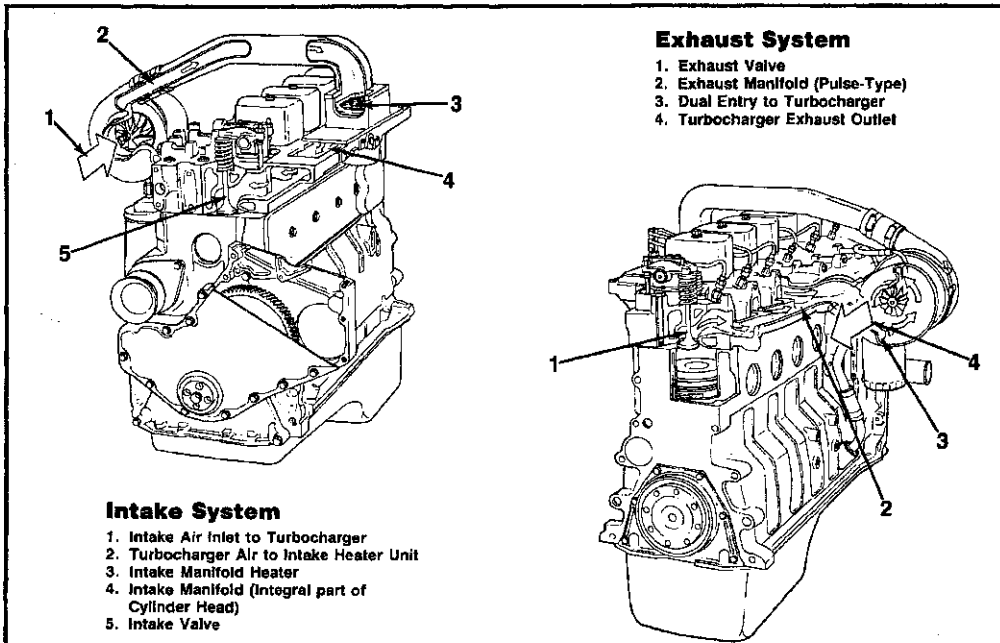
## Engine Diagrams

The following drawings depict flow the various engine systems. A knowledge of the systems can help you with troubleshooting and general engine maintenance.

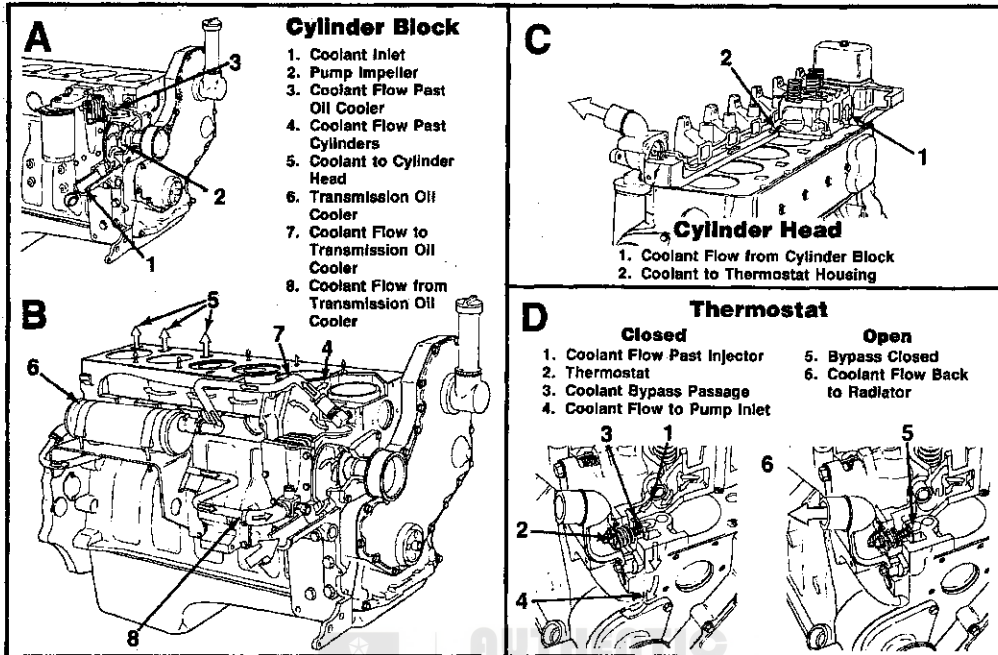
### Fuel System



### Air System

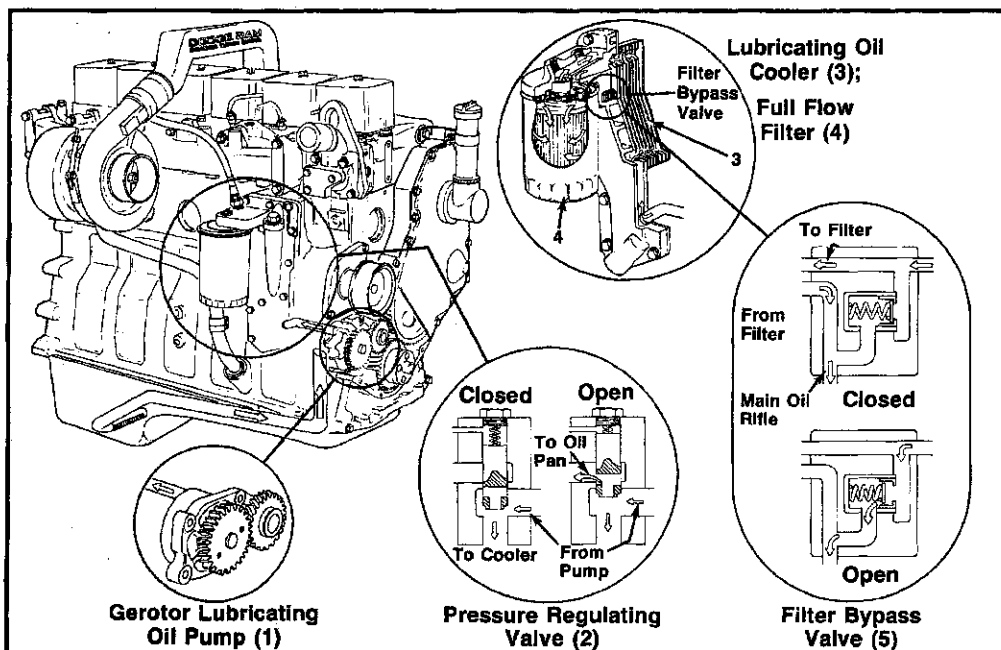


### Cooling System

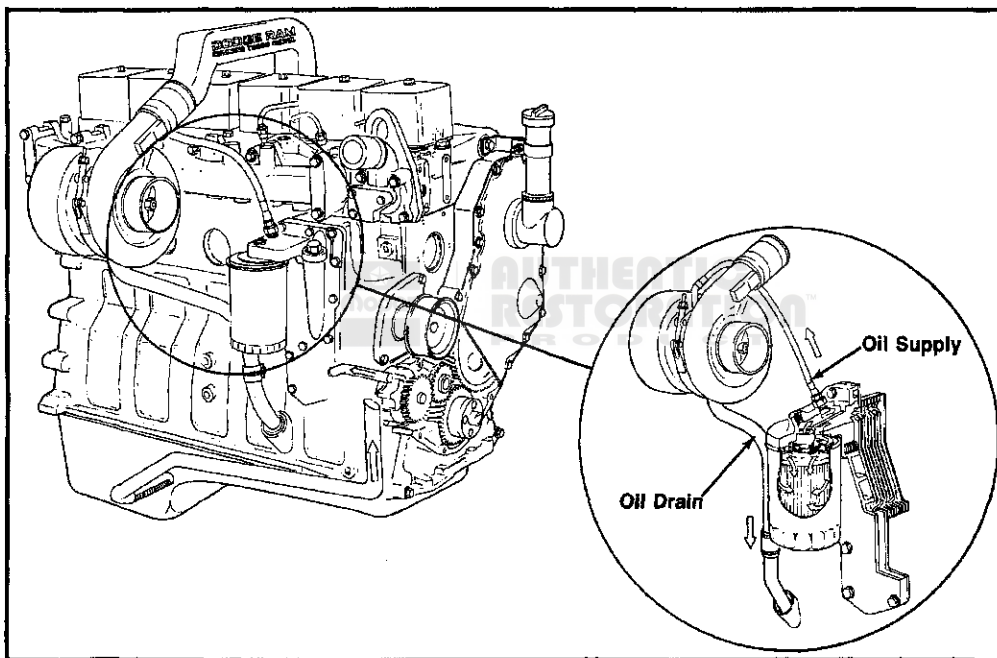


### Lubricating Oil System

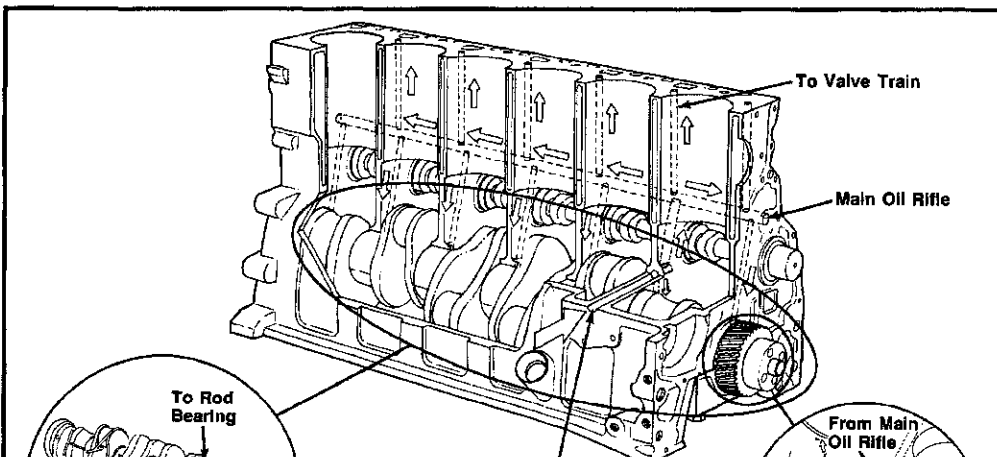
The schematics on the next three pages illustrate the engine oil lubrication system. The arrows indicate the flow path of the oil. The lubrication pump draws oil from the pan and forces it through the lubrication system. The pressure regulation valve controls the oil pressure in the system. The filter bypass valve ensures a supply of oil in the event the filter becomes plugged. The piston pins are lubricated by the splash from the piston cooling nozzles. The oil pump idler gear bushing is pressure lubricated. The remainder of the front gear train is lubricated by oil carry-over and splash.



### Lubrication for the Turbocharger

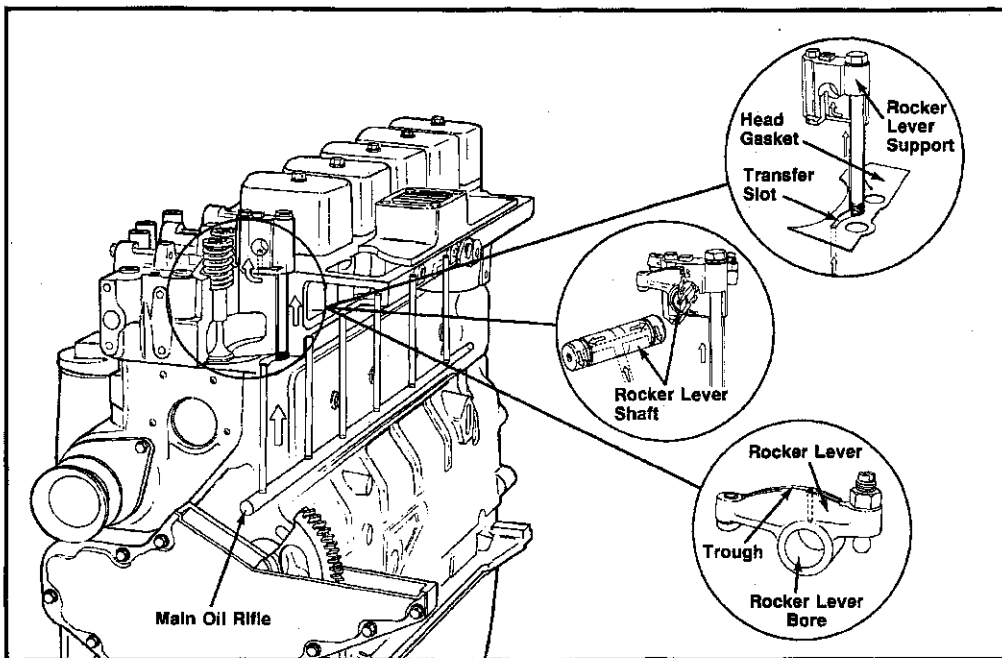


### Lubrication for the Power Components





### Lubrication for the Overhead





## Engine Specifications

### Section 0E

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Arctic Operations .....	0E-4
Fuel Specifications .....	0E-4

## Engine Specifications

Description	Specification
<b>General Engine Data</b>	
Bore - mm [in.] .....	102 [4.02]
Stroke - mm [in.] .....	120 [4.72]
Displacement - liter [in. <sup>3</sup> ] .....	5.88 [359]
Engine Weight (Dry) Less Flywheel and Electric kg.. [lbs.] .....	399 [880]
Firing Order .....	1,5,3,6,2,4
Valve Clearance - Intake - mm [in.] .....	.25 [.010]
Valve Clearance - Exhaust - mm [in.] .....	.51 [.020]
Compression Ratio .....	17.5:1
Rotation, viewed from front of engine .....	Clockwise
Aspiration .....	Turbocharged
<b>Lubrication System</b>	
Oil Pressure at Idle - (Minimum Allowable) kPa [PSI] .....	69 [10]
Oil Pressure at Rated - (Minimum Allowable) kPa [PSI] .....	207 [30]
Regulating Valve Opening Pressure kPa [PSI] .....	414 [60]
Differential Pressure to Open the Filter Bypass Valve - kPa [PSI] .....	138 [20]
Oil Capacity of Pan - liters [U.S. quarts] <b>High Mark</b> .....	10.5 [11]
Oil Capacity of Pan - liters [U.S. quarts] <b>Low Mark</b> .....	8.6 [9]
Oil Capacity of Oil Filter - liter [U.S. quart] .....	.95 [1]
<b>Cooling System</b>	
Total Cooling System Capacity* (Manual) liters [U.S. quarts] .....	14.7 [15.5]
Total Cooling System Capacity* (Automatic) liters [U.S. quarts] .....	15.7 [16.5]
Coolant Recovery Tank liter [U.S. quart] .....	.95 [1]
Cooling Capacity (Engine only) liters [U.S. quarts] .....	10.5 [11.1]
Standard Modulating Thermostat Maximum Range Start to Fully Open - °C [°F].....	83°C [181°F] to 95°C [203°F]
Pressure Cap - kPa [PSI] 110°C [230°F] System.....	103 [15]
<b>Intake Air, Exhaust Systems</b>	
Maximum Allowable Intake Restriction at Rated Speed and Load with Dirty Air Filter Element - mm H <sub>2</sub> O [in. H <sub>2</sub> O] .....	635 [25]
Maximum Allowable Exhaust Restriction (Back Pressure) at Rated Speed and Load - mm Hg [in. Hg] .....	177.8 [7]
<b>Fuel System</b>	
Maximum Allowable Restriction to Fuel Lift Pump - mm Hg [in. Hg] .....	95 [3.75]
Maximum Allowable Fuel Return line Restriction - mm Hg [in. Hg] .....	518 [20.4]
<b>Electrical System</b>	
Minimum Recommended Battery Capacity with Accessories - 12V Starter .....	1025CCA
Maximum Allowable Resistance of Starting Circuit - with 12V Starter - Ohms .....	.0012

\* Coolant Recovery Tank not included in Total Cooling System Capacity.

### Coolant Specifications

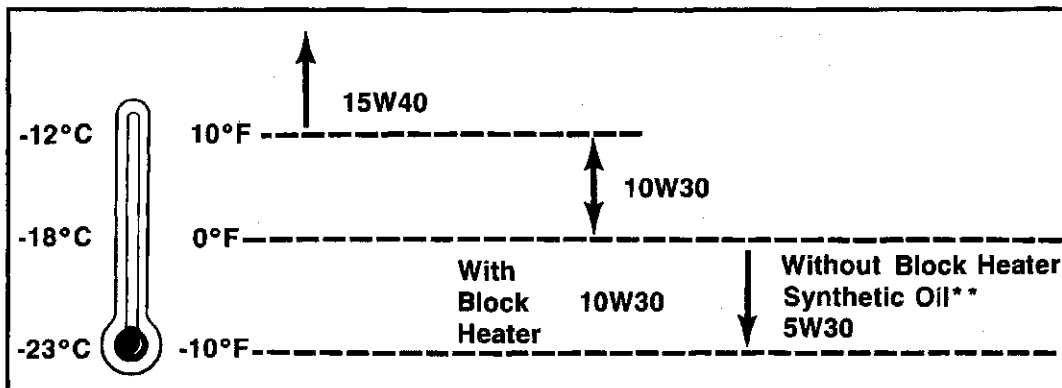
Use antifreeze during all seasons to protect the engine cooling system from corrosion as well as freezing damage. The antifreeze should be changed every two years.

A mixture of 50% water and 50% ethylene-glycol base antifreeze is required for operation of the engine in temperature environments above  $-37^{\circ}\text{C}$  [ $-34^{\circ}\text{F}$ ]. A mixture of 40% water and 60% antifreeze is recommended for temperatures below  $-37^{\circ}\text{C}$  [ $-34^{\circ}\text{F}$ ].

**Note:** In Tropical climates where antifreeze availability may be limited, use a corrosion inhibitor (Cummins liquid DCA) or equivalent to protect the engine cooling system.

### Oil Viscosity Recommendations

The use of a multi-grade lubricating oil has been found to improve oil consumption control and improve engine cranking in cold temperatures while maintaining lubrication at high operating temperatures. A multi-grade oil, with a viscosity grade as shown in the following table is recommended. The use of single grade lubricating oil is not recommended.



**Note:**\*20W20 is not considered a multi-grade oil.

**Note:\*\*** The same oil change interval is to be followed for synthetic oil as for petroleum based oil.



## Arctic Operations

Where there are no provision to keep the engine warm when it is operating in ambient temperatures consistently below -23°C [-10°F], use a lubricating oil that meets the following requirements.

SAE 5W30 viscosity grade synthetic oils may be used provided they meet the minimum viscosity at 100°C [212°F].

Parameter Test Method	Specifications
Performance Quality .....	API Classification CE-SG, CE-SF, CD-SF, or CC/CD-SF
Viscosity .....	10,000mPa <sup>0</sup> s Maximum at -35°C [-31°F] 4.1 mm <sup>2</sup> /s Minimum at 100°C [212°F]
Pour Point (ASTM D-97) .....	Minimum of 5°C [9°F] Below the Lowest Expected Ambient Temperature
Sulfated Ash Content (ASTM D-874) .....	Maximum of 1.85% by Weight Maximum

## Fuel Specifications

The Cummins Turbo Diesel engine has been developed to take advantage of the high energy content and generally lower cost No. 2 Diesel Fuels. Experience has shown that it also operates satisfactorily on No. 1 Diesel Fuels or other fuels within the following specifications.

Fuel Property	Specification	Lab Test Method
Viscosity .....	(ASTM D-445) .....	1.3 to 5.8 CentiStroke [1.3 to 5.8 mm <sub>2</sub> per Second] at 40°C [104°F]
Cetane Number .....	(ASTM D-613) .....	40 minimum except in cold weather or in service with prolonged low loads, a higher cetane number is desirable.
Sulfur Content .....	(ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment .....	(ASTM D-1796) .....	Not to exceed 1% by weight.
Carbon Residue .....	(Ramsbottom ASTM D-524 or 189)	Not to exceed 1% by weight on 10% residue.
Flash Point .....	(ASTM D-93) .....	52°C [125°F] minimum. Certain marine registries require higher flash points.
Density .....	(ASTM D-287) .....	-1 to 6°C [30 to 42°F] A.P.I. at 16°C [60°F] 0.816 to 0.876 Sp. Gr.
Cloud Point .....	(ASTM D-97) .....	-12°C [10°F] below lowest temperature expected to operate at.
Active Sulfur Copper Strip Corrosion .....	(ASTM D-130) .....	Not to exceed No. 2 rating after 3 hours at 50°C [122°F].
Ash .....	(ASTM D-482) .....	Not to exceed 0.02% by weight.
Distillation .....	(ASTM D-86) .....	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 360°C [680°F]. All of the fuel should evaporate at less than 385°C [725°F].

\*No. 1 Diesel Fuels should only be used where extended arctic conditions -23°C [-10°F] exist.

**SCHEDULED MAINTENANCE FOR VEHICLE EMISSION CONTROL & PROPER VEHICLE PERFORMANCE  
HEAVY DUTY CYCLE - DIESEL ENGINES**

	MILEAGE IN THOUSANDS (1)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108
COMPONENT MAINTENANCE	KILOMETERS IN THOUSANDS (1)	9.6	19	29	38	48	58	67	77	85	96	106	116	125	135	145	154	164	174
<b>EMISSION RELATED</b>																			
Engine Air Filter - Replace At	-----				X				X				X				X		
Engine Air Filter - Clean At (Inspect Air Inlet Pipe)	-----	X	X	X		X	X	X		X	X	X		X	X	X		X	X
<b>NON-EMISSION RELATED</b>																			
Alternator Brushes - Replace	-----													X					
Engine Coolant - Flush and Replace at 24 Months Or [24,000 Miles] 38,600 Km	-----				X				X				X				X		
Engine Coolant Condition, Coolant Hoses and Clamps - Check Every 12 Months	-----		X		X		X		X		X		X		X		X		X
Engine Oil - Change Every 6 Months Or	-----	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Engine Oil Filter - Replace At Every Oil Change	-----	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fuel Filter	-----		X		X		X		X		X		X		X		X		X
Drive Belt - Check Condition and Replace As Necessary	-----				X				X				X				X		
Vibration Damper - Inspect	-----				X				X				X				X		
Underhood Rubber and Plastic Components - Check and Replace If Necessary	-----				X				X				X				X		
Valve Adjustment	-----				X				X				X				X		



## Fluid Capacities

### Section 0G

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## Fluid Capacities

### Engine Crankcase

5.9 Liter Diesel (High Mark) .....	10.4 liters*	[11.0 U.S. quarts]*
*Add 0.9 liter [1 U.S. quart] for filter change		

### Cooling System

5.9 Liter Diesel (Manual) .....	14.7 liters	[15.5 U.S. quarts]
5.9 Liter Diesel (Automatic) .....	15.7 liters	[16.5 U.S. quarts]
Coolant Recovery Tank .....	1 liter	[0.9 quart]

### Front Axle

Dana 60/61 .....	3.0 liter	[6.3 pints]
------------------	-----------	-------------

### Rear Axle

Dana 70/71 .....	3.3 liters	[7.0 pints]
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### Transmission

<b>Manual Shift</b> (5 speed) .....	3.3 liters	[3.5 U.S. quarts]
<b>Automatic</b> Chrysler A-727 (Diesel) .....	10.4 liters	[11.0 U.S. quarts]

### Transfer Case 4WD Models

NP-205 .....	2.1 liters	[4.5 pints]
--------------	------------	-------------

### Fuel Tank

Standard 5.9 Liter Diesel Engine .....	68 liters	[30 gallons]
--	-----------	--------------

### Power Steering

All .....	1.29 liters	[2.7 pints]
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AUTHENTIC  
RESTORATION  
PRODUCT

## Recommended Lubricants, Fuels and Fluids

### Section 0H

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## Recommended Lubricants, Fuels and Fluids

### 1. Fuel

No. 2 Diesel Fuel  
No. 2 Climatized Diesel Fuel  
No. 1 Diesel Fuel

Note: No. 1 Diesel Fuels should only be used in extended Arctic conditions, -23°C [-10°F] and below.

### 2. Engine Oil\*

A.P.I. Quality CE-SG, CE-SF, CD-SF, or CC/CD-SF  
Max sulfated ash content of 1.85% mass is recommended for all oil used in this engine.  
**Operating Temperature**

MOPAR P/N 4467720	0.95 liter [1 U.S. quart]
15W-40	Above -10°C [14°F]
MOPAR P/N 4467718	0.95 liter [1 U.S. quart]
10W-30	-10°C [14°F] to -23°C [-10°F]**

\*\*Note: with Block Heater.

### 3. Automatic Transmission Fluid\*

MOPAR ATF Plus. (Automatic Transmission Fluid Type 7176)  
MOPAR P/N 4467721 0.95 liter [1 U.S. quart]  
Note: If above is not available use MOPAR Dextro II.

### 4. Manual Transmission Oil\*

5W-30 Engine Oil  
MOPAR P/N 4467717 0.95 liter [1 U.S. quart]  
Note: If not available use; SAE 5W-30 (A.P.I. Classification for service SG or SG1CD).

### 5. Antifreeze\*

MOPAR P/N 4267020  
Note: If not available use; Prestone II, Peak or antifreeze containing Alugard 340-2 Inhibitor system.

### 6. Power Steering Fluid\*

MOPAR Power Steering Fluid P/N 4318055  
Note: Do not use Gear Oil, Automatic Transmission, or Hydroboost Power Steering Fluid.

### 7. Drive Line/Slip Spline\*

MOPAR P/N 4318063  
Moly Disulfide Grease (NLGI Grade 2 EP)

### 8. Rear and Front Axles (Conventional and Limited Slip Differentials)\*

MOPAR Hypoid Lubricant. (A.P.I. Specification GL-5)  
MOPAR P/N 4318058  
SAE 80W-90 0.95 liter [1 U.S. quart]  
Limited Slip Differential add:  
MOPAR P/N 4318060 118 milliliters [4 ounces]

Recommended SAE Grade	Anticipated Temperature Range
SAE 140, SAE 80W-140, SAE 85W-140	Above 32°C [90°F]
SAE 90, SAE 80W-90, SAE 80W-140, SAE 85W-140	32°C [90°F] to -23°C [-10°F]
SAE 75, SAE 75W-90, SAE 80W, SAE 80W-140	Below -23°C [-10°F]

### 9. Transfer Case (NP-205)\*

Multipurpose Gear Oil (A.P.I. specification GL-5 or engine oils labeled A.P.I. Service SF/CC or SF/CD)

#### SAE Viscosity Grades - Multipurpose Gear Oils

If the anticipated minimum atmospheric temperature will be:

- Use SAE 140 ..... Above 32°C [90°F]
- Use SAE 90 ..... 32°C [90°F] to -23°C [-10°F]
- Use SAE 80 ..... Below -23°C [-10°F]

#### SAE Viscosity Grades - SG or SG/CD Engine Oil

- Use SAE 50 ..... Above 0°C [32°F]
- Use SAE 30 ..... Below 0°C [32°F]

\* Use the Lubricants and Coolants listed or Lubricants and Coolants containing equivalent properties.





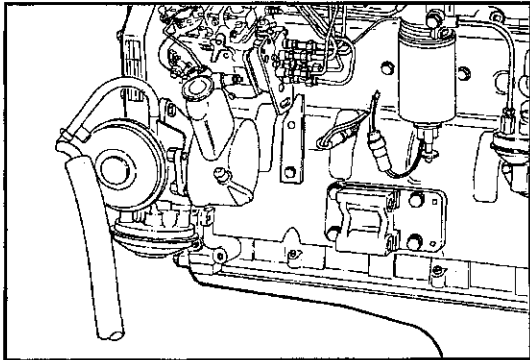
# Service Brakes



## Section 5

### Contents

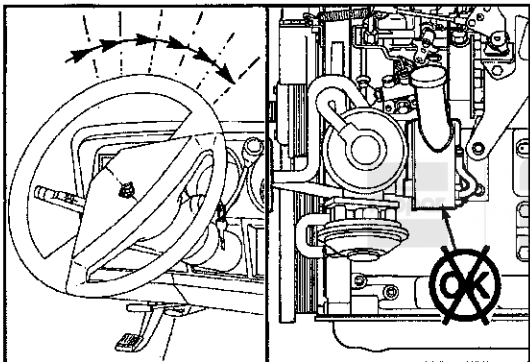
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## Power Steering and Vacuum Pump

The vacuum pump and power steering pump is one assembly which is driven from a common shaft from the front gear train.

To service either pump, the complete assembly must be removed from the front gear housing.



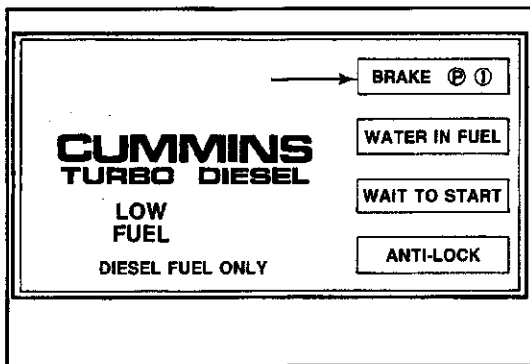
## Power Steering Pump



**Caution:** Be sure the pump is not low on fluid.

If the steering becomes hard to turn, either continuously or intermittently, the power steering pump could be at fault.

Reference the "Power Steering Pump" section of the 1989 Service Manual for the Rear Wheel Drive Trucks D&W 150-350 Ramcharger, for diagnostic and service procedures.

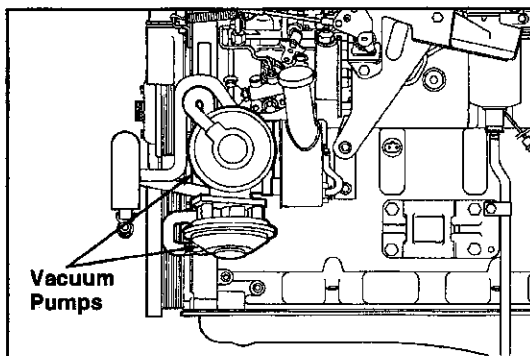


## Message Center Lights - Brake System

The engine warning light panel on the dash contains five warning indicator lights: Brake, Water in Fuel, Wait to Start, Anti-Lock, and Low Fuel.

The **Brake** light is connected to a sensor that monitors vacuum in the brake booster system. The **Brake** light when lit indicates **LOW VACUUM**. If this light is lit, the brake system must be serviced.

**Note:** The brake light will also be activated when the parking brake is on or there is a hydraulic brake failure.

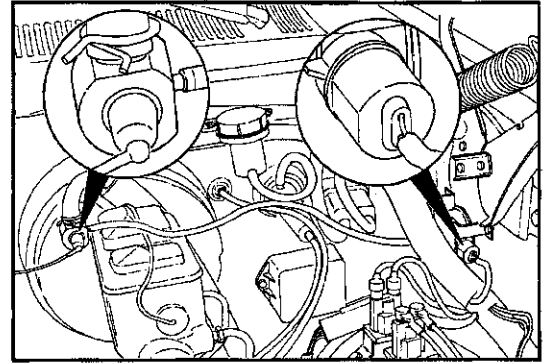


## Vacuum Pump

The vacuum pumps provides vacuum for the brake booster, dash controllers, etc..

The vacuum sensor is mounted under the left hood hinge in the engine compartment and vacuum is supplied by a hose teed off of the check valve in the brake booster.

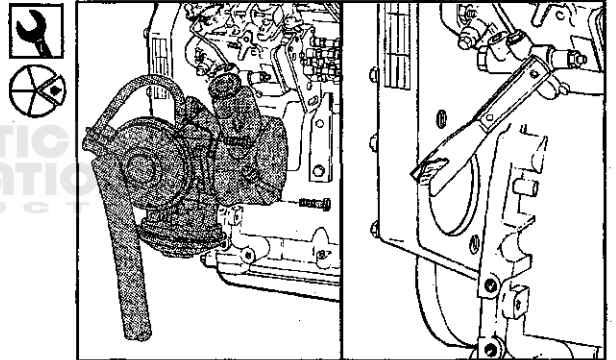
**Note:** The sensor will activate the brake light on the warning light panel in 10 seconds or less when the vacuum drops to 8.5 in Hg. or less in the brake system.



15mm

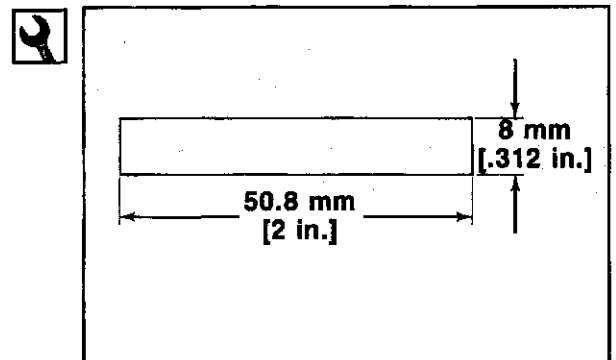
Remove the vacuum and the power steering pump assembly.

Clean the gasket from the engine gear cover.

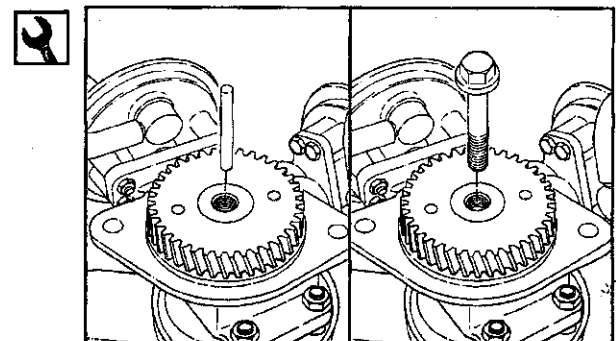


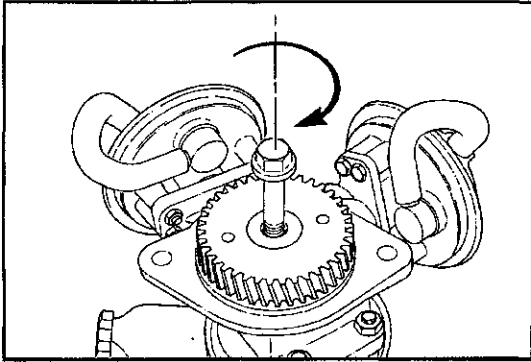
### Disassembly

Make a pin as illustrated from 8mm or .312 inch hardened drill rod or a 10.9 or SAE Grade 8 capscrew.

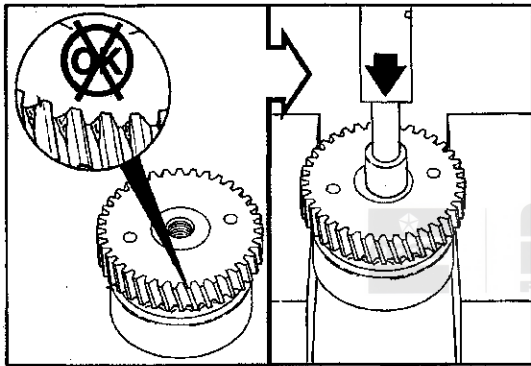


Insert the pin into the pump shaft and screw a M14-2mm threaded capscrew in against the pin.





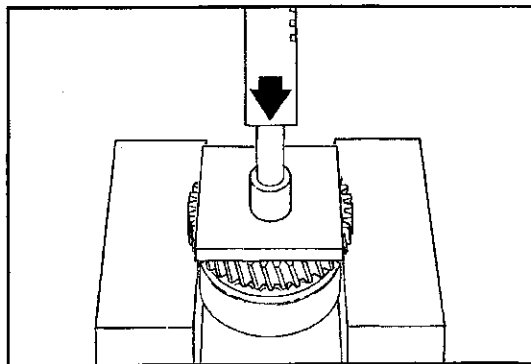
Tighten the capscrew against the pin, drawing the gear/eccentric/bearing assembly off of the power steering pump shaft.



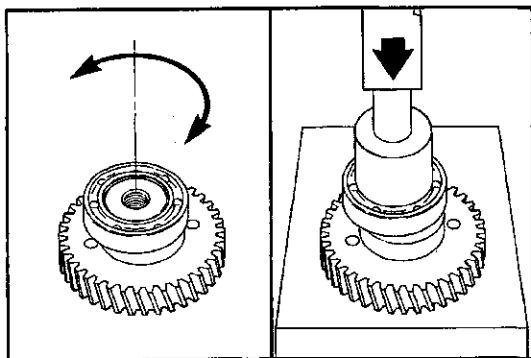
Check the gear for excessive wear or damage on the gear.

If the gear/eccentric is not damaged, do not separate them.

However, if there is damage, press the eccentric out of the gear.



Use a flat plate over a new gear and press it on to the eccentric until it bottoms.



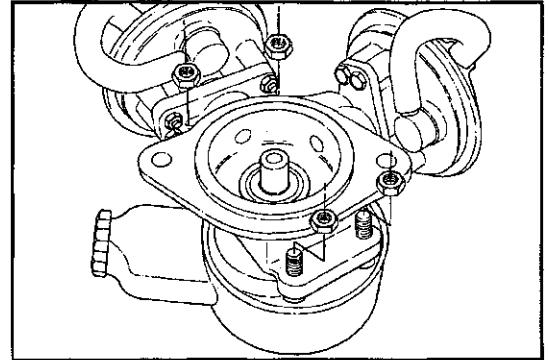
Visually inspect, and rotate the bearing by hand. If the bearing looks good and feels smooth to the turn, do not separate.

If the bearing/eccentric is bad, press the eccentric out of the bearing.

Using the appropriate size socket or tool that will press only on the inner race of the bearing, press it on until it bottoms.

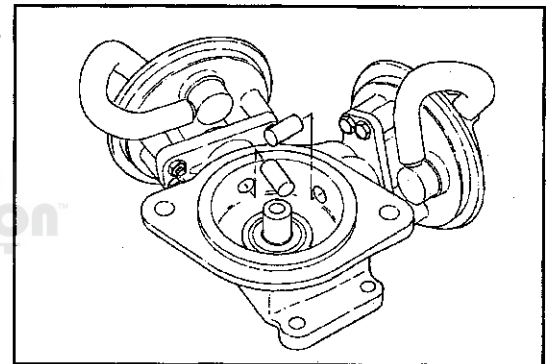
15mm

Remove the four nuts and separate the power steering pump from the vacuum pump housing.



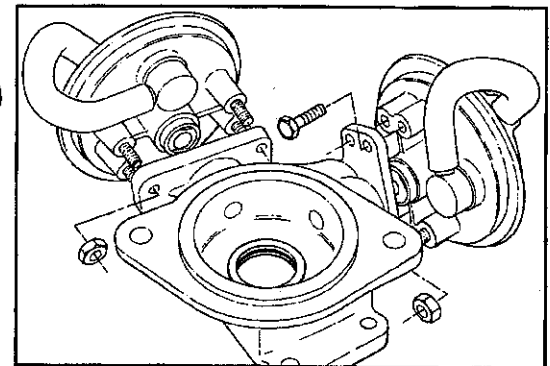
Remove the push rods from the vacuum pump housing.

Inspect the push rods. They should slide smoothly in the bushings but should not move side to side.

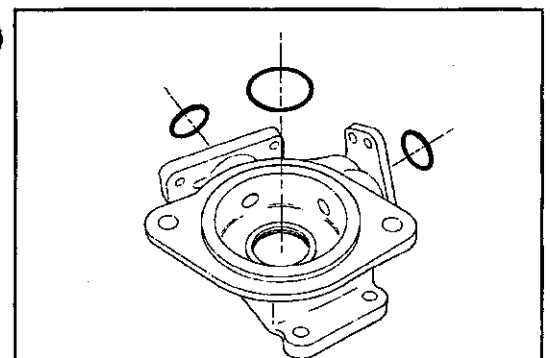


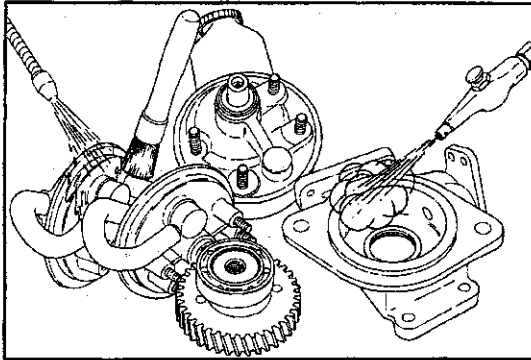
10mm

Remove the diaphragm assemblies from the housing. If the diaphragms are bad, they must be replaced as a unit.

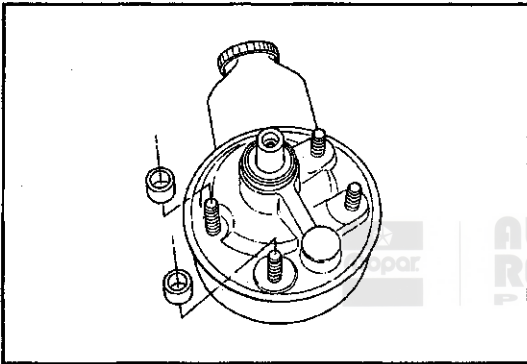


Remove and discard the o-rings from the center bore and push rod bores.



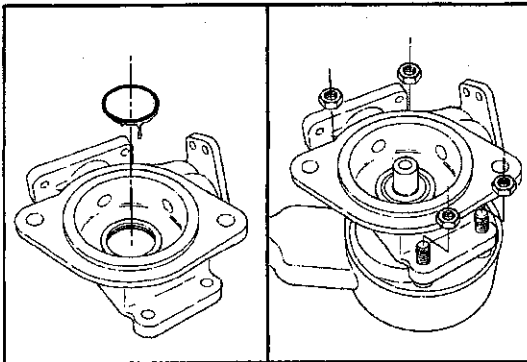


Clean parts in hot water and detergent or use a solvent and blow dry with compressed air.



**Reassembly**

Install the two spacers on the studs on the power steering pump.



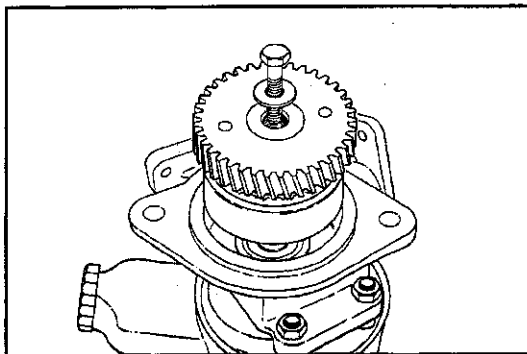
**15mm**



Install the accessory drive support on the power steering pump using a new o-ring lubricated with engine oil. Install the four retaining nuts.



**Torque Value: 24 N·m [18 ft-lbs]**



Install the gear/eccentric/bearing assembly by pulling it onto the power steering shaft with a 3/8 inch 18 thread capscrew with a flat washer threaded into the power steering pump shaft. Pull it on until it bottoms.



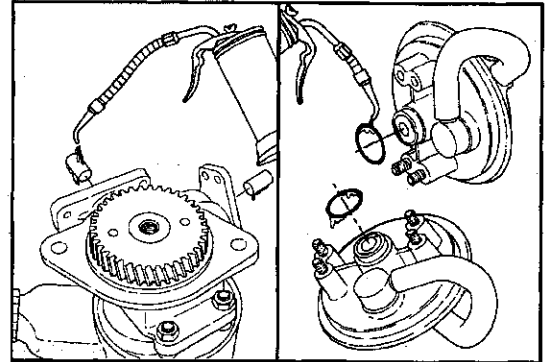
**Caution: This is a press fit and will require a minimum of SAE Grade 8 capscrew for thread strength.**

Remove capscrew and washer after pulling eccentric on to the shaft.

Lubricate the push rods with engine oil and install them in housing.

Install new o-rings on the diaphragm assemblies.

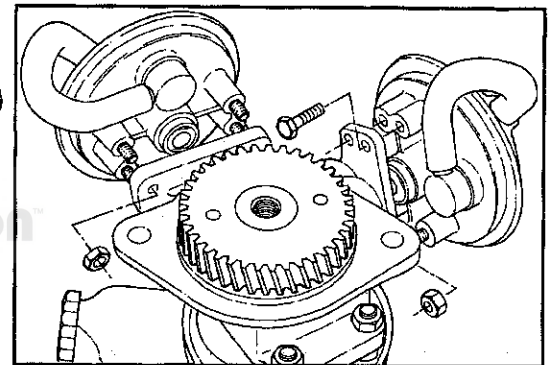
Lubricate with engine oil.



10mm

Install diaphragm assemblies.

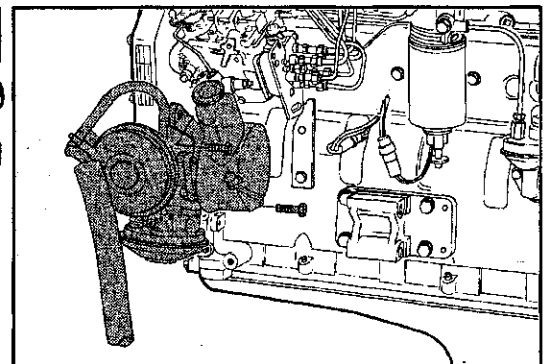
Torque Value: 9 N·m [7 ft-lbs]



15mm

Install the assembly onto the engine with a new gasket.

Torque Value: 77 N·m [57 ft-lbs]



## Specifications

Power Steering Pump to Vacuum Pump .....	Torque Value: 24 N·m [18 ft-lbs]
Vacuum Pump to Vacuum Pump Drive Housing .....	Torque Value: 9 N·m [7 ft-lbs]
Vacuum Power Steering Pump to Gear Housing .....	Torque Value 77: N·m [57 ft-lbs]
Operating Range .....	25- 8.5 in-Hg.

**Note:** If the system drops below 8.5 in Hg for 10 seconds, the brake warning light will be activated on the message center.





# Clutch

## Section 6

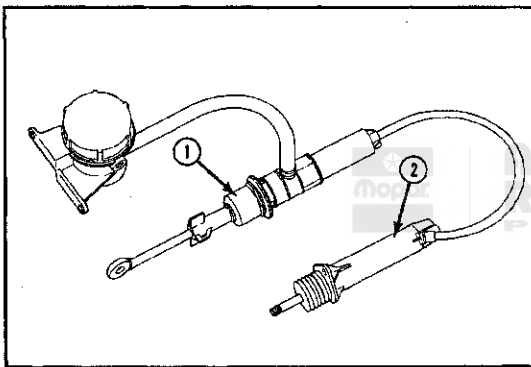
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## General Information

The clutches used are a single, dry disc type with no adjustment for wear being provided. Since the clutch housing has provisions for ventilation, condensation from steam vapors tend to accumulate on the internal clutch mechanism when the vehicle is steam cleaned. The facings of the disc will absorb moisture, and the force exerted by the cover plate assembly, will bond the facings to the flywheel and/or the cover plate assembly, if the vehicle is allowed to stand for some time before use. If this condition occurs, it will necessitate replacement of the disc assembly, flywheel, and/or the clutch assembly. Immediately after the cleaning operation, start the engine an "slp the clutch" in order to dry off the disc assembly, cover plate assembly and flywheel.



## Clutch Pedal and Bracket

The clutch pedal is connected to the release fork through a hydraulic master cylinder (1) and slave cylinder (2). The slave cylinder, master cylinder and reservoir must be replaced as an assembly.

The upper end of the clutch pedal pivots in the pedal bracket on two nylon bushings. These bearings do not require periodic lubrication.

## Service Diagnosis

Condition	Possible Cause	Correction
Clutch Chatter	(a) Worn or damaged disc assembly.	(a) Replace disc assembly.
	(b) Grease or oil on disc facings.	(b) Replace disc assembly and correct cause of contamination.
	(c) Improperly adjusted cover assembly.	(c) Replace cover assembly.
	(d) Broken or loose engine mounts.	(d) Replace or tighten mounts.
Clutch slipping	(a) Burned, worn or oil soaked facings.	(a) Replace disc assembly and correct cause of contamination.
	(b) Weak or broken pressure springs.	(b) Replace cover assembly.
Difficult Gear Shifting	(a) Worn or damaged disc assembly.	(a) Replace disc assembly.
	(b) Improperly adjusted cover assembly.	(b) Replace cover assembly.
	(c) Clutch disc splines sticking.	(c) Remove disc assembly and free up splines or replace disc.
	(d) Worn or dry pilot bushing.	(d) Lubricate or replace bushing.
Clutch Noisy	(a) Worn release bearing.	(a) Replace release bearing.
	(b) Worn disc assembly.	(b) Replace disc assembly.
	(c) Worn release levers.	(c) Replace cover assembly.
	(d) Worn or dry pilot bushing.	(d) Lubricate or replace bushing.

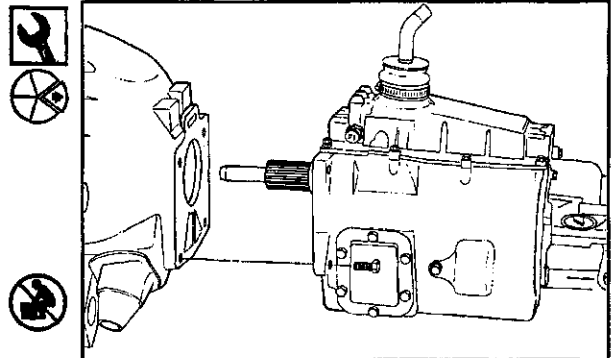
## Service Procedures

### 9/16 Inch

Improper operation or excessive wear may impair the clutch function to a point where it may be necessary to remove and replace the disc and/or cover assembly. Handle the clutch and the disc carefully to avoid contaminating the friction surfaces.

### Replacement

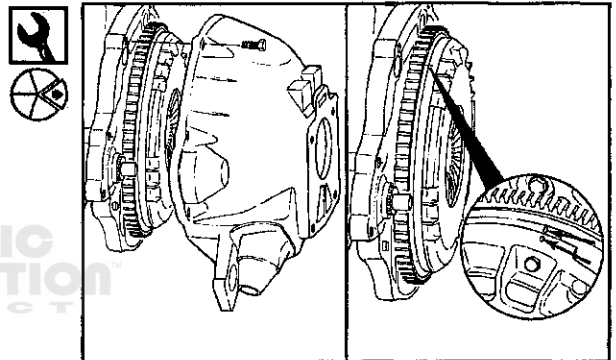
Remove the transmission.



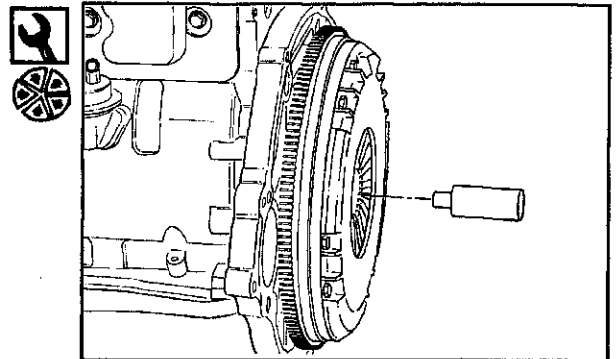
### 9/16 Inch

Remove the clutch housing, release fork and bearing assembly.

Mark the clutch cover and flywheel, to maintain their same relative positions when reinstalling clutch assembly.

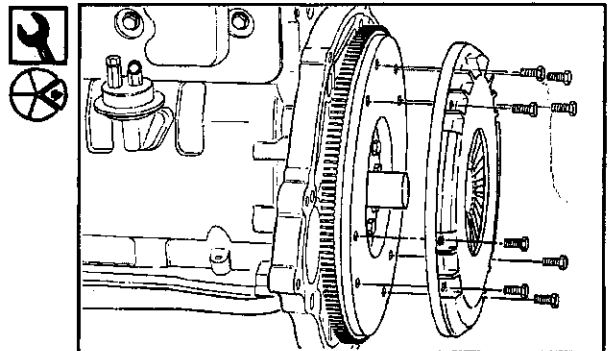


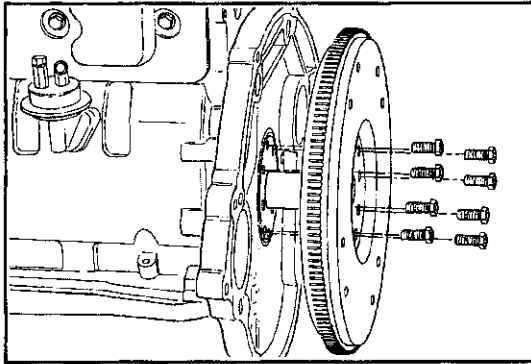
Insert a universal alignment tool through the clutch disc hub to prevent the clutch disc from falling and damaging the facings.



### 1/2 Inch

Loosen the clutch cover attaching bolts. Remove the clutch cover assembly and disc from the flywheel.

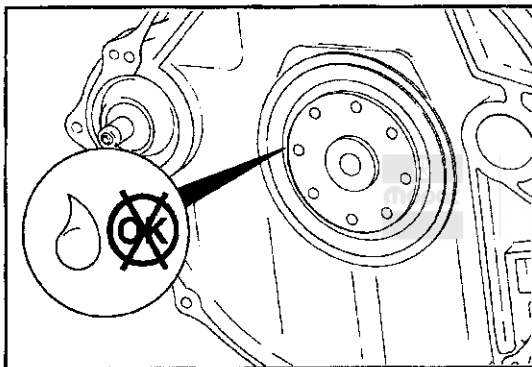




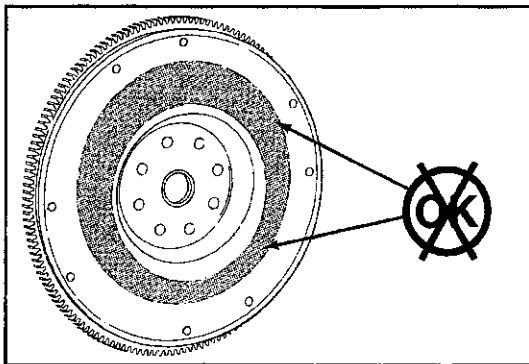
19mm



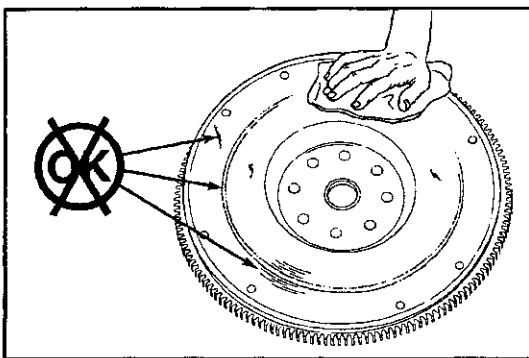
Remove the flywheel from the crankshaft. Handle the clutch cover assembly and flywheel carefully to avoid contaminating the friction surfaces.



Inspect for oil leakage through the engine rear crankshaft oil seal. If leakage is noted, it should be corrected at this time.

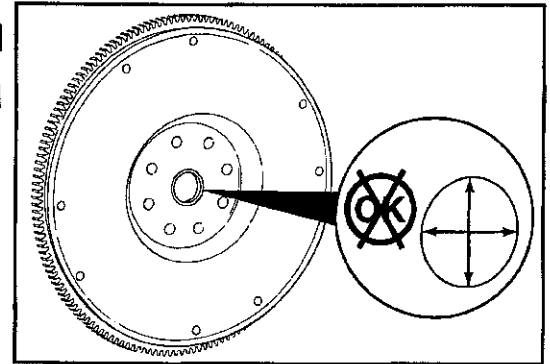


The friction face of the flywheel should have a uniform appearance throughout the entire clutch contact area. If there is evidence of heavy contact on one portion of the wear circle and a very light contact 180° from that portion, the flywheel may be improperly mounted or sprung. In either case, a dial indicator mounted on the clutch housing with the plunger in contact with the wear circle, should show **no more than .76mm [.003 inch]** runout throughout complete rotation of the flywheel.

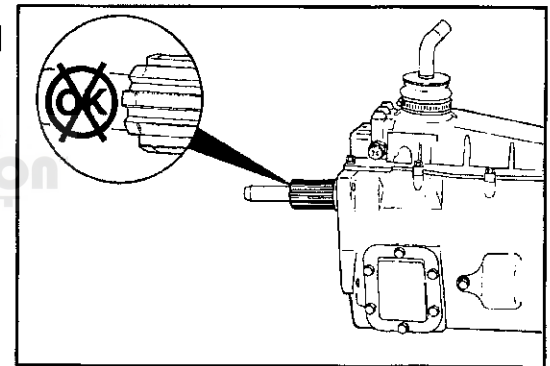


The friction face of the flywheel should also be free from excessive discoloration, burned areas, small cracks, grooves or ridges. Wipe the friction surface of the flywheel with kerosene, mineral spirits or other suitable solvent.

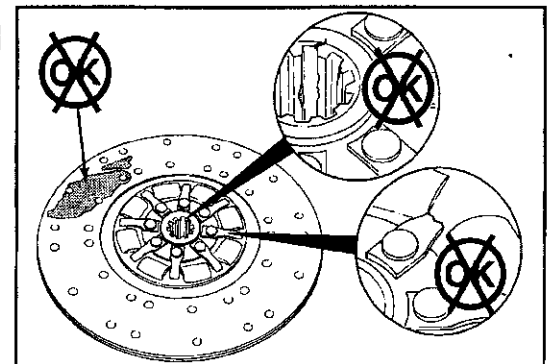
The drive pinion pilot bushing, pressed in the flywheel, should be smooth and show no excessive wear. The bushing I.D. must be no more than .127mm [.005 inch] out of round.



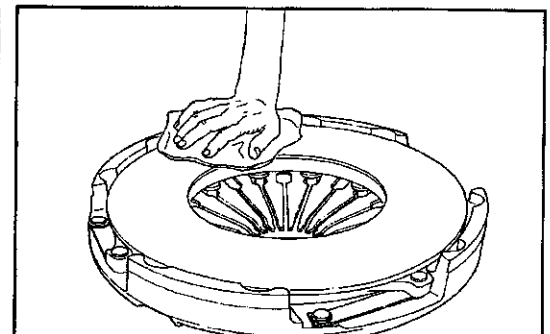
The end of the transmission main drive pinion should be smooth and bright, without grooves and ridges.

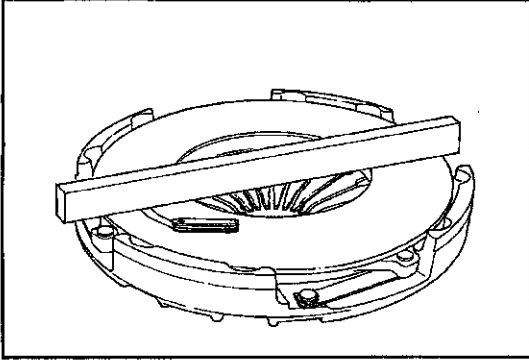


The disc assembly should be handled without touching the facings. Replace the disc if the facings show evidence of grease or oil soakage, or wear to within less than .015 Inch of the rivet heads. The hub splines and splines on the transmission main drive pinion should be a snug fit without signs of excessive wear. Metallic portions of the disc assembly should be dry and clean and show no evidence of having been hot. Each of the arched springs between the facings should be unbroken and all rivets should be tight.

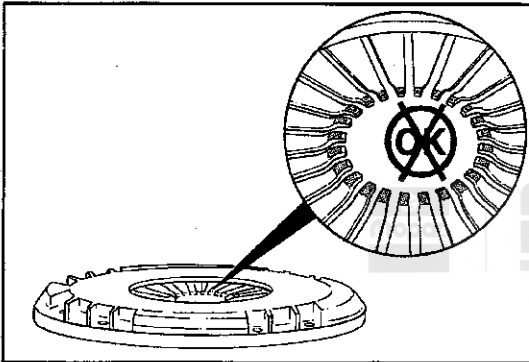


Wipe the friction surface of the pressure plate with kerosene, mineral spirits, or other suitable solvent.

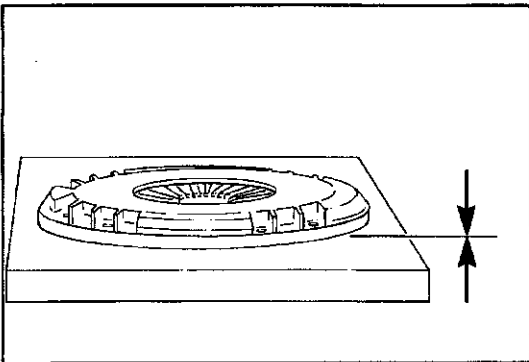




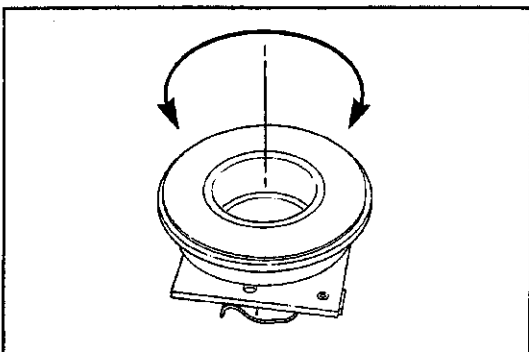
Using a straightedge, check the pressure plate for flatness. The pressure plate friction area should be flat within .076mm [.003 inch] and free from discoloration, burned areas, cracks, grooves or ridges.



The bearing contact area of the release diaphragm should have a uniform wear pattern.



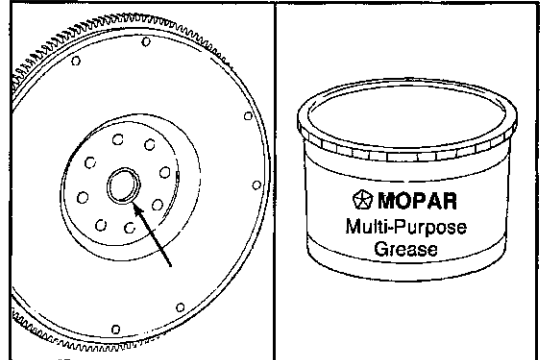
Using a surface plate, test the cover for flatness. All sections around the attaching bolt holes should be in contact with surface plate.



Examine the condition of the clutch release bearing. The clutch release bearing is a prelubricated, sealed thrust bearing and should not be immersed in solvent. The bearing should turn freely when turned by hand under light thrust load, with no evidence of roughness. If the bearing is noisy, rough or dry, replace the complete bearing assembly with a new assembly.

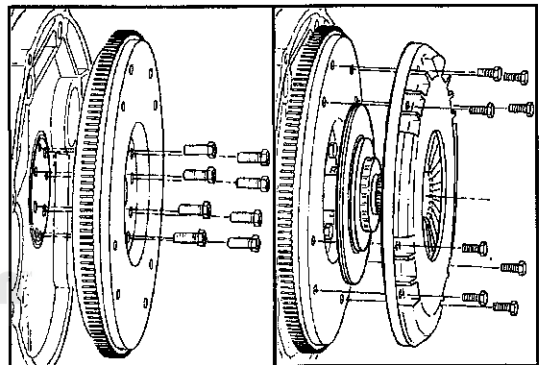
### Installation

The drive pinion pilot bushing in the flywheel requires a grease that will stay in place during high temperature operation. Use MOPAR Multipurpose Grease, Part Number 4318063 (or equivalent), which is a grease of this type and is recommended for all clutch lubrication points.



### 19mm, 1/2 Inch

Install the flywheel. Install the clutch cover assembly and disc on the flywheel, being careful to properly align the alignment marks made before removal. Insert a universal clutch alignment tool through the clutch disc into the pilot bearing to keep the disc centered while the cover plate capscrews are installed.

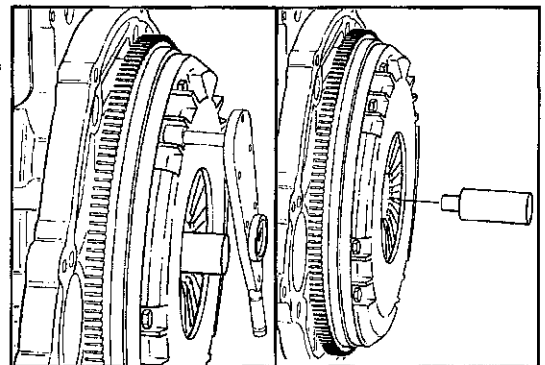


### Torque Value:

Flywheel to Crankshaft 137 N·m [101 ft-lbs]  
Clutch Cover to Flywheel 23 N·m [17 ft-lbs]

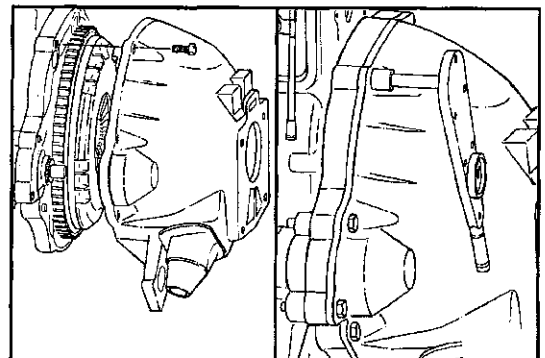


**Caution:** To avoid distortion of the clutch cover, the bolts should be tightened a few turns at a time, alternately, until they are all seated. Tighten to specifications. Remove the clutch disc alignment tool.



### 9/16 Inch

Install the clutch housing and torque all the clutch housing bolts to the transmission adapter.



### Torque Value:

Clutch Housing Bolts to  
Transmission Adapter (3/8") 41 N·m [30 ft-lbs]



## Specifications

### 13 Inch Clutch with 5.9 Liter Diesel Engine

Model Disc (F&S) .....	43 1861 999 160	Facing Material .....	Raymark M8400
Model Cover Plate (F&S) .....	13 3482 999 037	Release Bearing .....	Permanently Lubricated Ball
Actuation .....	Hydraulic	Pilot Bearing .....	Oilite Bushing
Facing-Thickness Total .....	.394 inch	Hub Spline Diameter .....	1 1/4 inch (10 splines)
Total Pressure (Lbs.) .....	2340	Vibration Damping Springs ..	8 main-stage 6 pre-stage
No. of Diaphragm Spring Fingers ...	24		

## Application

<b>Clutch Size</b>	<b>Transmission Speeds</b>	<b>Cover &amp; Pressure Plate Assembly</b>	<b>Disc Assembly</b>	<b>Engine</b>
13 inch	5	4429153	4429151	5.9 L Diesel

## Cover and Pressure Plate Identification

<b>Clutch Size</b>	<b>Assembly Part Number</b>	<b>Plate Load in Pounds</b>	<b>Springs No. &amp; Color</b>	<b>Mounting Bolt Circle Dia.</b>
13 inch	4429152	2340	Diaphragm Spring	345.0mm [13.58 inch]

## Clutch Disc Identification

<b>Clutch Size</b>	<b>Assembly Part Number</b>	<b>Facing Diameter Outside x Inside</b>	<b>Springs Number &amp; Color</b>
13 inch	4429151	13 x 7.28	6 Orange

## Tightening Reference

	<b>Newton Meters</b>	<b>Foot Pounds</b>
Clutch Cover to Flywheel Capscrews (5/16")	23	[17]
Clutch Fork Pivot	41	[30]
Clutch Housing to Engine Capscrews (3/8")	41	[30]
Flywheel to Crankshaft Capscrews	137	[101]
Transmission to Clutch Housing Capscrews	47	[35]

# Cooling System

## Section 7

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## Cooling System

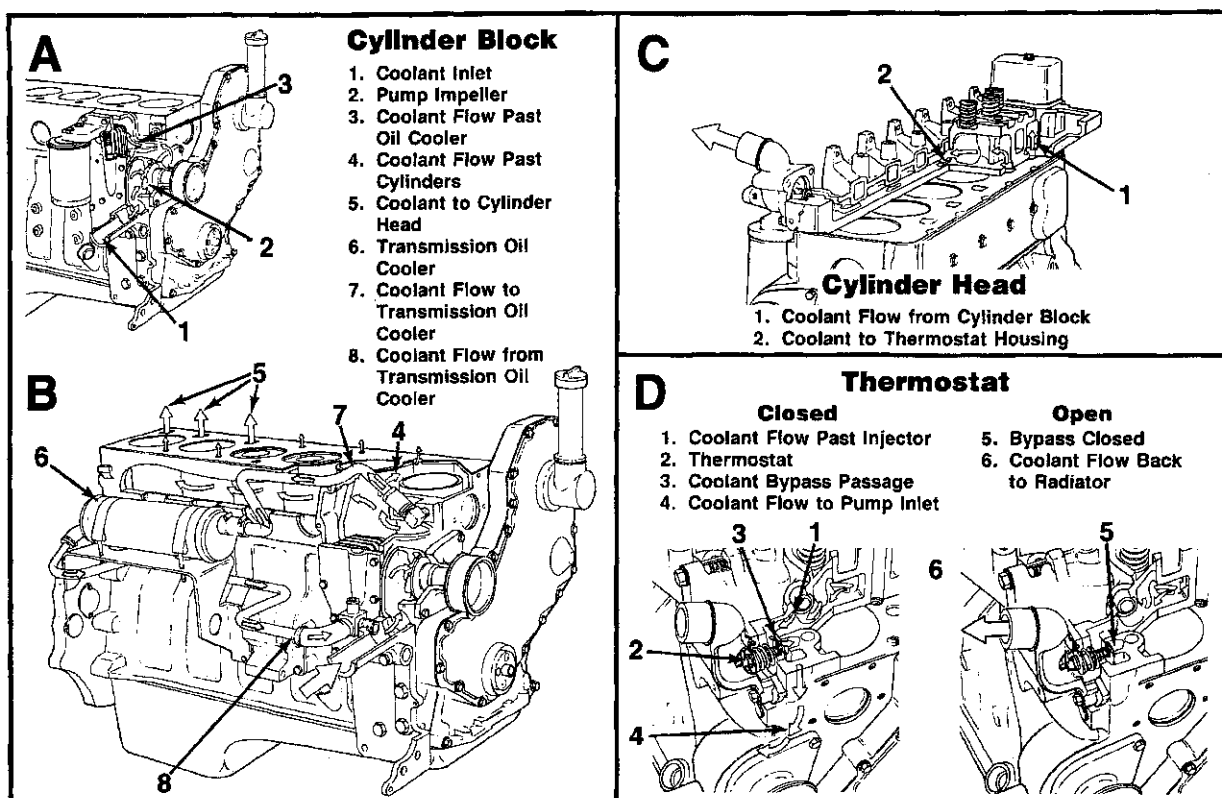
### Cooling System Components and Flow

The following illustration identifies the significant features of the coolant system.

1. Coolant is drawn from the radiator by the integrally mounted water pump. The output from the water pump empties into the oil cooler cavity of the cylinder block.
2. The coolant then circulates around each cylinder and crosses the block to the fuel pump side of the engine.
3. Coolant then flows up into the cylinder head, crosses over the valve bridges and down the exhaust manifold side of the engine to the integral thermostat housing.
4. As the coolant flows across the head toward the thermostat housing, it provides cooling for the injector nozzle. When the engine is below operating temperature, the thermostat is closed, and the coolant flow bypasses the radiator and goes to the water pump inlet via internal drillings in the block and cylinder head.

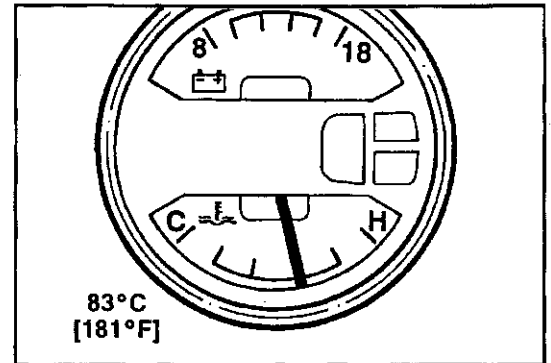
When operating temperature is reached, the thermostat opens, blocking the bypass passage to the water pump and opening the outlet to the radiator.

- Never operate the engine without a thermostat. Without a thermostat, the coolant will not flow to the radiator and the engine will overheat.



## Cooling System Malfunctions - Diagnosis

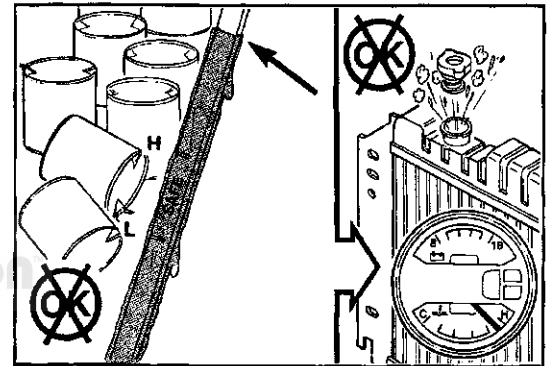
The function of the coolant system is to maintain a specified operating temperature for the engine. Some of the heat generated by the engine is absorbed by the coolant flowing through the passages in the cylinder block and head. Then, heat is removed from the coolant as it flows through the radiator. When you troubleshoot overheating, remember that too much oil in the oil pan can cause additional heat from friction when the rod journals are submerged in oil.



Overfilling the engine with oil raises the oil temperature. This additional heat is transferred to the coolant system at the oil cooler.

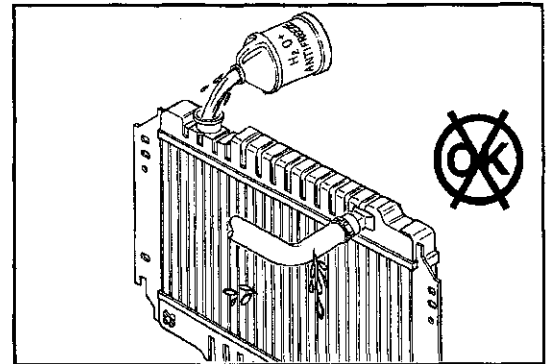


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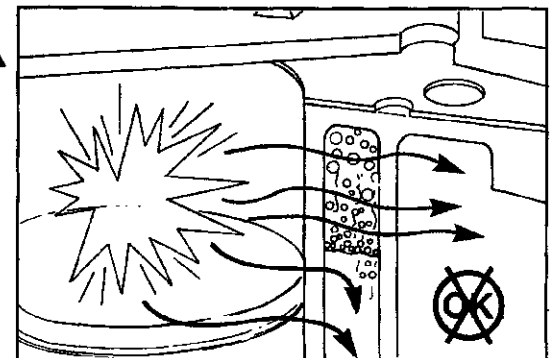
The system is designed to use a specific quantity of coolant. If the coolant level is low, the engine will run hot.

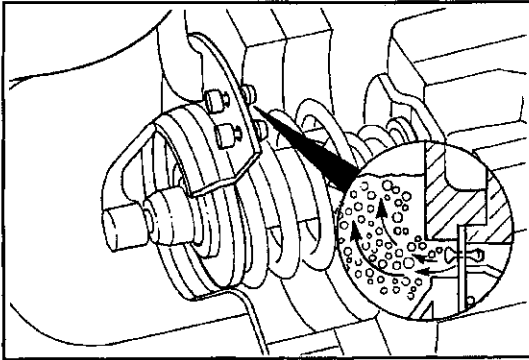
**Note:** The engine or system has a leak if frequent addition of coolant is necessary. Find and repair the leak.



**Caution:** The engine coolant passages must be completely filled with coolant. 

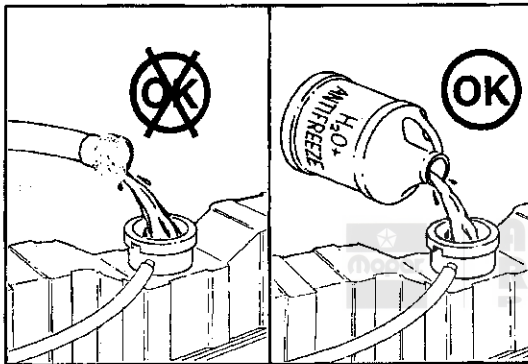
During operation entrapped air mixes with the coolant which results in cavitation corrosion and poor heat transfer. Highly aerated coolant can cause localized overheating of the cylinder head and block which can result in a cracked head, scored cylinder or blown head gasket.





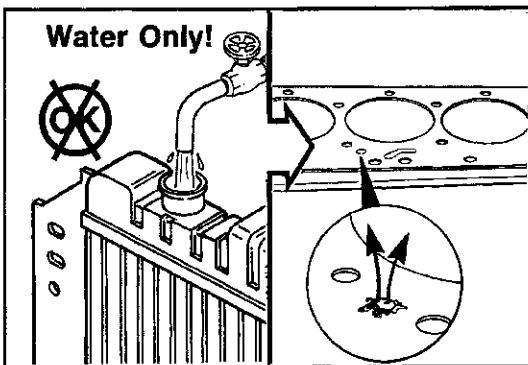
During filling, air must be vented from the engine coolant passages. The air vents through the "jiggle pin" openings to the top radiator hose and out the fill opening.

**Note:** Adequate venting is provided for a fill rate of 14 liter/minute [3.5 U.S. gallon/minute].



**Caution:** Never use only water for engine coolant. In tropical climates where antifreeze availability may be limited, use a corrosion inhibitor (Cummins Liquid DCA) to protect the engine cooling system.

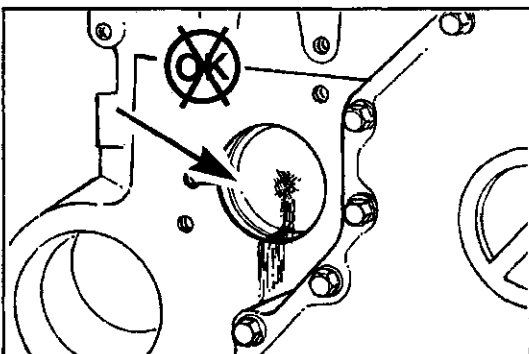
A mixture of 50% ethylene-glycol base antifreeze is required for operation of the engine in temperature environments above -37°C [-34°F]. A mixture of 40% water and 60% antifreeze is recommended for temperatures below -37°C [-34°F].



**Caution:** The small holes in the head gasket are especially susceptible to plugging.

Water will cause rust formation reducing the flow in the smaller coolant passages.

**Caution:** These holes are orifices and their size is critical. Do not enlarge the size of the orifices. To do so will disturb the coolant flow and will not solve an overheating problem.



**Caution:** Also, water used as a coolant for even a relatively short period can result in the cup plugs rusting through allowing the coolant to leak.

**Note:** A sudden loss of coolant from a heavily loaded engine can result in severe damage to the pistons and cylinder bore.

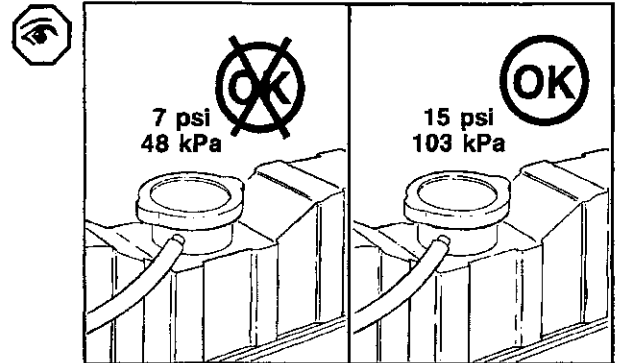
### Pressure Caps

The system is designed to use a pressure cap to prevent boiling of the coolant.

An incorrect or malfunctioning cap can result in the loss of coolant and the engine running hot.

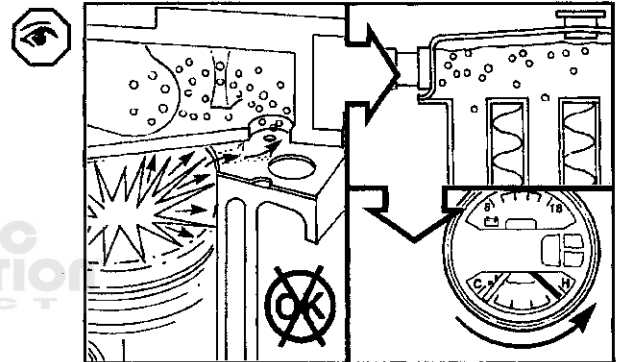
The cap specified for this system is:

System	Cap
110°C [230°F]	103kPa [15 PSI]



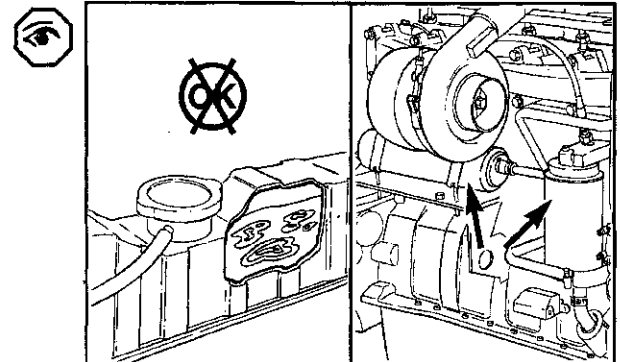
Air in the coolant can result in loss from the overflow when the aerated coolant is hot. The heated air expands, increasing the pressure in the system causing the cap to open.

Similarly, coolant can be displaced through the overflow if the head gasket leaks compression gasses to the coolant system.



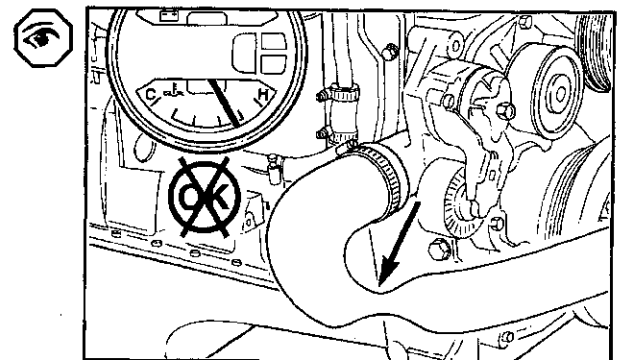
The operating pressure of the coolant system and the lubricating system can result in the mixing of the fluids if there is a leak between the systems: head gasket, oil cooler, etc. (refer to the Lubricating System).

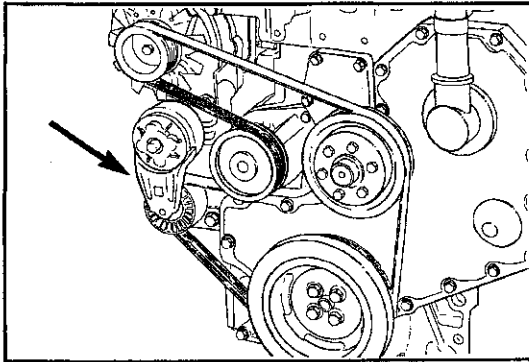
**Note:** Transmission oil can also leak into the coolant through a faulty transmission oil cooler.



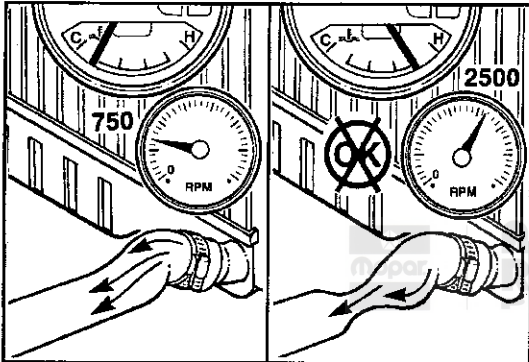
### Water (Coolant) Pump

The water pump pulls coolant from the bottom of the radiator and pumps it through the engine back to the top of the radiator for cooling. Reduced or interrupted flow will result in the engine running hot.



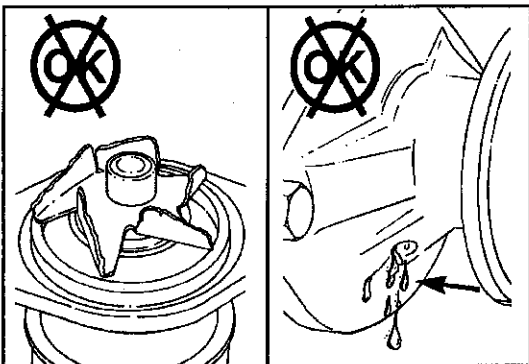


The pump is belt driven from the crankshaft pulley. An automatic belt tensioner is used to prevent the belt from slipping on the pump pulley. A malfunction of the tensioner will cause the water pump impeller to rotate at a slower speed reducing the amount of coolant flow.

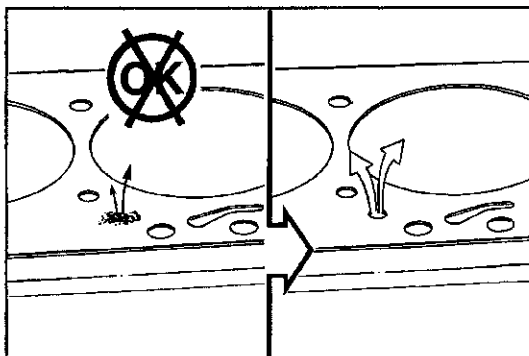


The coolant flow can also be reduced if the inlet hose to the water pump collapses. A hose will usually not collapse while the engine is running at low speed. Check the hose while the engine is running at rated speed.

**Note:** Be sure the engine is warm, a minimum of 83°C [181°F], so the thermostat is open.



A worn or malfunctioning water pump will not produce the flow required to prevent the engine from running hot. However, be sure to check the other possibilities indicated in the Troubleshooting Logic before checking the flow or replacing the pump.

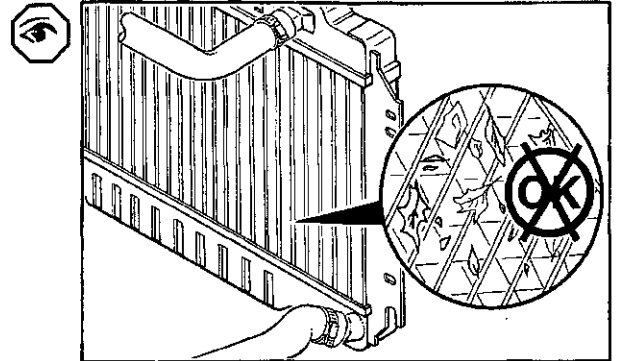


As stated in the coolant discussion, an obstruction in the passages can interrupt flow.



### Radiator Air Flow

Air forced through the fins of the radiator by a fan cools the coolant pumped through the radiator. Environmental debris (paper, straw, lint, dust, etc.) can obstruct the fins and stop the flow of air which will reduce the cooling effect of the radiator.

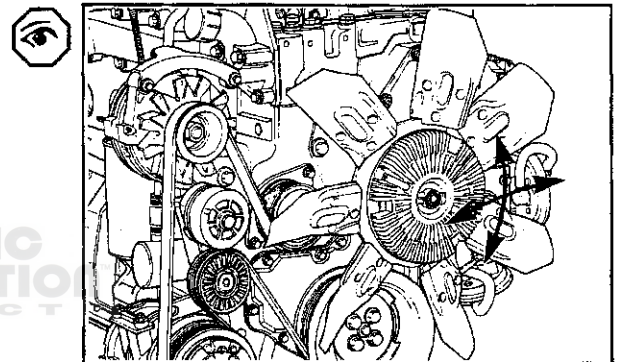


A slipping belt will result in a slower fan speed and reduced cooling. A malfunctioning automatic belt tensioner can be the problem.

**Note:** Check the bearings in the fan hub and other pulleys to make sure they are not causing excessive belt slippage and vibration.

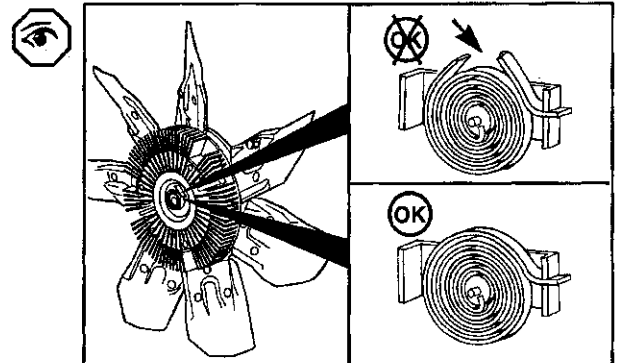


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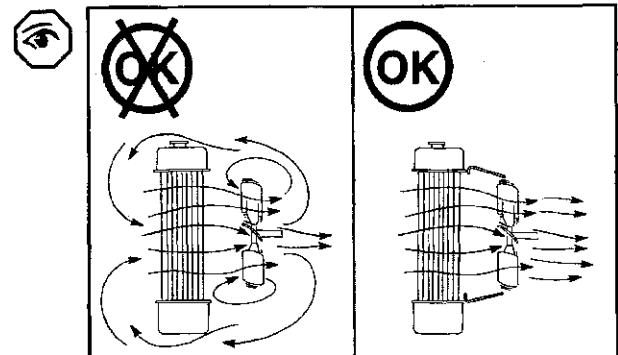
Thermostatic fans operate only as needed to keep the coolant at the correct temperature. If the fan does not operate when the coolant temperature increases, the engine will run hot. If the fan does not shut off when coolant temperature decreases, the engine will run cold.

**Note:** Make sure that the coolant temperature sensor is functioning correctly.

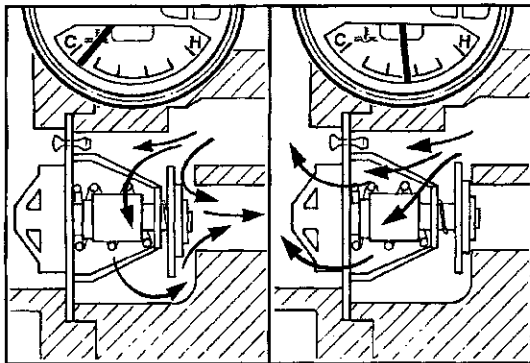


An incorrect fan shroud or obstructions can reduce air flow and cause the engine to run hot.

**Note:** Check to be sure air is not re-circulating. Check for missing baffles.

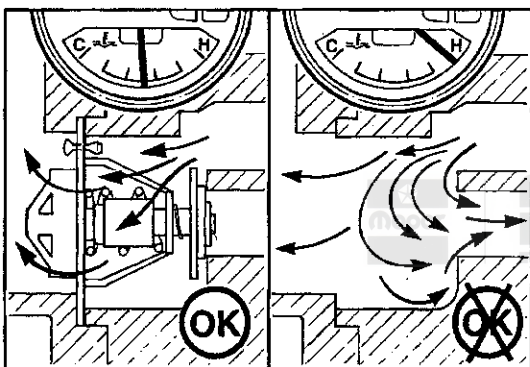




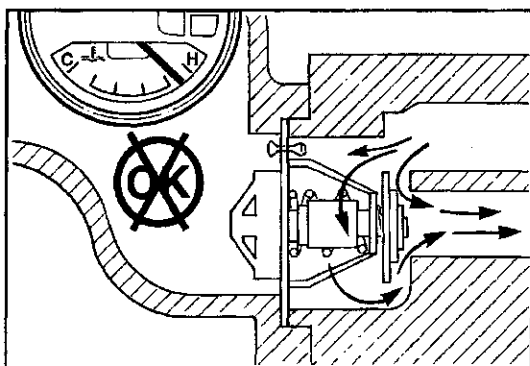


### Thermostat

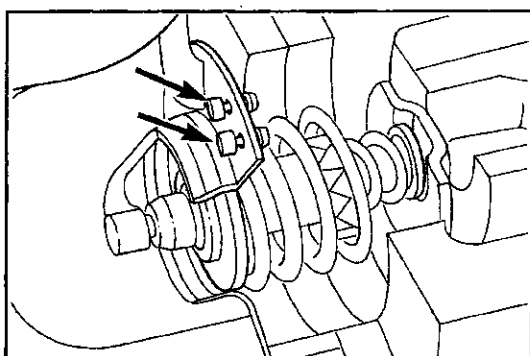
The thermostat controls the coolant temperature. When the coolant temperature is below the operating range, coolant is bypassed back to the inlet of the water pump. When the coolant temperature reaches the operating range, the thermostat opens, sealing off the bypass, forcing coolant to flow to the radiator.



**⚠ Caution:** Never operate the engine without a thermostat. Without a thermostat the path of least resistance for the coolant is through the bypass to the pump inlet. This will cause the engine to overheat.



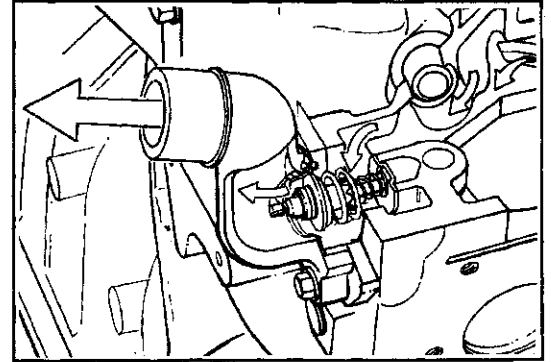
An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.



As previously discussed, jiggle pins are fitted to openings in the thermostat flange, to vent air from the cooling system during fill, and to act as check valves to block the flow of coolant through the openings during engine operation.

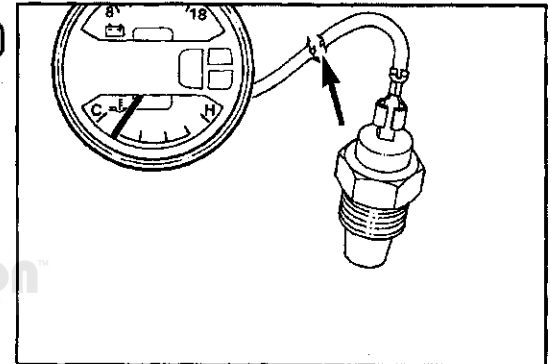
**Note:** A missing jiggle pin can cause the engine to run cold.

With the jiggle pins sealed, the flow to the radiator is controlled by the thermostat responding to the engine coolant temperature.

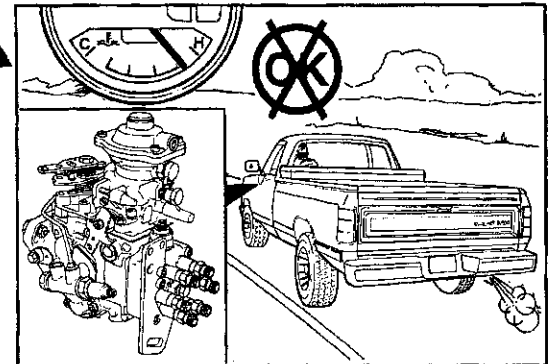


### Gauges, Overfueling and Loading

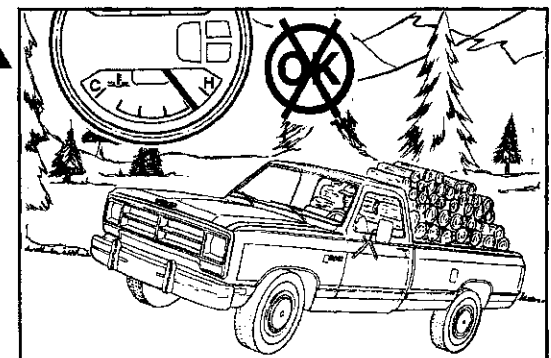
Gauges and sensors are used in the system to measure the coolant temperature. These can malfunction and provide an incorrect temperature indication.

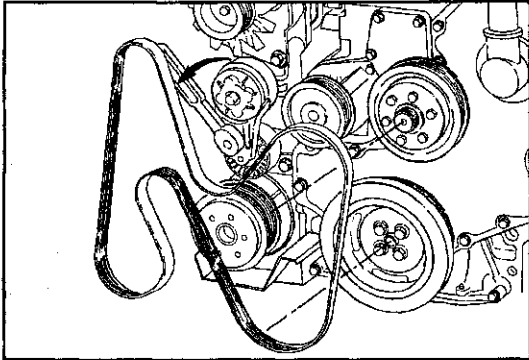


**Caution: Overfueling can cause the engine to overheat. Make sure that the fuel pump is calibrated correctly.**



**Caution: Constant overloading (lugging) can cause the engine to run hot.**





## Cooling System Replacement Procedures

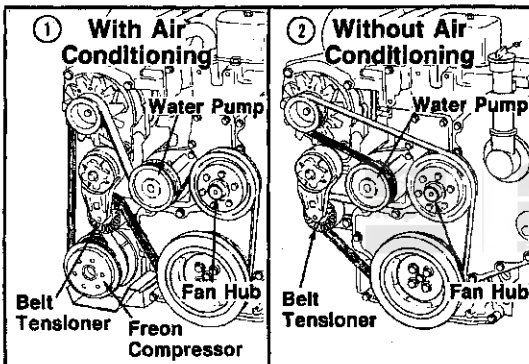


### Drive Belt - Replacement



#### 3/8 inch Drive Bar

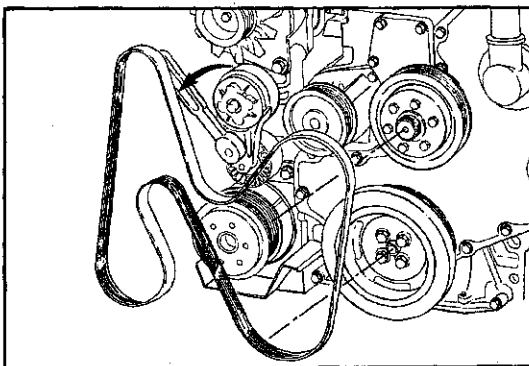
Lift the tensioner to remove and install the drive belt.



Two variations of Belt Drives are available on the 5.9 Liter Diesel.

1. With an Air Conditioning Option
2. Without Air Conditioning

Both Belt Drive Systems use an automatic belt tensioner.

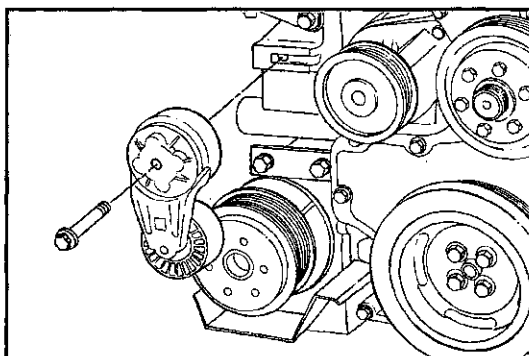


### Belt Tensioner - Replacement



Preparatory Step:

- Remove the drive belt



13mm



Remove the capscrew and replace the tensioner.



Torque Value: 43 N-m [32 ft-lbs]

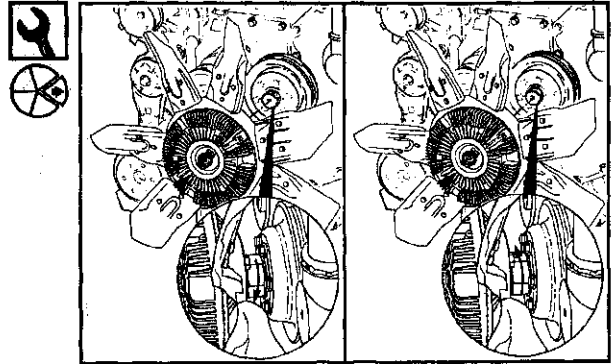


### Fan Pulley - Replacement

36mm

Remove the fan.

The thermatic fan housing is threaded onto the fan hub shaft, with left hand threads. Turn the 36mm nut clockwise (as viewed from the front) to loosen.

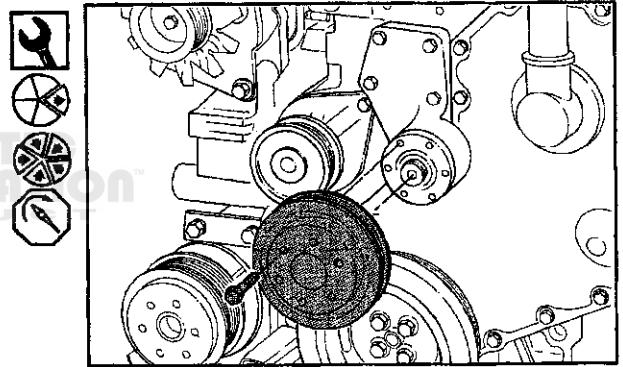


3/8 Inch Drive Bar , 10mm

Remove the fan belt.

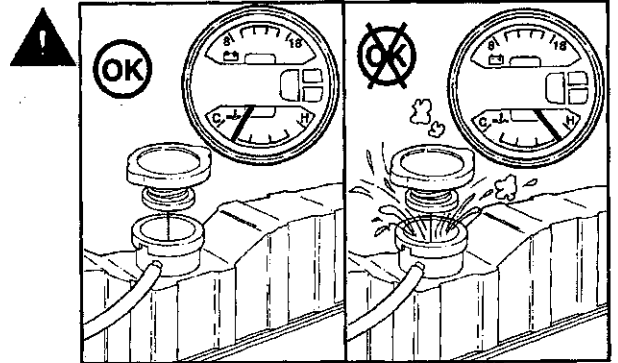
Remove the six capscrews and replace the fan pulley.

Torque Value: 9 N·m [7 ft-lbs]

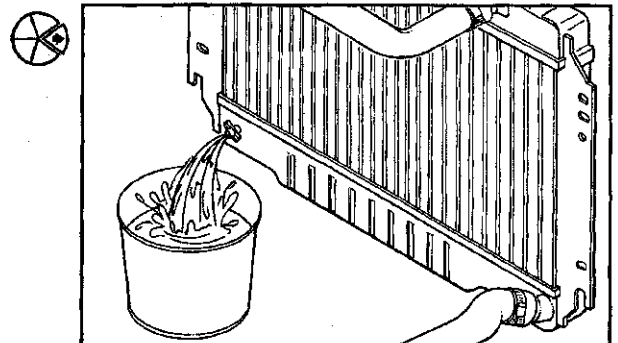


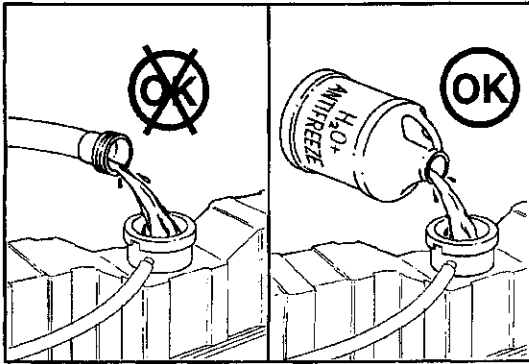
### Coolant - Draining

**Warning:** Wait until the temperature is below 50°C [120°F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

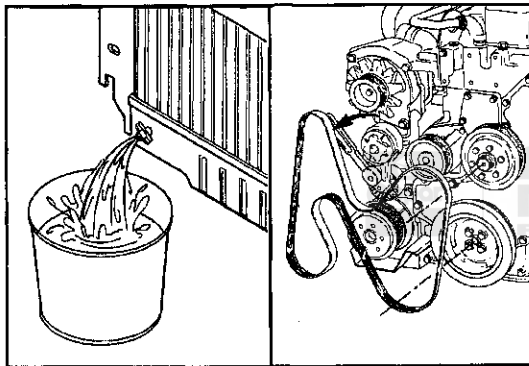


Drain the coolant system by opening the drain valve on the radiator. A drain with a capacity of 20 liters [5 U.S. gallons] will be adequate to hold the coolant.





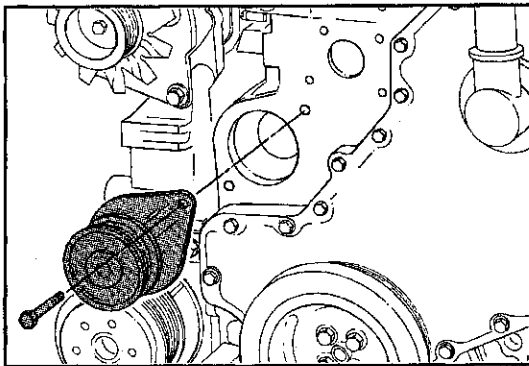
Re-fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze. Refer to the specifications for further details.



### Water Pump - Replacement

Preparatory Steps:

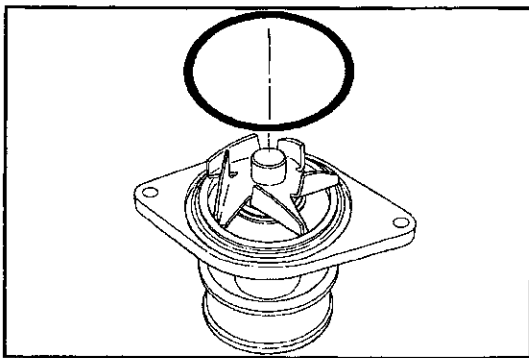
- Drain the coolant.
- Remove the drive belt.



13 mm



Remove the two capscrews and water pump from the cylinder block.



Clean the sealing surface on the cylinder block.

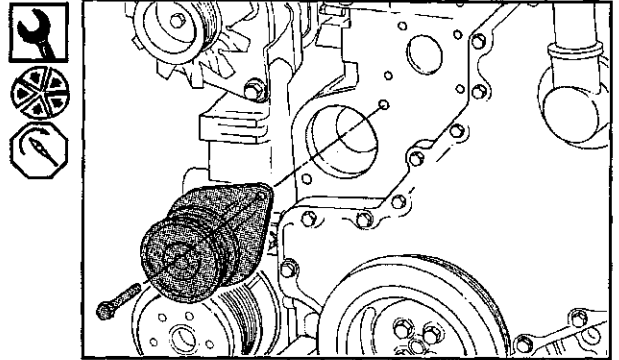


Install the new o-ring into the pump groove.

**13mm**

Install the water pump.

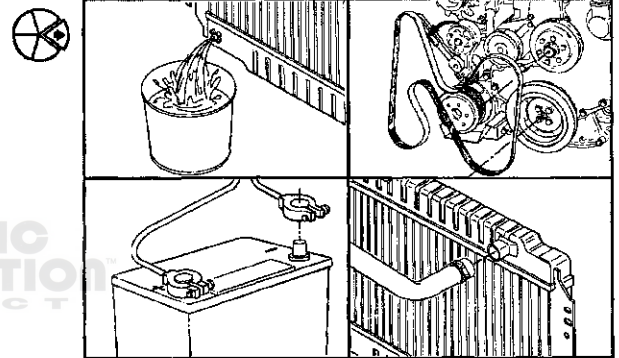
Torque the mounting capscrews to 24 N·m [18 ft-lbs].



### Thermostat – Replacement

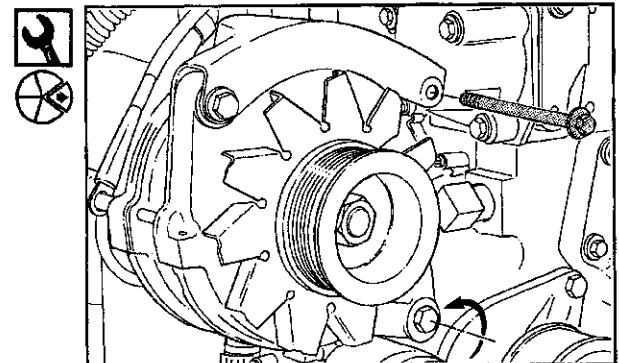
Preparatory Steps:

- Drain the coolant.
- Remove the drive belt.
- Disconnect negative battery cable.
- Disconnect the upper radiator hose.



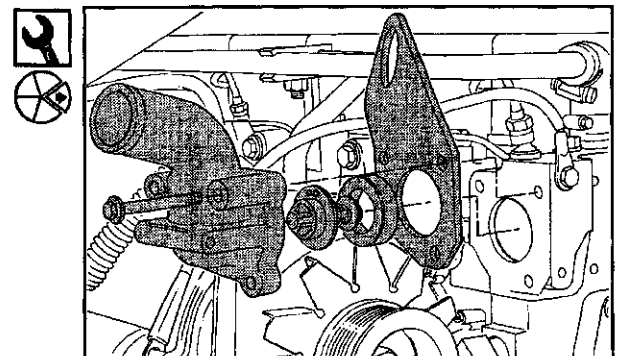
**10mm, 13mm, 15mm**

**Note:** Loosen the alternator mounting capscrew. Remove the alternator link capscrew and lower the alternator.

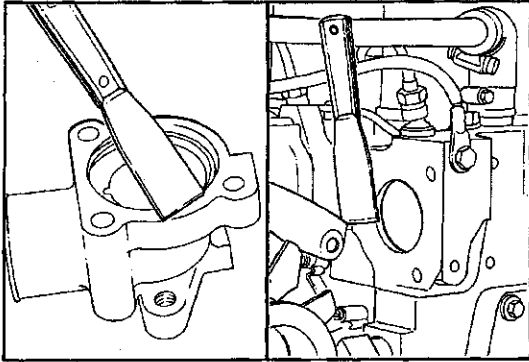


**10mm**

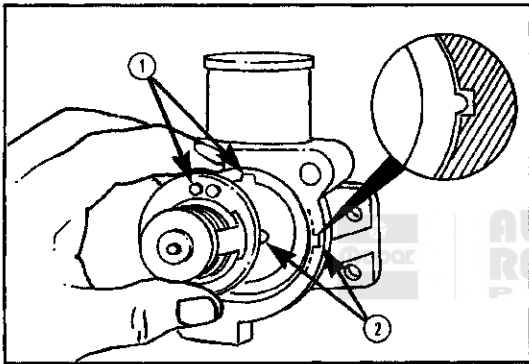
Remove the thermostat housing, lifting bracket and thermostat.



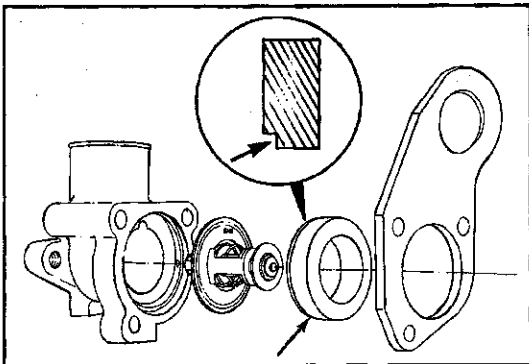




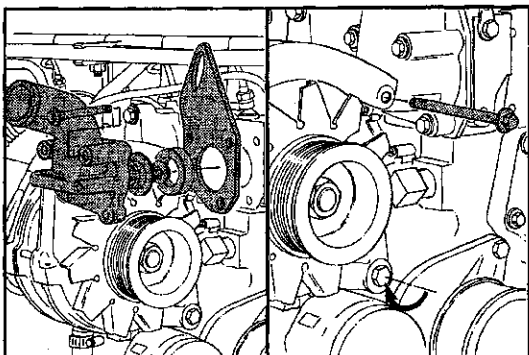
Clean the mating surface of the thermostat housing and the cylinder head.



Be sure the tang is in the slot in the housing (2). This ensures the correct positioning of the jiggle pins in the housing.



Position the rubber seal as shown for re-assembly.



10mm, 13mm, 15mm

Assemble the removed parts in the reverse order of removal.



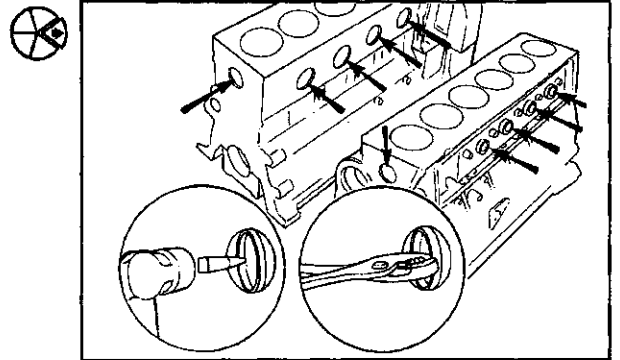
Torque Values:



Thermostat Mounting	24 N·m [18 ft-lbs]
Alternator Link (Upper Bolts)	24 N·m [18 ft-lbs]
Alternator Mounting (Lower Bolts)	43 N·m [32 ft-lbs]

### Cup Plugs - Replacement

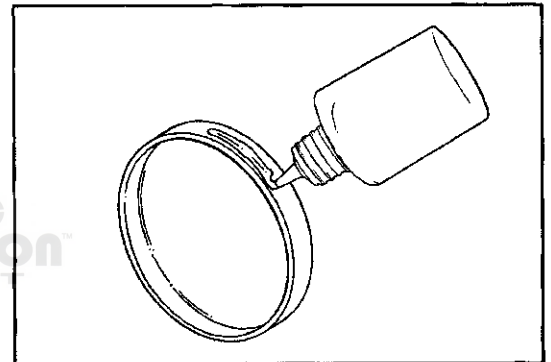
Remove the cup plugs from the coolant passages as shown.



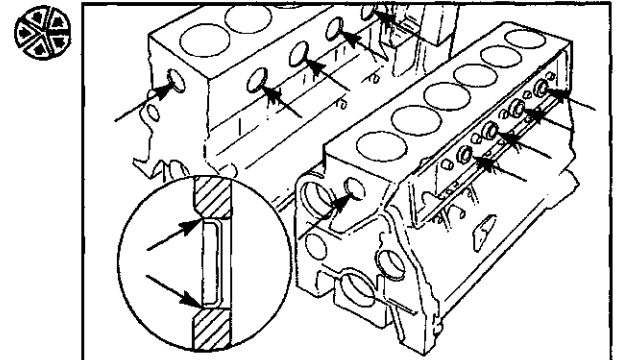
Apply a bead of Loctite 277 to the coolant passage cup plugs.



AUTHENTIC  
RESTORATION  
PRODUCT



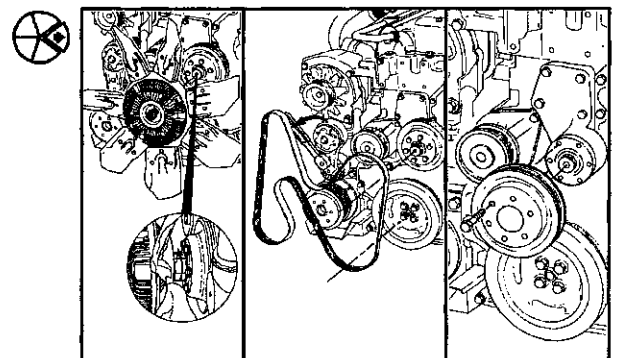
Drive the plugs in until the outer edge is flush with the counter sink in the block.



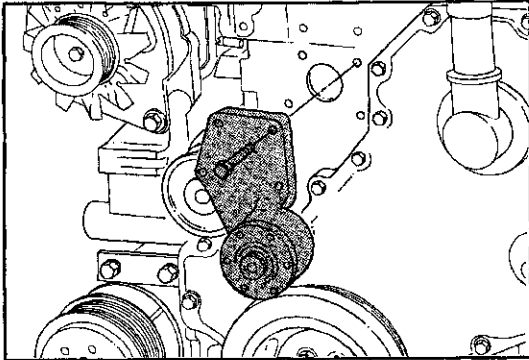
### Fan Hub - Replacement

Preparatory Steps:

- Remove the fan.
- Remove the drive belt.
- Remove the fan pulley.







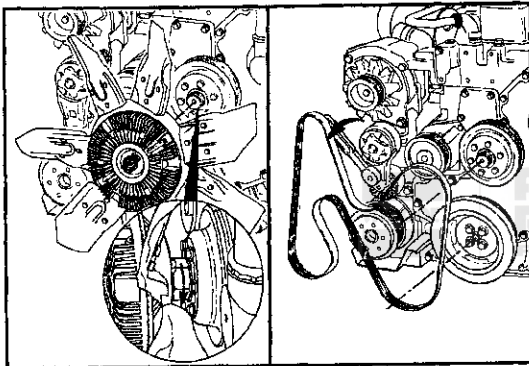
10mm



Remove the four cap screws and replace the fan hub.



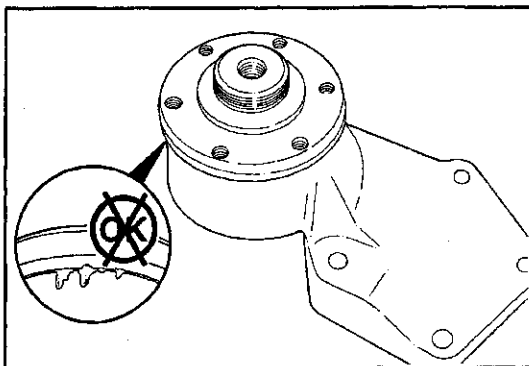
Torque Value: 24 N-m [18 ft-lbs]



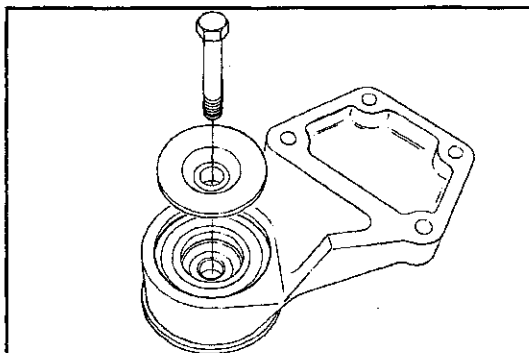
### Fan Hub - Inspection

Preparatory Steps:

- Remove the fan assembly
- Remove the drive belt
- Remove the fan hub



Check the end of the bearing for evidence that the lubrication has leaked between fan mounting hub and bearing housing.



### Fan Hub - Disassembly



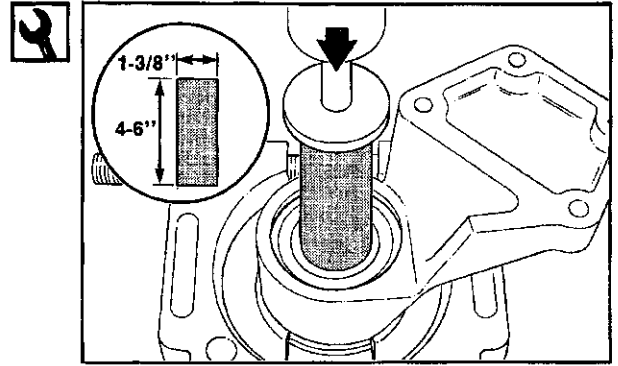
15mm

Secure the fan hub and remove the center cap screw and washer.

### 1 3/8 Inch Push Pin

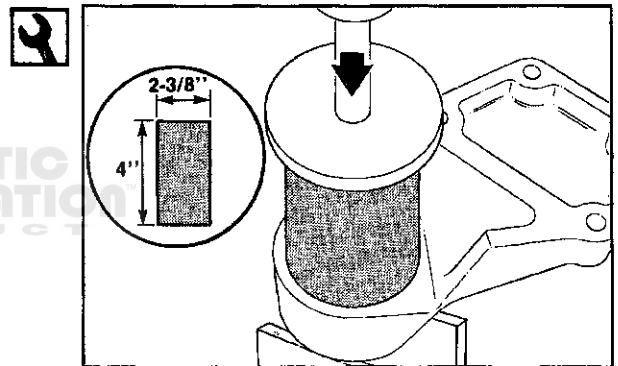
Support the bearing housing with a bearing splitter between the bearing and the fan mounting hub. Push the shaft out with a 1 3/8 inch diameter push pin.

**Note:** Approximately 6 tons of pressure is required.



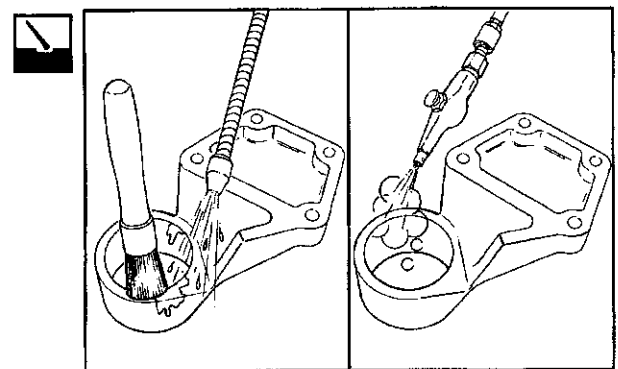
### 2 Inch Black Pipe – 2 3/8 Inch O.D. X 4 Inch long

Support the bearing housing and push the bearing out using a tool of suitable diameter to press on the outer race of the bearing. A 4-inch section of black pipe with 2 3/8 inch O.D. will work well. Make sure the ends of the pipe section are exactly perpendicular to the length.



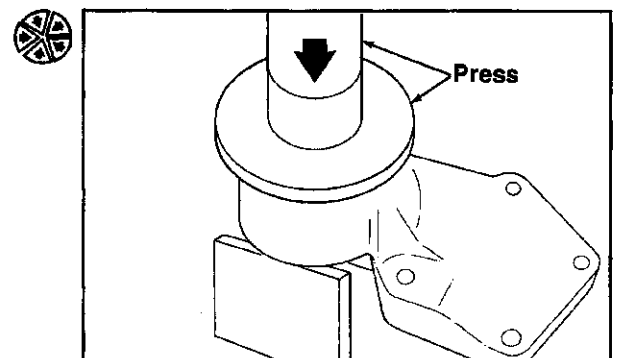
### Fan Hub – Assembly

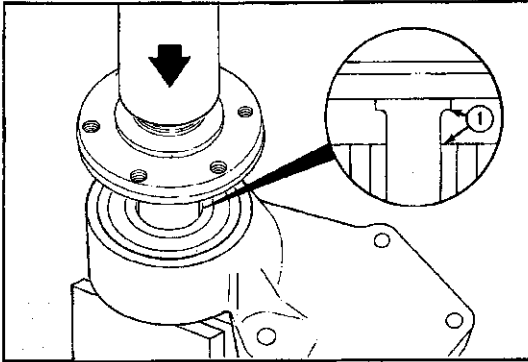
Clean all parts thoroughly in solvent and dry with compressed air.




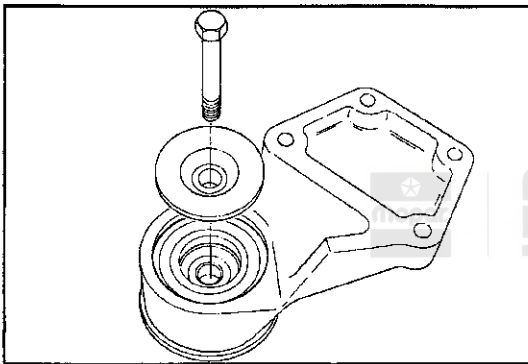
Support housing in press. Press a new bearing in from the front side with a flat plate over the bearing.




Push it flush with the front of the housing.

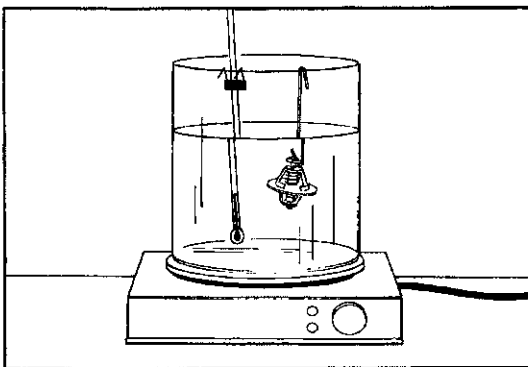




-  Support the inner race of the bearing from the bottom and press the fan mounting hub into the bearing from the front side. Press the hub until the hub shoulder contacts the inner race (1).



-  15mm
-  Install the retaining washer and capscrew.
-  **Torque Value:** 77 N·m [57 ft-lbs]

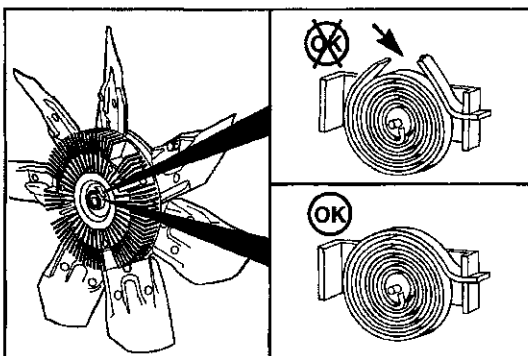


### Thermostat - Inspection

Check the thermostat operation by placing it in a flask of heated water. The thermostat operate as follows:

1. Maximum start to open at 83°C [181°F].
2. Maximum fully open at 95°C [203°F].
3. Minimum travel of 7.5mm [0.30 in] at 95°C [203°F]

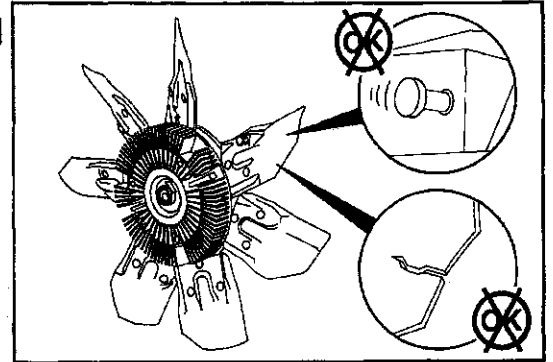
Replace the thermostat if its operation is other than above.



### Thematic Fan - Check

The thermatic fan has a temperature sensor located in the center front of the fan assembly. Check the condition of the temperature coil. It must not be broken or damaged.

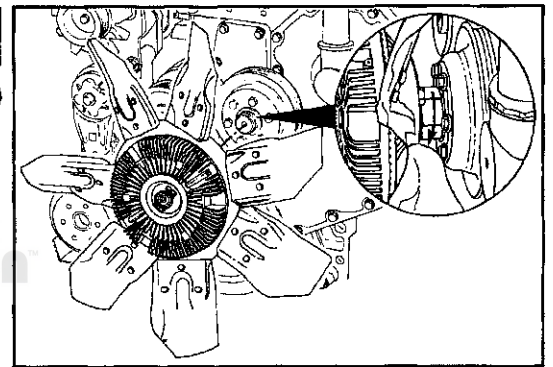
Check the fan for cracks, loose rivets and bent or loose blades. Make sure it is securely mounted. Tighten the capscrews if loose. Always replace a damaged fan.



### Thermatic Fan - Remove

36mm

The thermatic fan housing is threaded onto the fan hub shaft, with left hand threads. Turn the 36mm nut clockwise (as viewed from the front) to loosen.



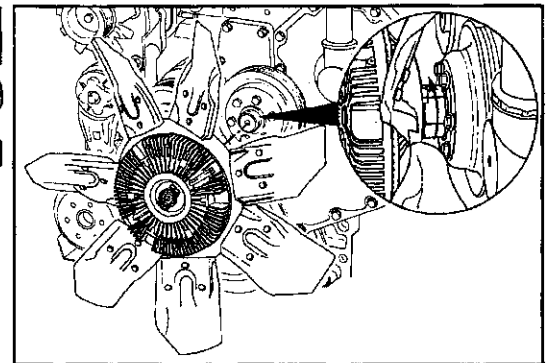
### Thermatic Fan - Install

36mm

Thread the fan housing onto the fan hub shaft. Tighten the housing thoroughly.

**Torque Value:** 57 N·m [42 ft-lbs]

**Note:** Left hand threads turn counterclockwise to tighten (as viewed from the front).

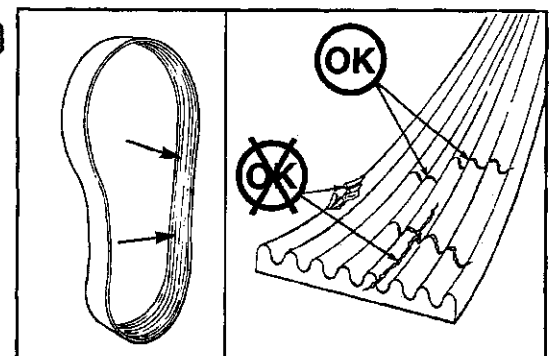


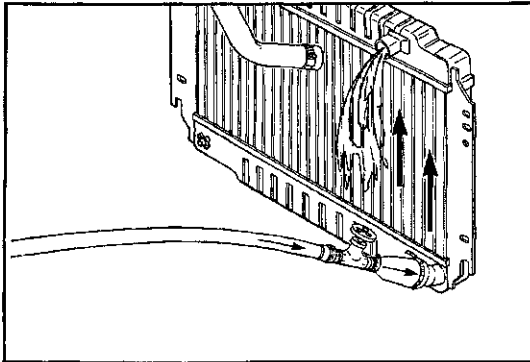
### Drive belt - Inspection

Check the belt for intersecting cracks.


- Transverse (across the belt width) cracks are acceptable.
- Longitudinal (direction of belt length) cracks that intersect with transverse cracks are **NOT** acceptable.

Replace the belt if it has unacceptable cracks, is frayed or has pieces of material missing.



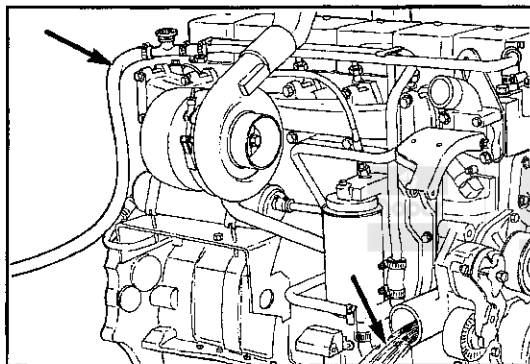



 **Flush the Cooling System**


 To clean the cooling system, back flush the radiator and engine with clean water.

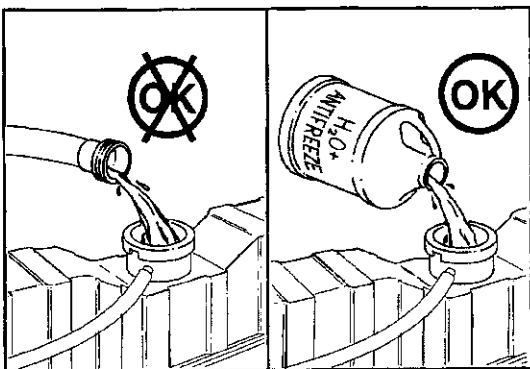
Remove both radiator hoses from the engine. Attach the water supply to the lower radiator connection and back flush the radiator.


If the radiator shows mineral build-up, scale, rust or oil, use a heavy duty radiator cleaner and follow the manufacturer's directions.

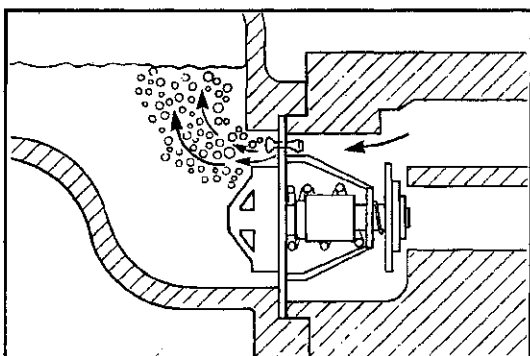



 Remove the top heater hose. Attach the water supply to the heater line and back flush the engine.

 If the radiator shows mineral build-up, scale, rust or oil, use a heavy duty radiator cleaner and follow the manufacturer's directions.



 Re-fill the cooling system with a mixture of 50% water and 50% ethylene-glycol type antifreeze. Refer to the Specifications, Section 0E for further details.



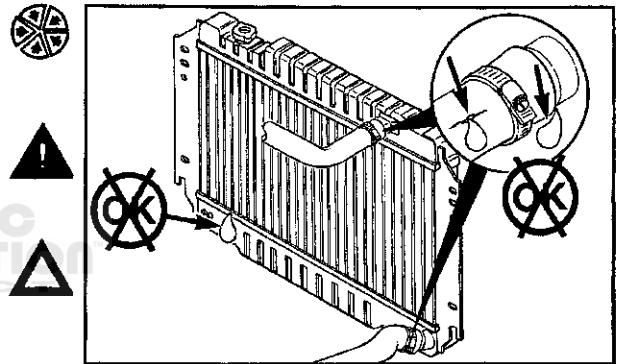
 During filling, air must be vented from the engine coolant passages. The air vents through the "jiggle pin" openings in the thermostat out the top radiator hose and fill opening.

The system has a maximum fill rate of 14 liters/minute [3.5 U.S. gallons/minute]. Do not exceed this fill rate.

Install the pressure cap. Start the engine and operate it until it reaches a temperature of 83°C [181°F]. Check the system for leaks.

**Warning:** If the engine has been operating and the coolant is hot, wait until the temperature is below 50°C [120°F] before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

**Caution:** Re-check the cooling system to insure total system is full of coolant.



## Cooling System Specifications

Coolant Capacity (Engine Only) - liter [U.S. quarts] .....	10.5 [11.1]
Standard Modulating Thermostat - Range ° C [°F] .....	Maximum Start 83 [181] Maximum Fully Open 95 [203]
Pressure Cap kPa [PSI] 110°C [230°F] Systems .....	103 [15]

## Cooling System Capacity

Engine Liter	Model	Drive	Radiator Width (Inches)	Capacity U.S. Quarts-Liter
5.9 Liter Diesel	D250, 350	2-Wheel (Automatic)	30.19	15.7 [16.5]
5.9 Liter Diesel	D250, 350	2-Wheel (Manual)	30.19	14.7 [15.5]
5.9 Liter Diesel	W250, 350	4-Wheel (Automatic)	30.19	15.7 [16.5]
5.9 Liter Diesel	W250, 350	4-Wheel (Manual)	30.19	14.7 [15.5]

## Component Capscrew Torque Values

	N·m	Inch Pounds	N·m	Foot Pounds
Water Pump C/S .....	--	--	24 N·m	[18 ft-lbs]
Viscous Fan Drive Attaching Nut .....	--	--	57 N·m	[42 ft-lbs]
Fan Attaching C/S (to Viscous Fan Drive) .....	--	--	20 N·m	[15 ft-lbs]
Fan Pulley C/S .....	--	--	9 N·m	[7 ft-lbs]
Fan Hub C/S .....	--	--	24 N·m	[18 ft-lbs]
Alternator Link C/S .....	--	--	24 N·m	[18 ft-lbs]
Alternator Mounting Bolt .....	--	--	43 N·m	[32 ft-lbs]
Fan Hub Shaft C/S .....	--	--	77 N·m	[57 ft-lbs]
Thermostat Housing C/S .....	--	--	24 N·m	[18 ft-lbs]
Shroud Mounting Nuts .....	11 N·m	[95 in-lbs]	--	--
Radiator Mounting Nuts .....	11 N·m	[95 in-lbs]	--	--
Drain Cock .....	17 N·m	[150 in-lbs]	--	--
Drain Cock Handle .....	2-4 N·m	[18-35 in-lbs]	--	--
Oil Cooler Fittings-				
Lines to Connector (Trans. End) and				
Engine MTG Cooler .....	54 N·m	[40 ft-lbs]	--	--
Trans. Cooler Hose Clamps .....	2 N·m	[18 in-lbs]	--	--
Radiator Hose Clamp .....	4 N·m	[35 in-lbs]	--	--

# Electrical System

## Section 8

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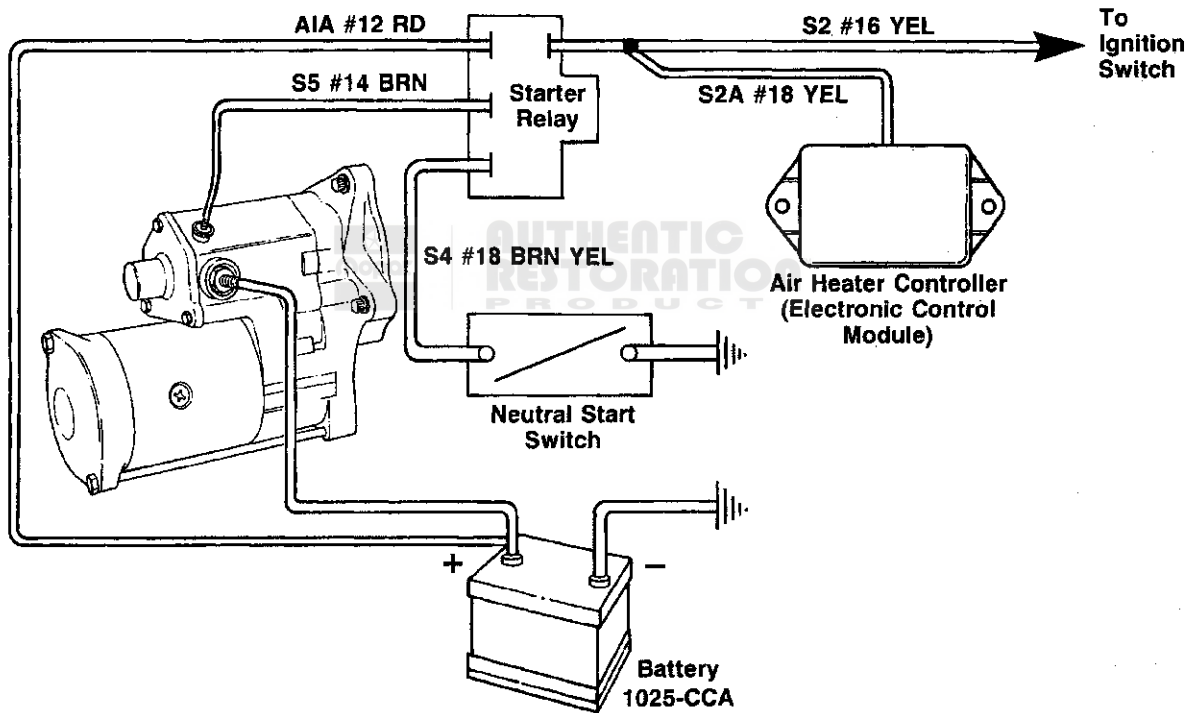


## Electrical System Description/Operation

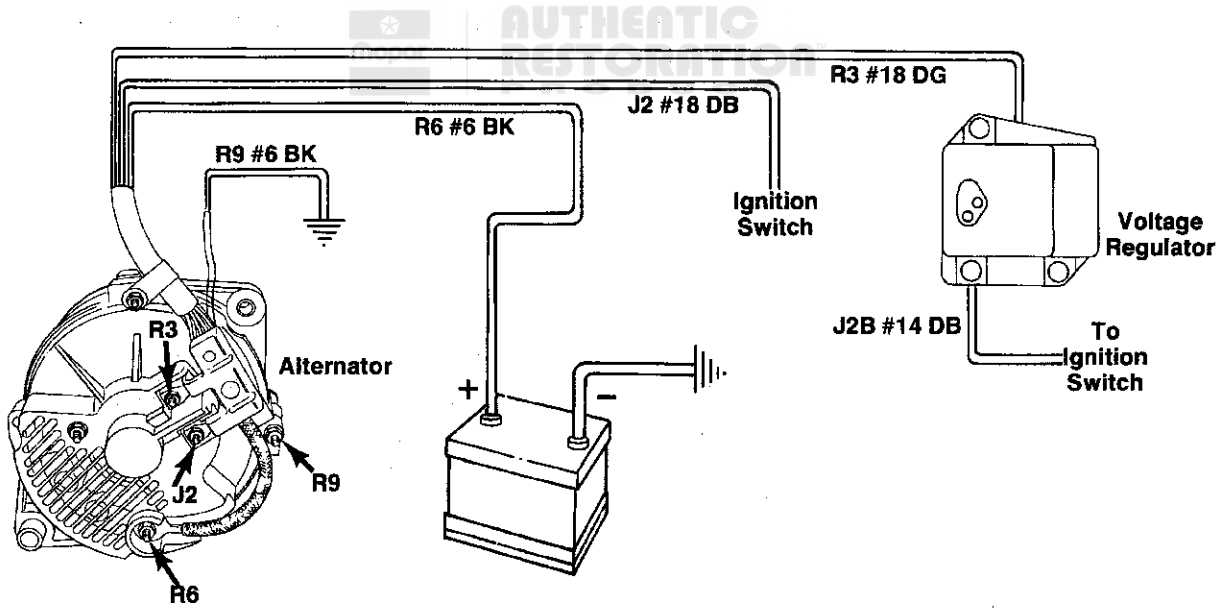
For purposes of this manual, the electrical system consists of the starting motor, alternator, heaters and control devices.

The injection pump uses an electrical fuel shut off valve. The engine has water temperature and oil pressure sensors connected to gauges on the instrument panel. The engine is also fitted with a block heater.

### Starting Motor

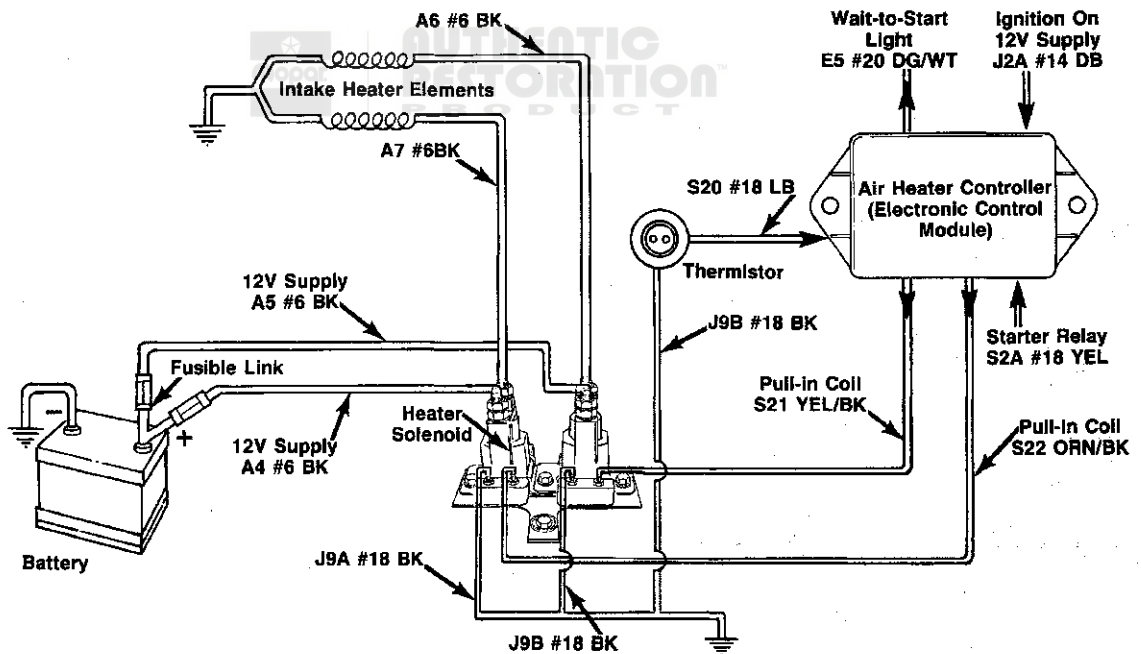


### Alternator

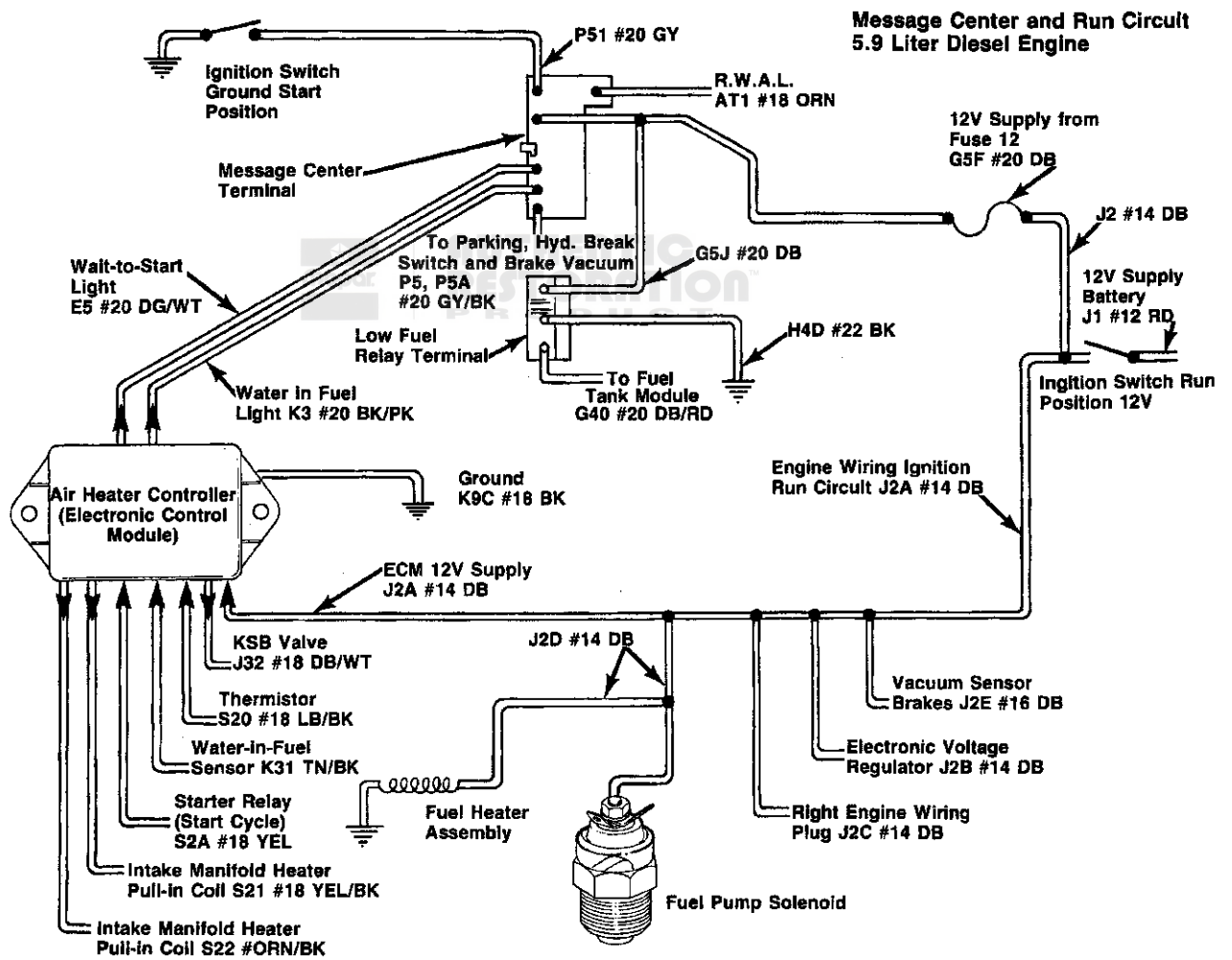


### Intake Manifold Heater System

Intake Manifold Heater System  
5.9 Liter Diesel Engine



Message Center and Run Circuit



### Electrical System Specifications

Minimum Recommended Battery Capacity ..... 1025CCA

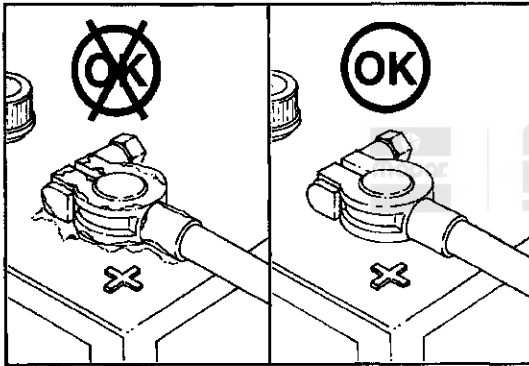
Maximum Allowable Resistance  
of Starting Circuit ..... .0012 Ohms

Starting Motor  
Nippondenso - 12 VDC ..... 3.0 Kw

Nut Size:

-Battery Connection 3/8x16 inch

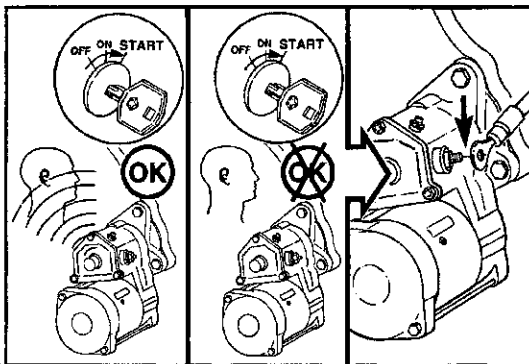
-Switch Connection 8-32 inch



### Diagnosing Electrical Malfunctions

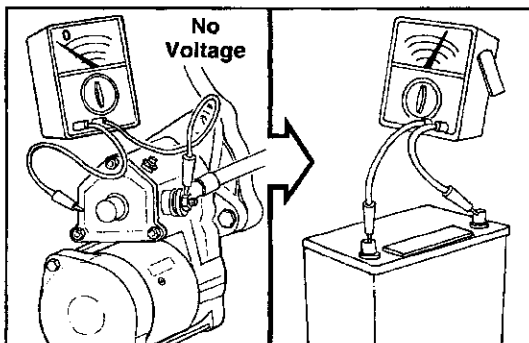
#### Starting Motor

Before you troubleshoot the starting motor, make sure the battery terminals are not loose or corroded.



#### Engine Does Not Crank

If the solenoid does not make an audible sound, check for loose wiring connections.



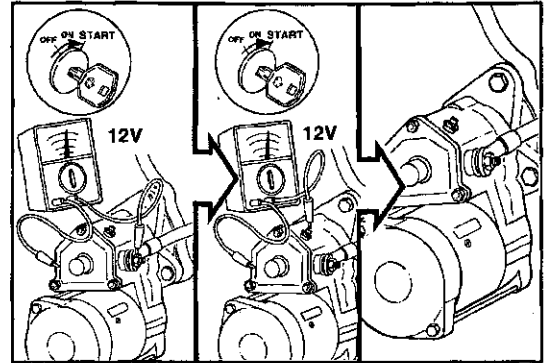
Check the voltage at the solenoid battery post.

- No voltage - check the condition of the battery. Check the connections at the battery, engine and solenoid.

- 12 volts at the solenoid battery post - check the voltage at the S (switch) terminal on the solenoid. The ignition switch must be in the start position.

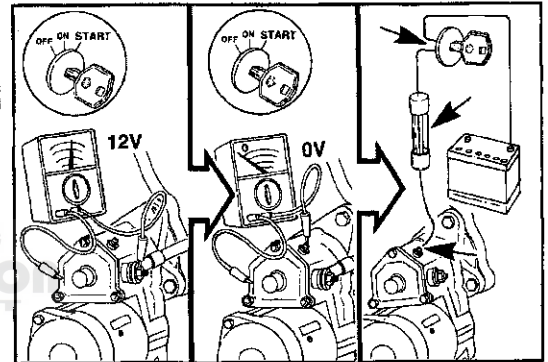


The solenoid is at fault if the check indicates 12 volts at the S terminal.



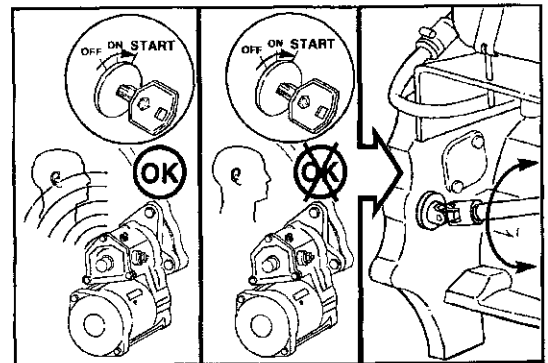
If no voltage is indicated at the S terminal, check:

- Check the fuses.
- Check the voltage at the ignition switch.
- Check the clutch switch or the neutral safety switch.
- Check starter relay switch.



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If the solenoid does make an audible sound, turn the switch off and attempt to bar the engine in both directions.

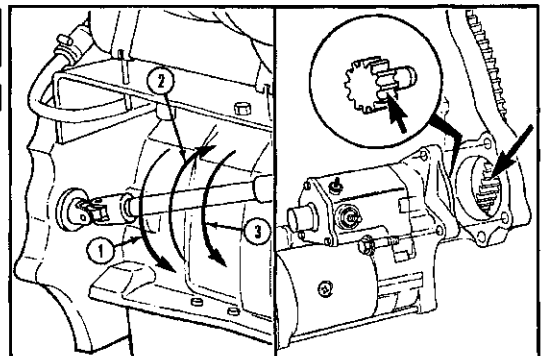


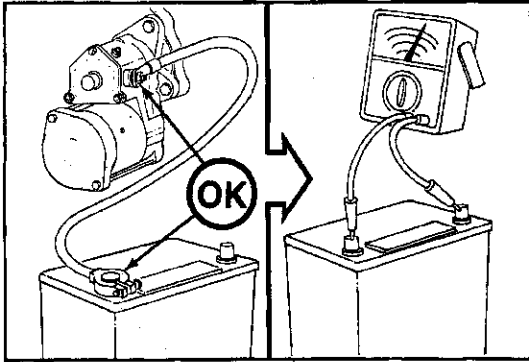
Bar the engine as follows:

1. Direction of engine rotation
2. Direction opposite engine rotation
3. Direction of engine rotation



If the engine will bar at Step 3, attempt to start the engine. If the starter cranks the engine, check the starter pinion gear and flywheel ring gear for damage.

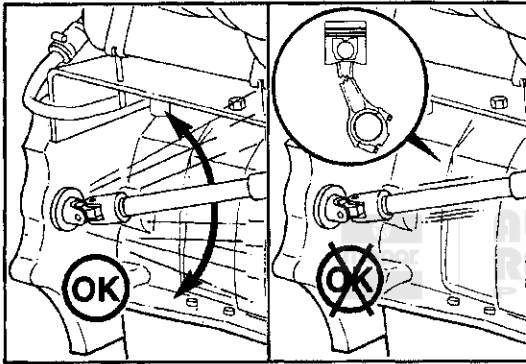




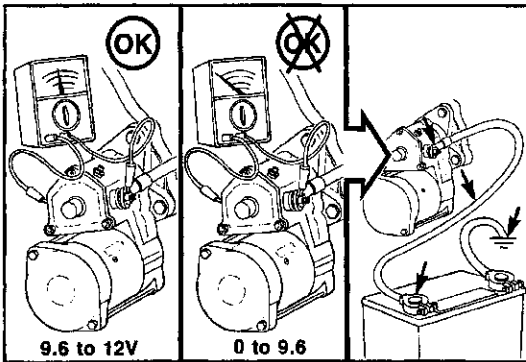
### Engine Cranking Speed Too Slow

Make sure the wiring connections are clean, tight and not damaged.

Check the battery voltage.

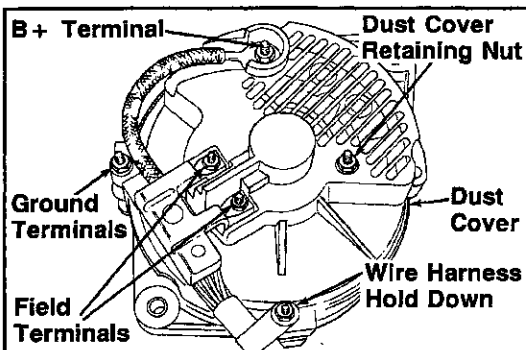


Bar the engine in the direction of engine rotation to make sure the engine is free and does not have an internal malfunction.



If the engine is free, check the voltage at the starter during cranking. If the voltage drops more than 2.4 volts, check that all connections are tight and the connections are ok.

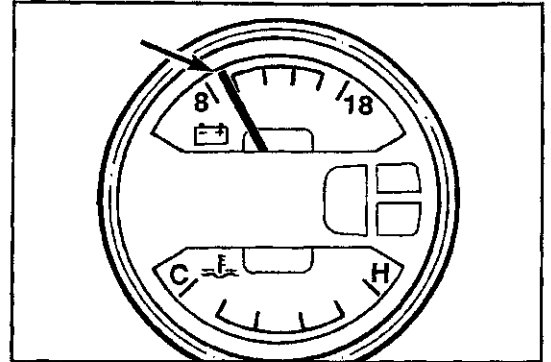
If the cables are correct and the voltage drop exceeds the limit, check the battery for a bad cell. If all cells are ok, replace the starter.



### Alternator

The terminals on the alternator are shown in this illustration.

Trouble with the charging system may be indicated by the ammeter.



### Abnormal Ammeter Operation

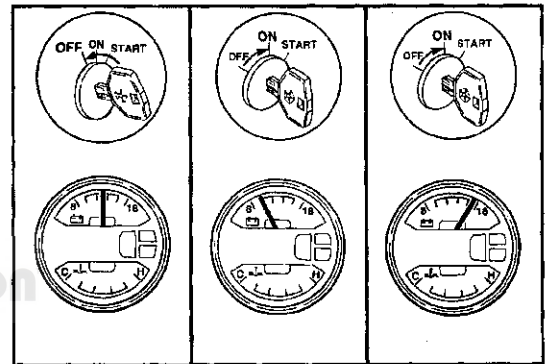
Check the ammeter for normal operation as shown below.

**Engine Switch Ammeter**

Stopped	Off	0
Stopped	On	-
Running	On	+

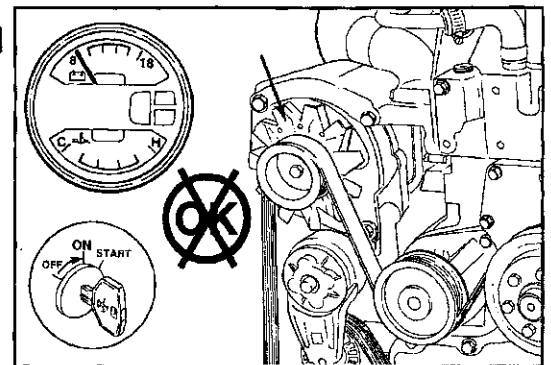


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### Switch On, Negative (-) on Ammeter, Engine Running.

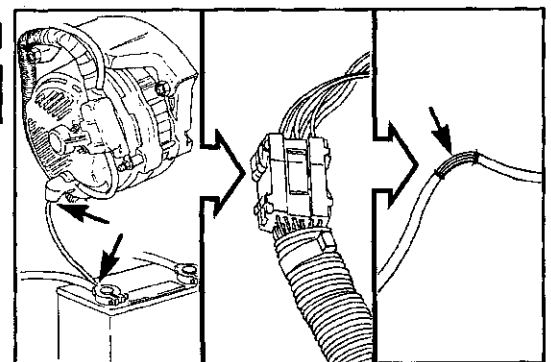
If the ammeter is indicating a discharge during engine operation, inspect the alternator drive pulley and drive belt for slippage.



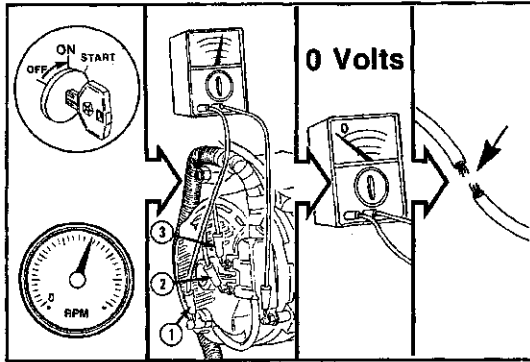
### Abnormal Charging System Operation

Check the battery and all wiring connections.

Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the slip connectors and connections at the battery.



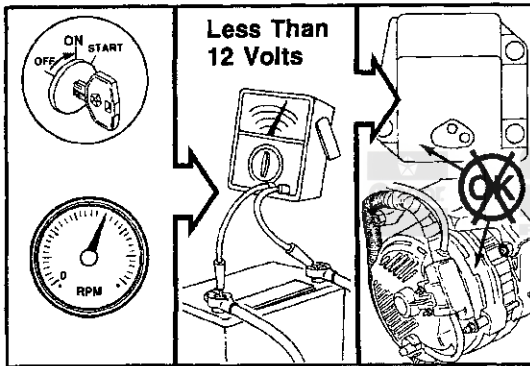




With Ignition switch on and all wiring harness leads connected, connect a voltmeter from:

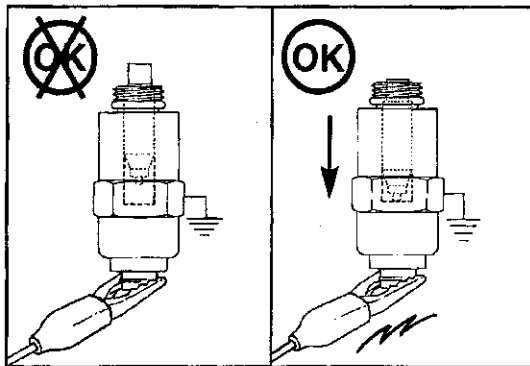
1. Alternator "BAT" terminal to ground
2. Alternator field terminal to ground
3. Alternator field terminal to ground

A zero reading indicates an open circuit between the voltmeter connection and the battery. Locate and repair the open circuit.



With all accessories turned off, connect a voltmeter across the battery. Operate engine at moderate speed.

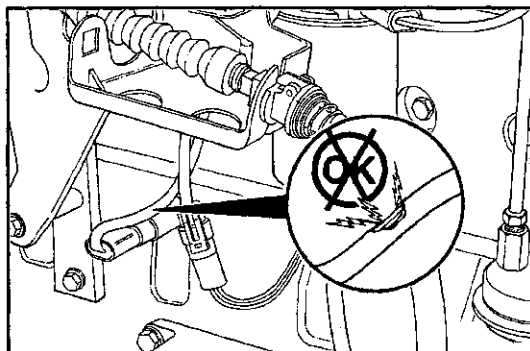
If voltage is 12 Volts or less, repair the alternator or voltage regulator as necessary.



### Fuel Shut off Valve - Check

**Note:** Check all connections for loose or corroded connections and for broken wires.

Remove the valve. Ground the valve and connect 12 volts DC to the terminal and observe plunger movement.



### Oil Pressure Switch and Temperature Sensor

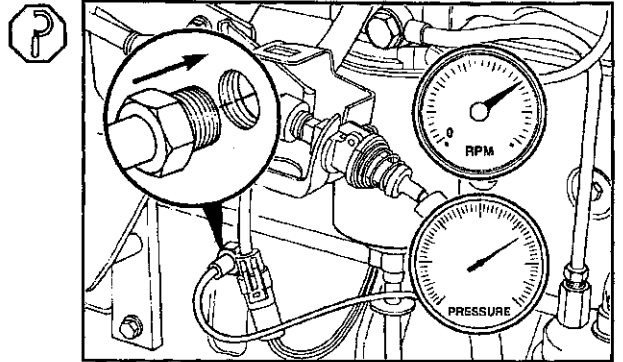
When diagnosing problems with either the pressure switch or the temperature sensor, check for loose or corroded connections and for broken wires.

### Oil Pressure Switch/Sending Unit - Check

Remove the pressure switch, install a gauge, start the engine and measure oil pressure. Minimum oil pressure:

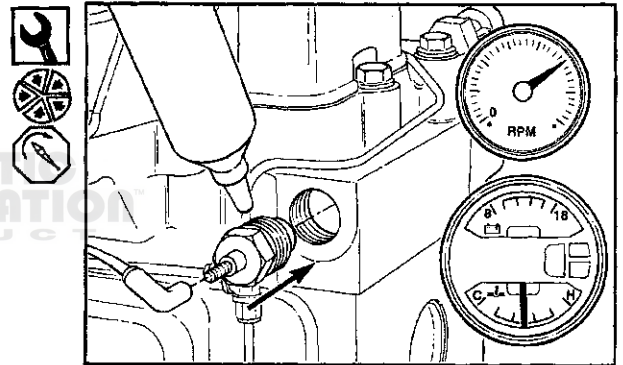
Idle	69 kPa	[10 psi]
Rated Speed	207 kPa	[30 psi]

**Note:** The Pressure switch is set to actuate when oil pressure drops to 55 kPa [8 PSI]. The pressure switch will activate a **Low Pressure Warning Light** on the dash of the truck.



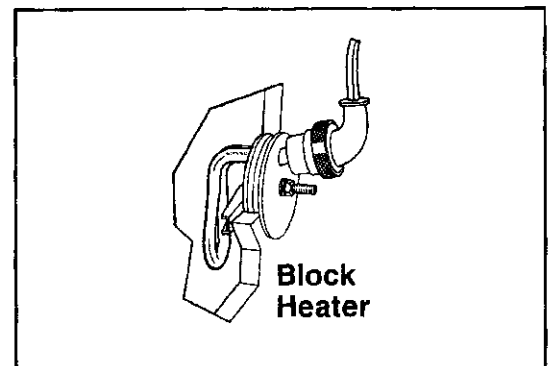
### Coolant Temperature Sensor - Check

Replace the sensor and rerun engine to confirm the temperature.

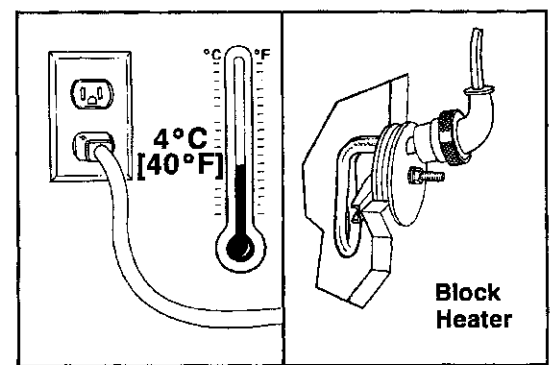


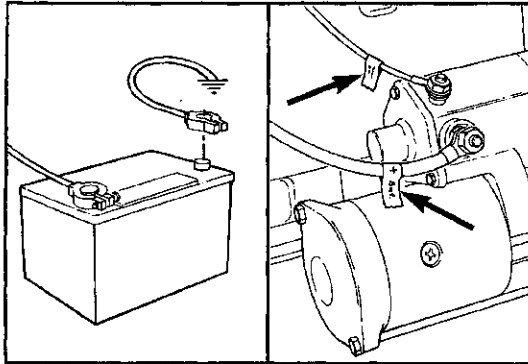
### Coolant Heater - Check

When operating, the engine block heater should make an audible sound and the adjacent parts should be warm to the touch.



The heater will operate continuously when plugged into the correct voltage electrical socket (110 volt A.C., 6.5 amp). Operate **only** when the ambient temperature is below 4°C [40° F].



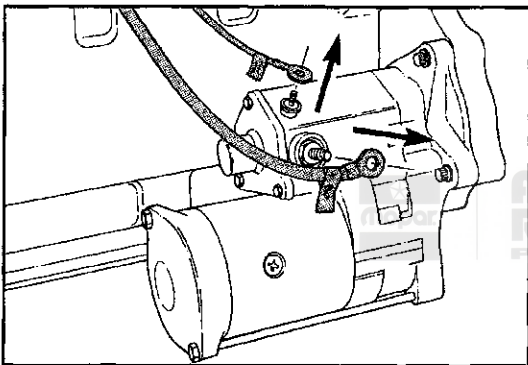


## Engine Electrical System Replacement Procedures

### Starting Motor - Replacement

#### Preparatory Steps:

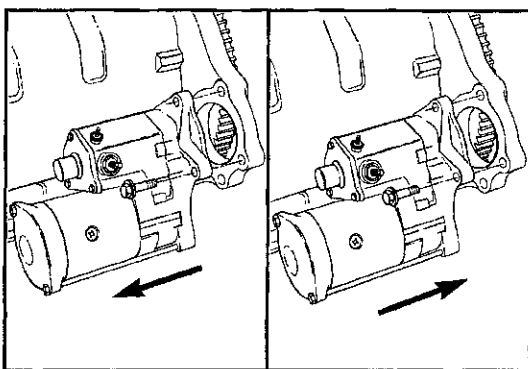
- Disconnect the ground cable from the battery terminal.
- Identify each electrical wire with a tag indicating location.



15mm, 8mm



Remove the battery cable, accessory and switch wires from the solenoid.



8mm, 10mm (12 point socket), 15mm



Remove the starting motor.

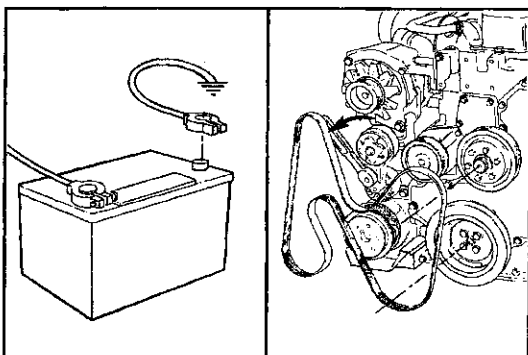


Install the starting motor in the reverse order of removal.



#### Torque Value:

Starter mounting capscrews	43 N•m [32 ft-lbs]
Positive cable nut	22 N•m [16 ft-lbs]
Solenoid nut	5 N•m [44 in-lbs]



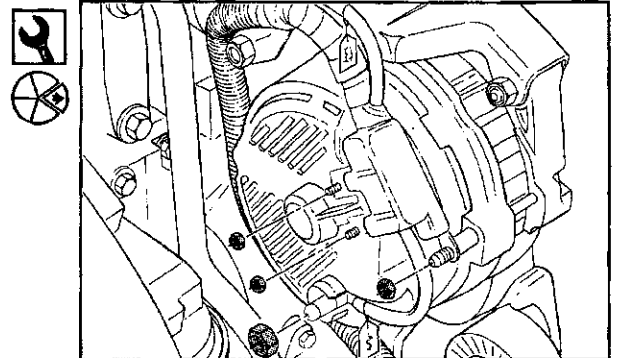
### Alternator - Replacement

#### Preparatory Steps:

- Disconnect the ground cable from the battery terminal.
- Remove the drive belt from the alternator pulley.

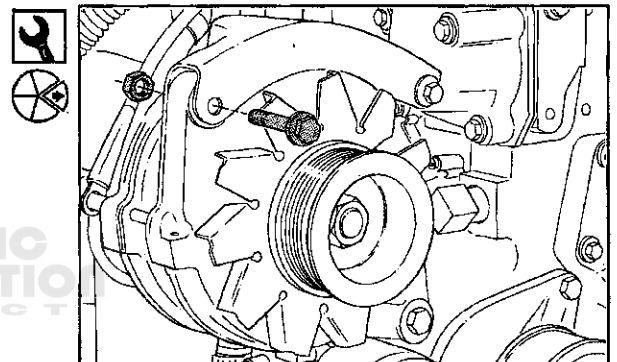
7mm, 8mm, 10mm

Remove and tag all wires and complete the following steps.



13mm

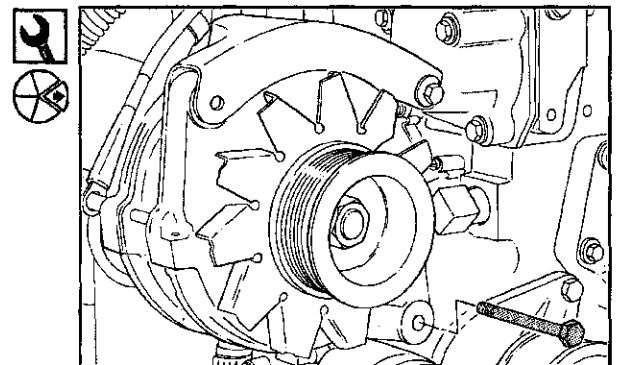
Remove the alternator link capscrew.



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13mm, 15mm

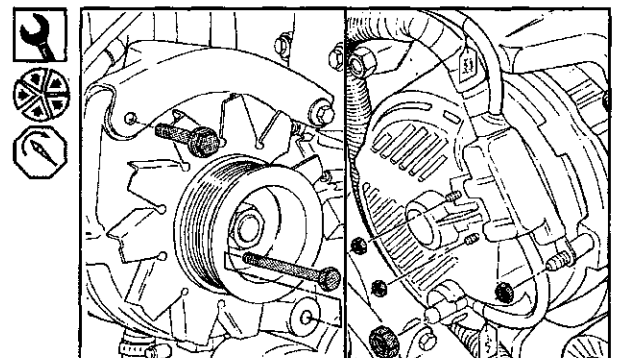
Remove the alternator mounting capscrew.

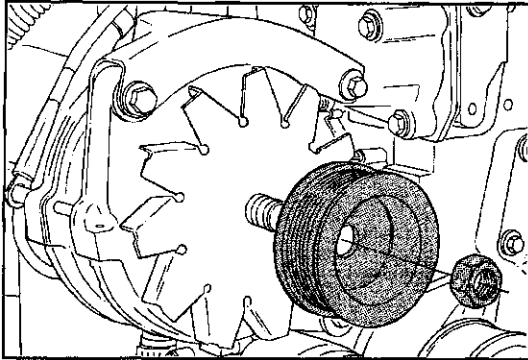


7mm, 8mm, 10mm, 13mm, 15mm

Install the alternator. Tighten the upper mounting capscrews before tightening the lower mounting bolt. Re-connect all wires.

**Torque Value:**    Upper Capscrew - 24 N·m [18 ft-lbs]  
                             Lower Bolt - 43 N·m [32 ft-lbs]





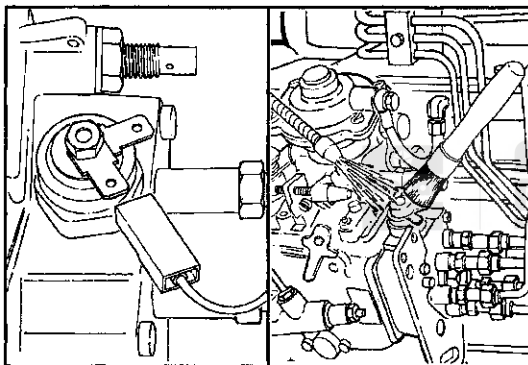
15/16 inch



Remove and replace alternator pulley.



Torque Value: 80 N·m [60 ft-lbs]

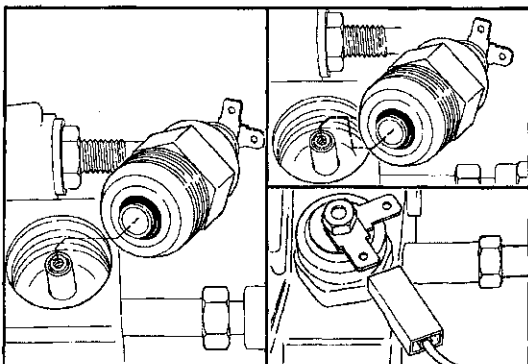


**Electric Fuel Shut Off Valve - Replacement**



8mm

Remove the electrical wire from the valve. Clean the area around the valve thoroughly.



24mm

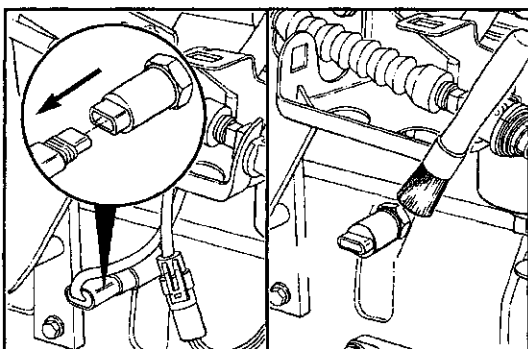


**Caution: When removing the valve, be careful not to drop the piston and spring from inside the valve housing.**



Replace the valve and connect the electrical wire.

Torque Value: 43 N·m [32 ft-lbs]



**Oil Pressure Switch - Replacement**



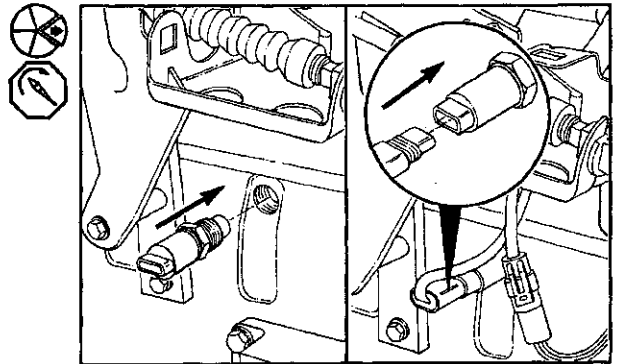
Remove the electrical connector from the switch. Clean the area around the switch thoroughly.

### Oil Pressure Switch/Sending Unit Socket

Replace the switch and connect the electrical connector.

Tighten the oil pressure switch.

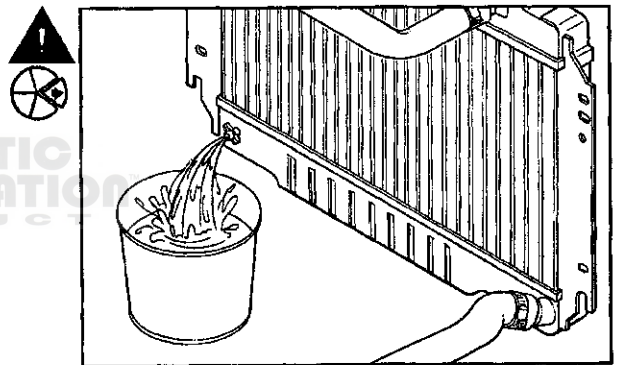
**Torque Value:** 16 N-m [12 ft-lbs]



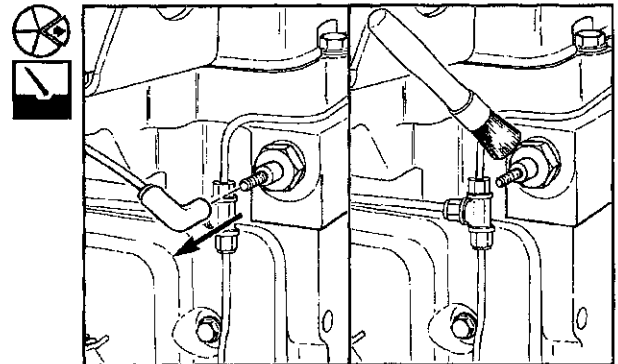
### Temperature Sensor – Replacement

**Warning:** Wait until the temperature is below 50°C [120°F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Drain the coolant system by opening the drain valve on the radiator. A drain pan with a capacity of 20 liters [5 U.S. gallons] will be adequate to hold the coolant.

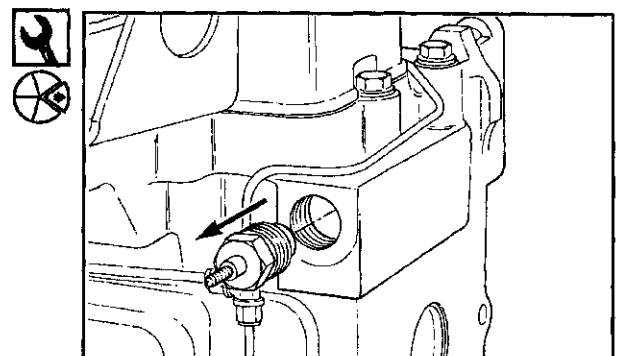


Disconnect the temperature sensor wiring. Clean the area around the sensor thoroughly.

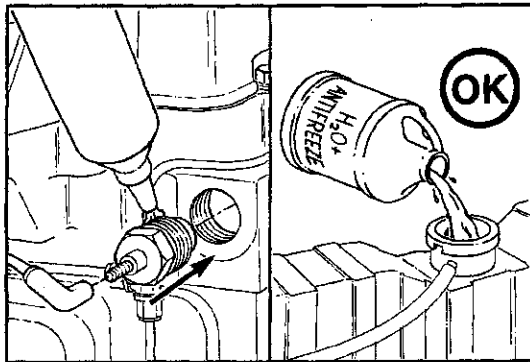


### 1 1/16 Inch Socket

Remove the temperature sensor.







1 1/16 inch Socket



Apply liquid teflon sealant to the threads when installing the temperature sensor. Re-connect the wiring.

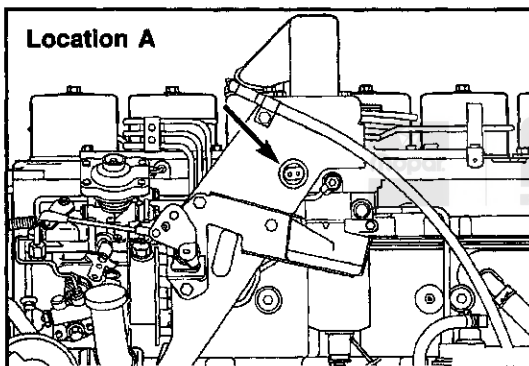


Tighten the sensor.



Torque Value: 24 N·m [18 ft-lbs]

Re-fill the cooling system.



Thermistor - Replacement



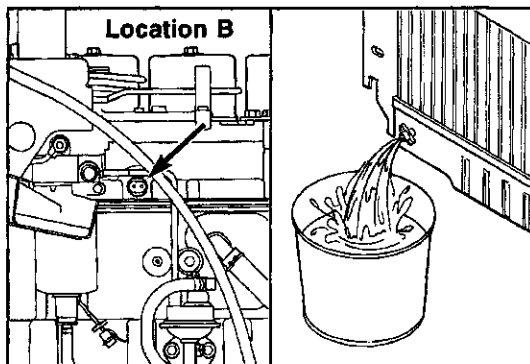
1 1/16 inch Socket



Location - A (Intake Manifold)

- Disconnect wiring
- Remove thermistor
- Apply liquid teflon sealant to threads.
- Tighten the thermistor

Torque Value: 24 N·m [18 ft-lbs]

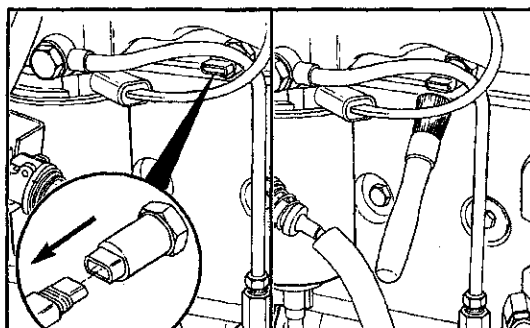


Location - B (Head Water Jacket)



**Warning:** Wait until the temperature is below 50°C [120° F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Drain the coolant system by opening the drain valve on the radiator. A drain pan with a capacity of 20 liters [5 U.S. gallons] will be adequate to hold the coolant.

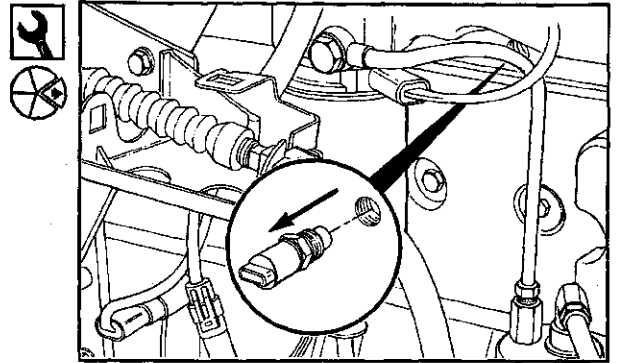


Disconnect the thermistor wiring harness. Clean the area around the thermistor thoroughly.



**1 1/16 inch Socket**

Remove the thermistor.



**1 1/16 inch Socket**

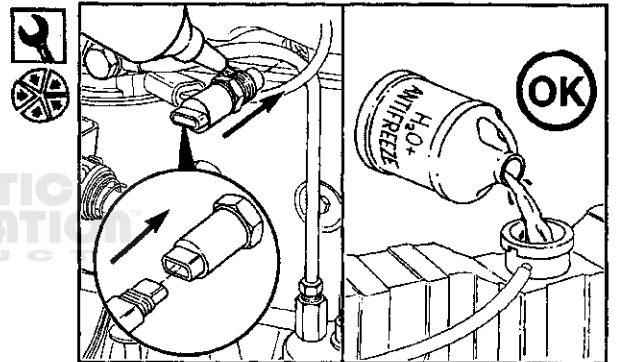
Apply liquid teflon sealant to the threads when installing the thermistor. Re-connect the wiring harness.

- Tighten the sensor
- Refill Cooling System

Torque Value: 24 N·m [18 ft-lbs]



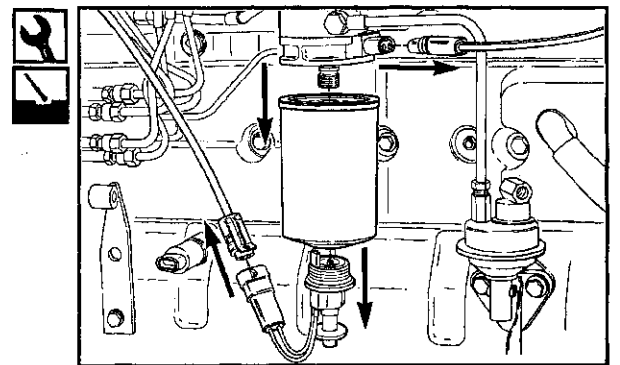
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**Fuel Heater - Replacement**

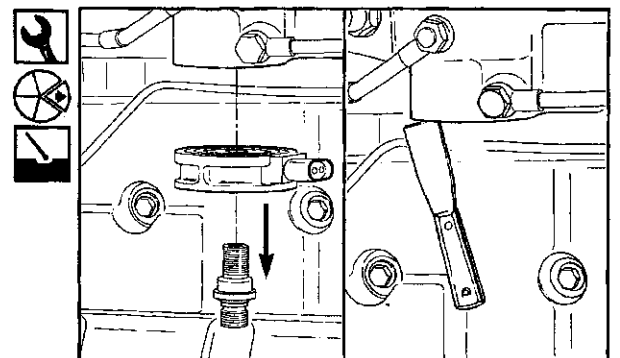
**75-80mm Filter Wrench**

Clean the area around the fuel filter and fuel heater thoroughly. Remove the fuel filter, electrical connectors and sensor from the fuel heater.

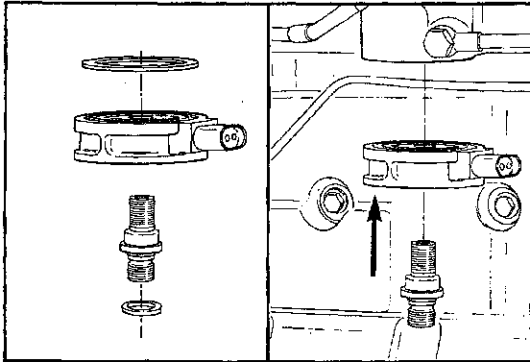


**Screwdriver Adapter**

Remove the center adapter and the fuel heater assembly from the cylinder head. Clean the surface of the head to remove any remaining seal.







**Screwdriver Adapter**

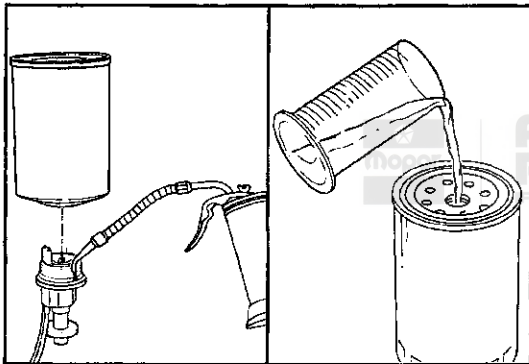


Install new seals in the fuel heater assembly and in the adapter.  
Install the fuel heater and adapter.



Tighten the adapter.

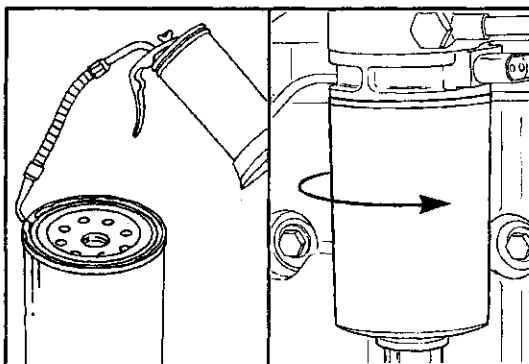
**Torque Value: 32 N·m [24 ft-lbs]**



Apply a light film of lubricating oil to the sealing ring of the fuel water sensor. Install the sensor in the fuel water separator /filter. Hand tighten the sensor snug against the filter body.



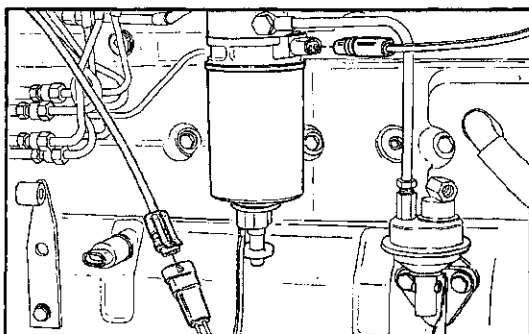
Fill the new fuel water separator/filter with clean fuel.



Apply a light film of lubricating oil to the sealing surface of the filter before installing.



Install the fuel water separator/filter and tighten it 1/2 turn after its seal contacts the filter head.



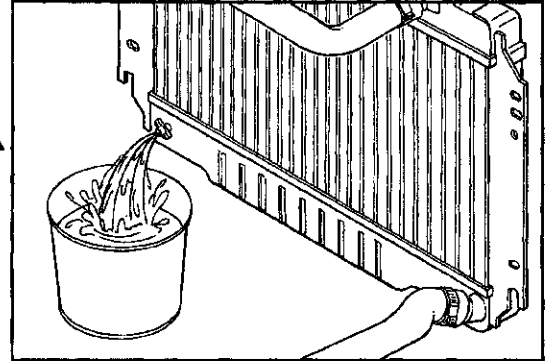
Plug in the electrical connections.

## Engine Block Water Heater - Replacement

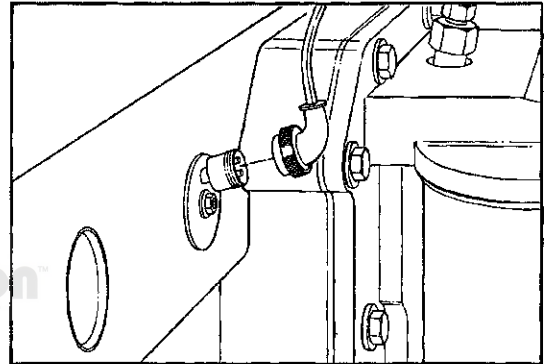
Preparatory Step:

**Warning:** Wait until the temperature is below 50°C [120° F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Drain the coolant system by opening the drain valve on the radiator. A drain pan with a capacity of 20 liters [5 U.S. gallons] will be adequate to hold the coolant.

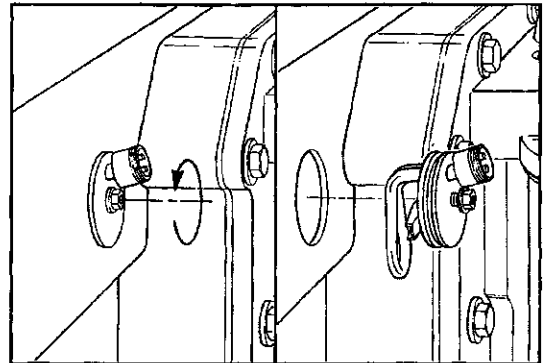


Disconnect the block heater electrical cord.



5mm

Loosen the block heater screw and remove the block heater from the block.

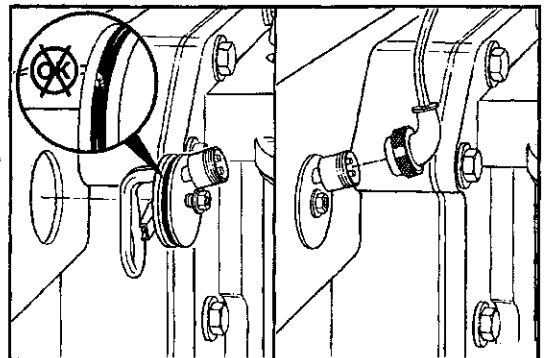


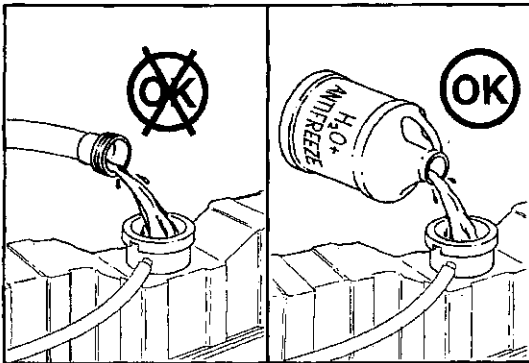
5mm


Clean the bore in the cylinder block. Check the o-ring on the heater to make sure it is not damaged. Slide the heater into the seated position and tighten the retaining screw.

**Torque Value:** 12 N·m [9 ft-lbs]

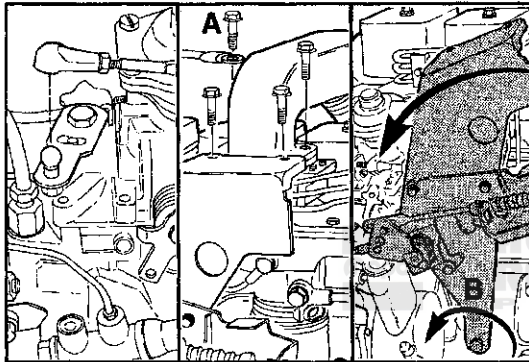
Connect the electrical cord to the heater.





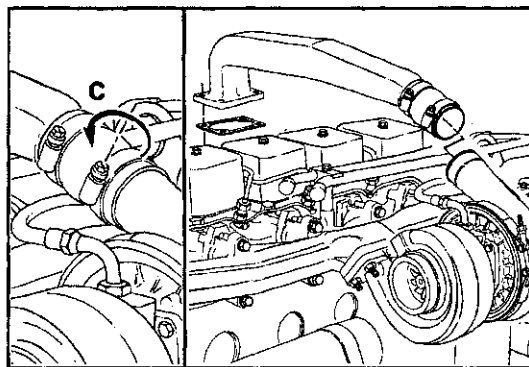
 Re-fill the cooling system.



### Intake Manifold Heater - Replacement



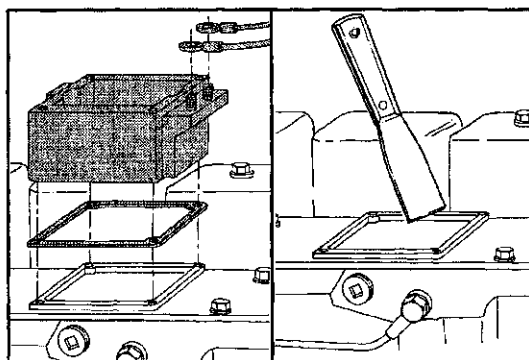
 Remove  
 10mm


Disconnect the throttle rod from the throttle lever. Remove the four mounting capscrews (A). Loosen the throttle control bracket lower mounting capscrew (B) and move the top end away from the engine.



 5/16 inch  
 Loosen the hose clamp (C).

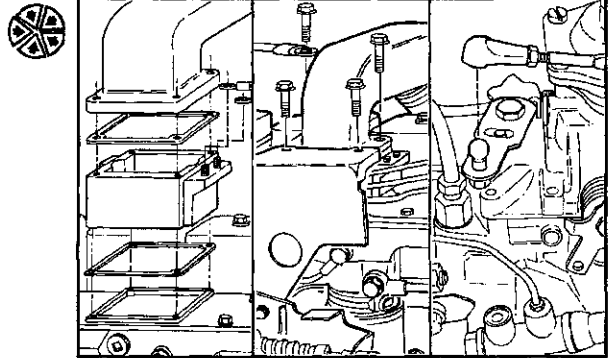
Remove the air crossover and gasket. Stuff a clean shop towel into the turbocharger opening.



 Disconnect the electrical wiring and remove the intake manifold heater and gasket. Clean the mounting surface of the intake manifold.

### Install

Install the new gasket and the intake manifold heater. Connect the intake manifold power supply connections.



**Torque Value:** 14 N•m [10 ft-lbs]

Install the air crossover and gasket. Install the intake manifold heater ground wire.

Install the throttle control bracket.

Attach the throttle rod to the throttle lever.

5/16 inch, 10mm

Tighten the four mounting capscrews (A).

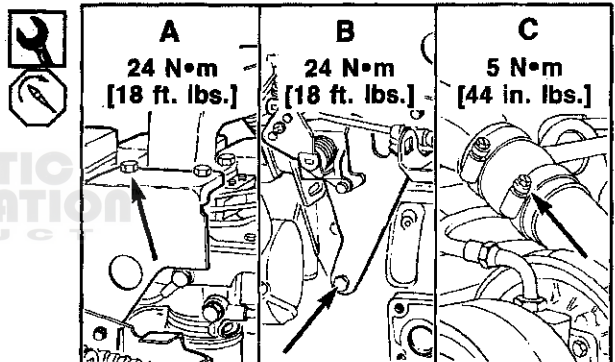
**Torque Value:** 24 N•m [18 ft-lbs]

Tighten the throttle bracket lower mounting capscrew (B).

**Torque Value:** 24 N•m [18 ft-lbs]

Tighten the hose clamp (C).

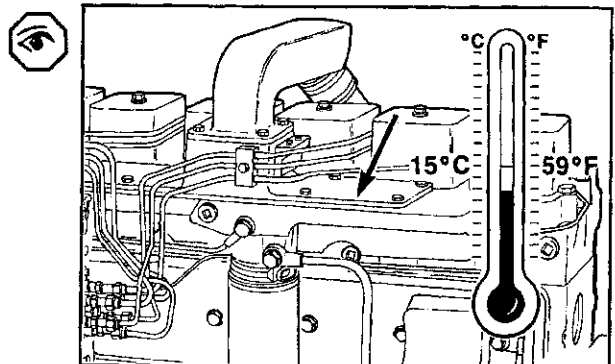
**Torque Value:** 5 N•m [44 in-lbs]



### Intake Manifold Heater Controls - Check

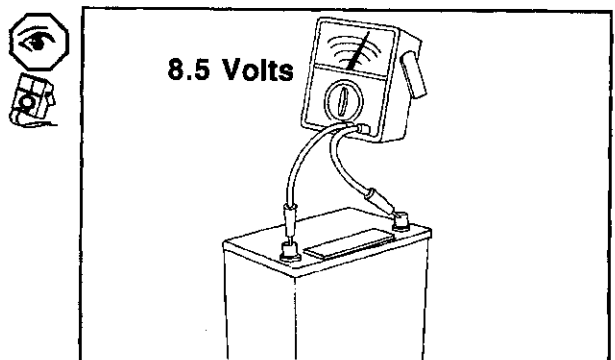
#### Operating Temperature

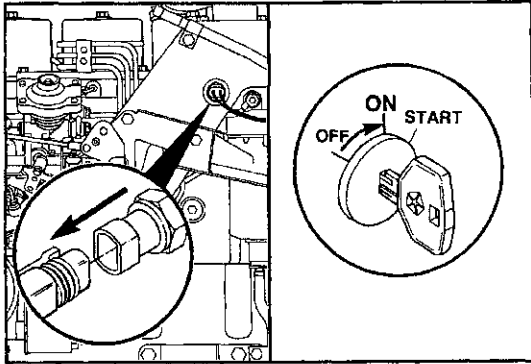
The temperature in the intake manifold must be below 0°C [32°F] for early electronic control modules before serial number 0080000A and 15°C [59°F] for later electronic control modules, for preheat to occur.



### Battery Voltage - Check

Check the voltage across the posts of the battery. There must be a minimum of 8.5 Volts for the intake manifold heater or the electronic control module to operate.

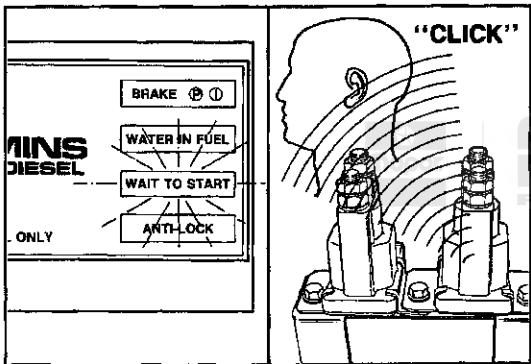




**Thermistor – Check**

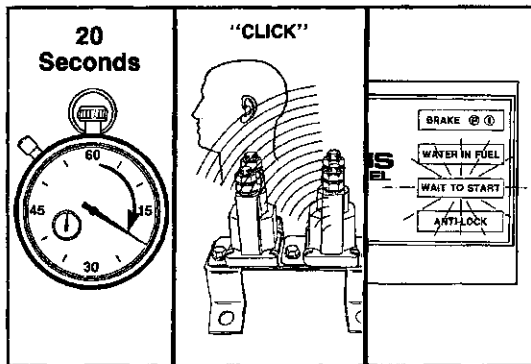
Remove the electrical connector from the thermistor. Prepare to time the Preheat cycle by watching the WAIT to START light.

Turn the ignition key to the ON position, but do not start the engine.



The WAIT to START light will come on and the heater solenoids should CLICK on.

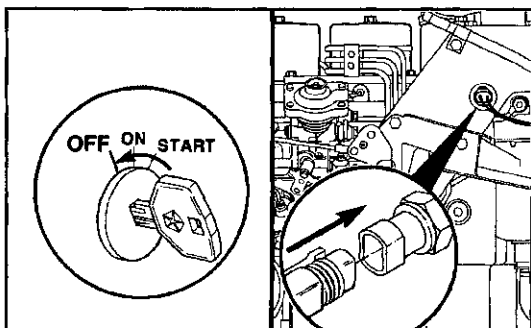
**Note:** There should be no voltage at the KSB valve if the intake manifold temperature is less than 15°C [59°F].



The WAIT to START light should stay on (Preheat Cycle On) for 20 seconds. After 20 seconds, the WAIT to START light should go off and the heater solenoids should CLICK off.

After 20 seconds the WAIT to START light should start flashing. This is an indication that the thermistor circuit is open (because it is unplugged).

The KSB valve should have voltage at the valve terminal if the intake manifold has heated to 15°C [59°F] or above.

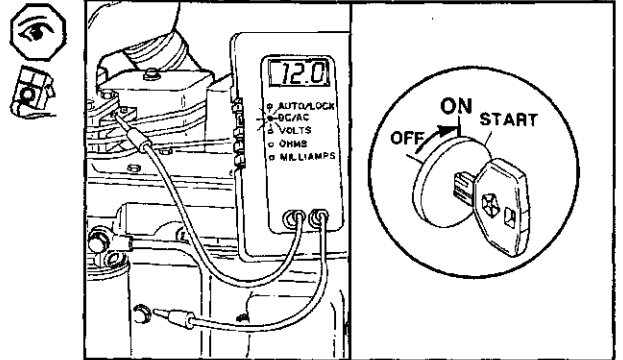


Turn the key to the off position. Plug the wiring connector back onto the thermistor.

### Preheat/Postheat Cycle - Check

Prepare to time the Preheat cycle by watching the WAIT to START light or using a voltmeter or testlight at the manifold heater terminals. Turn the ignition key to the ON position, but do not start the engine.

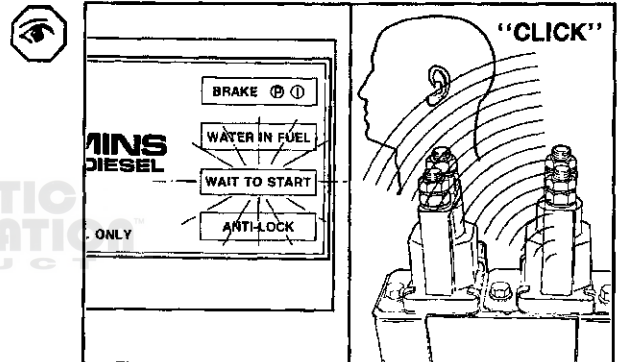
**Note:** The temperature in the intake manifold must be below 0°C [32°F] (for early electronic control modules before serial number 0080000A) and 15°C [59°F] (for later electronic control modules), for preheat to occur.



If the engine has not been running and the ambient temperature is less than 15°C [59°F], the WAIT to START light will come on and the heater solenoids should activate with an audible CLICK.

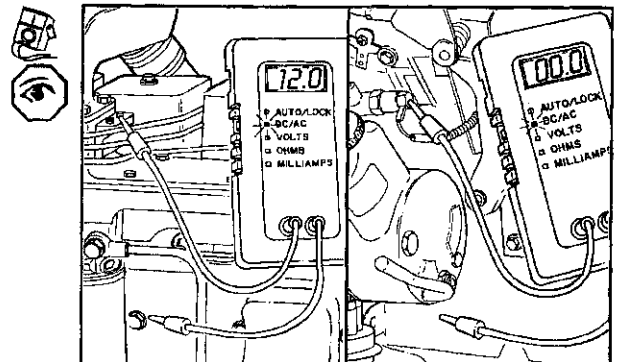


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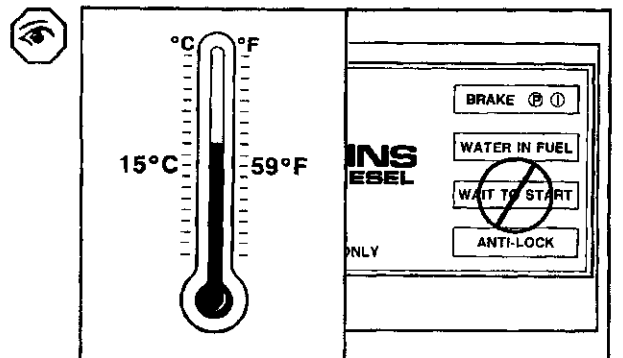


Check the voltage at both heater terminals. There should be voltage at both terminals for the first 10 to 20 seconds of Preheat. See the chart on a following page (Normal intake heater operation) for the sequence of heater operation.

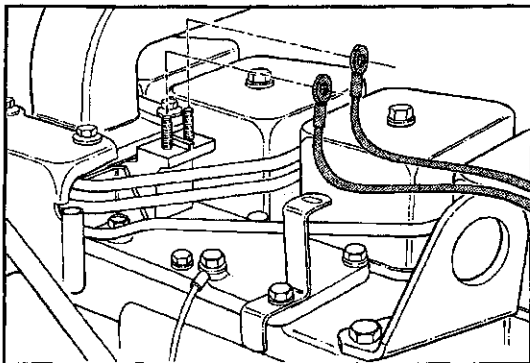
There should no voltage at the KSB valve during the Preheat cycle, if the temperature is less than 15°C [59°F].



If the engine has been running or the ambient temperature is above 0°C [32°F] (for early electronic control modules before serial number 0080000A) or 15°C [59°F] (for later electronic control modules), the heater solenoids and Wait to Start light will not come on. There is no Preheat cycle above these temperatures.



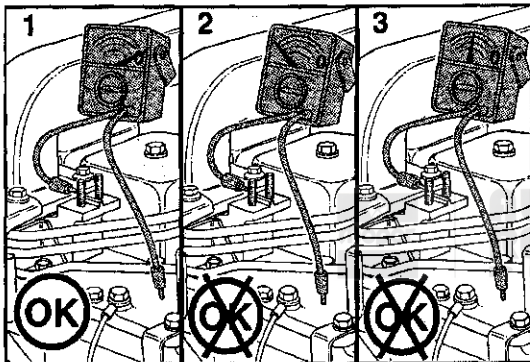




**Intake Manifold Heater - Check**

3/8 inch

Remove the two wires from the heater. Position the wires so they do not touch any other component.



Use an ohmmeter and check the resistance from ground to each heater terminal. The resistance should read "0". Replace the heater or repair connections if necessary.

1. Meter reading "0" = Good heaters
2. Meter does not move = Bad heaters
3. Meter reads, but not "0" = Dirty or corroded connections - clean and repair as necessary

**Temperature/Cycle Time Chart of Normal Operation**

Engine intake manifold temperature	Preheat Cycle time Ignition key ON Before crank cycle	Postheat Cycle occurrence Ignition key ON After crank cycle
Above 15°C [59°F]	0 Seconds	No
-9°C [15°F] to 15°C [59°F]	10 Seconds *	Yes
-18°C [0°F] to -9°C [15°F]	15 Seconds	Yes
-25°C [-15°F] to -18°C [0°F]	17.5 Seconds	Yes
Below -26°C [-15°F]	20 Seconds	Yes

**Note:** The KSB valve activation voltage is independent of the intake manifold heater control system. The KSB valve will be activated any time the manifold temperature is above 15°C [59°F] and the ignition key is in the ON position.

\* Heater Control Modules / Electronic Control Modules with serial numbers below 0080000A will not have Preheat during this cycle.

## Specifications

### Electrical Capacity

Battery Connection - Nut Size .....	3/8x16 inch
Maximum Allowable Resistance of Starting Circuit .....	.0012 Ohms
Minimum Recommended Battery Capacity .....	1025CCA
Starter Switch Connection - Nut Size .....	8-32 inch
Starting Motor - Nippondenso .....	12 VDC 3 Kw

### Pressures:

Minimum Oil Pressure - Idle .....	69 kPa [10 psi]
Minimum Oil Pressure - Rated Speed .....	207 kPa [30 psi]

### Torque Values:

Alternator Lower Mounting Capscrew .....	43 N·m	[32 ft-lbs]
Alternator Pulley Retainer Nut .....	80 N·m	[60 ft-lbs]
Alternator Upper Mounting Capscrew .....	24 N·m	[18 ft-lbs]
Cylinder Block heater .....	12 N·m	[9 ft-lbs]
Fuel Heater Adapter .....	32 N·m	[24 ft-lbs]
Fuel Pump Solenoid Valve .....	43 N·m	[32 ft-lbs]
Intake Air Cross Over Tube - Hose Clamps .....	5 N·m	[44 in-lbs]
Intake Air Cross Over Tube - Mounting Capscrews .....	24 N·m	[18 ft-lbs]
Oil Pressure Switch .....	16 N·m	[12 ft-lbs]
Starter Mounting Capscrews .....	43 N·m	[32 ft-lbs]
Starter Positive Cable Nut .....	22 N·m	[16 in-lbs]
Starter Solenoid Nut .....	5 N·m	[44 in-lbs]
Thermistor .....	24 N·m	[18 ft-lbs]
Throttle Control Bracket .....	24 N·m	[18 ft-lbs]





Base Engine Components  
DODGE Turbo Diesel

## Base Engine Components

### Section 9

### Contents

Section  
Number



Subject

9A	Troubleshooting
9B	Engine Lubricating System
9C	General Overview - In and Out of Chassis Repairs
9D	In-Chassis Repairs - General
9E	In-Chassis Diagnostic Procedures
9F	In-Chassis Repairs
9G	Out-of-Chassis Repairs - General
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9I	Out-of-Chassis Repairs
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9K	Alternative Repair Procedures
9L	Engine Specifications



Base Engine Components  
DODGE Turbo Diesel

Troubleshooting Logic  
Page 9A-1

## Troubleshooting Logic

### Section 9A

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Problem Isolation and Correction .....	9A-2
Troubleshooting Logic (List of Symptoms) .....	9A-3

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## Troubleshooting Logic

### Engine Diagrams

A schematic of each of the major engine systems is provided at the beginning of the Section of the manual devoted to troubleshooting and repairing that particular system.

The diagrams depict flow through the various engine systems. The information and configuration of the components illustrated in the drawings are of a general nature.

Each Section also contains a discussion regarding diagnosing malfunctions for that specific system. A knowledge of the systems can help you troubleshoot and repair the engine.

### Problem Isolation and Correction

The following Troubleshooting logic is designed to help you organize your study of a problem and plan a procedure to correct it. The series of fault/logic charts given do not provide all the answers, but they should stimulate a train of thought that will lead you to the source of the trouble.

Be sure to consider any maintenance or repair action that could have caused the problem.

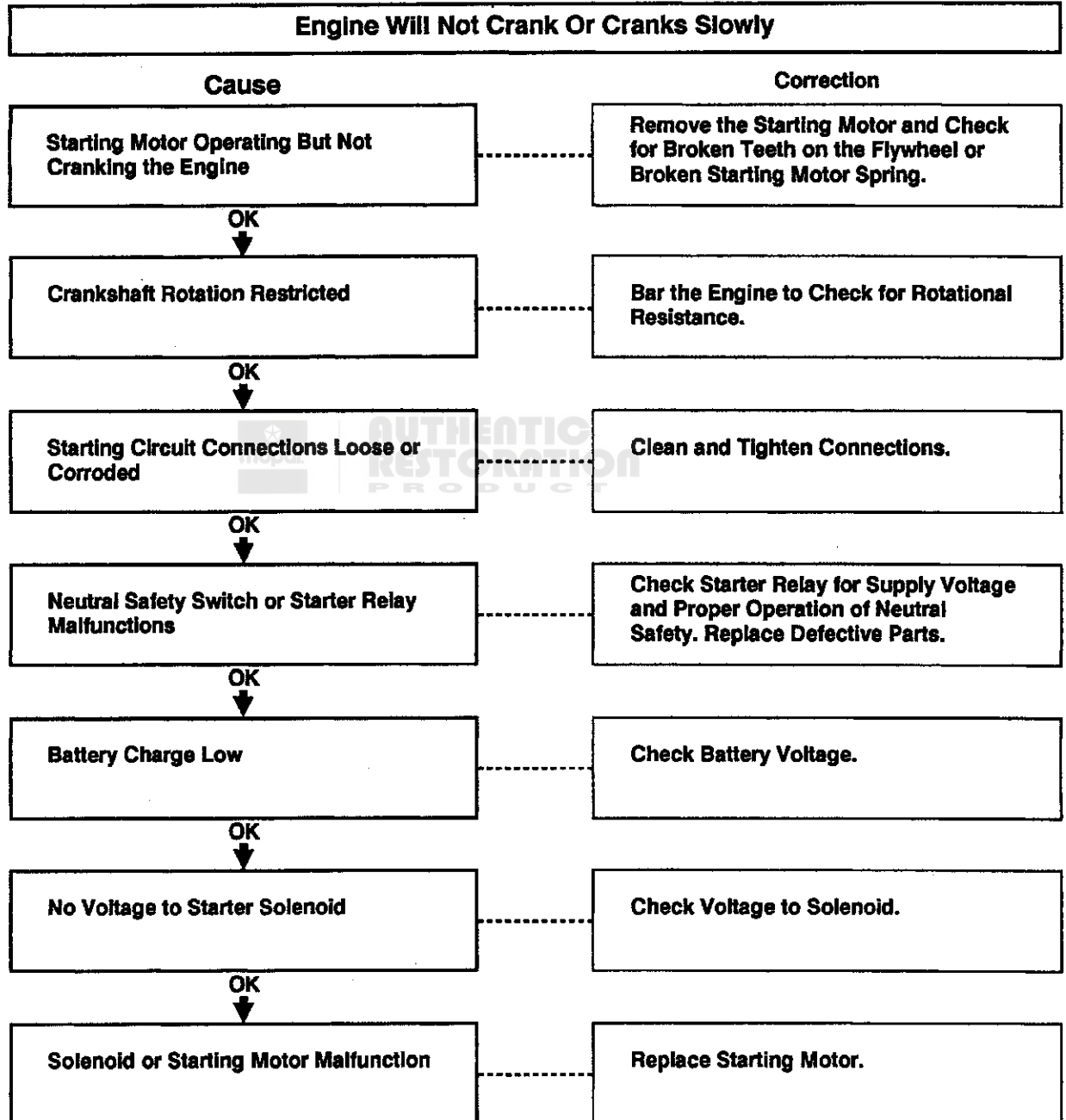
If the engine surges or runs rough initially after not being used for 2 months or more, do not assume that the engine has a malfunction. Varnish can form on the internal parts of the injection pump and the oil film can drain from the piston rings. Operate the engine for at least 5 minutes before troubleshooting.

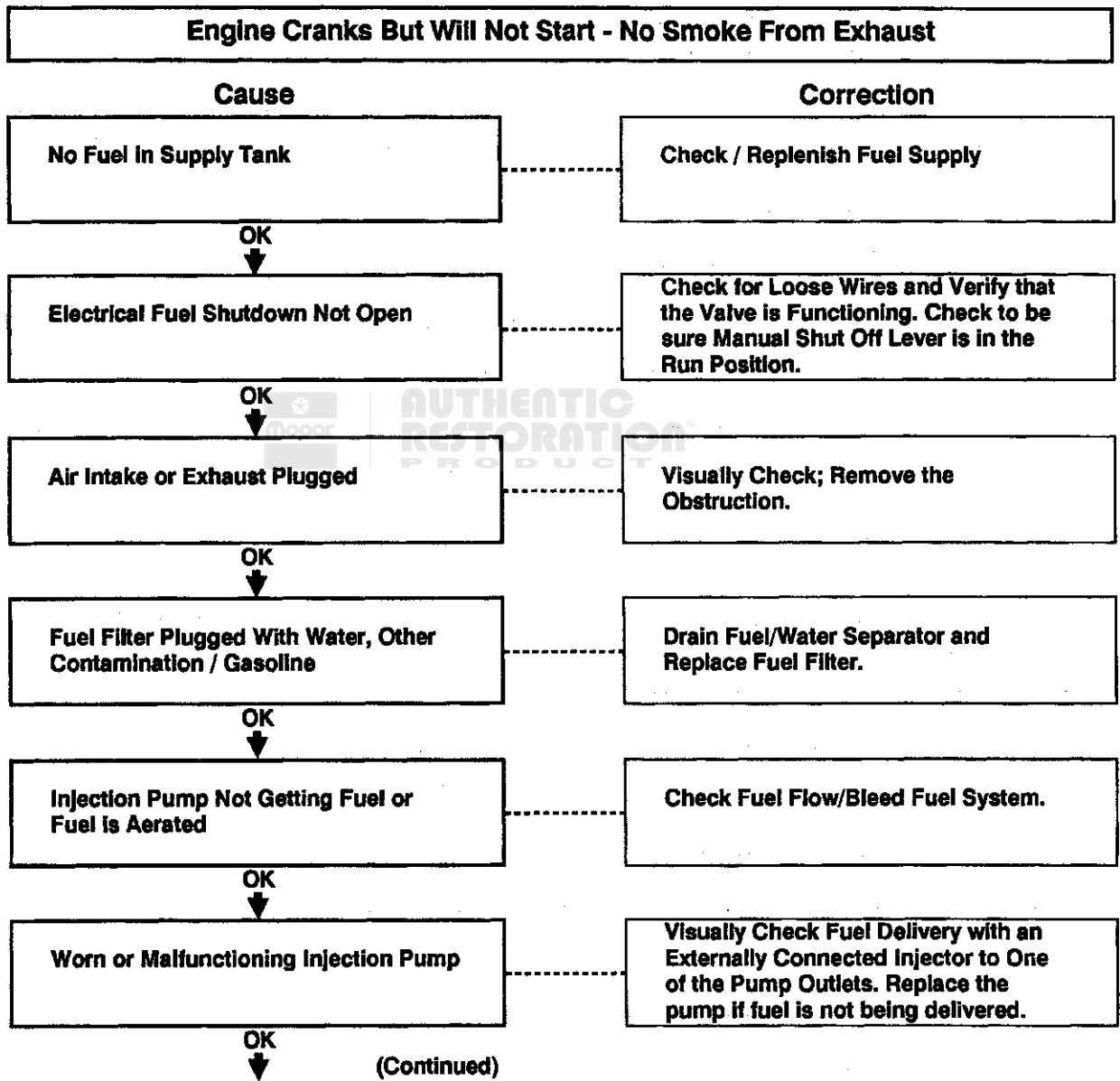
The basic procedure is as follows:

- Study the problem thoroughly.
- Relate the symptoms to your knowledge of the engine components and systems.
- Double-check before beginning the disassembly.
- Solve the problem by deduction starting with the easiest things.
- Determine the cause of the problems and make a thorough repair.
- After making corrections, operate the engine in normal conditions to verify the cause of the problem was corrected.

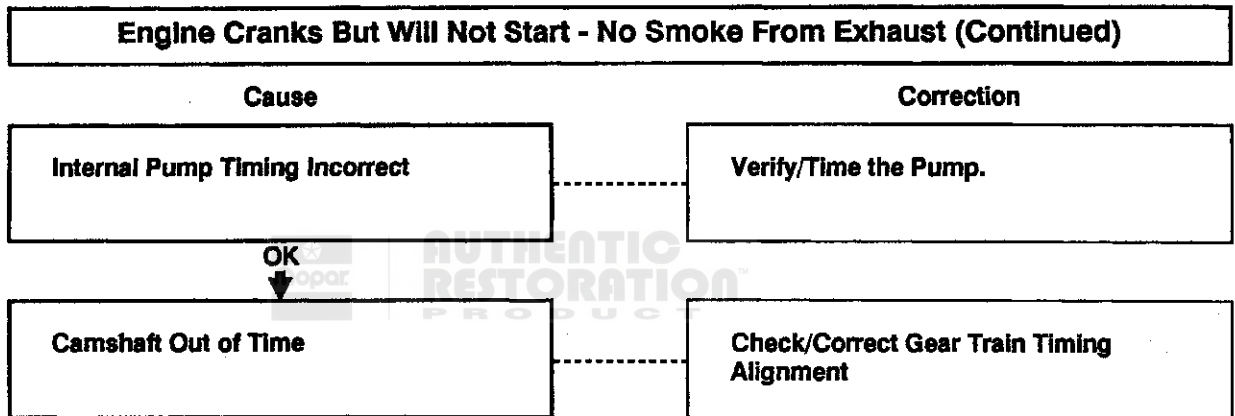
## Troubleshooting Logic

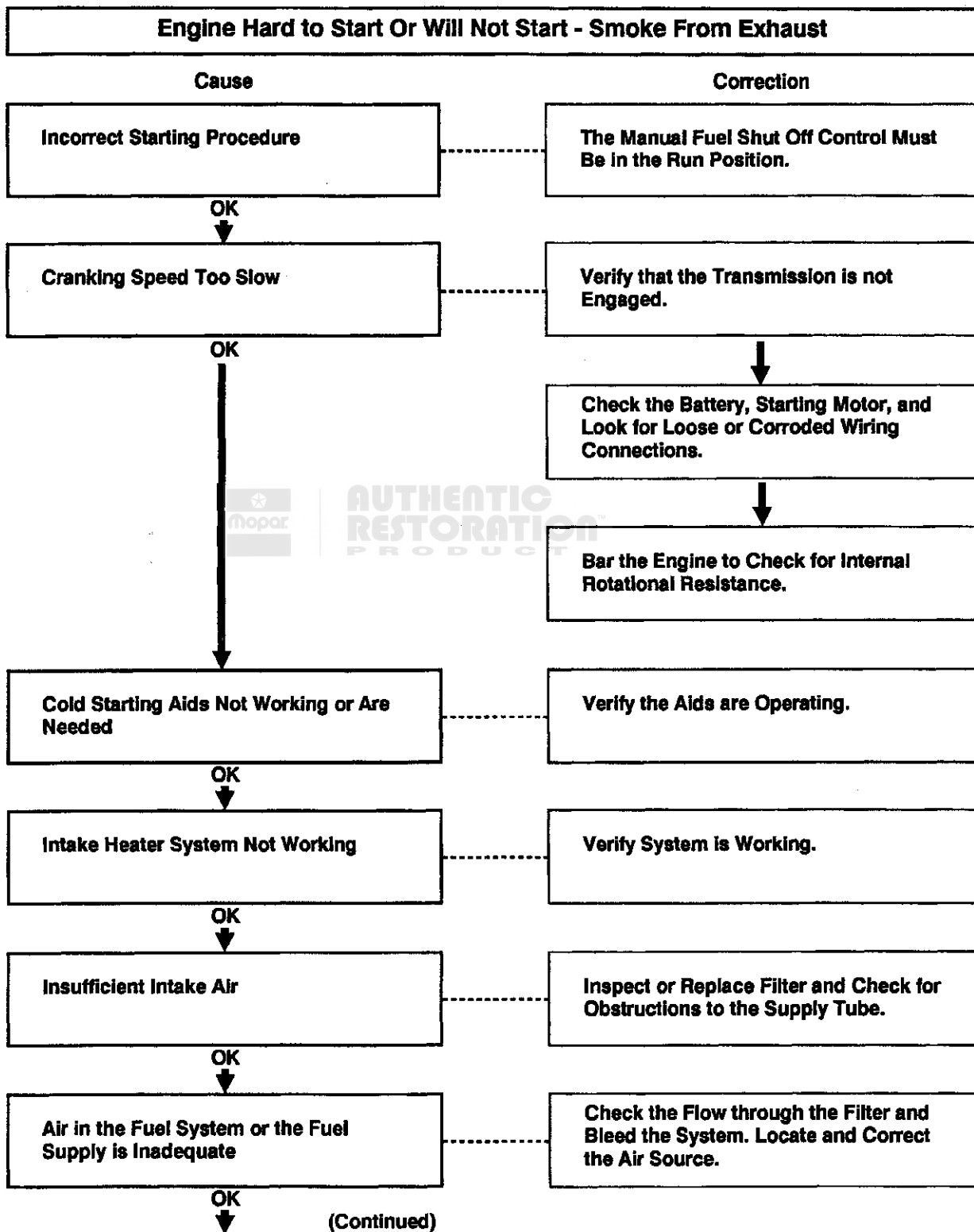
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Coolant temperature above normal .....	9A-20
Coolant temperature below normal .....	9A-23
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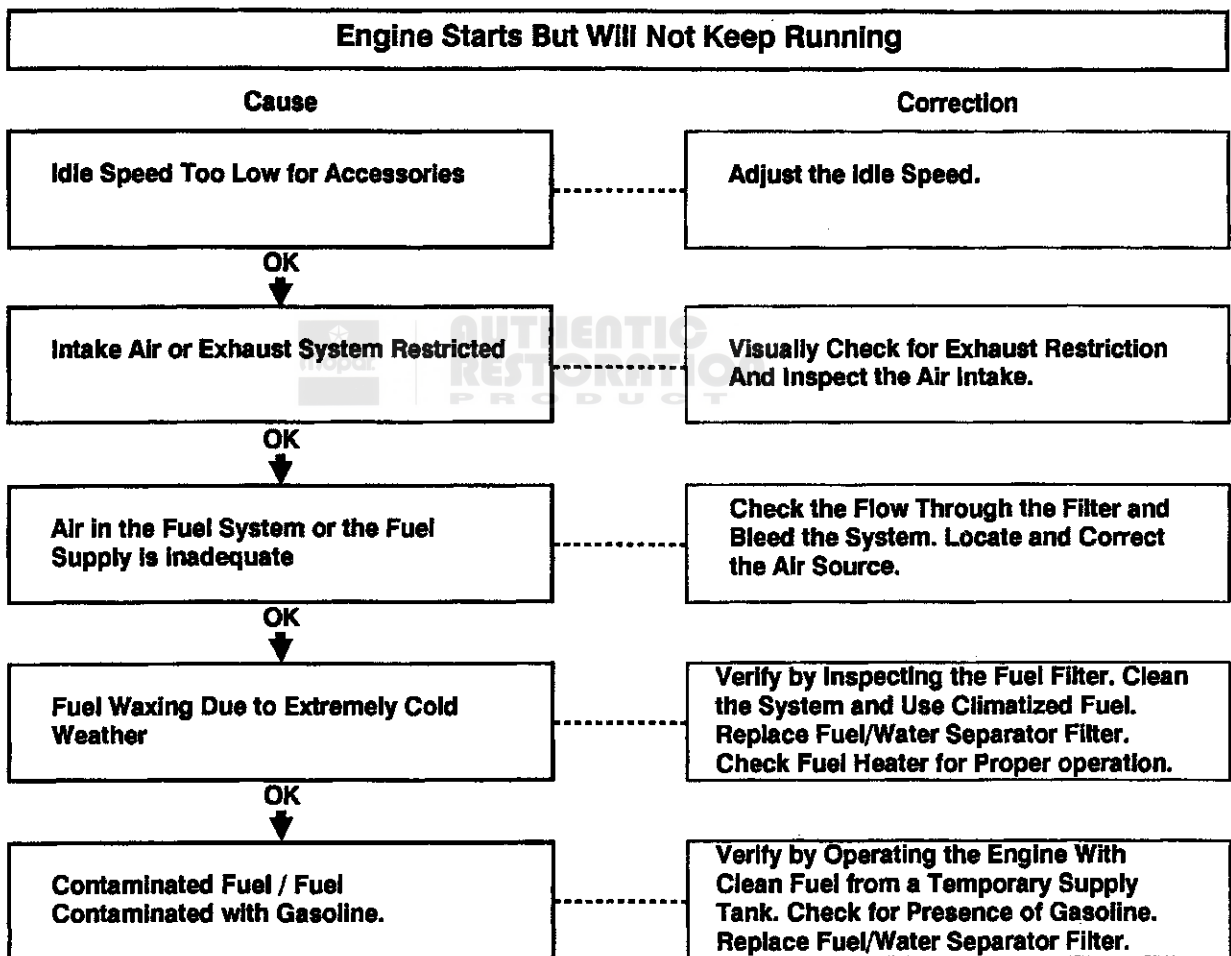


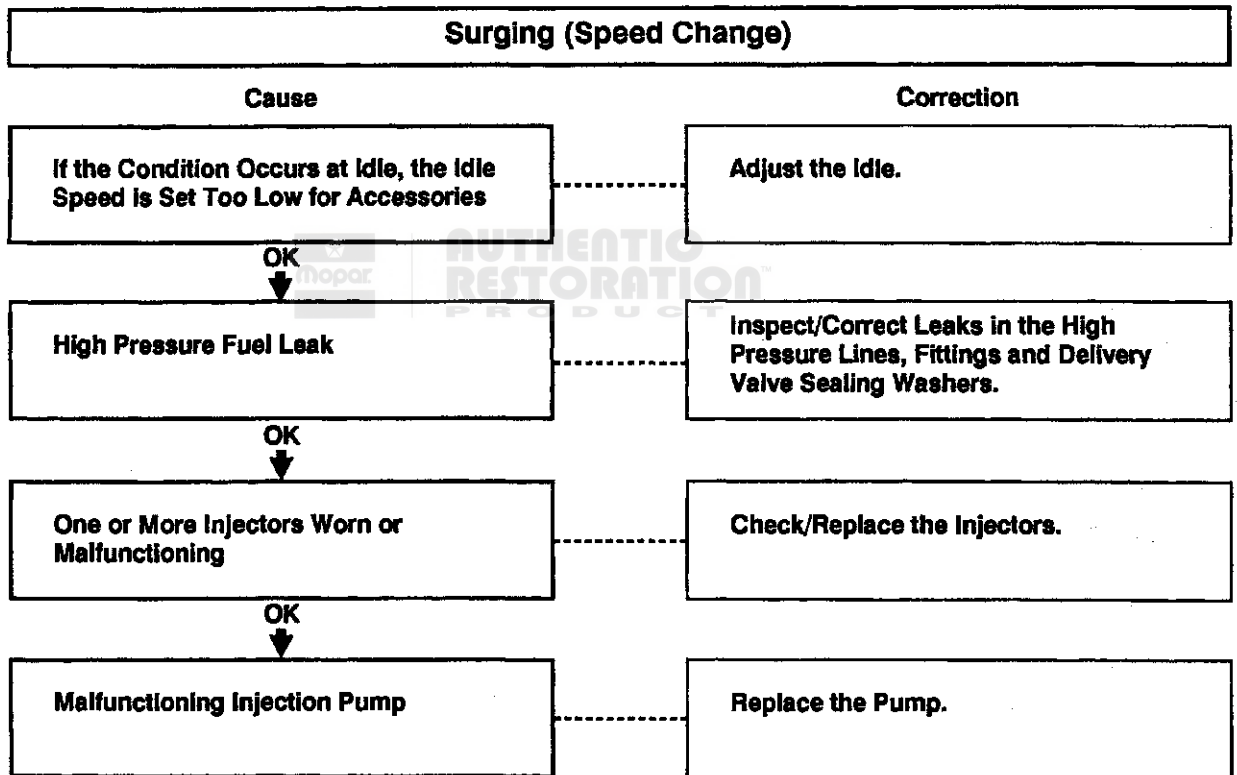


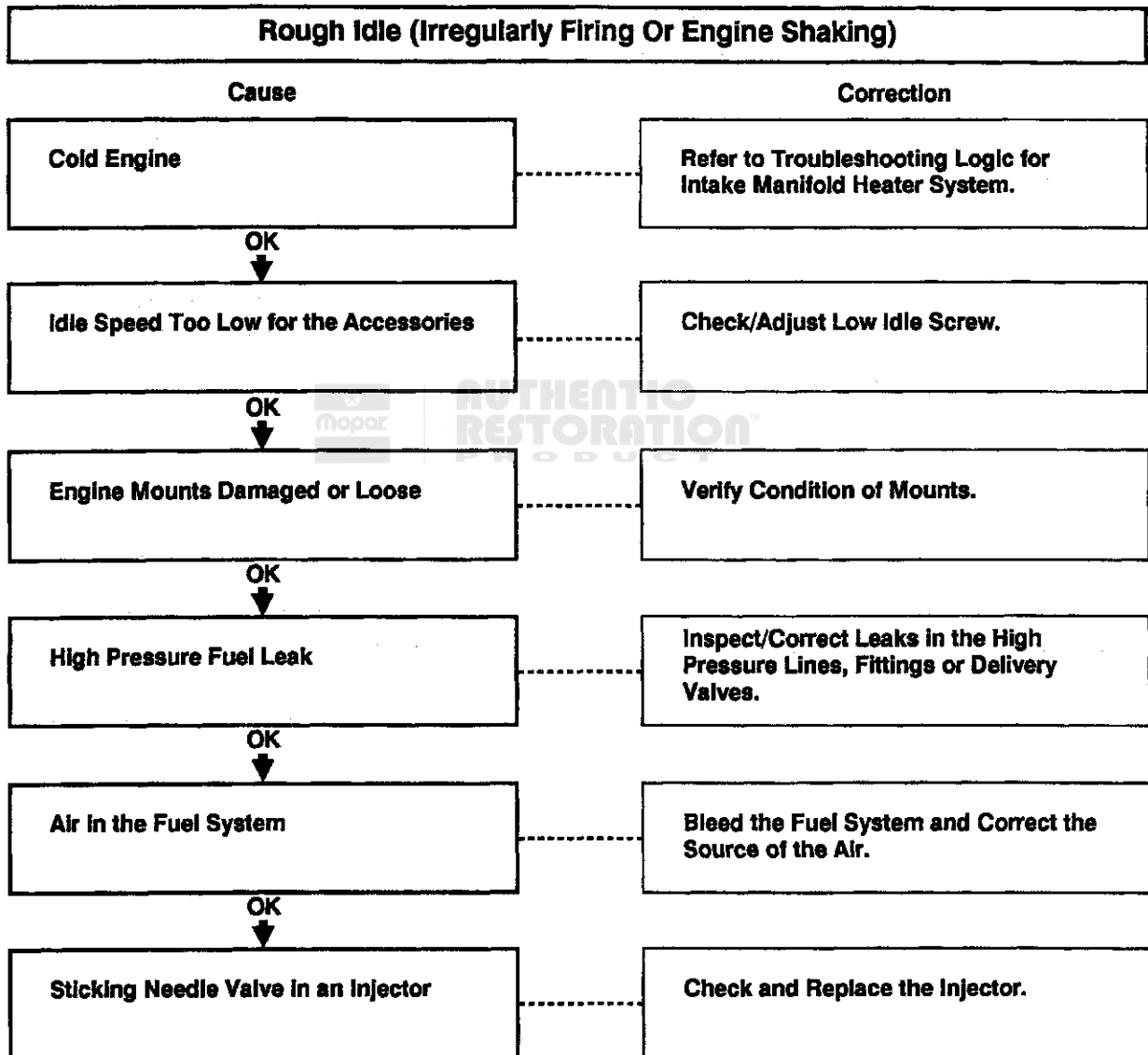


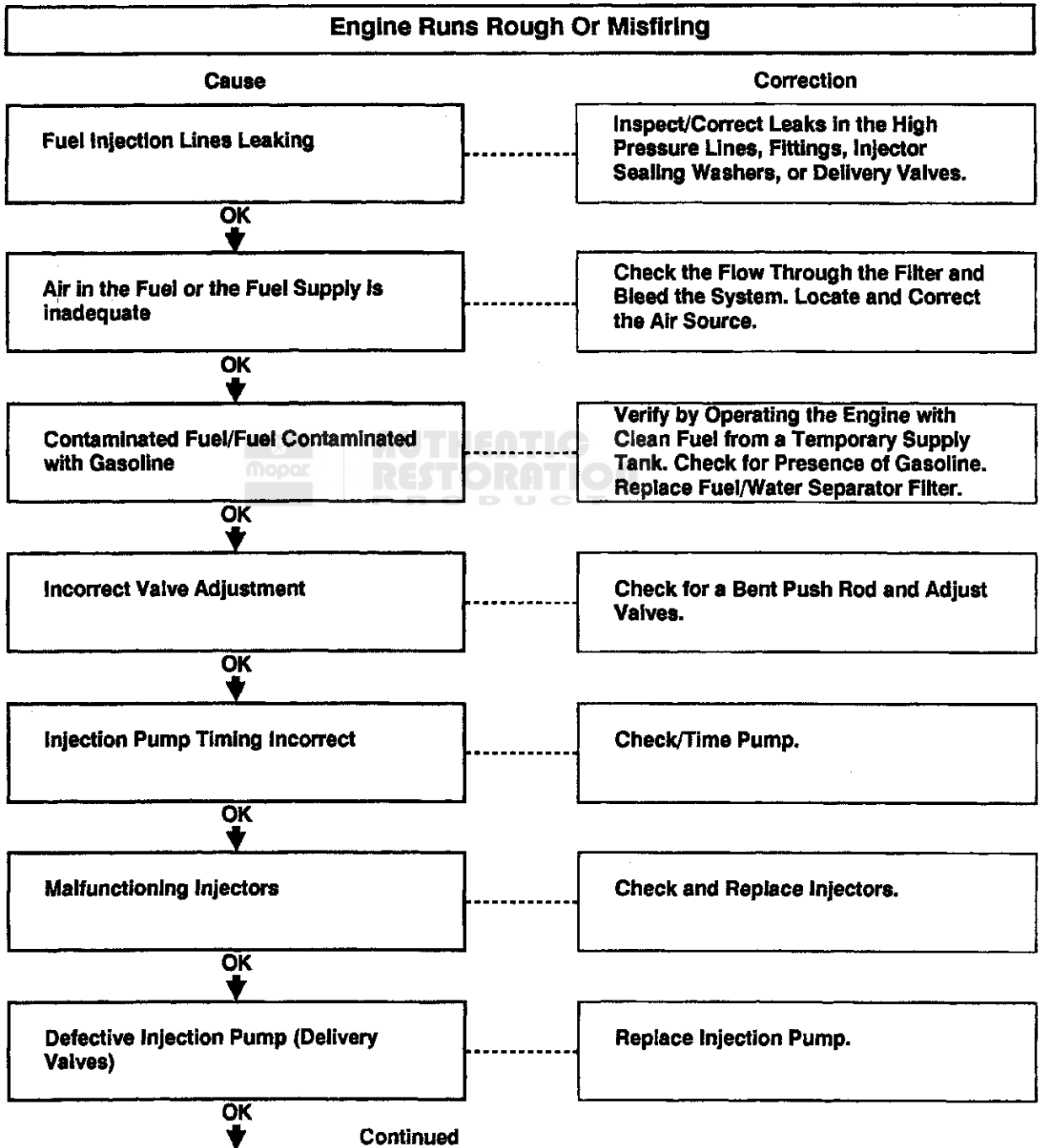
**Engine Hard to Start Or Will Not Start - Smoke From Exhaust (Continued)**

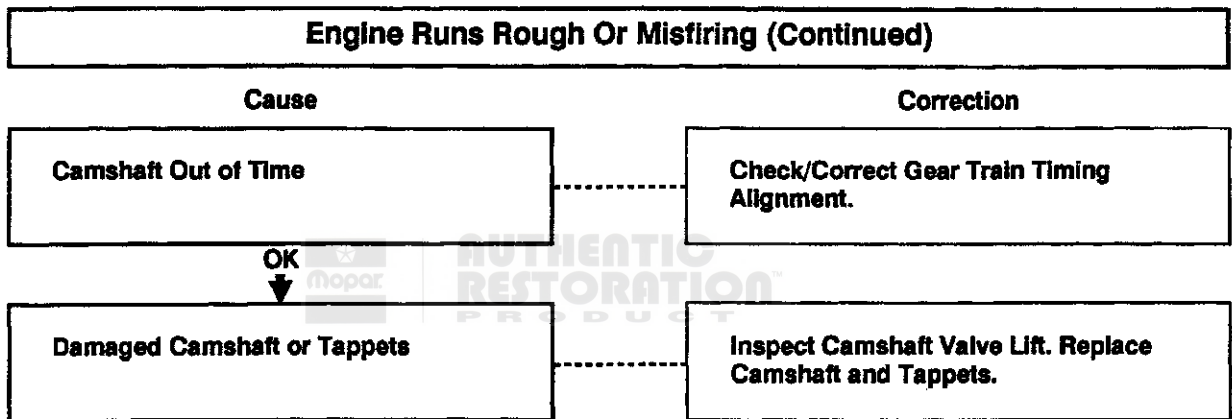
Cause	Correction
Fuel Lift Pump Malfunctioning	Disconnect Fuel Line and Verify Fuel Delivery.
OK ↓	
Injection Pump Throttle Linkage Loose or Damaged	Visually Check The Linkage.
OK ↓	
Contaminated Fuel / Fuel Contaminated with Gasoline	Verify by Operating the Engine with Clean Fuel from a Temporary Tank. Check for Presence of Gasoline. Drain and Flush Fuel Supply Tanks. Replace Fuel/Water Separator Filter.
OK ↓	
Worn or Malfunctioning Injection Pump	Visually Check Fuel Delivery With an Externally Connected Injector to one of the Pump Outlets. Replace the Pump if Fuel is Not Being Delivered.
OK ↓	
Injection Pump Out of Time	Check/Time the Pump.
OK ↓	
Valves Incorrectly Adjusted	Adjust Valves.
OK ↓	
One or More Injectors Worn or Malfunctioning	Check/Replace Injectors.



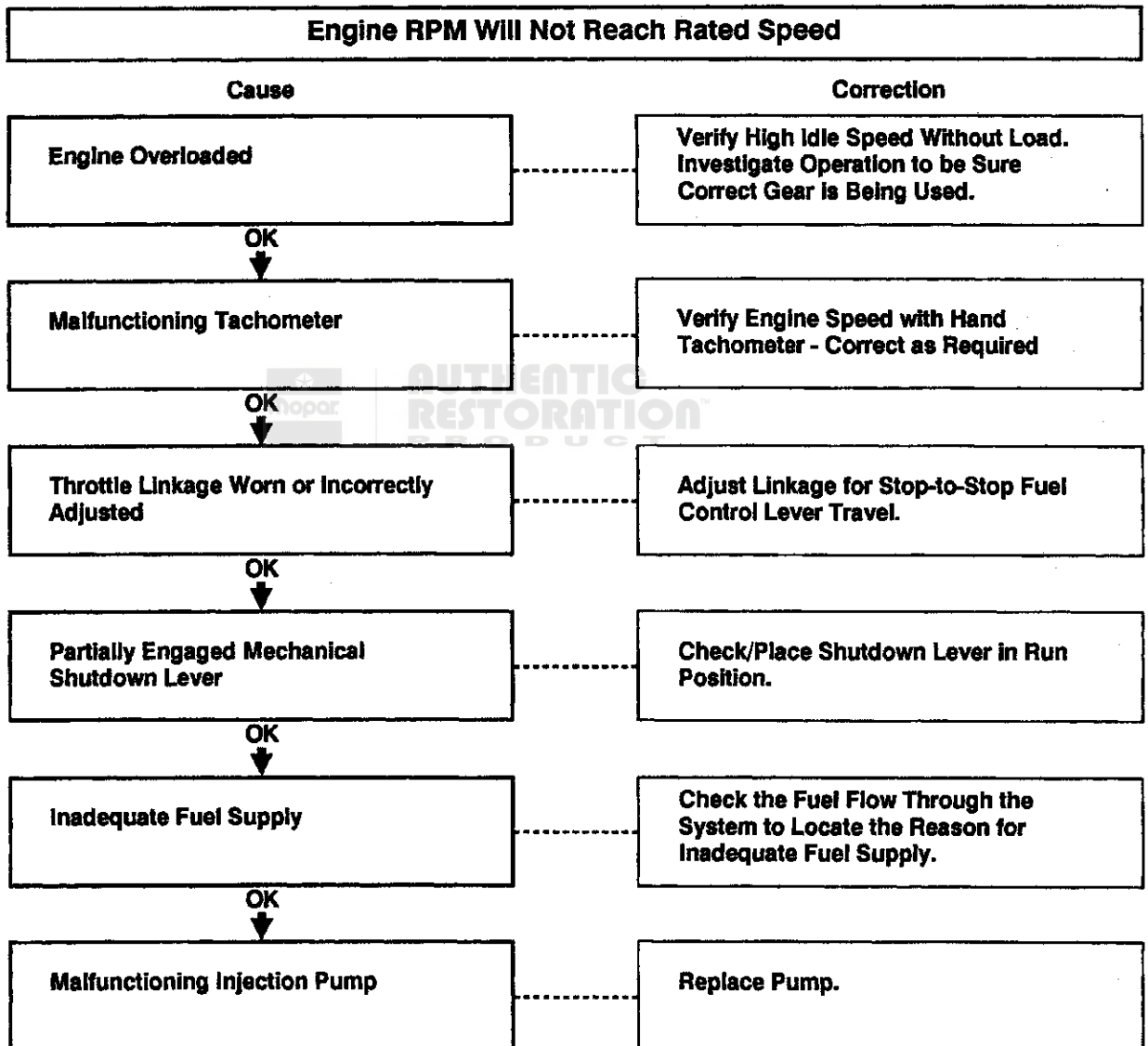


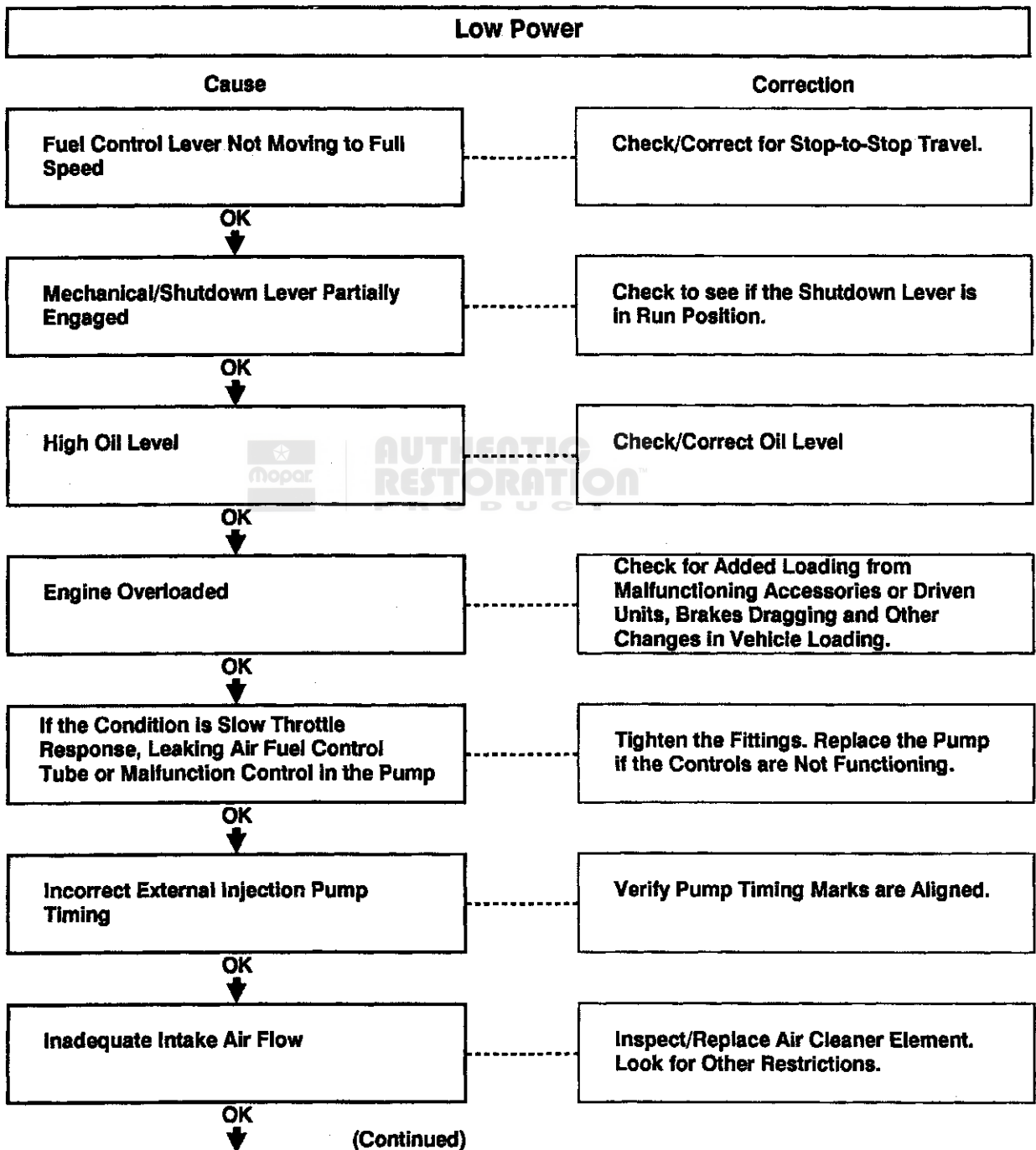


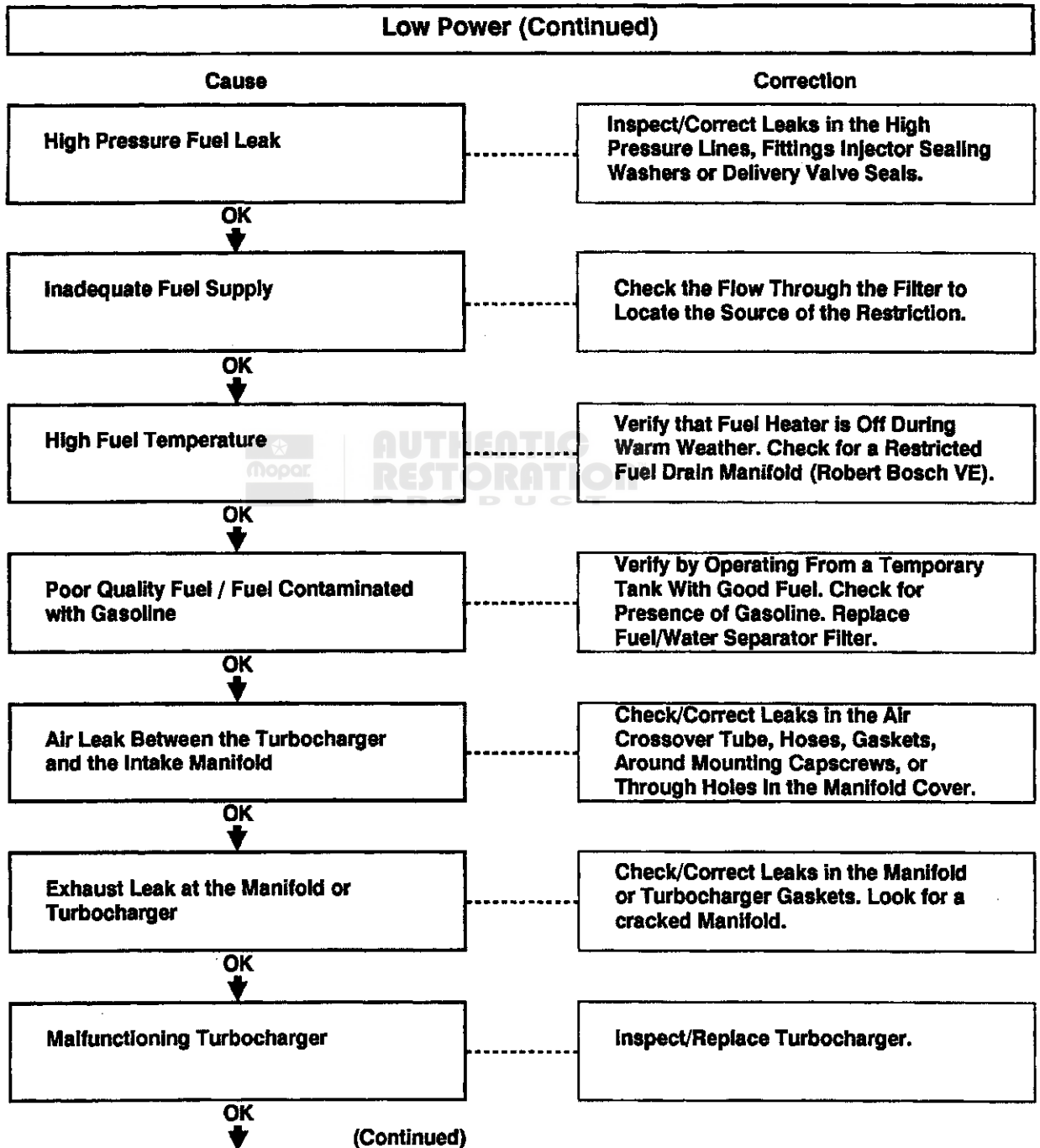


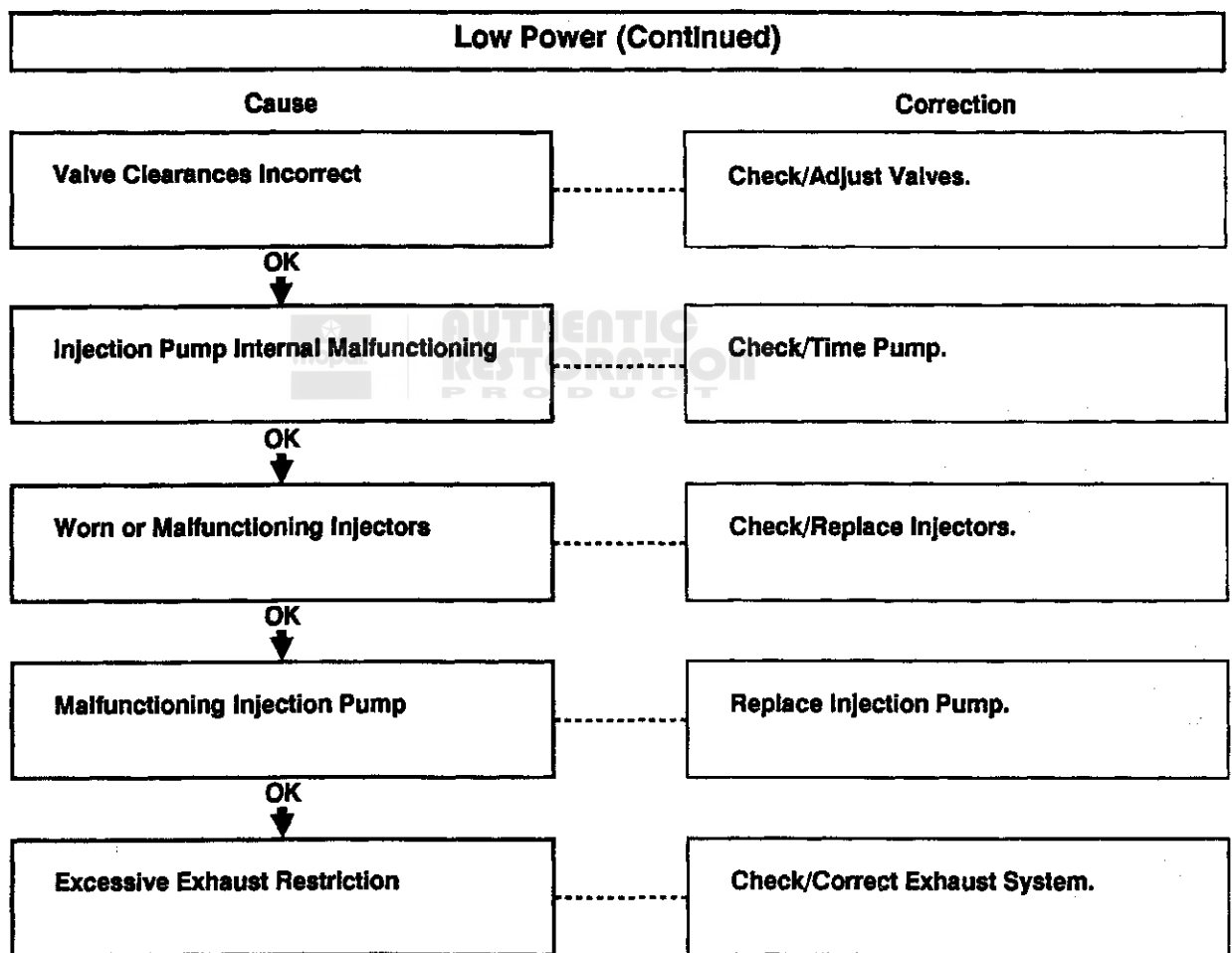


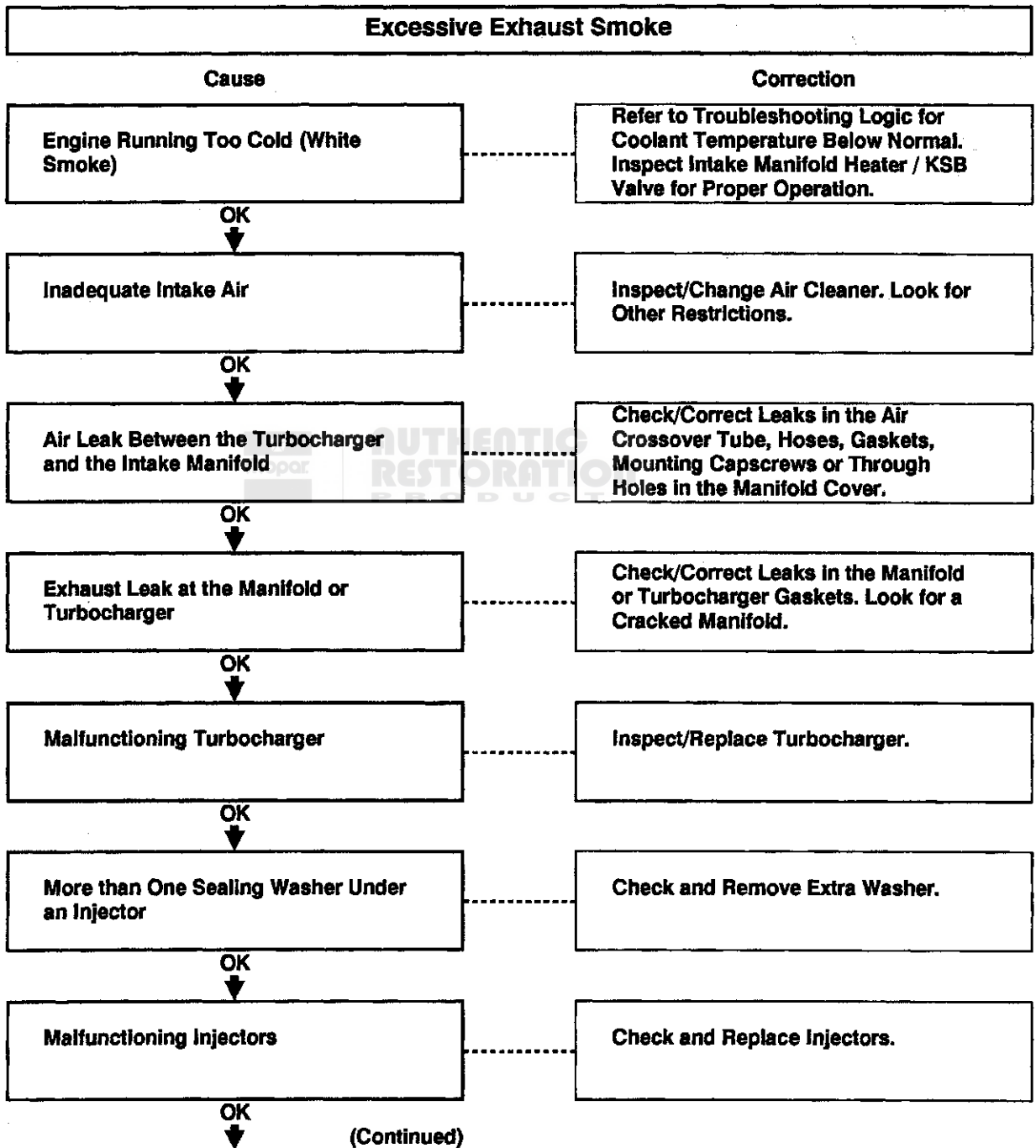


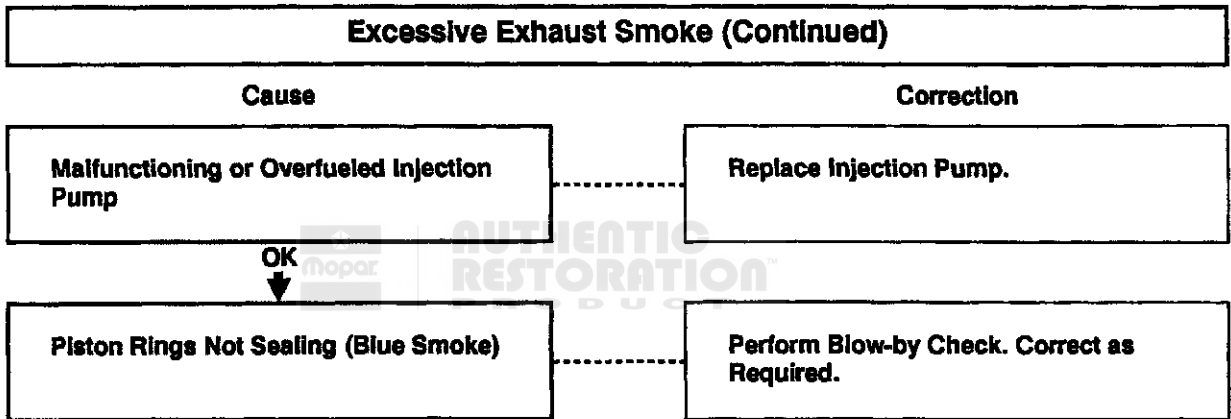


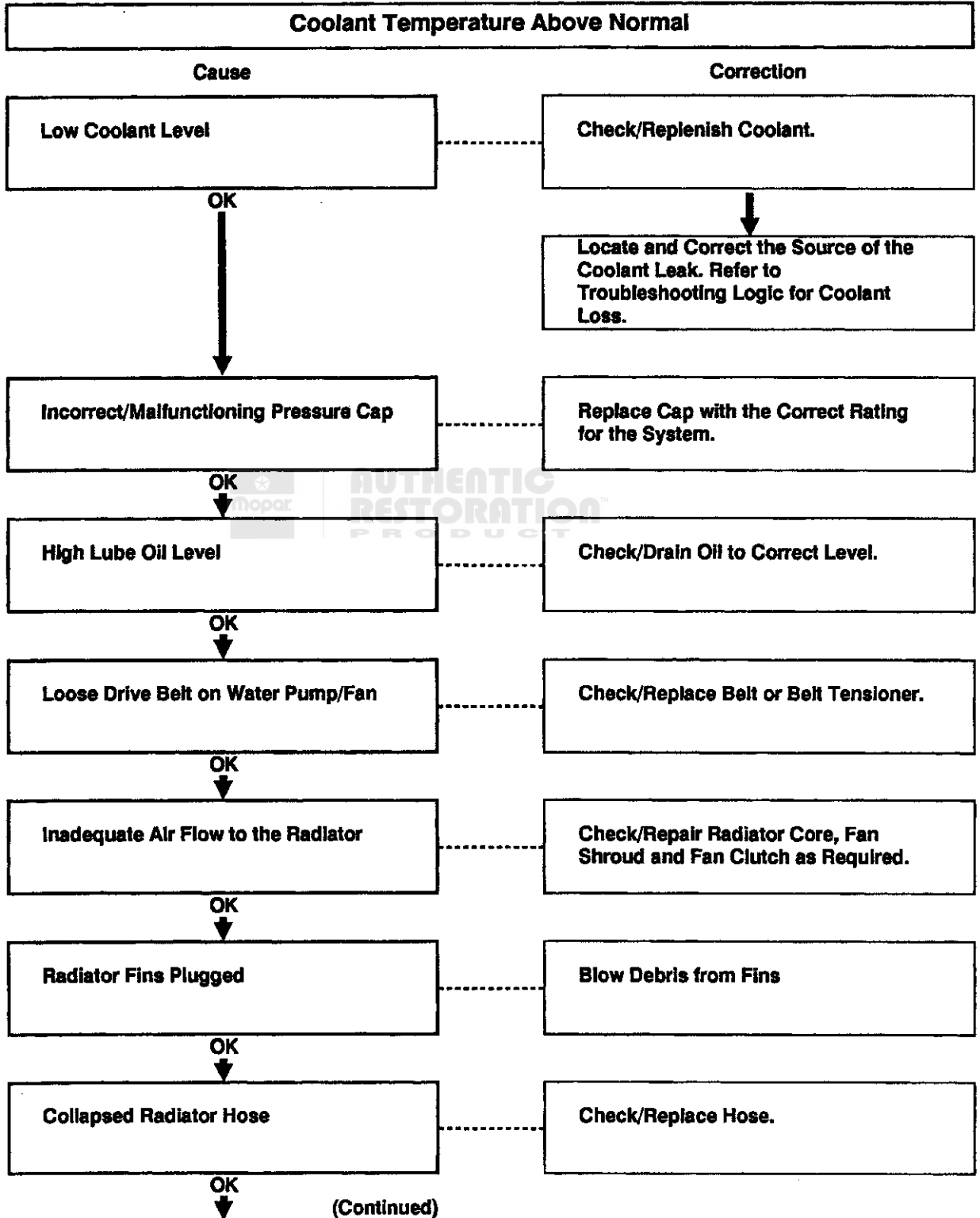


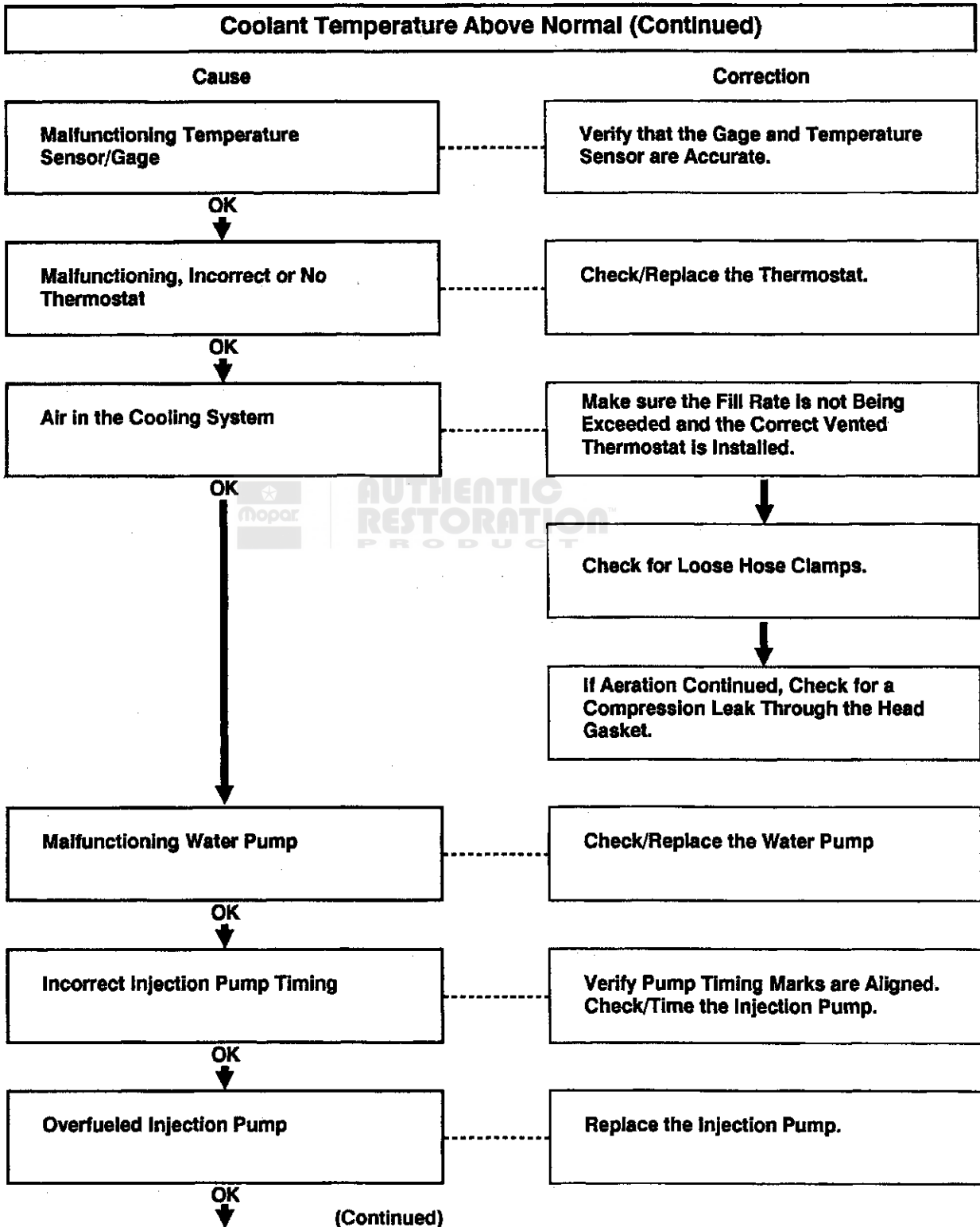




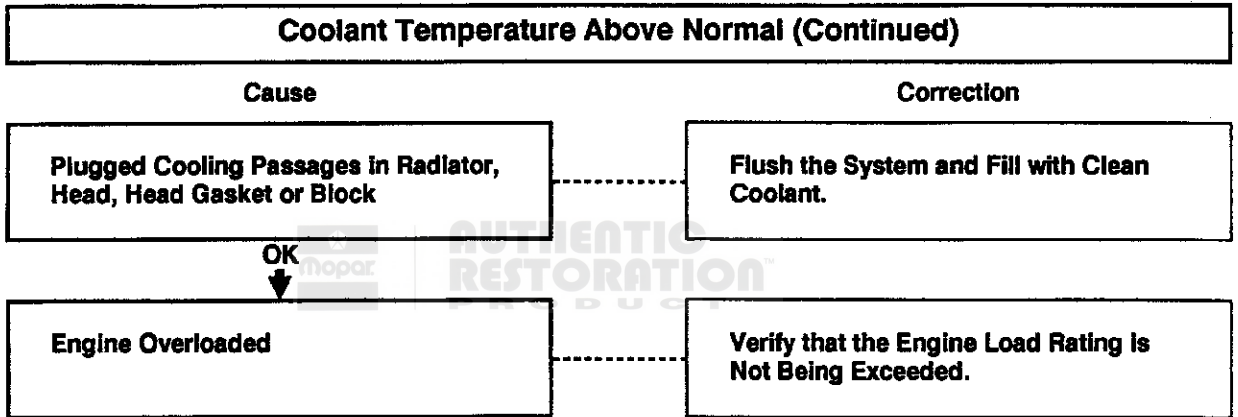


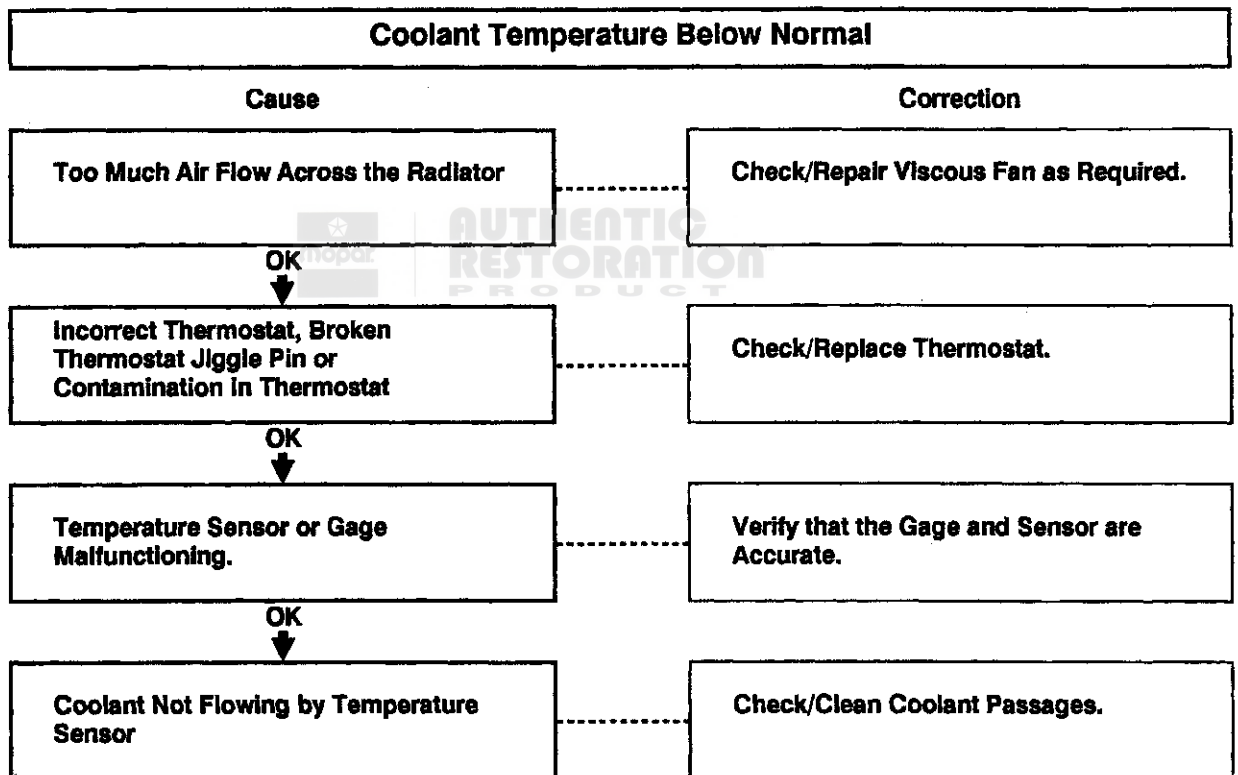


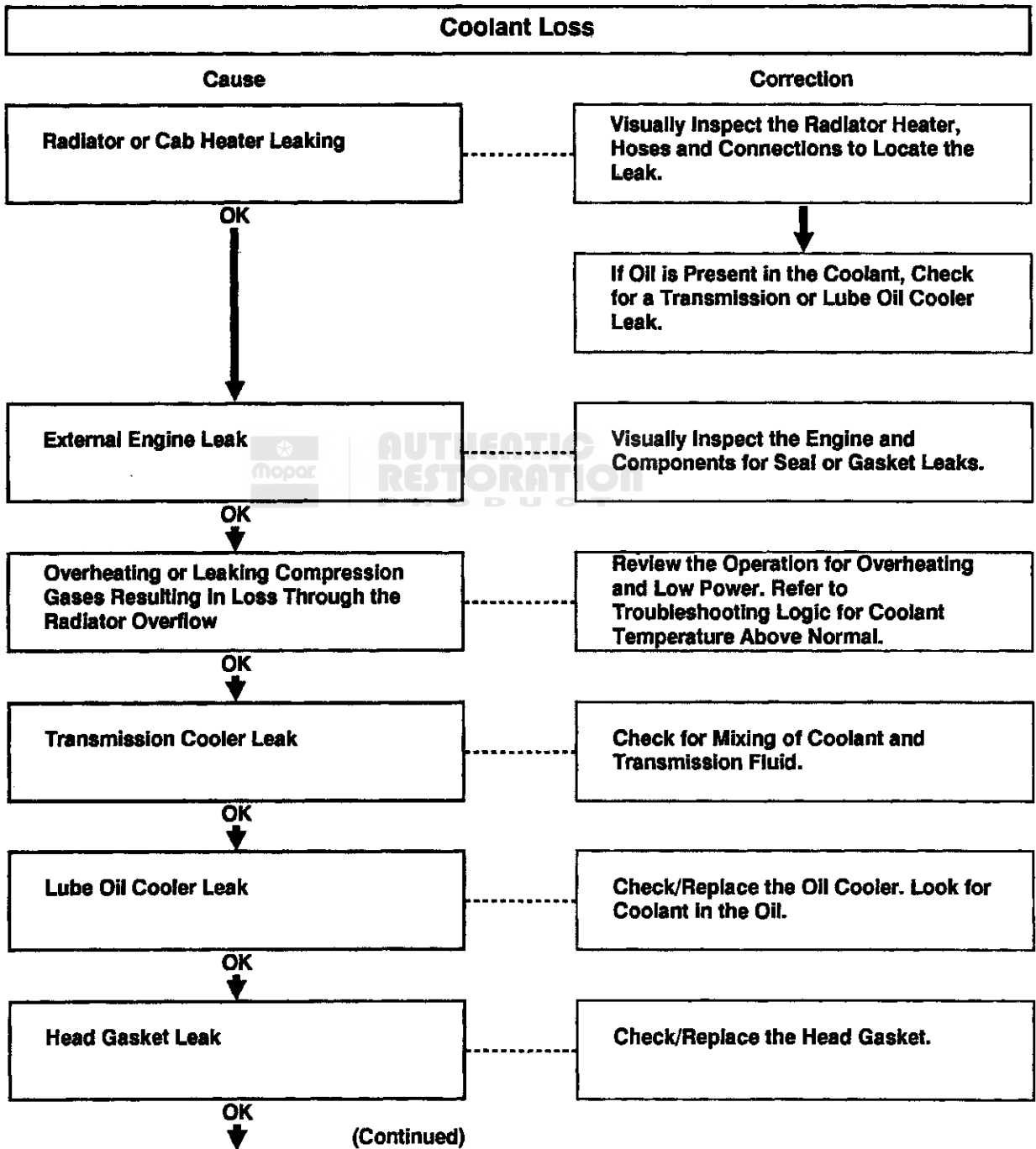


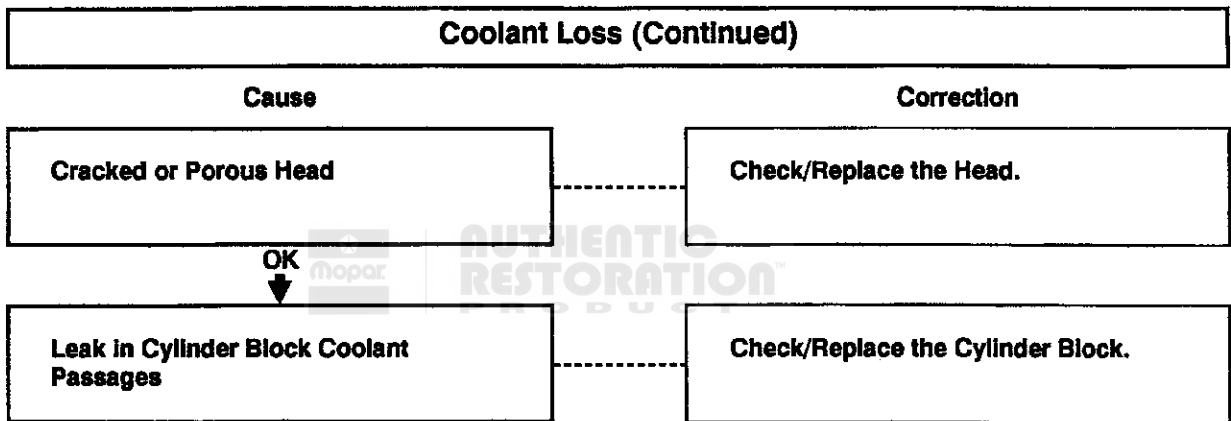


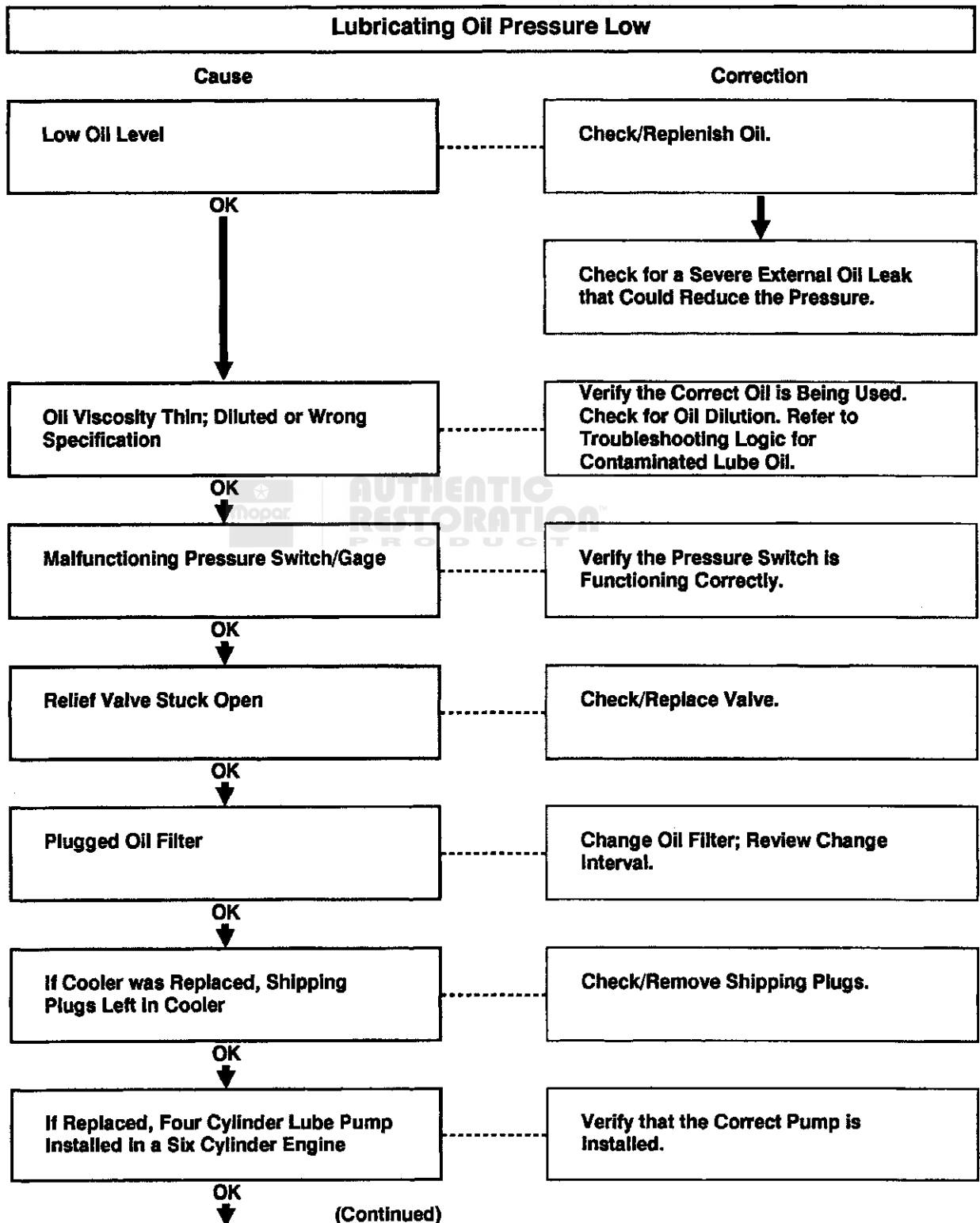


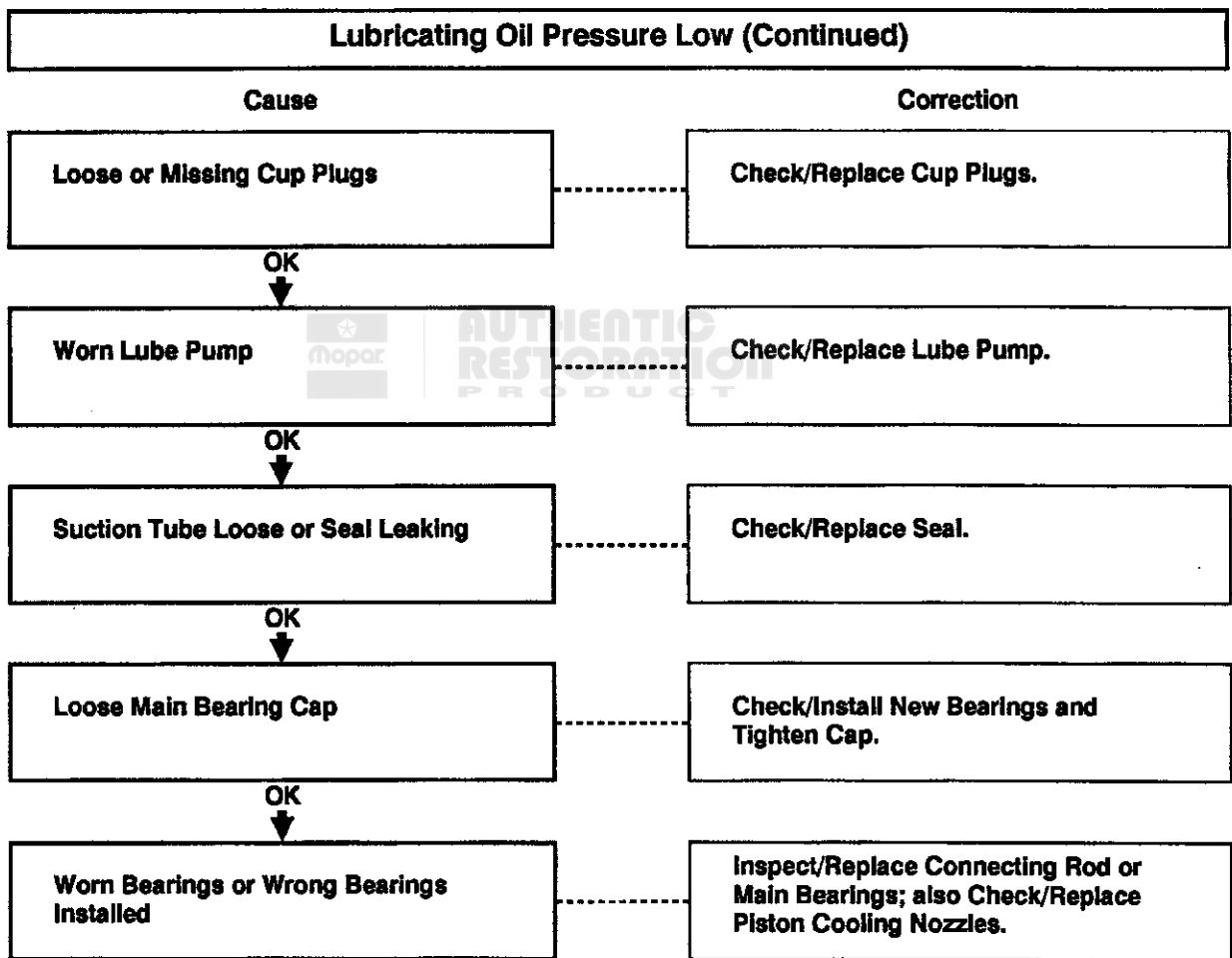


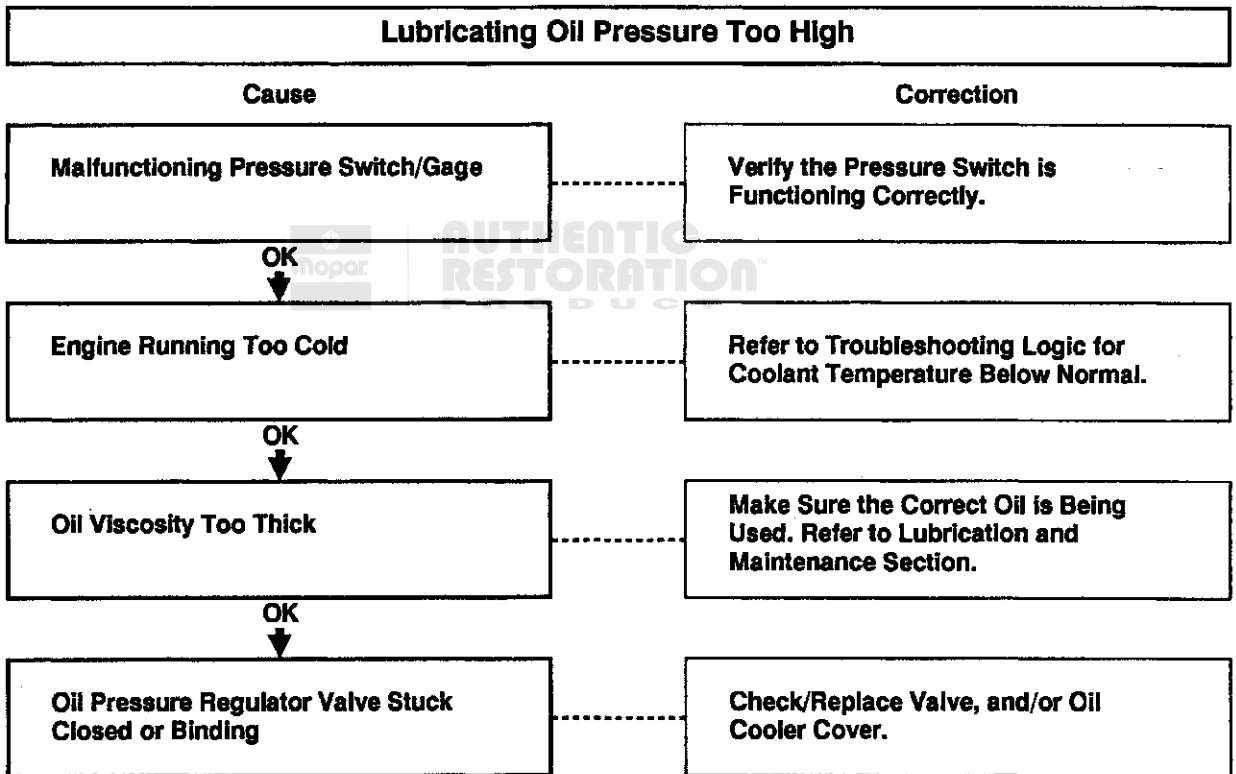


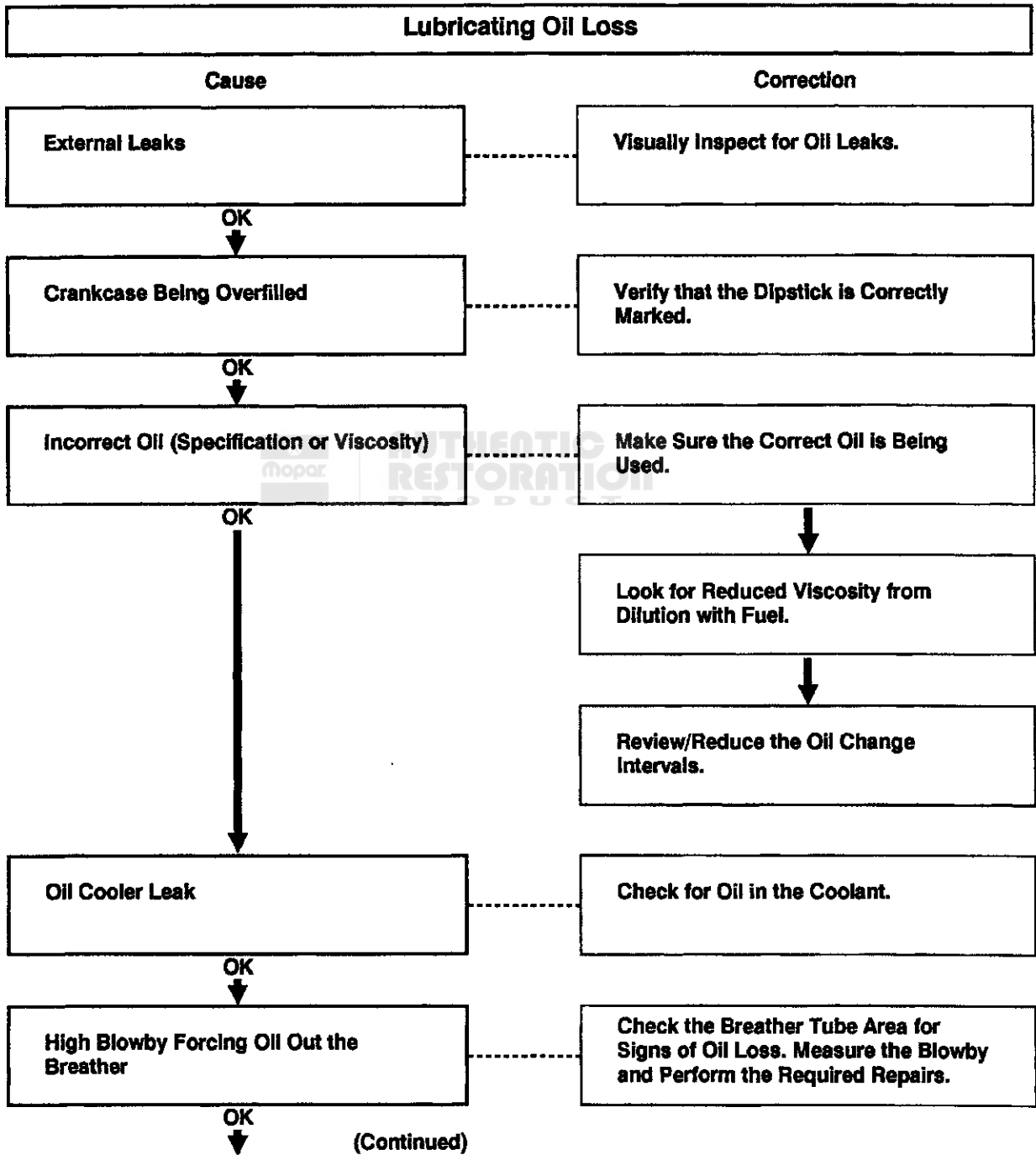




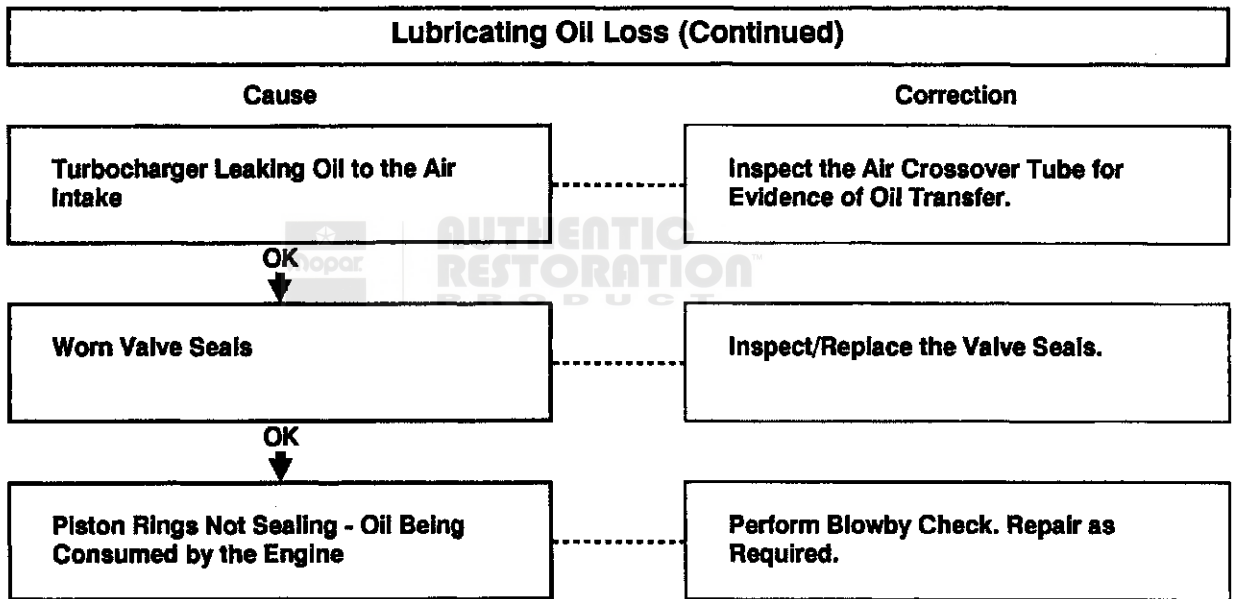


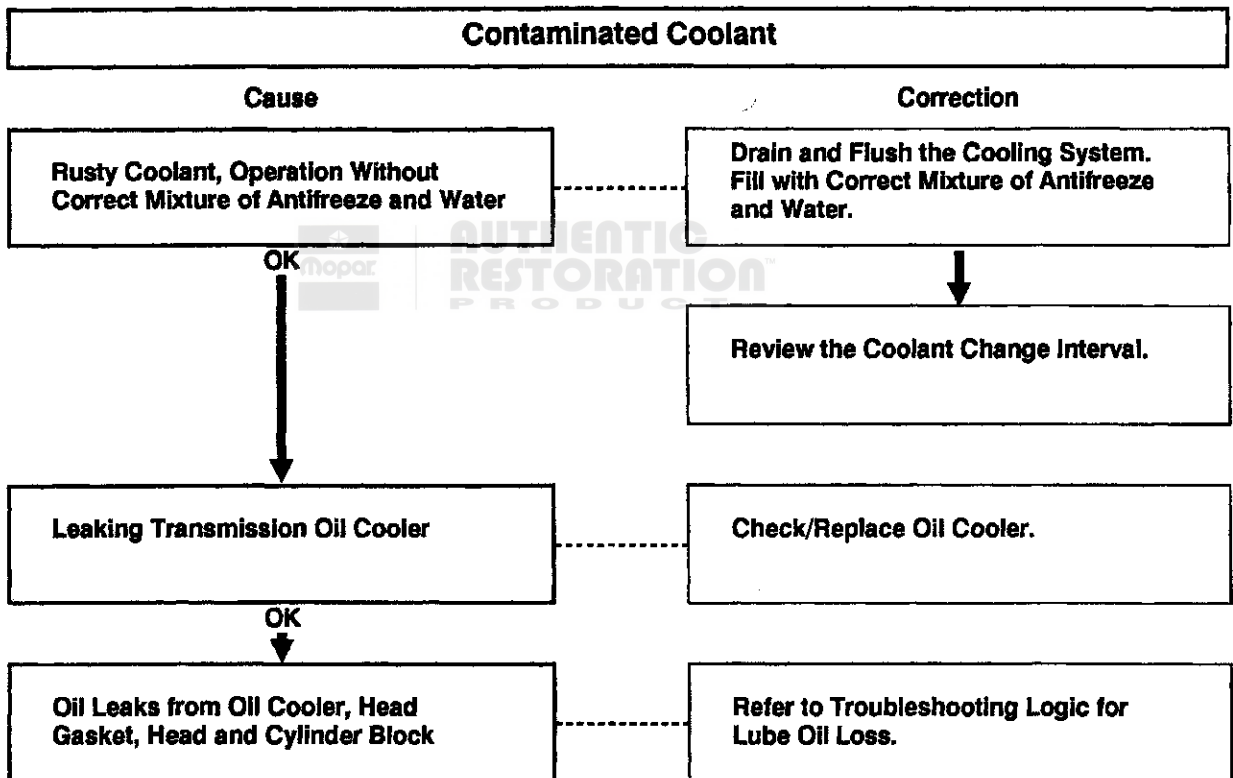


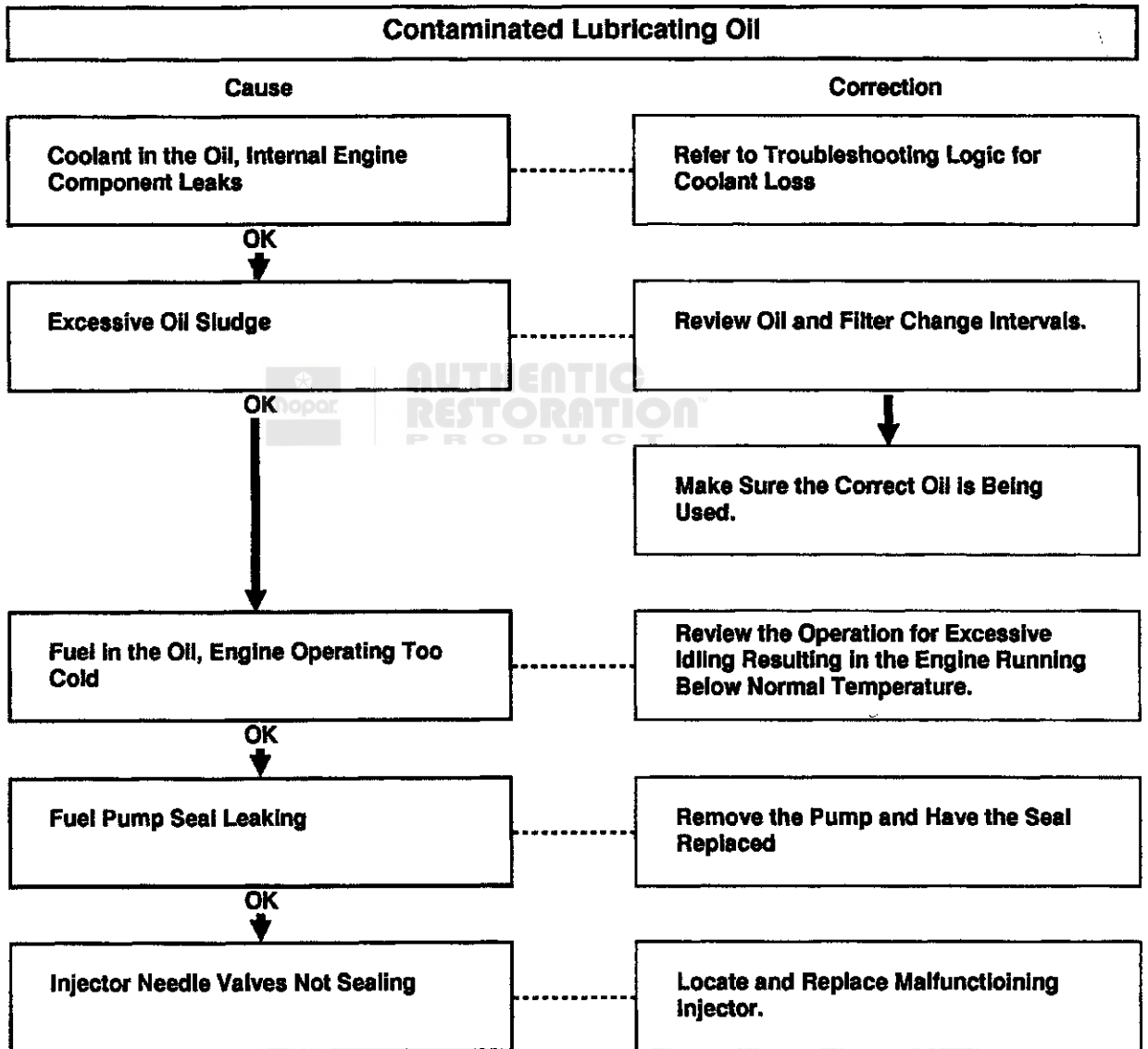


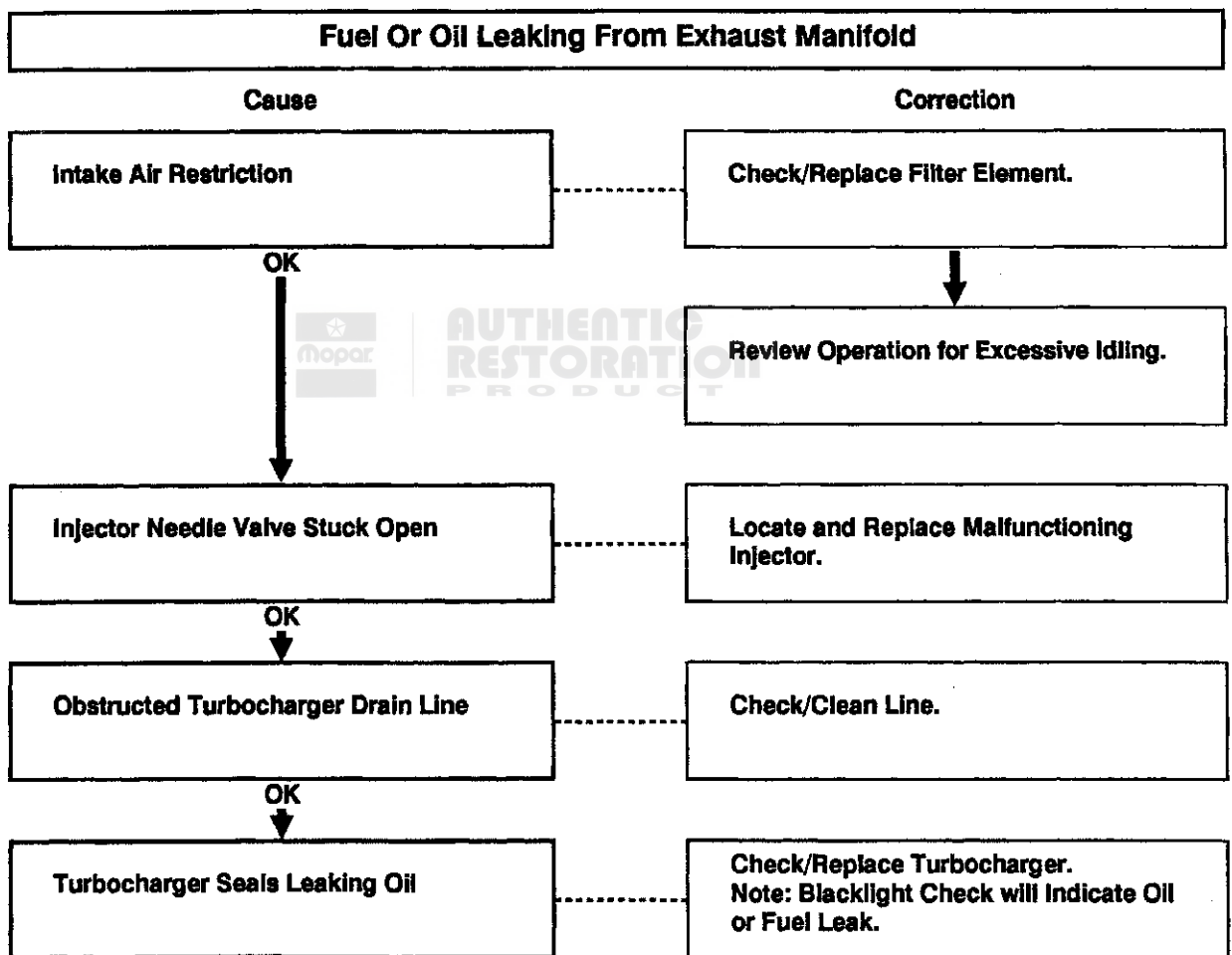


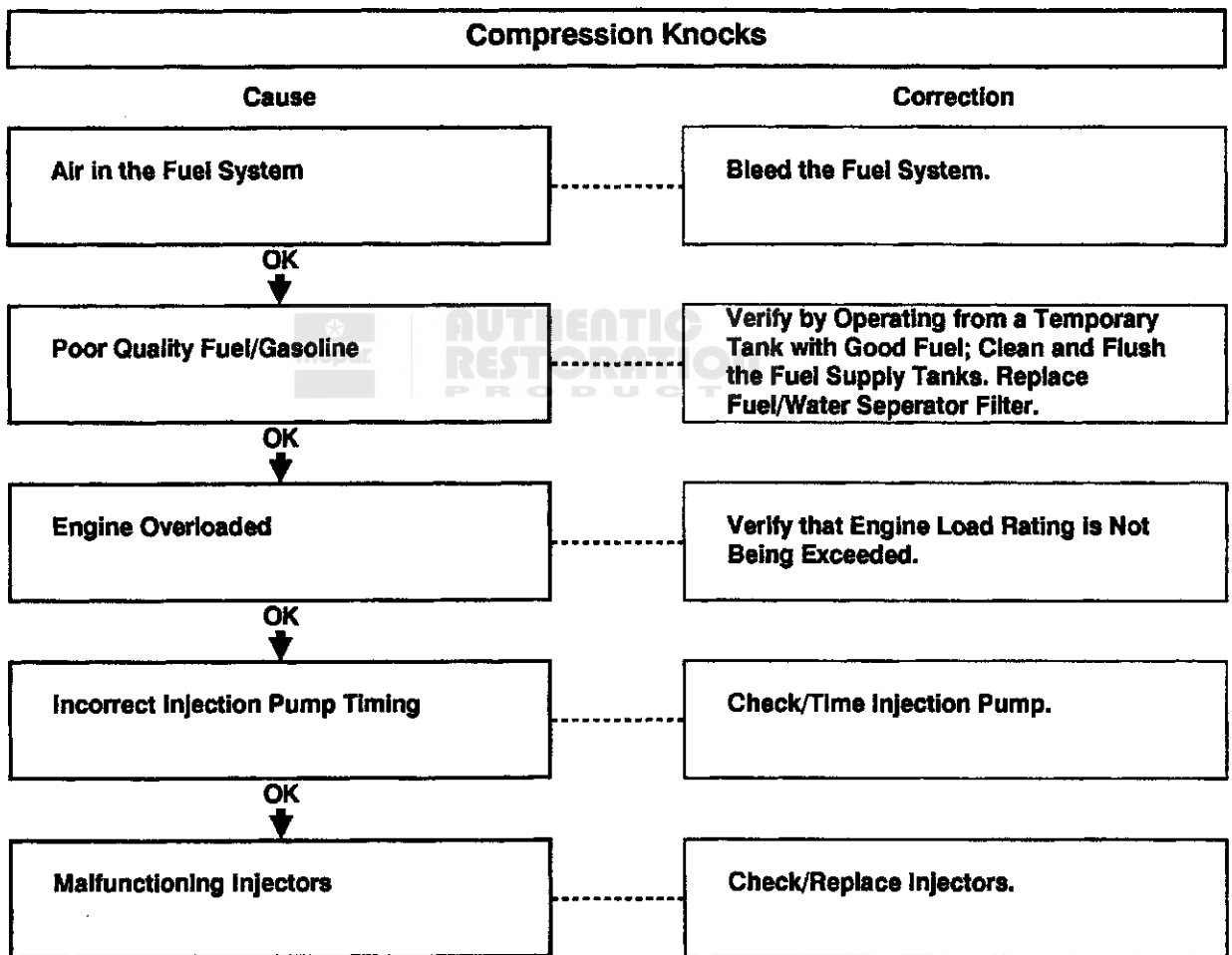


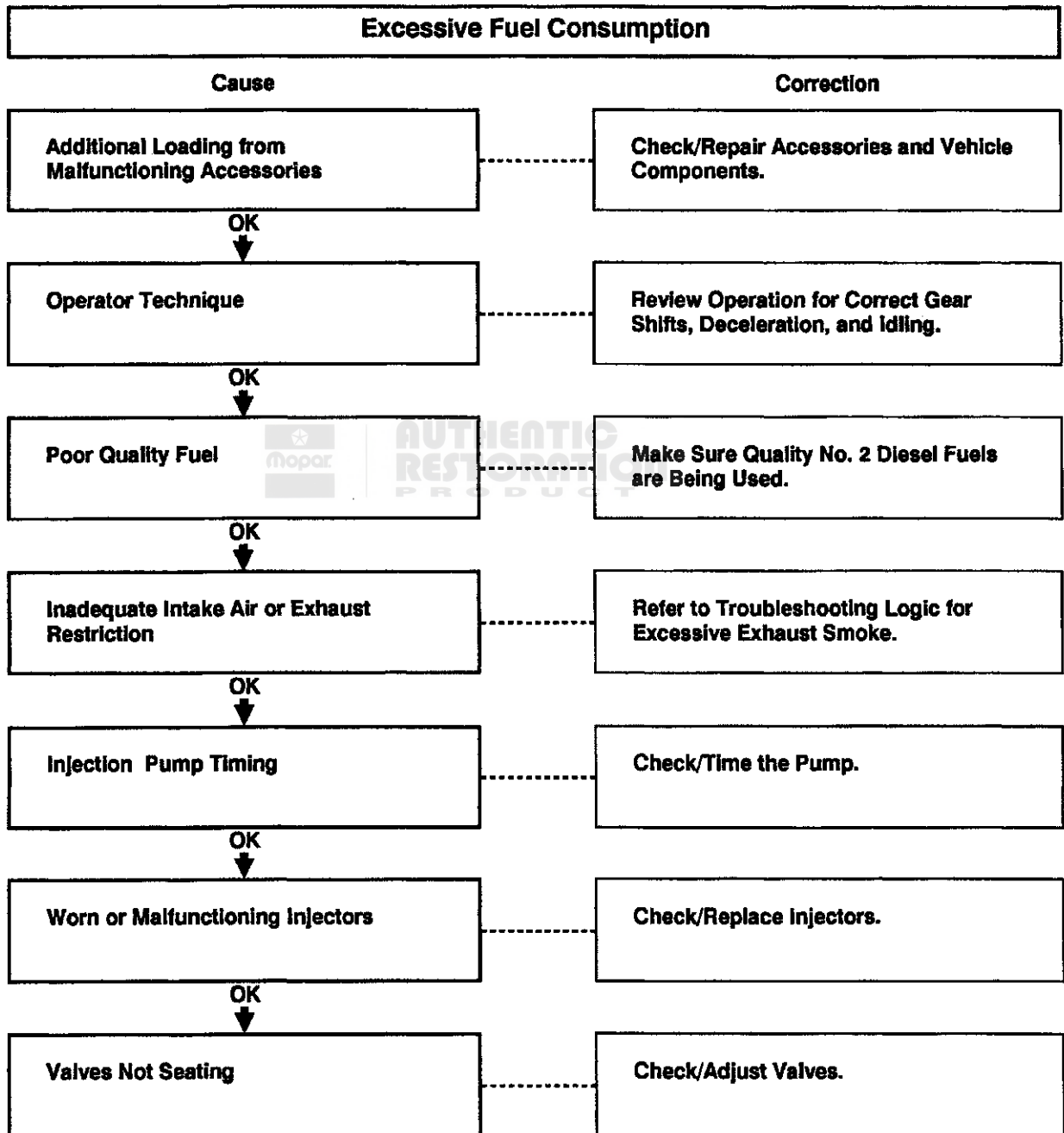


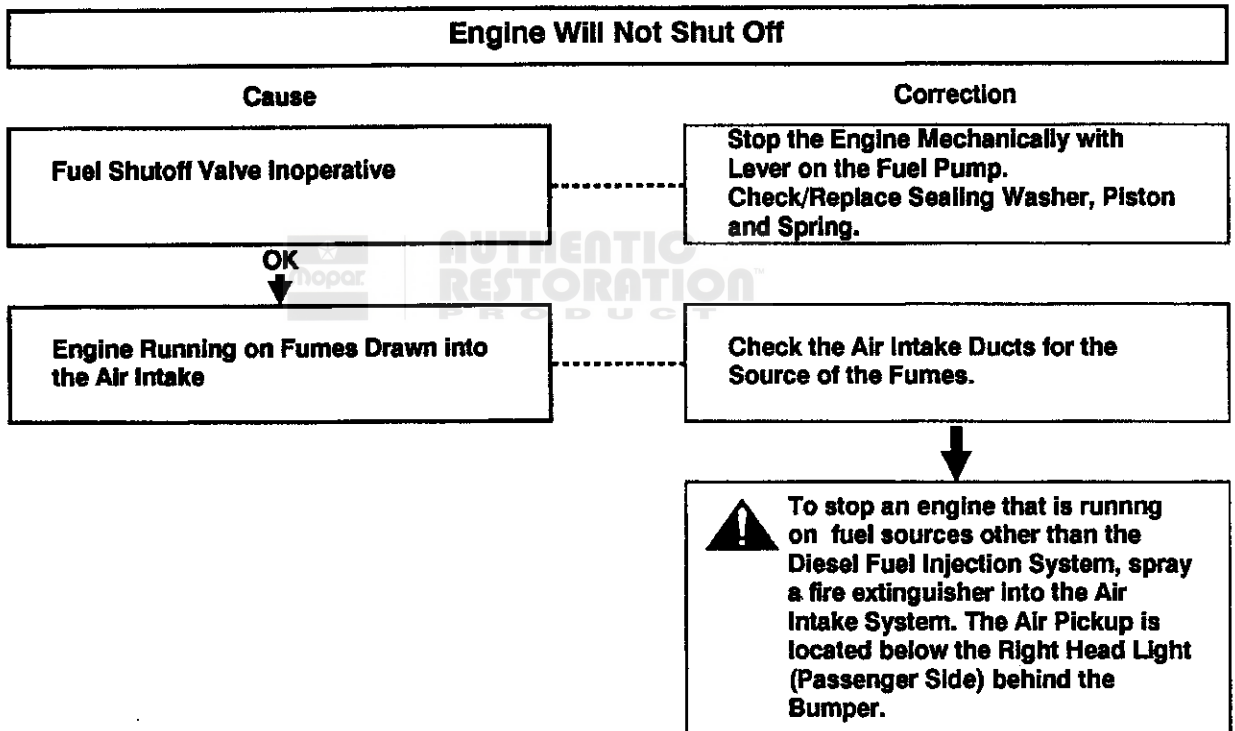


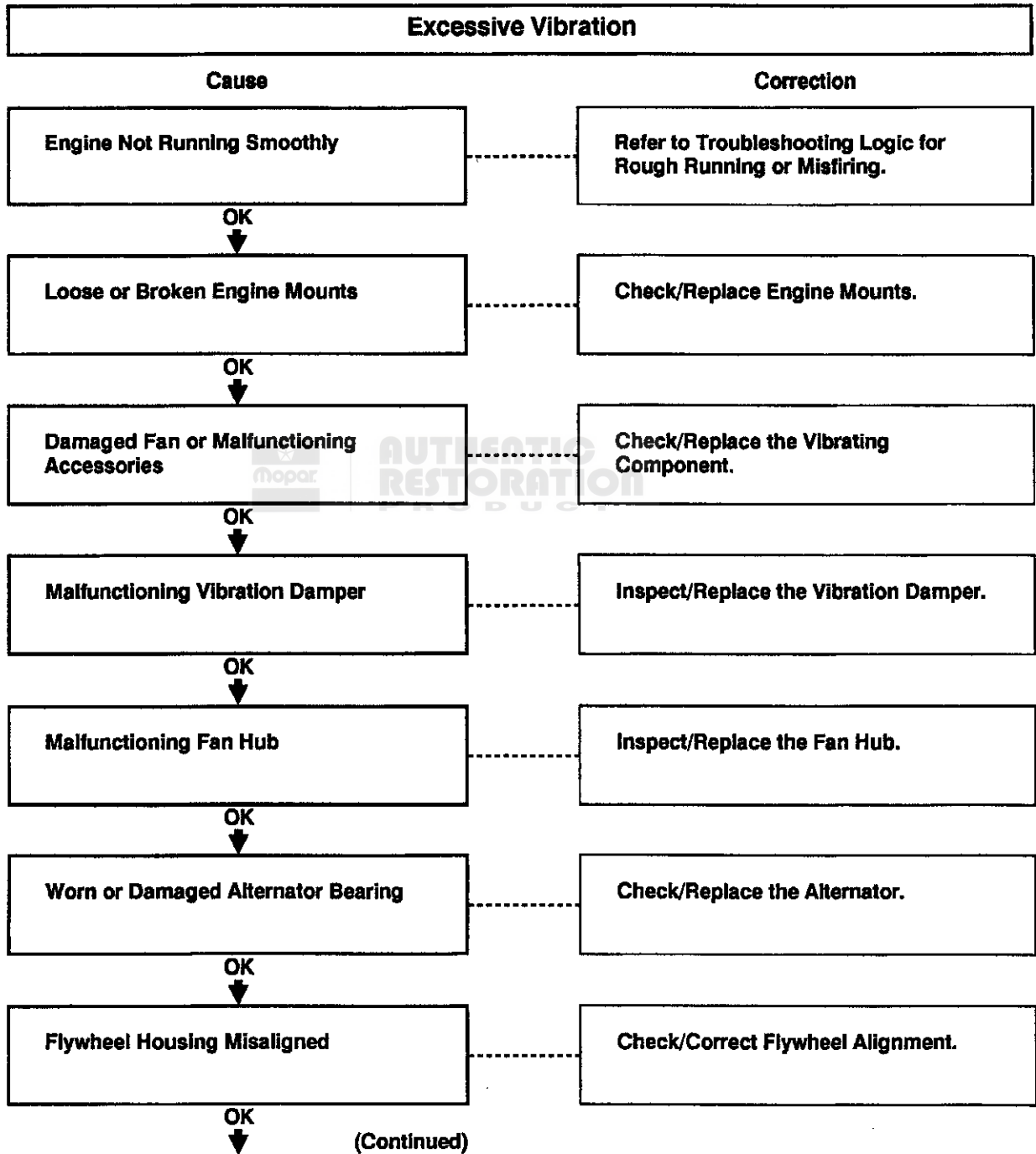




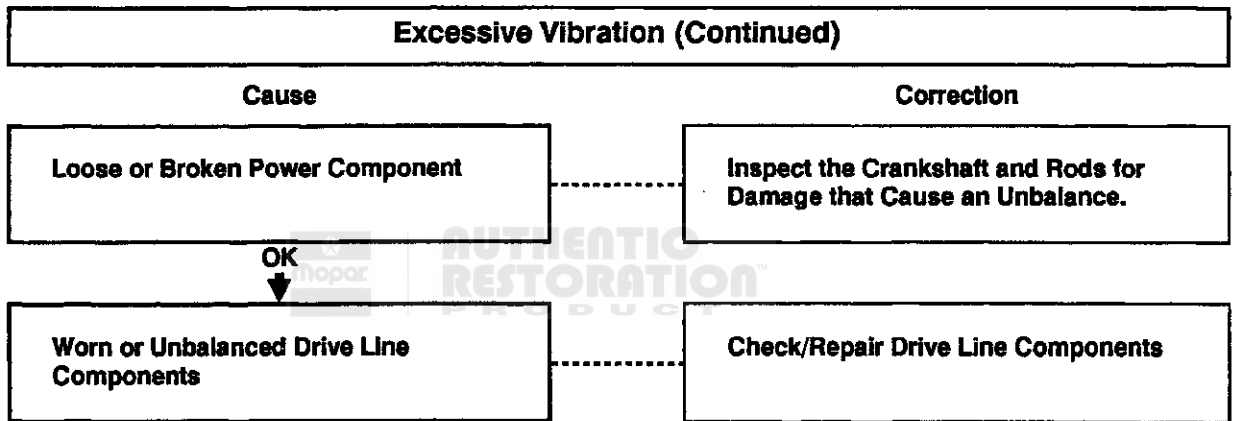


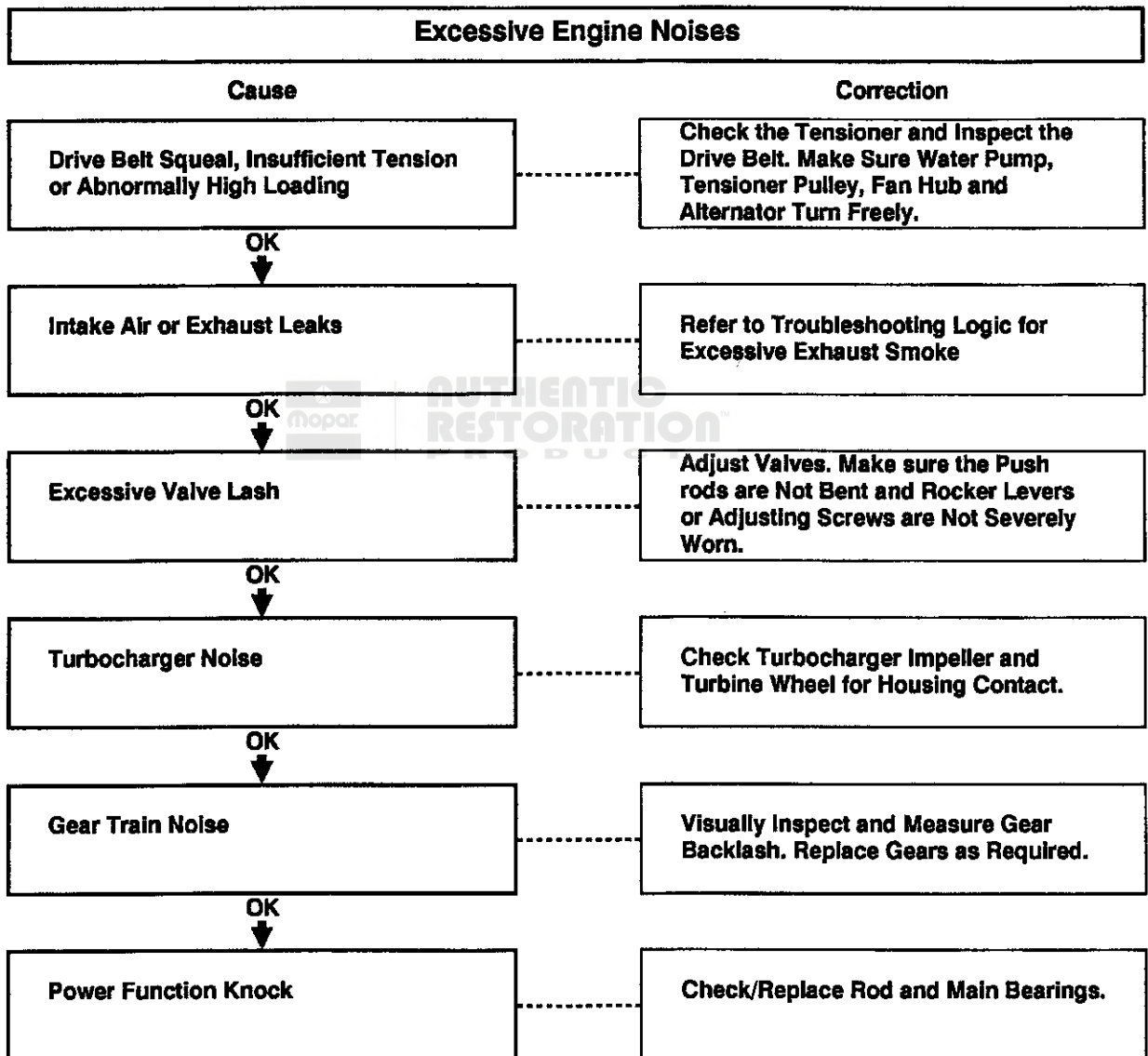


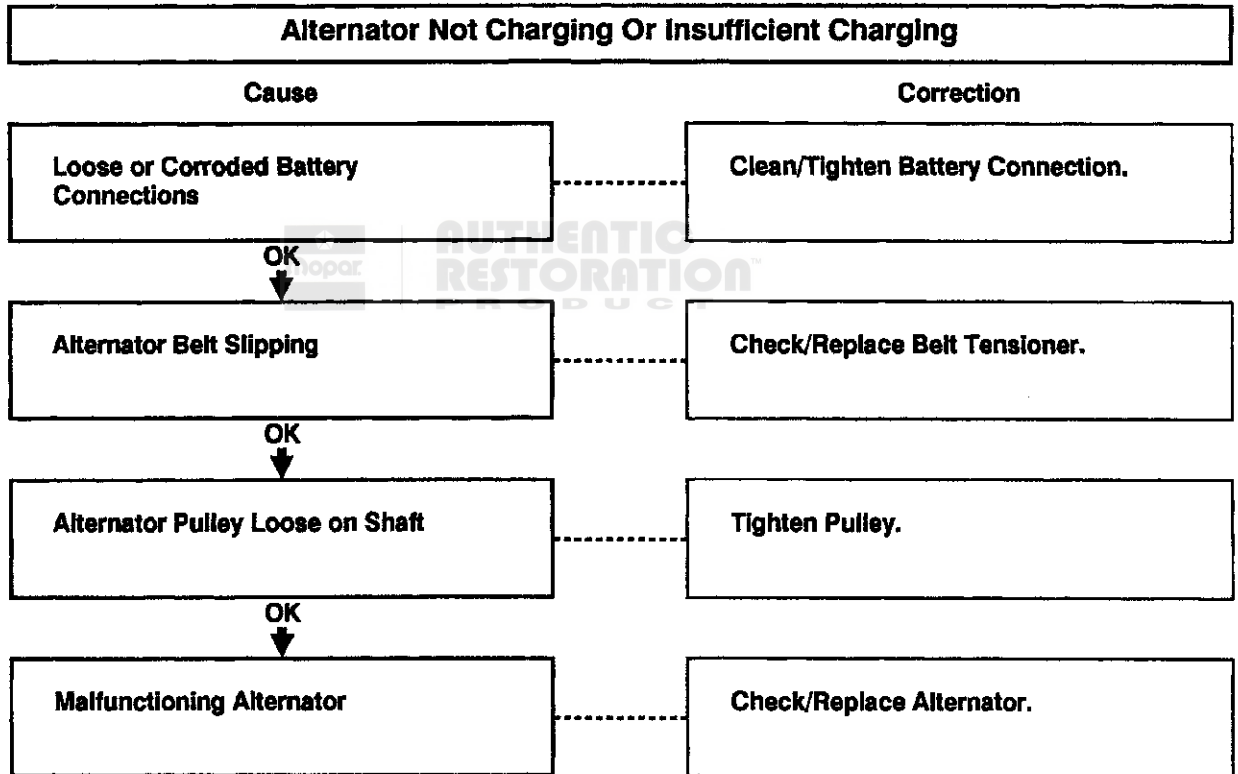












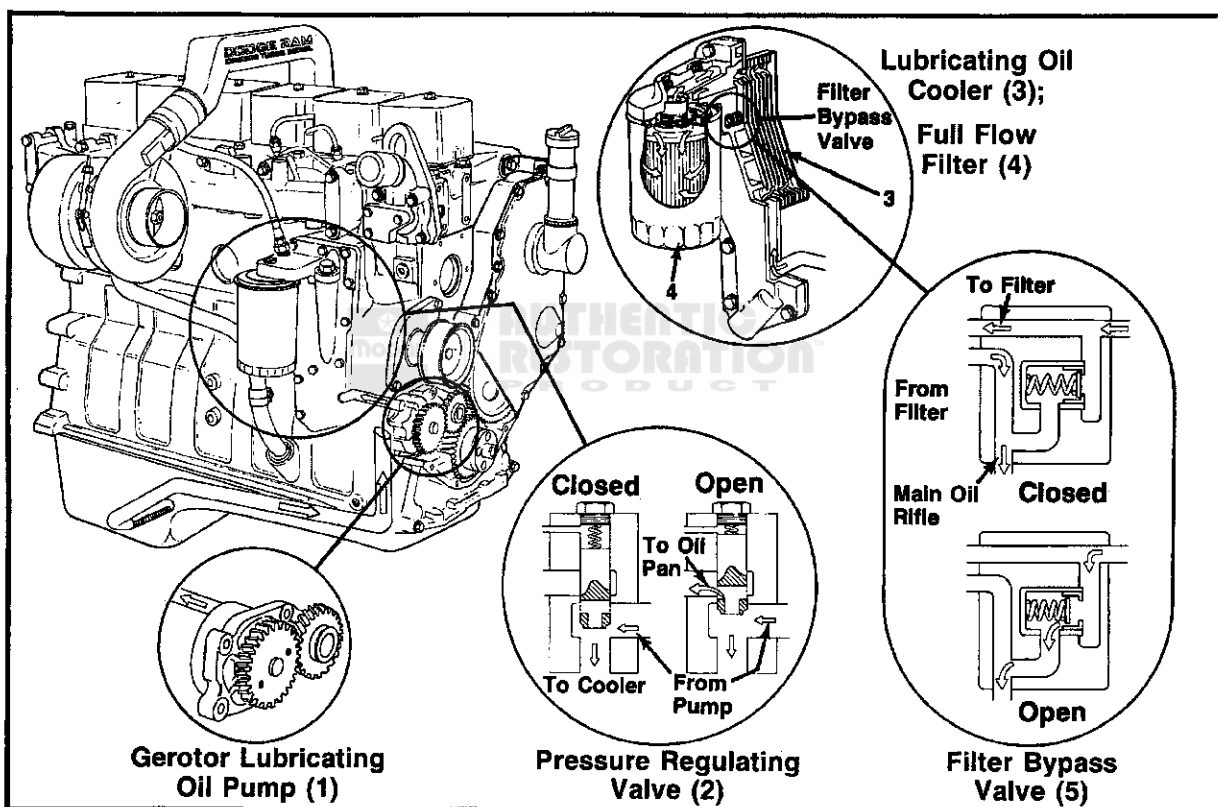
## Engine Lubricating System Section 9B

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## Lubricating System Flow

The schematics on the next four pages illustrate the engine oil lubrication system. The arrows indicate the flow path of the oil. The lubrication pump draws oil from the pan and forces it through the lubrication system. The pressure regulation valve controls the oil pressure in the system. The filter bypass valve ensures a supply of oil in the event the filter becomes plugged. The piston pins are lubricated by the splash from the piston cooling nozzles. The oil pump idler gear bushing is pressure lubricated. The remainder of the front gear train is lubricated by oil carry-over and splash.



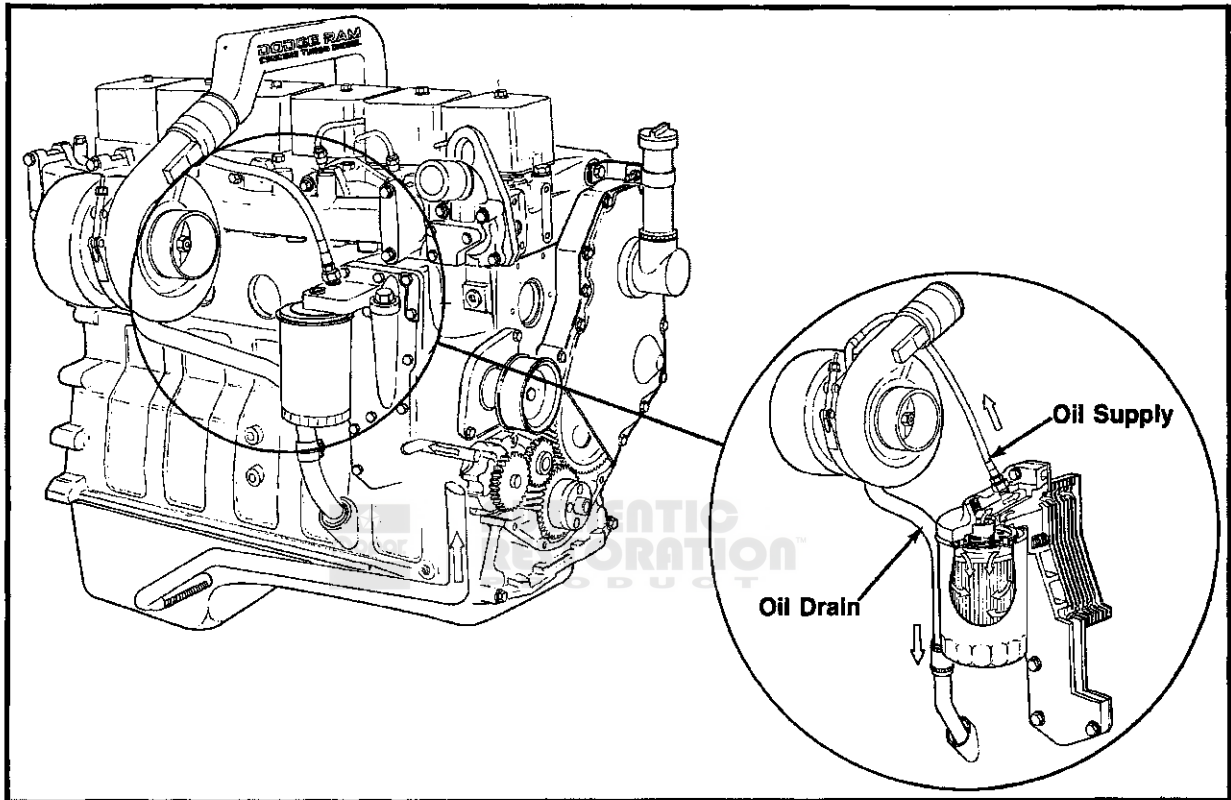
### Lubricating Oil Pump

The engine uses a gerotor type pump.

### Pressure Regulating Valve

The pressure regulating valve (2) is designed to keep the oil pressure from exceeding 414 kPa [60 PSI]. When the oil pressure from the pump is greater than 414 kPa [60 PSI], the valve opens uncovering the dump port so part of the oil is routed to the oil pan. Because of manufacturing tolerances of the components and the oil passages, the oil pressure can differ as much as 69 kPa [10 PSI] between engines.

## Lubrication for the Turbocharger



The turbocharger receives filtered, cooled and pressurized lubricating oil through a supply line from the filter head. A drain line connected to the bottom of the turbocharger housing returns the oil to the oil pan through a fitting in the cylinder block.

## Oil Coolers

The engines use full flow, plate type oil coolers (3). The oil flows through a cast passage in the cooler cover and through the element where it is cooled by engine coolant flowing past the plates of the element.

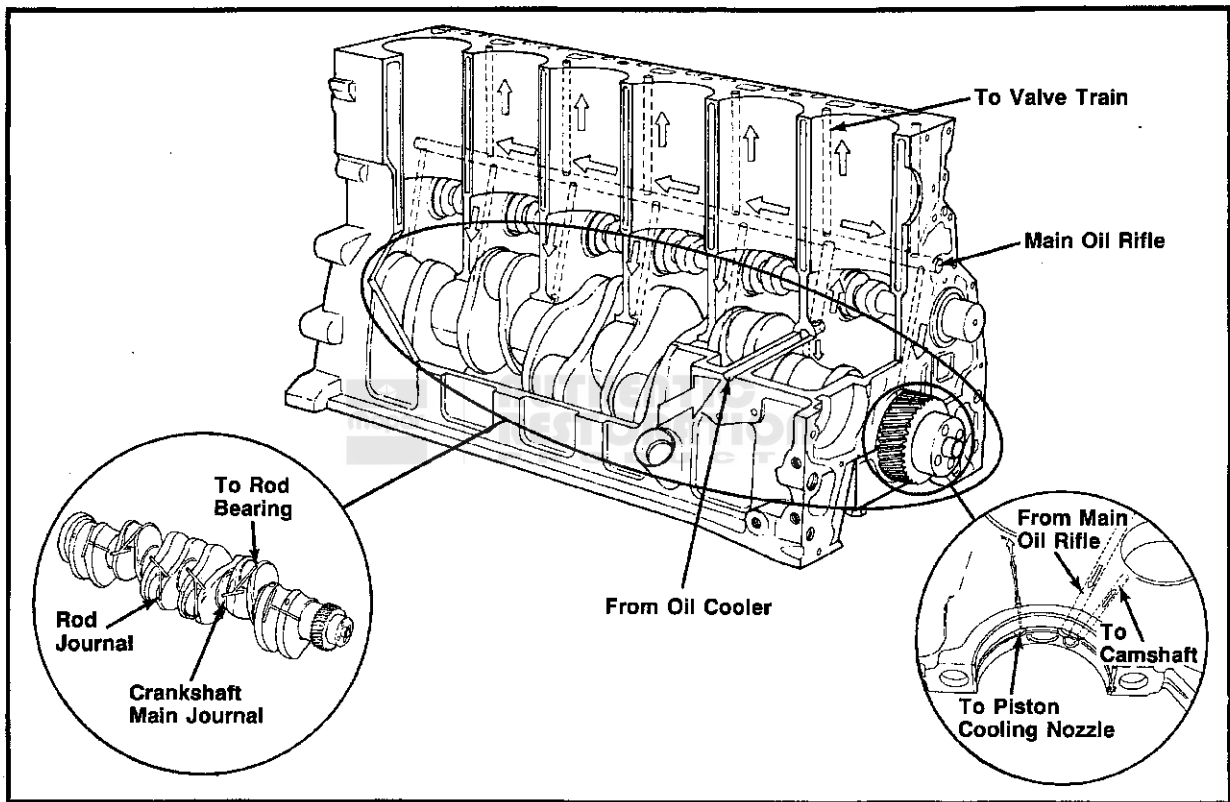
## Oil Filters

After the oil is cooled, it flows through the full flow oil filter. From the filter oil flows to the turbocharger and engine.

## Oil Filter Bypass Valve

The oil cooler cover contains a bypass valve (5) that will let the oil flow bypass a plugged filter. The valve is designed to open when the pressure drop across the filter is more than 138 kPa [20 PSI], as with a plugged filter, and lets the oil continue on through the engine. When a filter becomes plugged, an oil pressure decrease of 60 kPa [10 PSI] or less from the normal operating pressure can be observed on the vehicle oil pressure gauge.

## Lubrication for the Power Components



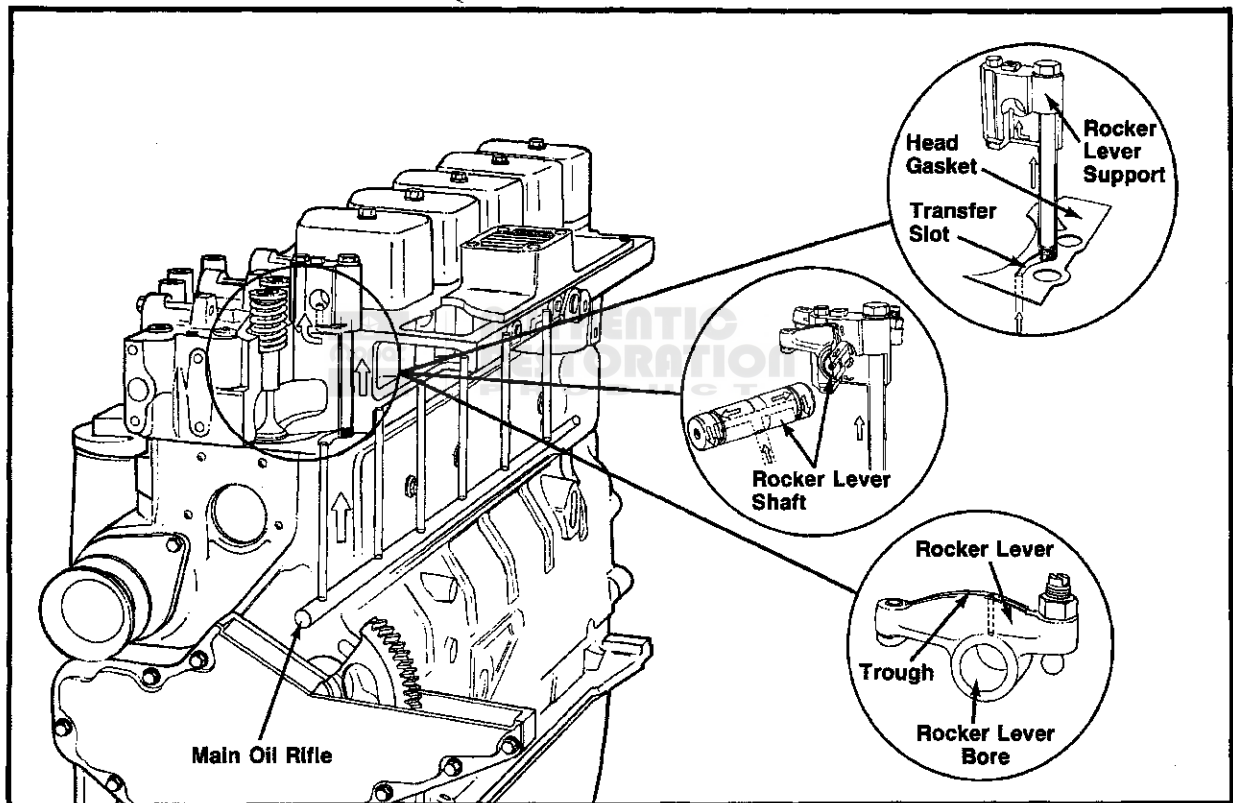
### General Description of Oil Flow

The main bearings and the valve train are lubricated by pressurized oil directly from the main oil rifle. The other power components, connecting rods, pistons, and camshaft receive pressurized oil indirectly from the main oil rifle.

The drillings in the crankshaft supply oil to the connecting rod bearings. The oil is supplied to the camshaft journals through drillings in the main bearing saddle. Smaller drillings in the main bearing saddle supply oil to the piston cooling nozzles. The spray from the nozzles also provides lubrication for the piston pins.

The number one main bearing saddle does not contain a piston cooling nozzle. **Cylinder Number One** receives the lubricating and cooling spray from the nozzle located in the **Number Two Bearing Saddle**. **Cylinder Number Two** receives the spray from the **Number Three Bearing Saddle**, etc.

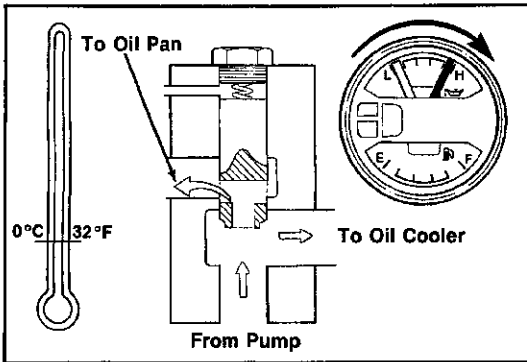
## Lubrication for the Overhead



Lubrication for the valve train is supplied through separate drillings in the cylinder block. The oil flows through the drillings and across the oil transfer slot in the cylinder head gasket. From the transfer slot, the oil flows around the outside diameter at the cylinder head capscrew, across a slot in the bottom of the rocker lever support, and up a vertical drilling in the support. From these drillings, oil flows through drillings in the rocker lever shaft to lubricate the rocker levers. Oil flows through a drilling in the rocker levers to fill a trough cast into the top of the levers. The oil from the trough lubricates the valve stems, push rods and tappets.



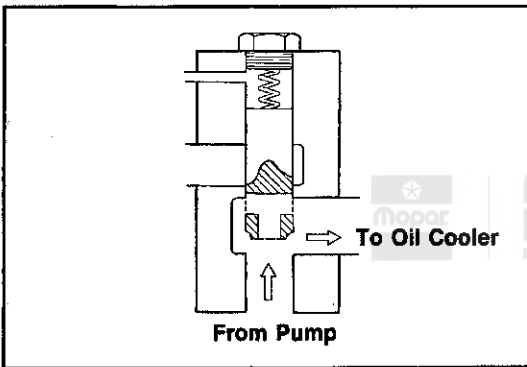
### Diagnosing Lubricating System Malfunctions



Be sure to check items related to oil pressure, such as: gauges, high and low oil level, excessive oil contamination, oil viscosity, etc.

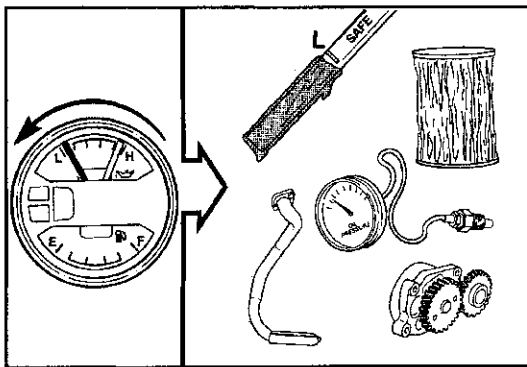
#### High Oil Pressure

High oil pressure usually occurs after the engine is first started in cold weather. The lubrication system does not have a cold start relief valve. The pressure regulating valve components are machined to a size that will relieve the excessive pressure created by cold engine oil.



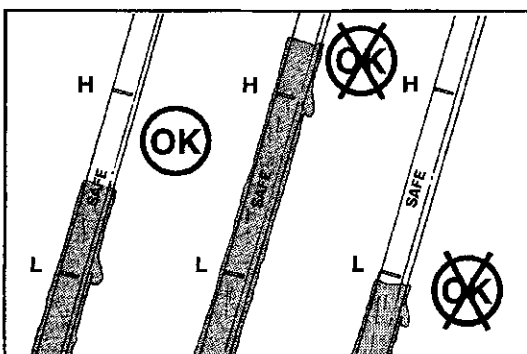
#### Oil Pressure Regulating Valve

The engine will have high oil pressure if the regulator sticks in the closed position. Check the regulator for freedom of movement.



#### Low Oil Pressure

Low oil pressure can be caused by several lubrication system related malfunctions. To begin the investigation, determine the engine operating conditions when the low pressure was first observed.



#### Oil Level

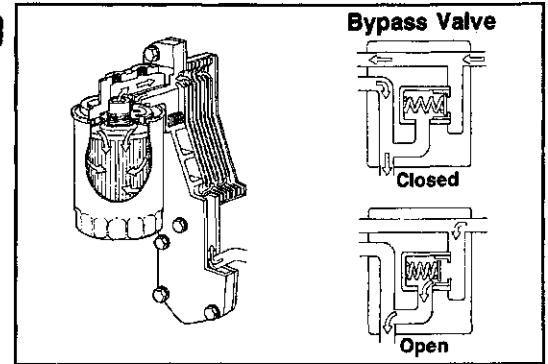
Low oil level can cause low oil pressure.



**Caution:** Never operate the engine with the oil level below the low (L) mark.

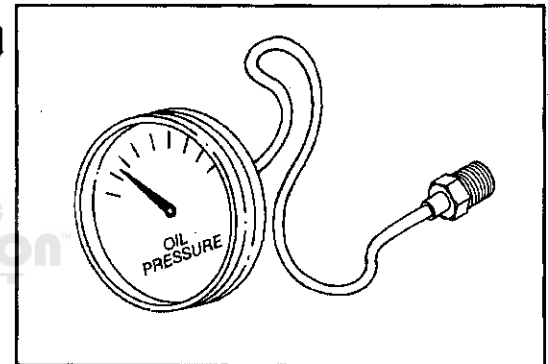
### Oil Filter

A plugged filter will cause a gradual loss of oil pressure by approximately 69 kPa [10 PSI]. The pressure will return to normal when the filter bypass valve opens.



### Oil Gauge

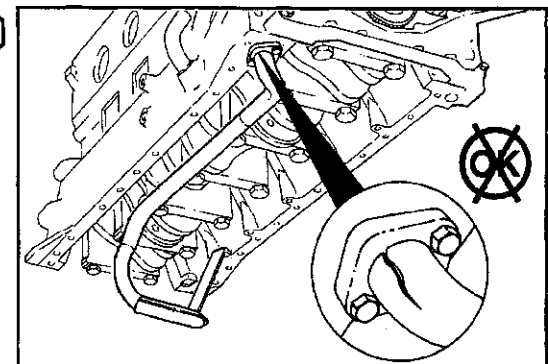
Check the oil gauge and sending unit to make sure they are operating correctly by verifying the pressure with a manual gauge.



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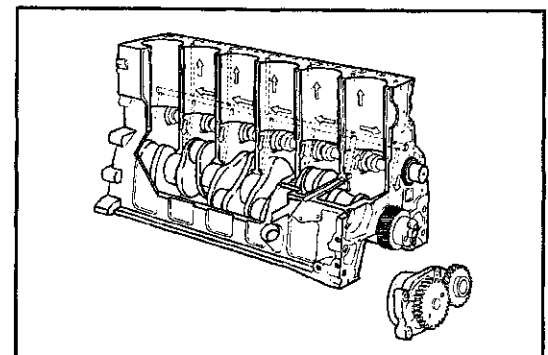
### Oil Suction Tube

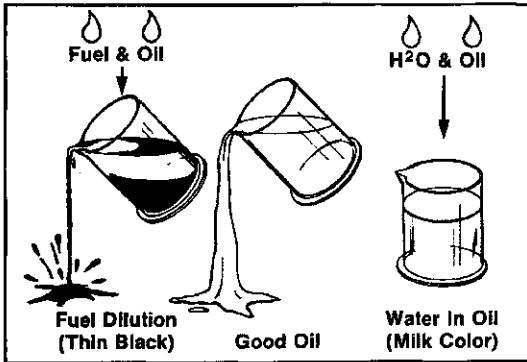
A loose suction tube, damaged gasket or crack in the suction tube can cause a temporary loss of prime for the oil pump. The engine will have low pressure or no oil pressure at starting followed by normal oil pressure.



### Bearings and Oil Pump

A steady decrease in oil pressure over a long period of time can be an indication of worn bearings or excessive oil pump wear.





### Oil Dilution



**Caution: Diluted oil can cause severe engine damage.**

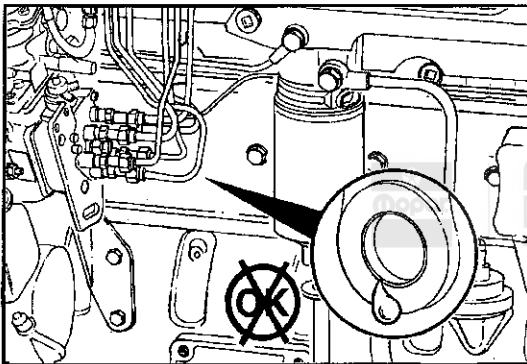


Check the condition of the oil.

- Thin, black oil is an indication of fuel in the oil.
- Milky discoloration is an indication of coolant in the oil.

Coolant in the oil can be caused by:

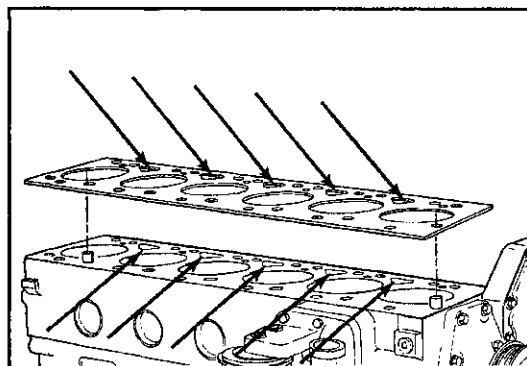
- Cup plugs leaking.
- Damaged cylinder head gasket.
- Oil cooler element leaking.



### Coolant Diluted Oil

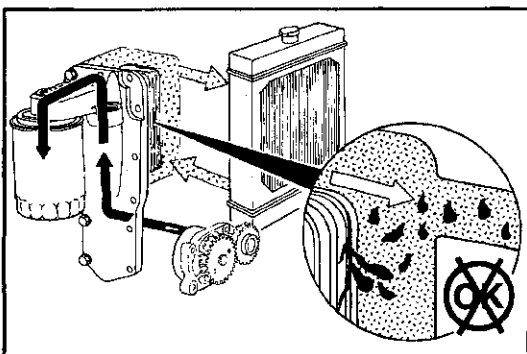
Coolant leaking from the cup plugs in the cylinder block water jacket will dilute the oil.

To check for leaks, remove the tappet cover and pressurize the cooling system.




Coolant in the oil can also be caused by a damaged cylinder head gasket.

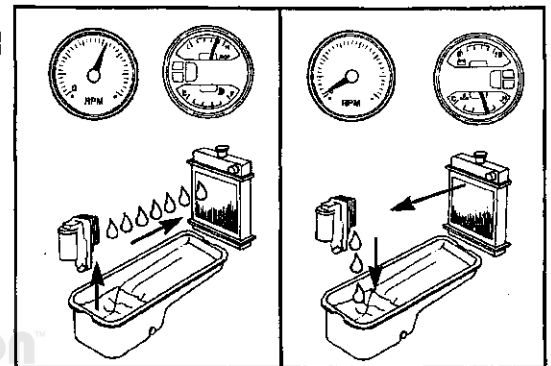
Pressurize the cooling system to check for leaks. It may be necessary to remove the oil pan to locate internal leaks.



Since the oil cooler design does not require gaskets or seals to maintain the separation of oil and coolant, the element itself must leak to allow mixing of the fluids.

During operation the oil pressure will be higher than coolant pressure. A leak in the oil cooler will show as oil in the coolant. 

However, following an engine shutdown, the residual pressure in the coolant system can cause coolant to seep through the leak path into the oil.

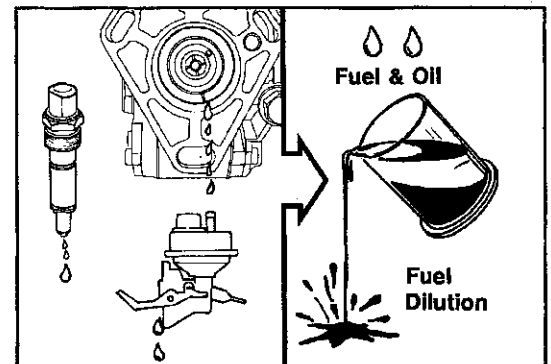


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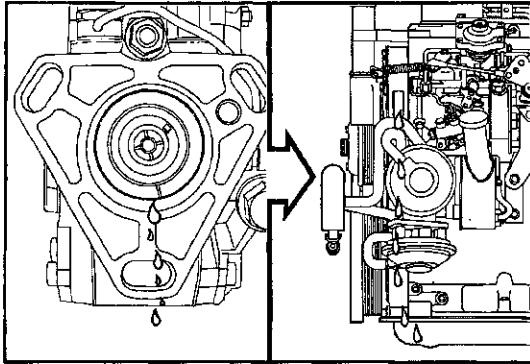
### Fuel Diluted Oil

Fuel dilution is limited to four sources:

1. Injection pump shaft seal
2. Fuel leaking by the rings
3. Lift pump
4. A crack in the cylinder head from the fuel filter location to the air intake

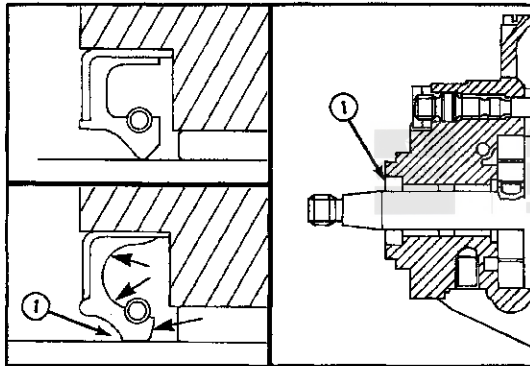


Use the following logic to determine the source of the oil dilution with fuel.



### Injection Pump Shaft Seal

A worn or damaged injection pump shaft seal will allow fuel to leak into the gear housing and then into the oil pan.

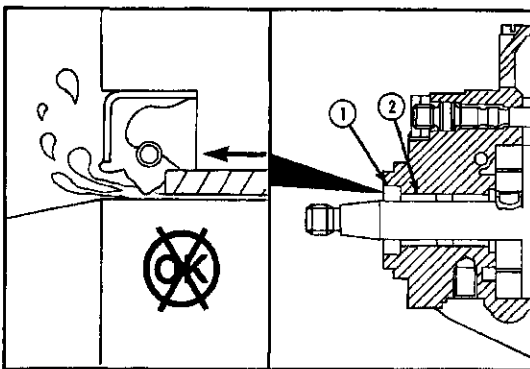


The seal is designed to provide increased sealing as the pump case pressure increases. Pressure forces the lip (1) tighter around the shaft.

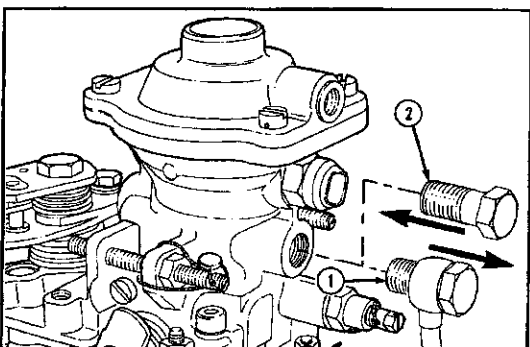
A worn seal is more apt to leak during start up and shut down when case pressure is low.



**Caution:** A worn seal can not be detected by pressurizing the pump with normal operating pressure. By increasing the pressure in the pump, the sealing force will also be increased.

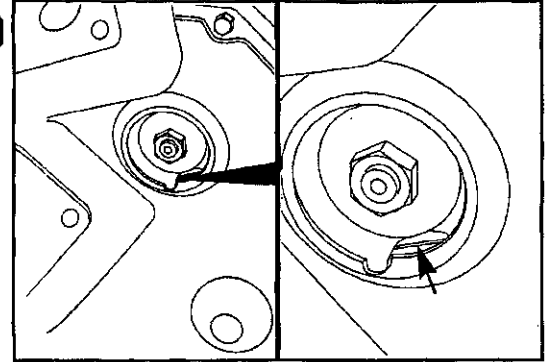


The bushing (2) in the Bosch VE pump can cause a seal leak. If the bushing is loose in the housing it will move toward the seal raising the lip (1) and providing a leak path for fuel.

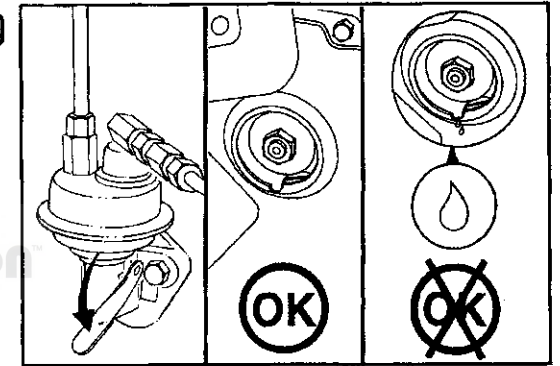


To check for such a leak (Bosch VE only), remove the fuel drain manifold connection (1) at the pump and install a plug (2).

Remove the oil fill tube and rotate the engine so one of the holes in the fuel pump gear exposes the back gear housing.



Use a small mirror to check for leaks while pumping the priming lever on the lift pump. If a leak is found, remove the injection pump. The seal can be replaced.

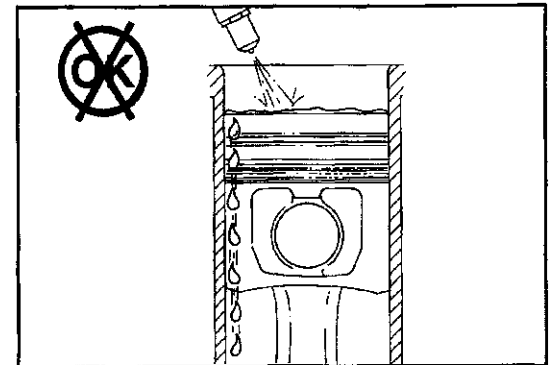


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### Fuel Leakage by the Rings

Incomplete combustion in the cylinders can result in unburned fuel draining into the oil pan.

This condition can be caused by a leaking injector or reduced compression caused by inadequate piston ring sealing.

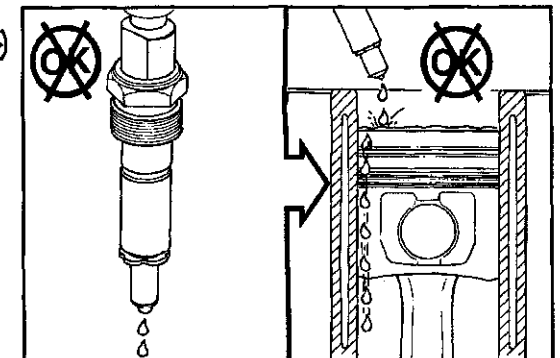


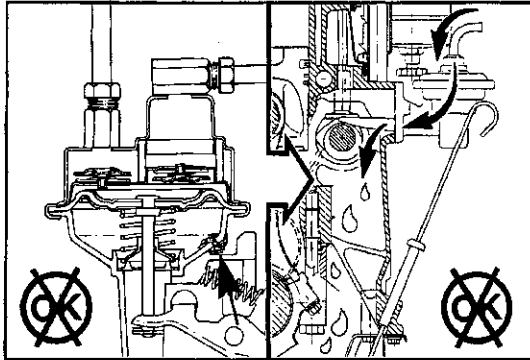
An increase in white exhaust smoke during the first start of the day is a symptom that an injector may be leaking.



An injector leak will also cause the engine to run rough and have low power.

Remove and replace leaking injectors.

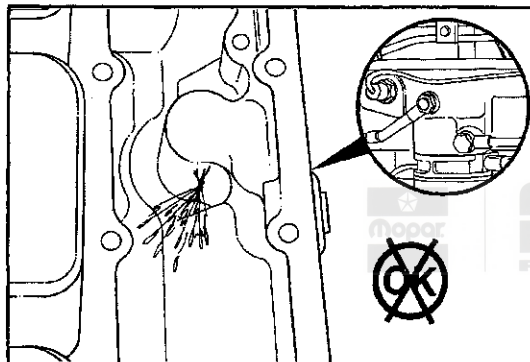




 **Lift Pump Leakage**

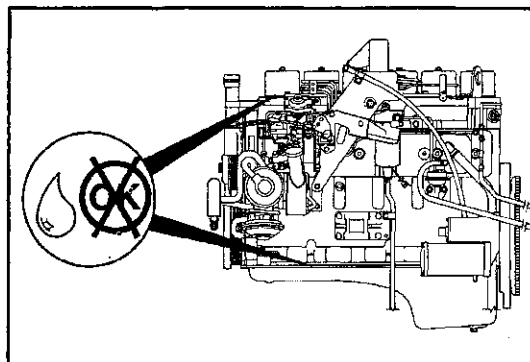
There is a remote possibility for fuel to drain into the oil from the lift pump.

For this to happen, the diaphragm in the pump would have to break and the drain hole would have to be plugged.



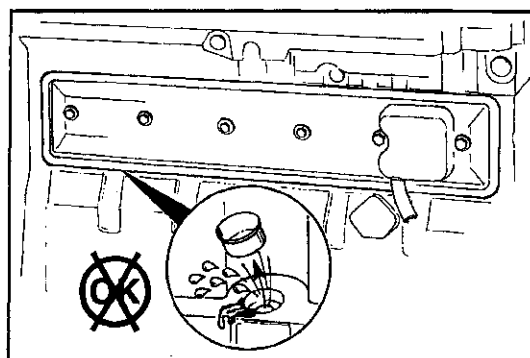
 **Cylinder Head Leakage**


Another remote possibility, is a crack or porosity in the head casting could allow fuel to leak to the air intake and on to the cylinders.



 **Oil Leaks**

Various gaskets, seals and plugs are used to contain the oil. Most leaks can be identified during routine inspection of the engine and vehicle.

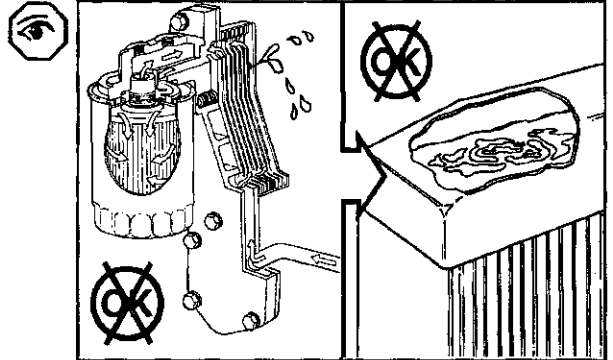


 **A blown cup plug can allow a relative large quantity of oil to escape resulting in a sudden drop in the oil pressure.**

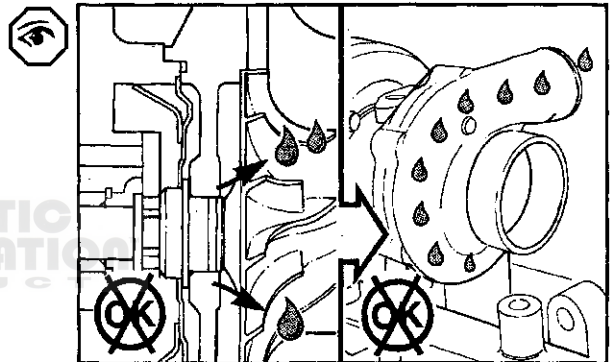
When checking for such a leak, be sure to check the plug behind the tappet cover as well as those that may be obscured by chassis parts.



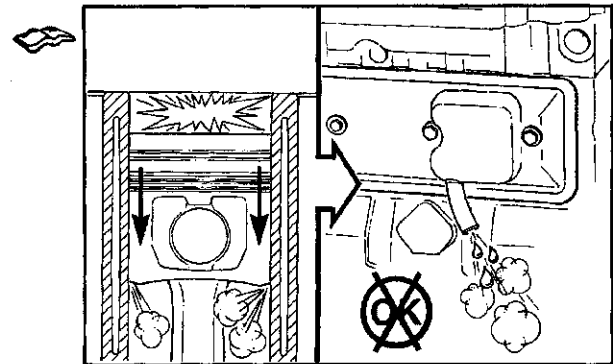
If the oil cooler element ruptures, the oil pressure will force oil into the coolant system. Oil in the coolant should be visible when the radiator cap is removed.



Worn or damaged seals in the turbocharger can also allow oil to leak into the air crossover pipe and be burned in the engine. The condition can be verified by removing the air crossover tube and looking for oil.



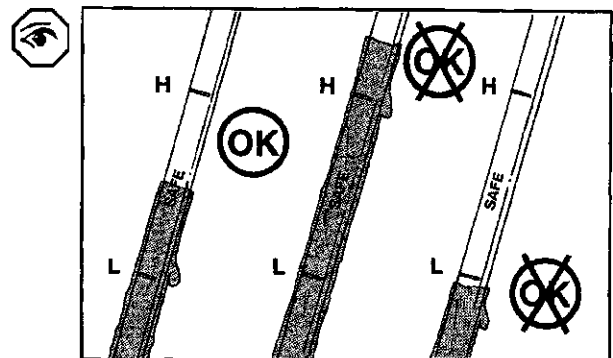
Inadequate sealing of the piston rings and/or turbocharger seals will result in oil being blown out the breather tube and/or consumed by the engine.



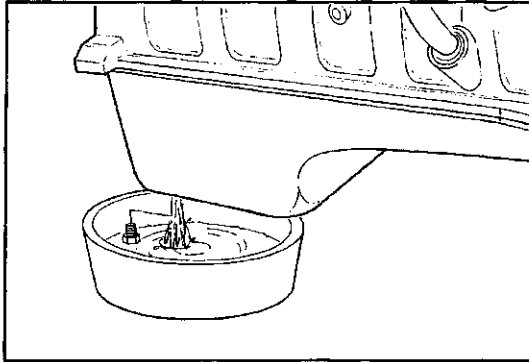
### Lubricating Oil Level - Check

Check the engine oil level. Never operate the engine with the oil level below the "L" (LOW) mark or above the "H" (High) mark.

The oil capacity between the low mark and the high mark on the oil dipstick is 1.89 liters [2 U.S. quarts].







### Lubricating Oil and Filter – Change

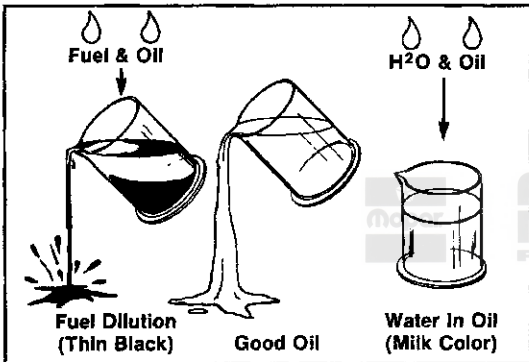
17mm



**Warning: Hot oil can cause personal injury.**

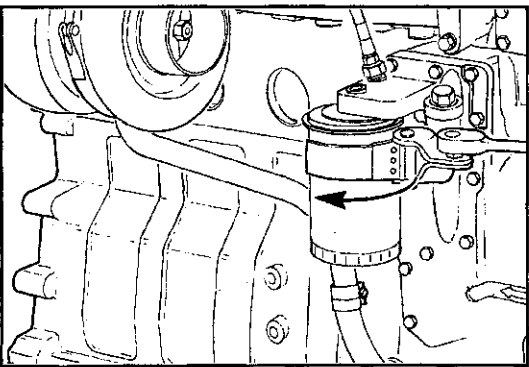
Operate the engine until the water temperature reaches 60°C [140°F]. Shut the engine off. Remove the oil drain plug.

Use a container that can hold at least 14 liters [15 U.S. quarts] to hold the used oil.



Always check the condition of the used oil. This can give you an indication of some engine problems that might exist.

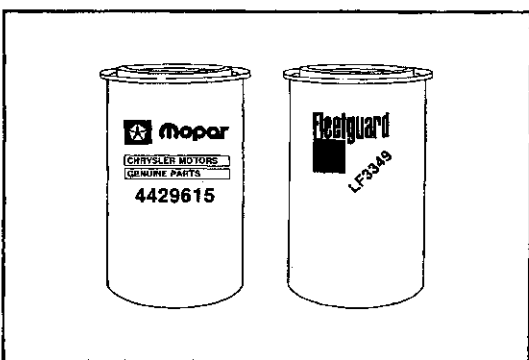
- Thin, black oil indicates fuel dilution.
- Milky discoloration indicates coolant dilution.



Clean the area around the lubricating oil filter head. Remove the filter using a 90-95mm filter wrench.



Clean the gasket surface of the filter head. The filter canister o-ring seal can stick on the filter head. Make sure it is removed.



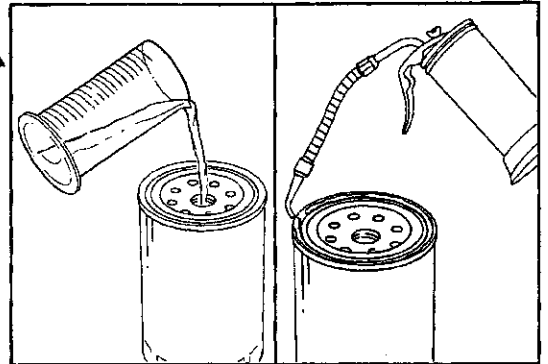
Any one of the following lubricating oil filters can be used on the Cummins Turbo Diesel engine.

Part No.	Manufacturer
4429615 .....	Chrysler
LF3349 .....	Fleetguard

**Caution:** Fill the oil filter element with clean oil before installation. Use the same type oil that will be used in the engine.



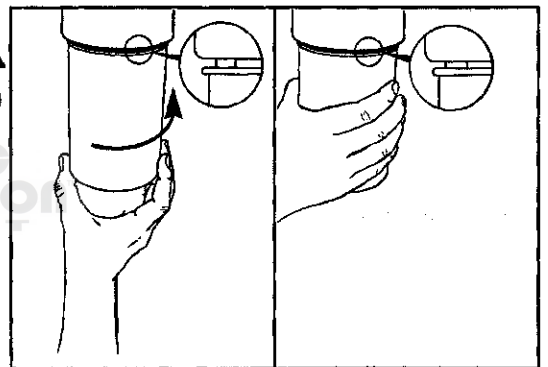
Apply a light film of lubricating oil to the sealing surface before installing the filter.



**Caution:** Mechanical over-tightening may distort the threads or damage the filter element seal.



Install the filter as specified by the filter manufacturer.

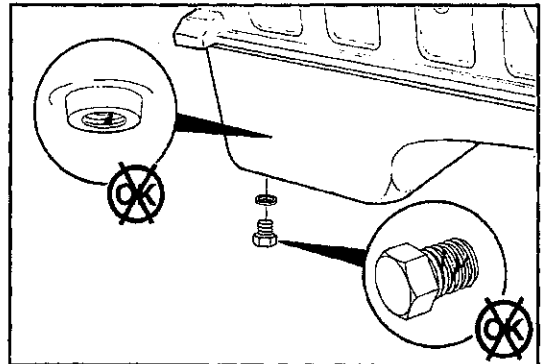


17mm

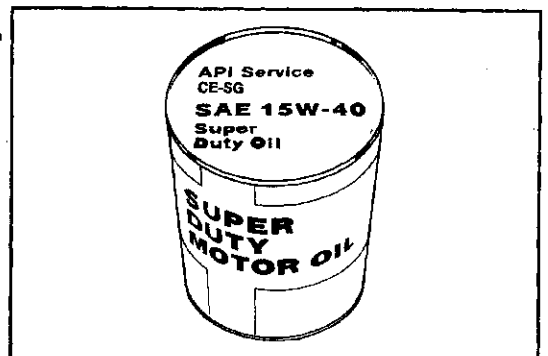
Check the condition of the threads and sealing surface on the oil pan and drain plug.

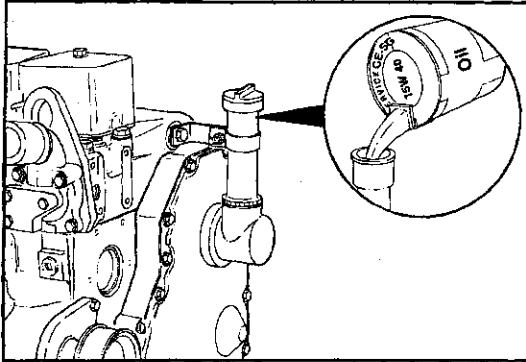
Clean the drain plug and the sealing surface of the pan. Install a new drain plug sealing washer, Chrysler Part #4429216. Tighten the drain plug and sealing washer.

**Torque Value:** 80 N-m [60 ft-lbs]

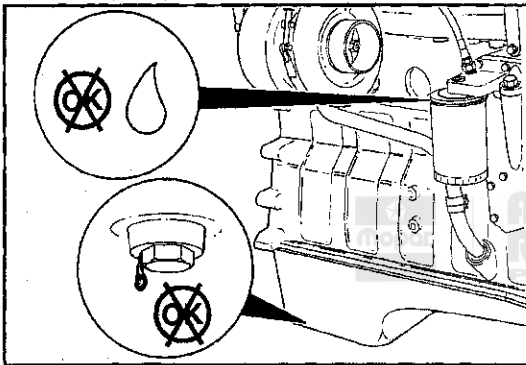


Use High-Quality Multi-Viscosity lubricating oil in your Dodge Turbo Diesel Engine. Choose the correct oil for your operating conditions as outlined in the Oil Specifications.

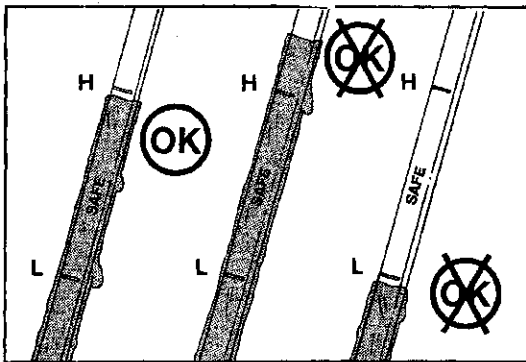




Fill the engine with the correct grade of new oil. The engine capacity is 10.4 liters [11 U.S. quarts] in the crankcase and .95 liter [1 U.S. quart] in the lubricating oil filter.

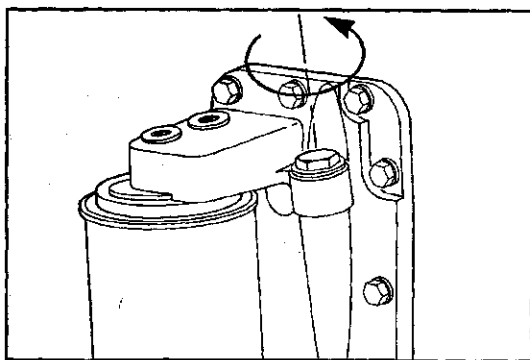


Start the engine and operate it at idle for several minutes. Check for leaks at the filter and drain plug.



Stop the engine. Wait approximately 5 minutes to let the oil in the upper parts of the engine drain back to the pan. Check the oil level again.

Add oil as necessary to bring the level to the "H" (High) mark on the dipstick.



### Lubricating System Replacement Procedures



Oil Pressure Regulator Valve and/or Spring – Replacement

19mm

Remove the threaded plug, gasket, spring and valve.

### Oil Pressure Regulator Spring

Check or replace the spring.

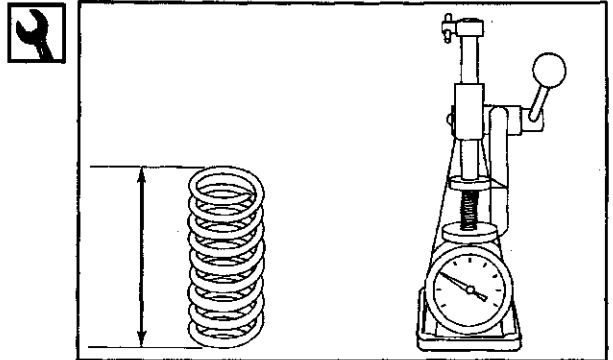
Limit

#### Valve Open

- Height: 39.98mm [1.574 inch]
- Load: 91 N [20.5 lb]

#### Assembled

- Height: 44.98mm [1.77 inch]
- Load: 60 N [13.5 lb]



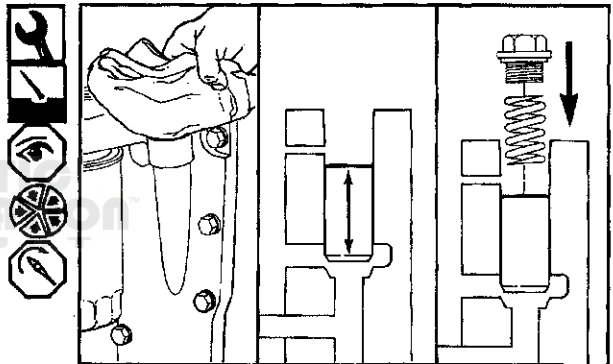
### 19mm

Clean and inspect the plunger, bore and seat before assembly.

**Note:** The plunger must move freely in the valve bore.

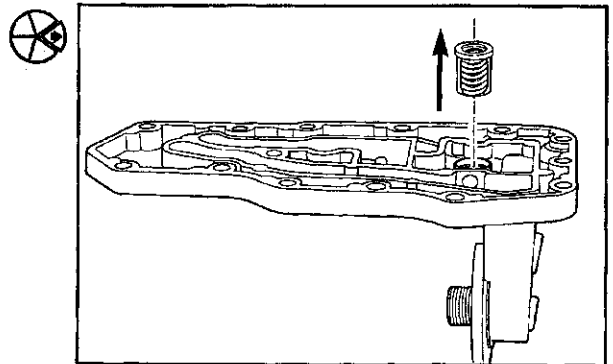
Assemble the valve in the reverse order of disassembly.

**Torque Value:** 80 N·m [60 ft-lbs]

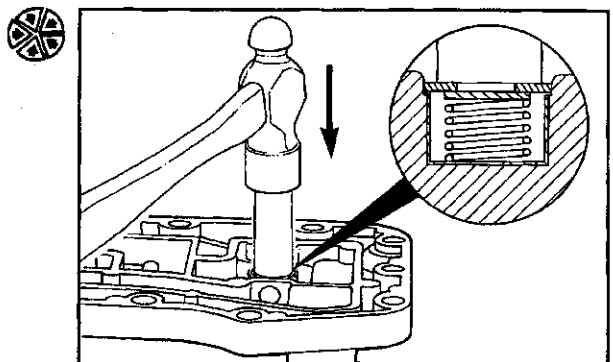


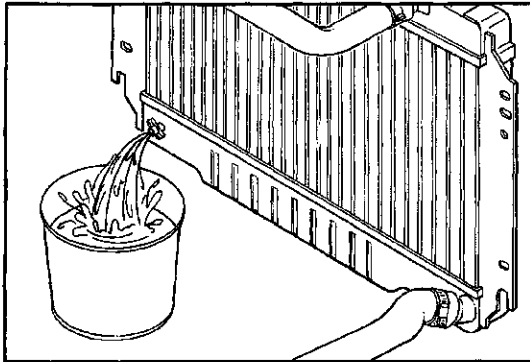
### Replacement of the Filter Bypass Valve

Remove the valve from the cooler cover.



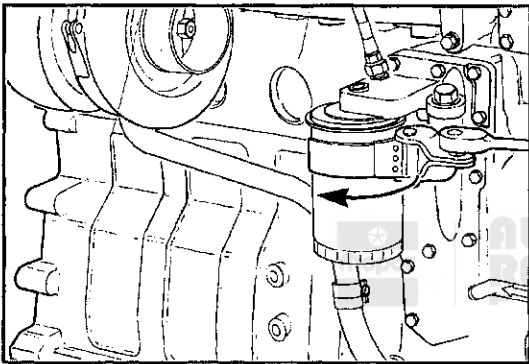
Drive the new valve in until it bottoms against the step in the bore.





### Oil Cooler Element and/or Gasket – Replacement

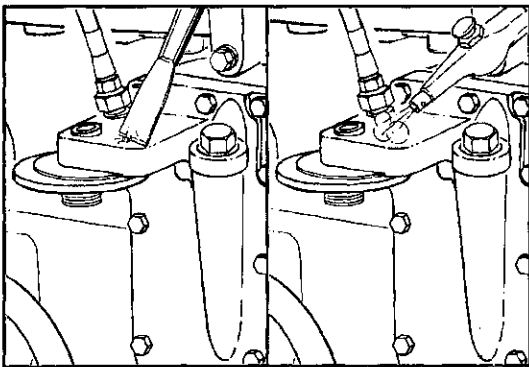
- Preparatory Step:
- Drain the coolant.



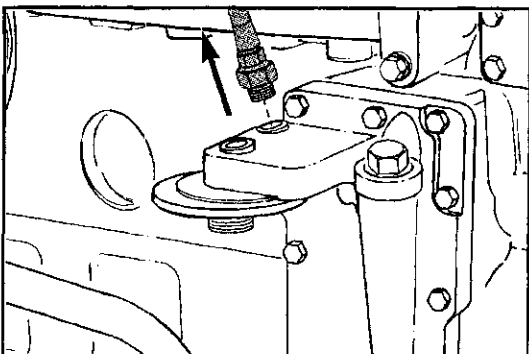
90–95mm



Remove the oil filter.



Clean around the oil cooler cover.



5/8 Inch, 19mm

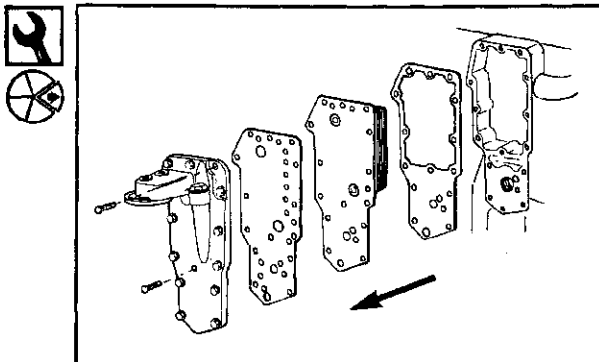


Disconnect the turbocharger supply line.

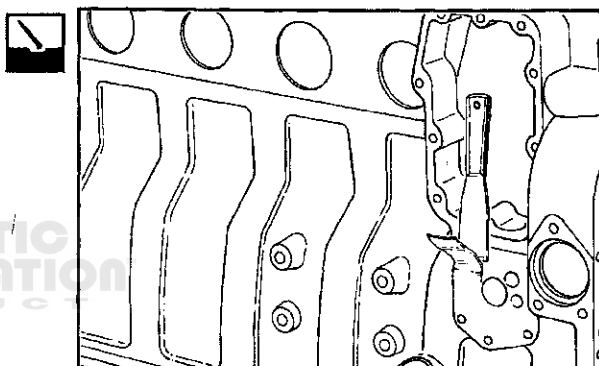
Torque Value: 15 N•m [11 ft-lbs]

10mm

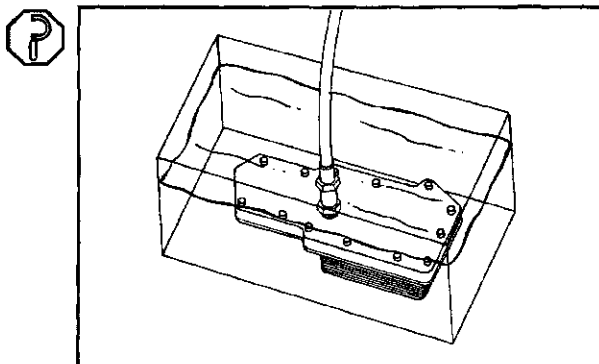
Remove the oil cooler cover, gaskets and cooler element.



Clean the sealing surfaces.



Apply 483 kPa [70 PSI] air pressure to the element to check for leaks.

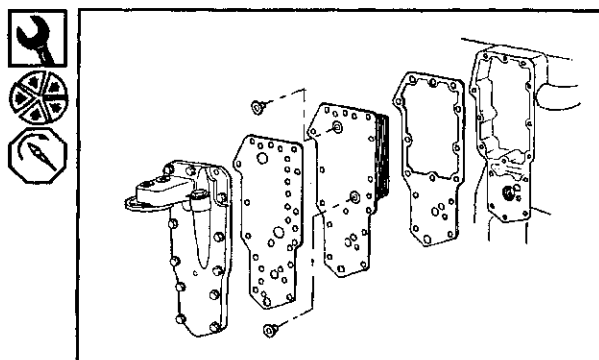


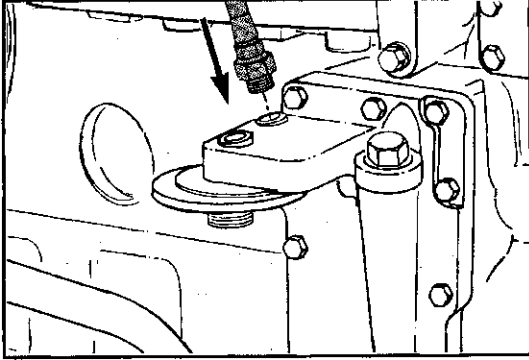
10mm

Assemble the oil cooler gaskets, element and cover.

**Torque Value:** 24 N·m [18 ft·lbs]

**Note:** Be sure to remove the plastic shipping plugs from a new element.



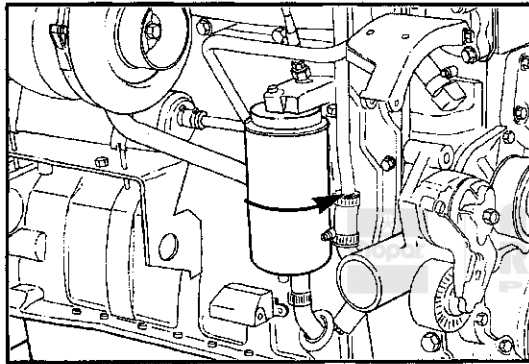


5/8 inch, 19mm



Connect the turbocharger oil supply line.

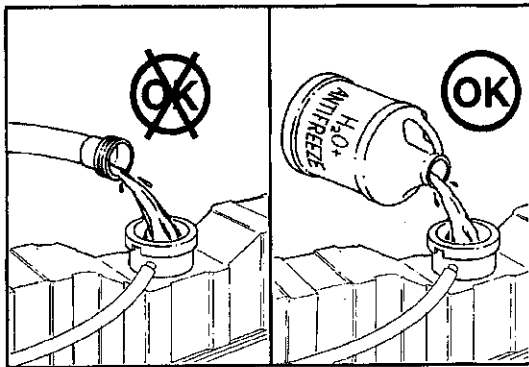
**Torque Value: 15 N·m [11 ft-lbs]**



Fill the filter with clean lubricating oil and apply a light coat of oil to the sealing gasket.

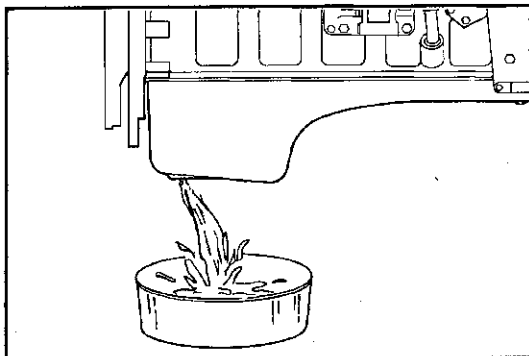


Install the oil filter.



Fill the coolant system and operate the engine to check for leaks.

Stop the engine and check the coolant and oil level.



**Oil Pan, Suction Tube and/or Gaskets - Replacement**



17mm, 10mm

**Note:** This operation will require engine removal.

Drain the oil and remove the pan and gasket.

10mm, 13mm

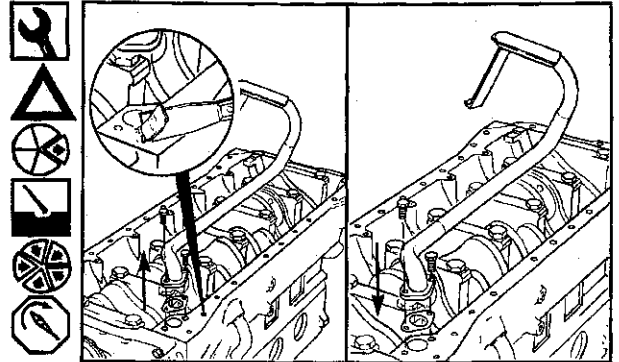
If required, remove the suction tube and gasket.

Clean the sealing surfaces.

Install the suction tube and gasket.

**Caution: Be sure to connect the support bracket.**

**Torque Value: 24 N·m [18 ft-lbs]**



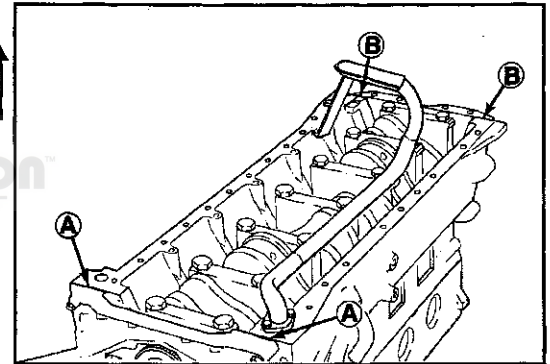
**Caution: Be sure to fill the joints between the pan rail, gear housing and rear cover. Use Three Bond 1207-C.**

**Sealing surfaces**

- A - Pan rail to gear housing
- B - Pan rail to rear cover



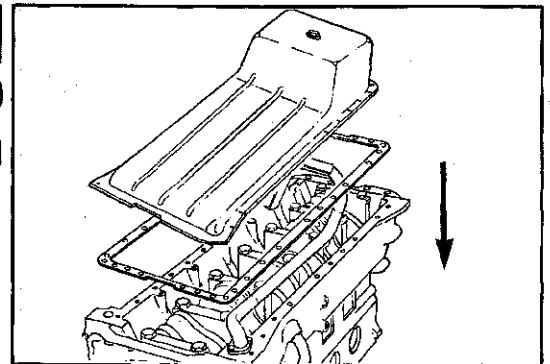
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10mm, 17mm

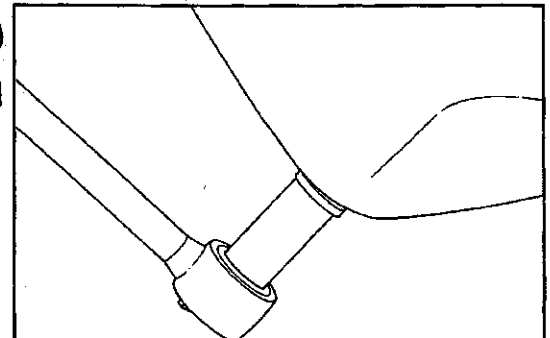
Install the pan and gasket.

**Torque Value: 24 N·m [18 ft-lbs]**

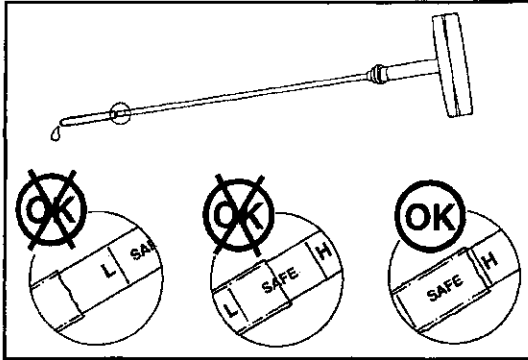


Install the drain plug.

**Torque Value: 80 N·m [60 ft-lbs]**

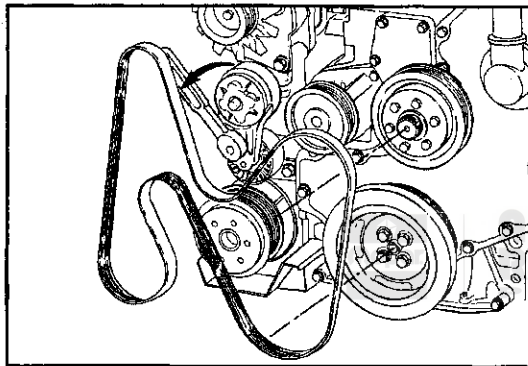






Fill the engine with oil. Run the engine and check for leaks.

Stop the engine and check the oil level with the dipstick.



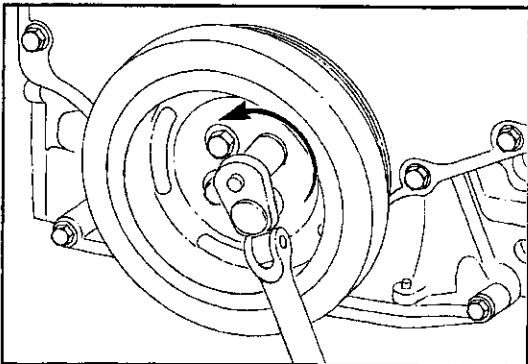
### Oil Pump - Replacement

3/8 Inch Square Drive

Preparatory Step:

- Remove the drive belt
- Remove the radiator
- Remove the fan clutch assembly
- Remove the fan hub
- Remove the oil fill

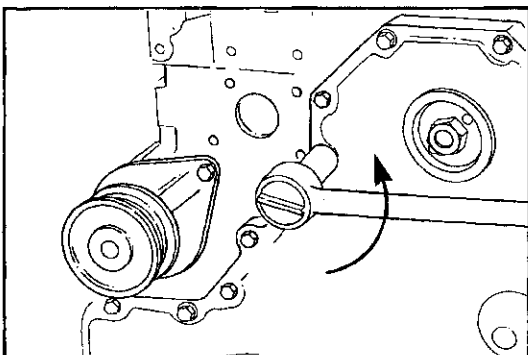
**Note:** Removal is easier if the crankshaft vibration damper is loosened before removing the belt.



15mm



Remove the crankshaft vibration damper.



10mm



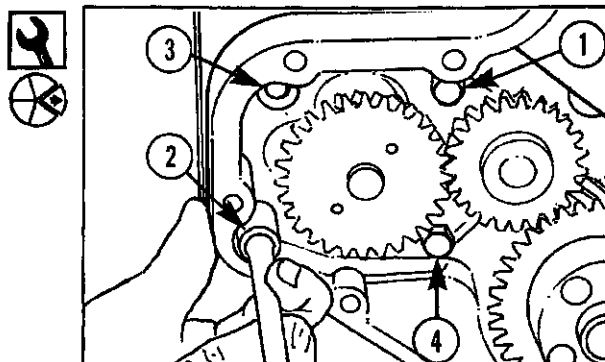
Remove the front cover.

### Remove the Lubricating Oil Pump

13mm

Remove the four mounting capscrews.

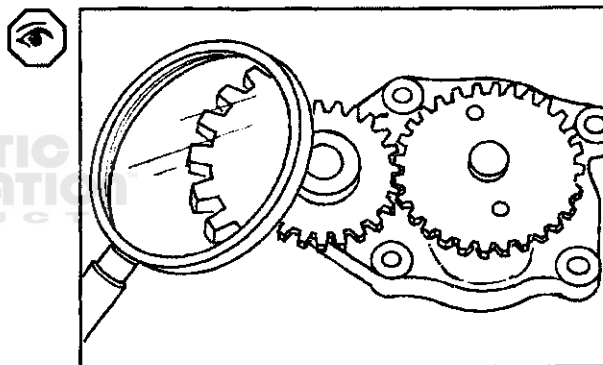
Remove the pump from the bore in the cylinder block.



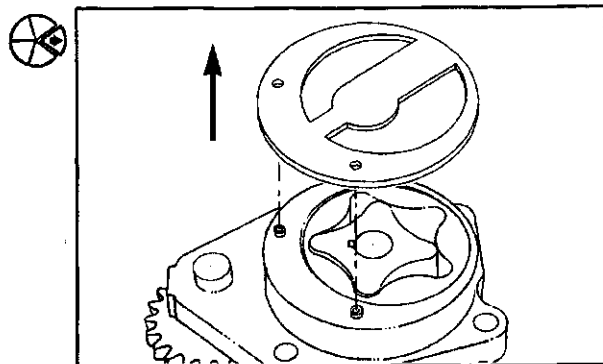
### Clean and Inspect

If the pump is to be inspected for reuse, follow these steps.

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

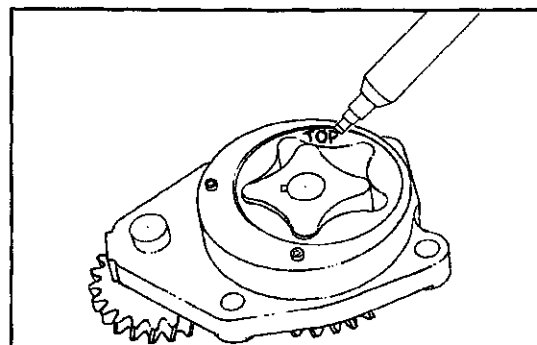


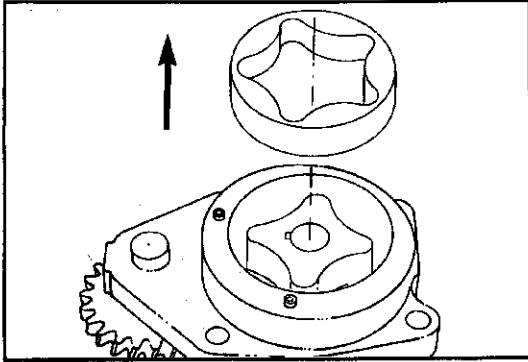
Remove the back plate.



Mark "TOP" on the gerotor planetary.

**Note:** Mark with felt tip pen.

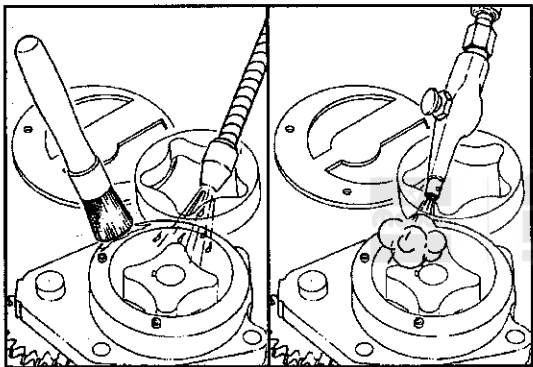




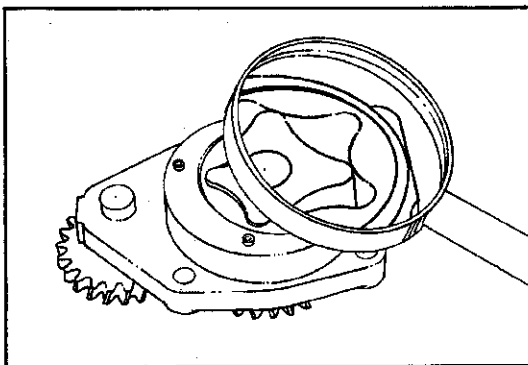
Remove the gerotor planetary.



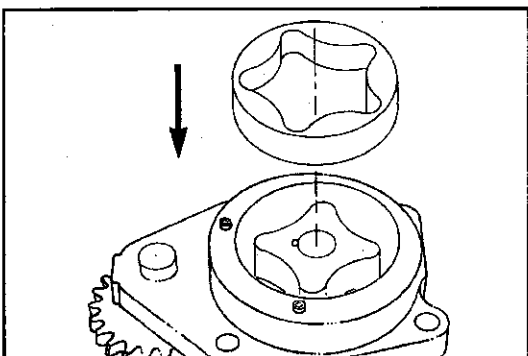
Inspect for excessive wear or damage.



Clean all parts in solvent and dry with compressed air.



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



**Caution:** Be sure the gerotor planetary is installed in the original position.



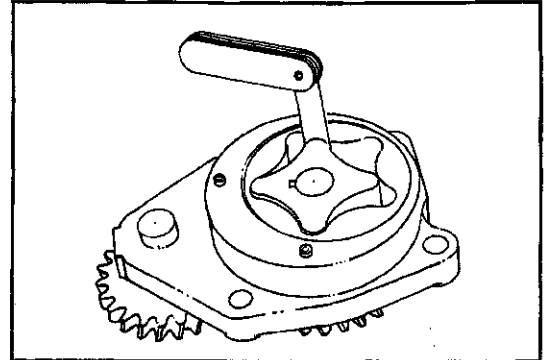
**Note:** Chamfer must be on O.D. Down.

Install the gerotor planetary.

Measure the tip clearance.

Limit

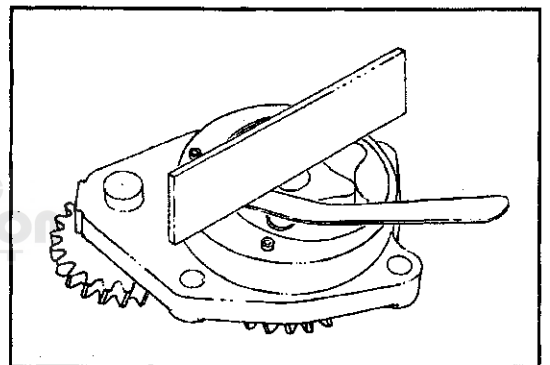
**Maximum Clearance: 0.1778mm [0.007 inch]**



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

Limit

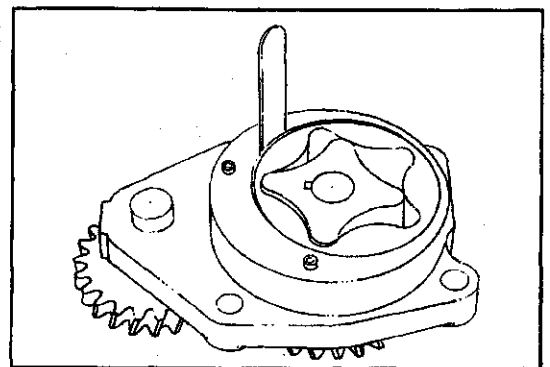
**Maximum Clearance: 0.127mm [0.005 inch]**



Measure the clearance of the gerotor planetary to the body bore.

Limit

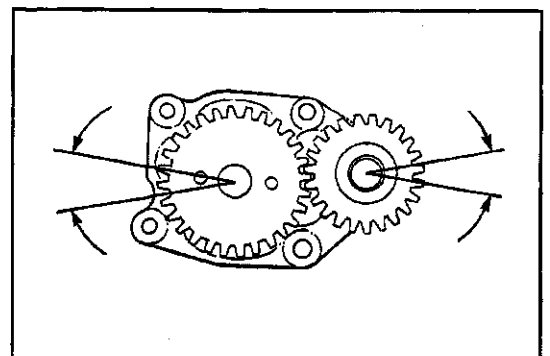
**Maximum Clearance: 0.381mm [0.015 inch]**

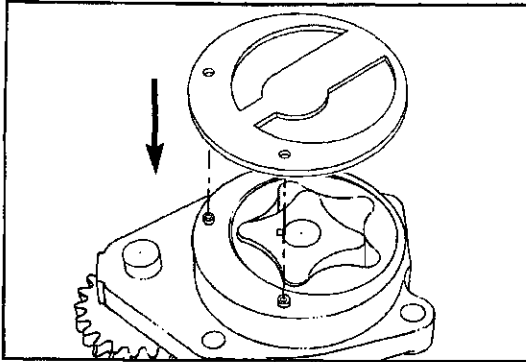



Measure the gears backlash.

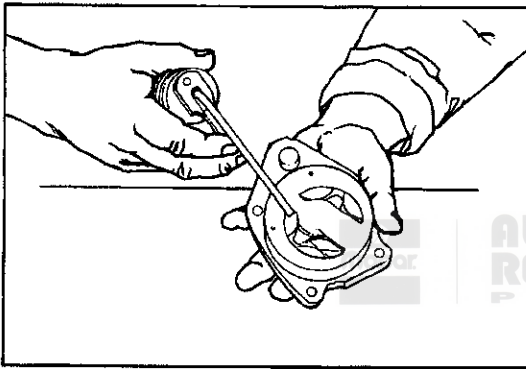
Limits (Used Pump)

0.08 to 0.38mm  
[0.003 to 0.015 inch]





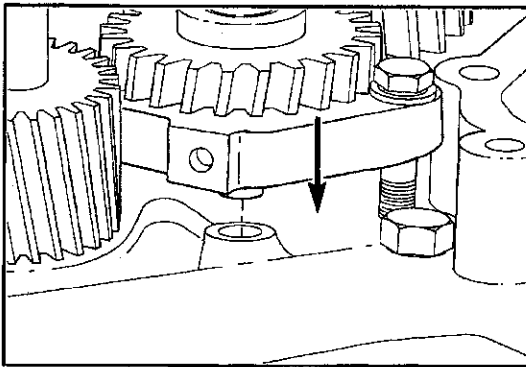
 Install the back plate.




 **Installing the Lubricating Oil Pump**

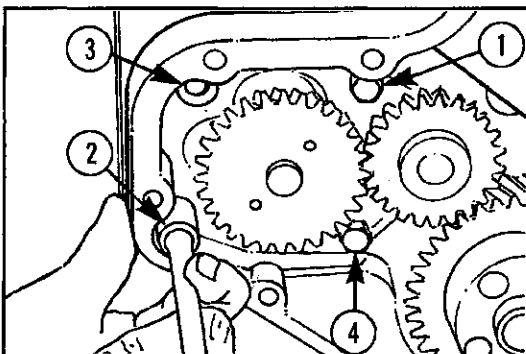
Lubricate the pump with clean engine oil.


**Note:** Filling the pump with oil during installation will help to prime the pump at engine start up.



 **Caution:** Make sure the idler gear pin is installed in the locating bore in the cylinder block.

 Install the pump.



 13mm

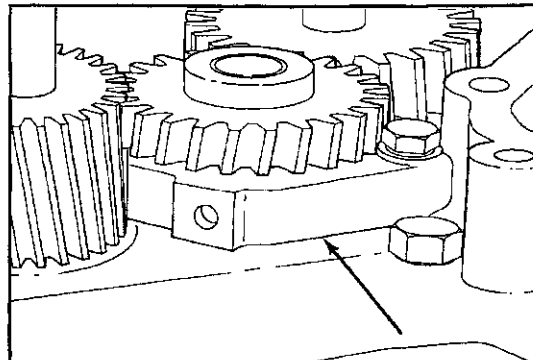
 Tighten the oil pump mounting cap screws in the sequence shown.

**Torque Value:**

Step 1 - 5 N·m [44 in-lbs]

Step 2 - 24 N·m [18 ft-lbs]

**Note:** The back plate on the pump seats against the bottom of the bore in the cylinder block. When the pump is correctly installed, the flange on the pump will not touch the cylinder block.

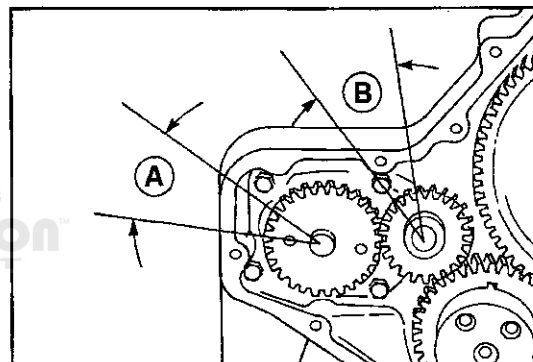


**Note:** Be sure the gear backlash is correct if installing a new pump.



Measure gear backlash.

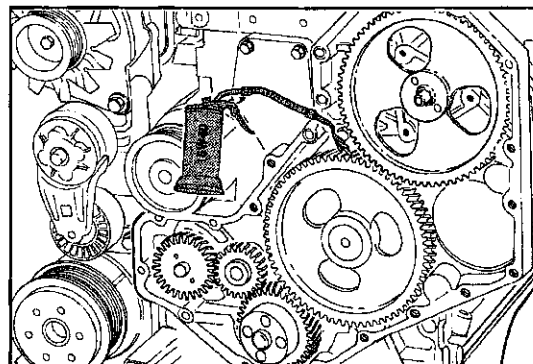
Backlash Limits	
<b>A - Idler to Pump Drive</b> .08 to 0.33mm [.003 to .013 Inch]	<b>B - Idler to Crankshaft</b> .08 to 0.33mm [.003 to .013 Inch]



**Note:** If the adjoining gear moves when you measure the backlash, the reading will be incorrect.

### Gear Cover - Installation

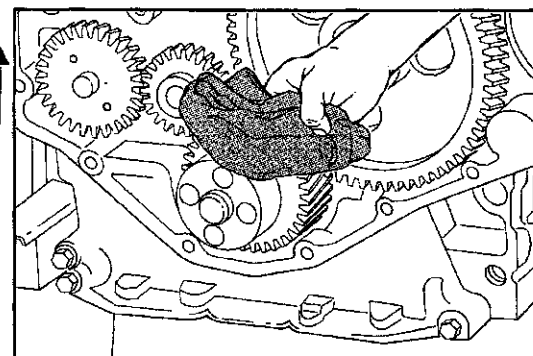
Lubricate the front gear train with clean engine oil.

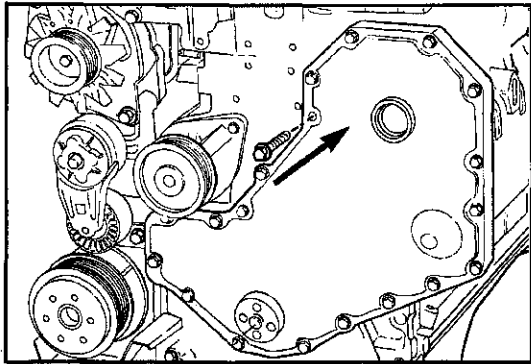


**Caution:** The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.



Thoroughly clean the front seal area of the crankshaft.



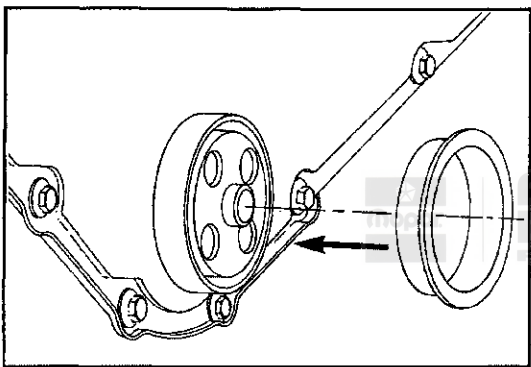


10mm

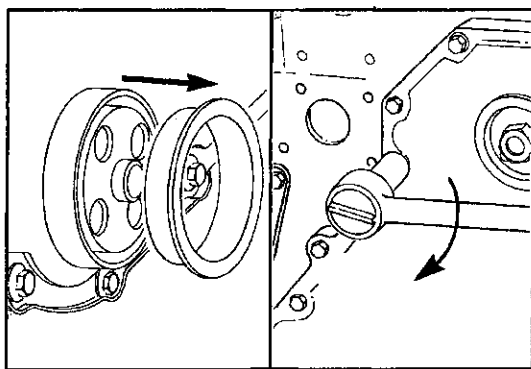


Install the front cover and gasket.

**Note:** Install the capscrews but do not tighten at this time.



Use the alignment/Installation tool from the seal kit to align the cover to the crankshaft.



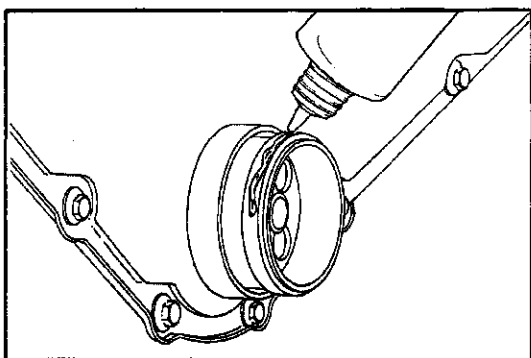
10mm



Tighten the front cover capscrews.

**Torque Value:** 24 N·m [18 ft-lbs]

Remove the alignment/installation tool.

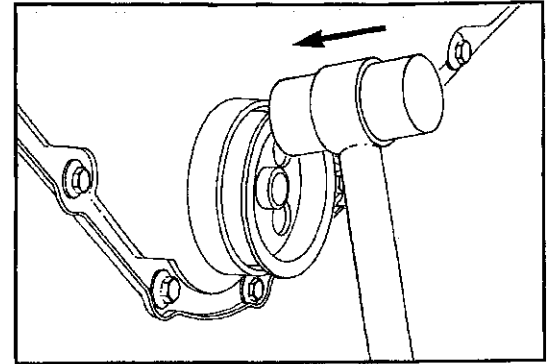


**Caution:** Always use a seal pilot when you install a seal.

Apply a bead of Loctite 277 to the outside diameter of the seal. Install the pilot from the seal kit onto the crankshaft. Install the seal onto the pilot and start into the front cover. Remove the pilot.

**Note:** To prevent damage to the seal carrier, hit the alignment/installation tool alternately at the 12, 3, 6 and 9 o'clock positions.

Use the alignment/installation tool and a plastic hammer to install the seal to the correct depth.

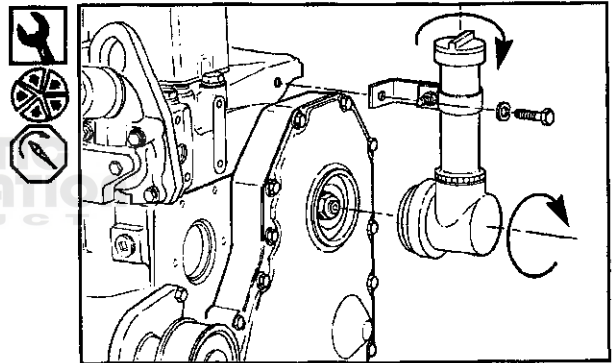


**17mm**

Install the front cover oil fill and seals.

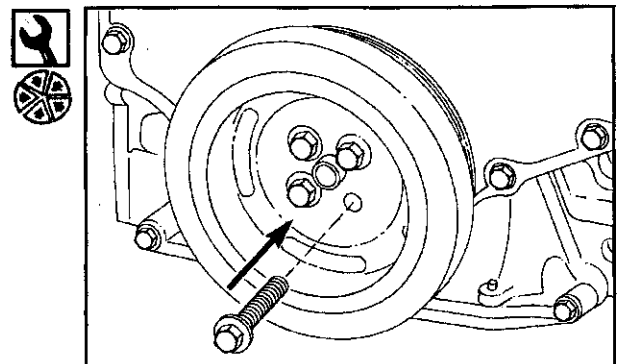
Install oil fill tube bracket capscrew.

**Torque Value:** 43 N·m [32 ft-lbs]



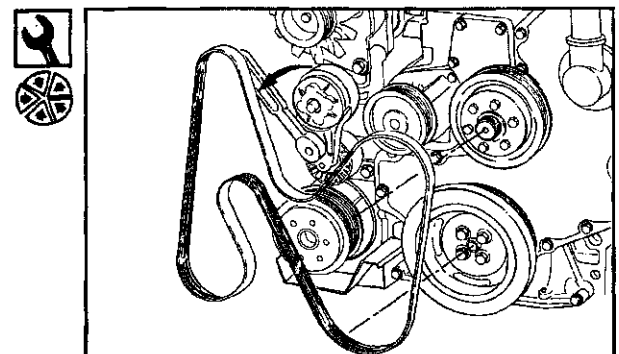
**15mm**

Install the crankshaft vibration damper. Do not tighten the capscrews to the correct torque value at this time.

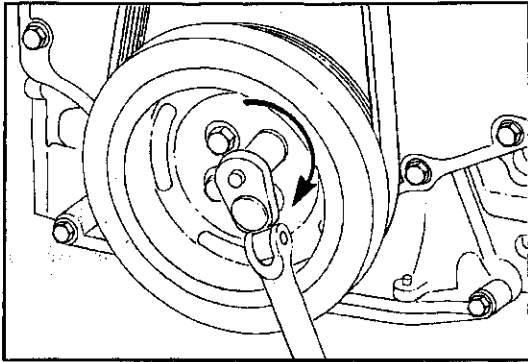


**3/8 Inch Square Drive**

Raise the belt tensioner to install the belt.







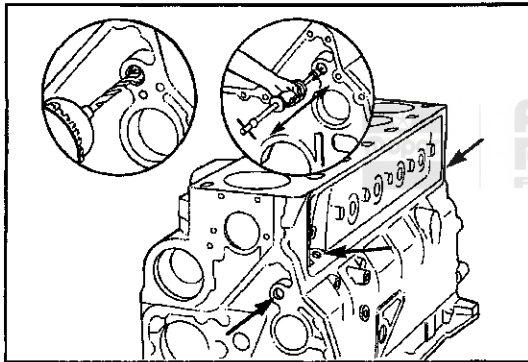
15mm



Install the vibration damper cap screws.

**Torque Value:** 125 N·m [92 ft-lbs]

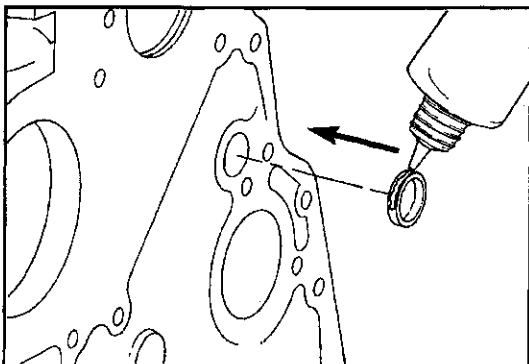
**Note:** Use an engine barring tool to keep the engine from rotating during torquing operation.



### Cup Plugs - Replacement

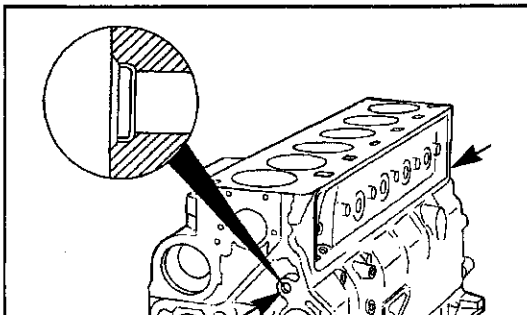
Remove the cup plugs from the oil passages.

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### To Install the Cup Plugs

Apply a bead of Loctite 277 around the outside diameter of the oil passage cup plugs.



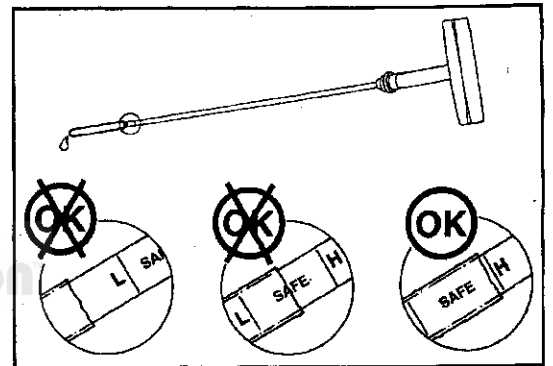
Drive the cup plugs in until they bottom in the bore.

Base Engine Components  
DODGE Turbo Diesel

Engine Lubricating System  
Page 9B-31

Fill the engine with oil. Run the engine and check for leaks.

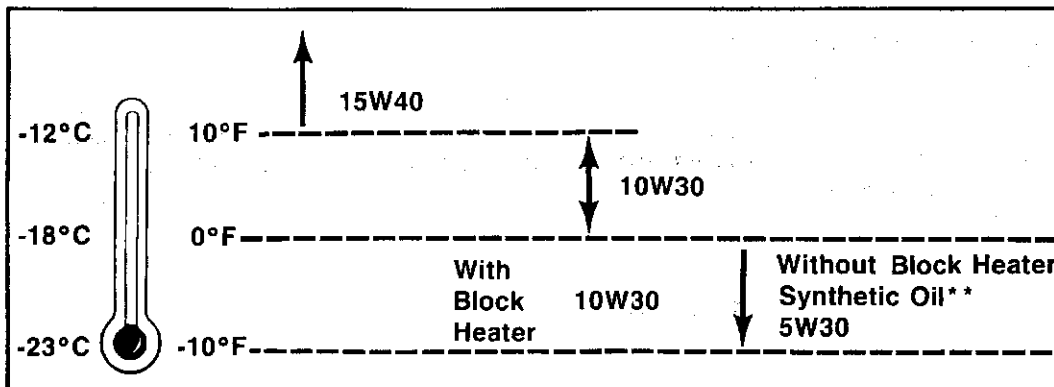
Stop the engine and check the oil level with the dipstick.



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## Lubricating Oil Viscosity Recommendations

Use a multi-graded\* oil, with the viscosity grades shown below, in the Cummins Turbo Diesel Engine. The use of single grade lubricating oil is not recommended.



- Notes:**
- \* 20W20 is not considered a multi-grade oil.
  - \*\* The same oil change interval is to be followed for synthetic oil as for petroleum based oil. Also, synthetic oil must meet the same performance specifications as petroleum oil.

## Lubricating Oil, Arctic Operation

Where there are no provisions to keep the engine warm when it is operating in ambient temperatures consistently below -23°C [-10°F], use a lubricating oil that meets the following requirements.

SAE 5W30 viscosity grade synthetic oils may be used provided they meet the minimum viscosity at 100°C [212°F].

Parameter Test Method	Specifications
Performance Quality .....	API Classification CE-SG, CE-SF, CD-SF, or CC/CD-SF
Viscosity .....	10,000mPa's Maximum at -35°C [-31°F] 4.1mm <sup>2</sup> /s Minimum at 100°C [212°F]
Pour Point (ASTM D-97) .....	Minimum of 5°C [9°F] Below the Lowest Expected Ambient Temperature
Sulfated Ash Content (ASTM D-874) .....	Maximum of 1.85% by Weight Maximum

## Lubrication System Specifications - Dodge Ram 5.9 Liter Diesel

Oil Pressure at Idle - (Minimum Allowable) kPa [PSI] .....	69 [10]
Oil Pressure at Rated - (Minimum Allowable) kPa [PSI] .....	207 [30]
Oil Pressure at Rated - (Maximum Allowable) kPa [PSI] .....	483 [70]
Regulating Valve Opening Pressure kPa [PSI] .....	414 [60]
Differential Pressure to Open the Filter Bypass Valve - kPa [PSI] .....	138 [20]
Oil Capacity of Pan - Liter [U.S. Quarts] <b>High Mark</b> .....	10.5 [11]
Oil Capacity of Pan - Liter [U.S. Quarts] <b>Low Mark</b> .....	8.6 [9]
Oil Capacity of Oil Filter - Liter [U.S. Quarts] .....	.95 [1]

## General Overview - In and Out-of-Chassis Repairs

### Section 9C

This section defines the base engine components, describes the operation of those components, provides guidelines for diagnosing malfunctions and gives procedures for component replacement. Many of the component replacement procedures described are performed with the engine in the chassis. For the purpose of this manual, Base Engine Components are defined as those parts and assemblies which are not included in the other major engine systems. They are: Cylinder head and valve train, front gear housing and gear train, flywheel housing and flywheel, camshaft, tappets and push rods, front crankshaft seal, piston and connecting rod assemblies, and the crankshaft and main bearings.

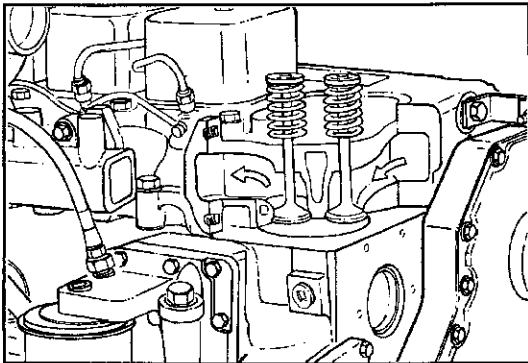
### Contents

<b>Subject</b>	<b>Page</b>
Operation and Description - Base Engine Components .....	9C-2
Cylinder Head and Valve Train (In-Chassis Repair) .....	9C-2
Front Gear Housing and Gear Train (Out-of-Chassis Repair) .....	9C-3
Front Crankshaft Seal (In-Chassis Repair) .....	9C-3
Camshaft, Tappets and Push Rods (In-Chassis Repair) .....	9C-3
Flywheel Housing and Flywheel (In-Chassis Repair) .....	9C-4
Piston and Connecting Rod Assemblies (Out-of-Chassis Repair) .....	9C-5
Crankshaft and Main Bearings (Out-of-Chassis Repair) .....	9C-6

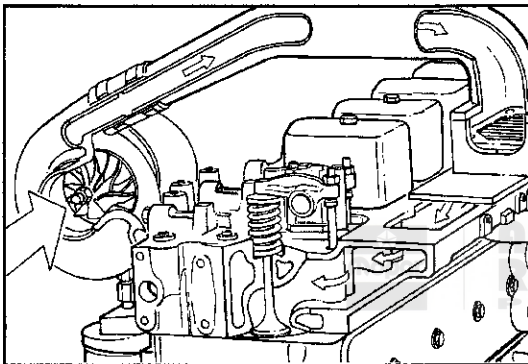
## Operation and Description - Base Engine Components

### Cylinder Head and Valve Train In-Chassis Repair

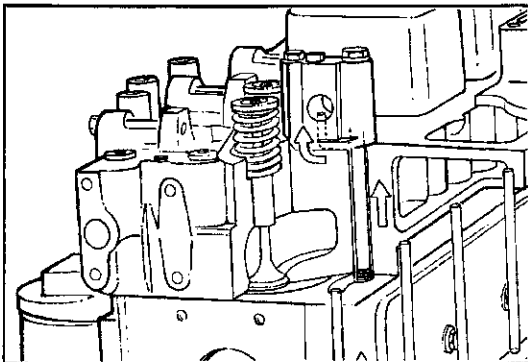
The cylinder head is a one piece, crossflow design with two valves per cylinder. The head has integrally cast valve guides and hardened valve seat surfaces which can be repaired in a machine shop using the appropriate service parts.



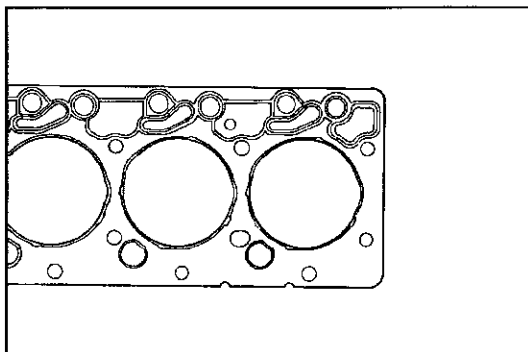
The cylinder head has a cast intake manifold, fuel filter head, thermostat housing and an internal water bypass. The injectors are mounted in the head for direct injection into the cylinders.



Separate pedestals for each cylinder are used to support and route oil to the rocker levers.



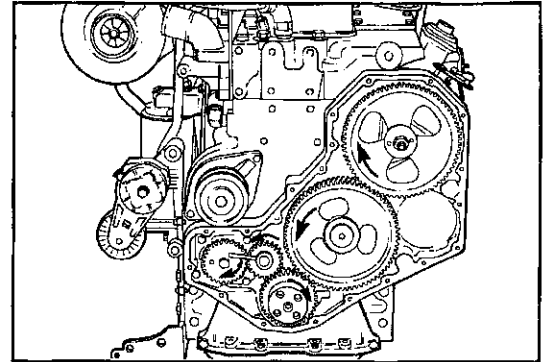
The cylinder head gasket is a steel plate design with print o-seal on both sides around the water holes. A fire ring in the gasket seals the cylinder bores. As discussed in the Cooling System, the gasket also provides orifices to control coolant flow.



## Front Gear Housing and Gear Train

**Note:** Removal of the gear housing is an out-of chassis repair.

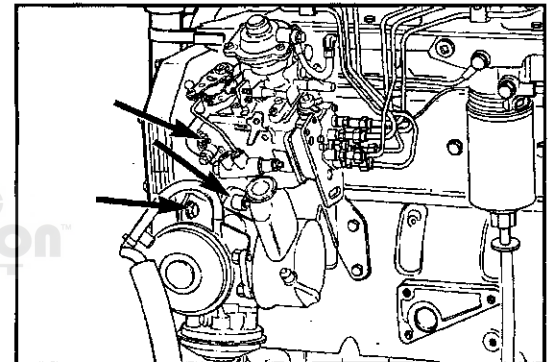
The gear train consists of the crankshaft gear, lube pump gear idler and drive gear, the camshaft gear, the fuel pump gear and the accessory drive gear.



The gear housing provides a support for the injection pump, the timing pin and the accessory drive gear.

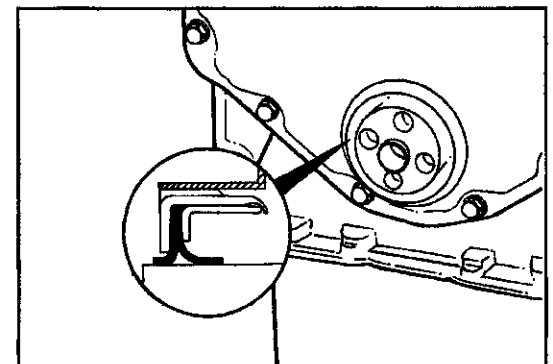


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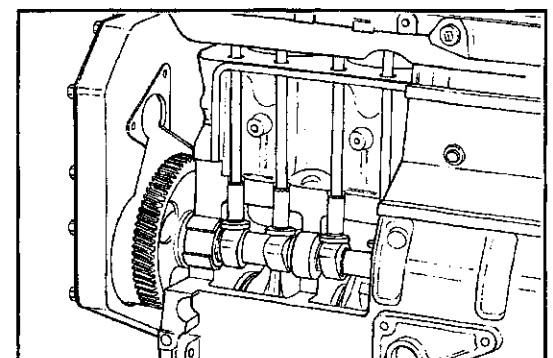
## Front Crankshaft Seal In-Chassis Repair

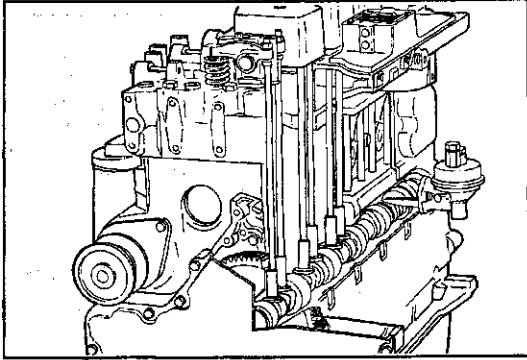
The front crankshaft seal is mounted in the front gear cover. A double lipped Teflon seal is used. The sealing surface on the crankshaft must be clean, dry and free of oil during assembly.



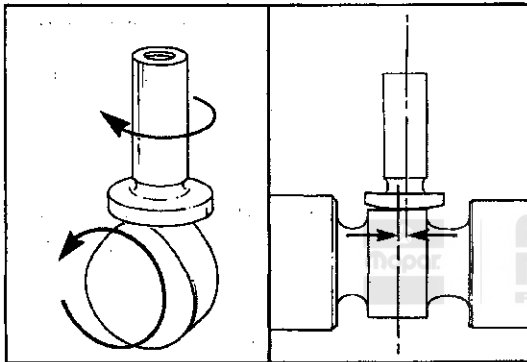
## Camshaft, Tappets and Push Rods In-Chassis Repair

The camshaft is gear driven from the crankshaft. A replaceable bushing is used for the front journal to carry the side loading from the accessory drive. The remainder of the journals operate in cast iron bores in the cylinder block.

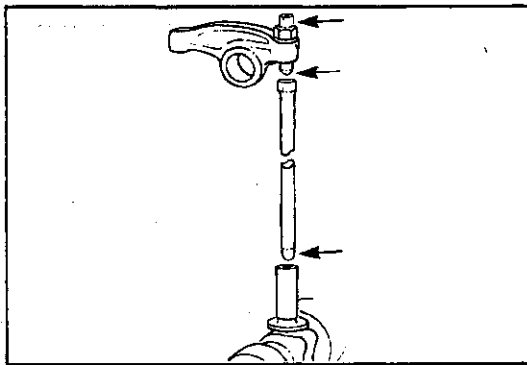




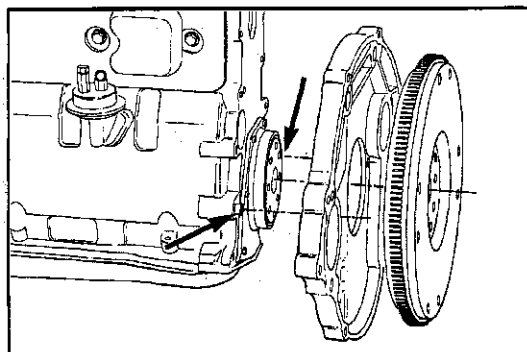
The camshaft has lobes to operate the intake and exhaust valves and a special lobe to drive the lift pump. The valve lobes contact "mushroom" shaped valve tappets which operate the push rods. The operating arm of the lift pump rides directly on the special lobe on the camshaft. The profile of the cam lobes is the same for all B Series engines.



The center line of the tappet is slightly offset from the center line of the cam lobe. This design feature and the slightly convex surface of the tappet causes the tappet to rotate as it is lifted by the cam.



The ball end of the push rod fits into a ball socket in the tappet. The other end of the push rod is fitted with a socket into which the ball end of the rocker lever adjusting screw operates.

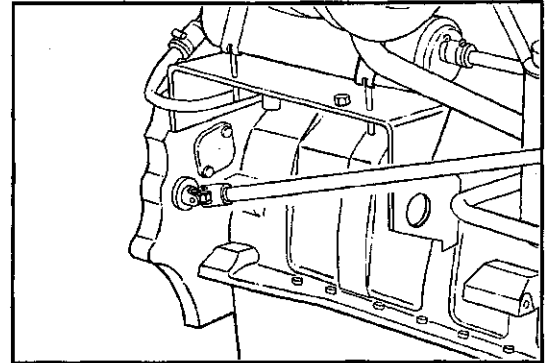


### Flywheel Housing and Flywheel In-Chassis Repair

Ring dowels are used to locate the housing within 0.20mm [0.008 in.] TIR.

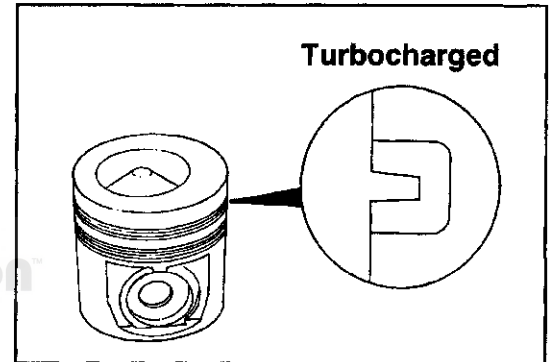
**Note:** Service housings are drilled. Re-dowelling is not required when installing a new or different housing.

The housings are machined for the use of an optional engine barring device.

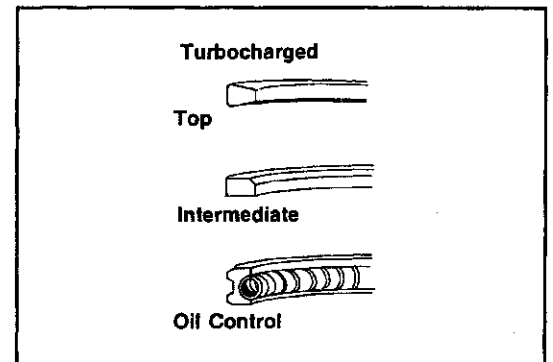


### Piston and Connecting Rod Assemblies Out-of-Chassis Repair

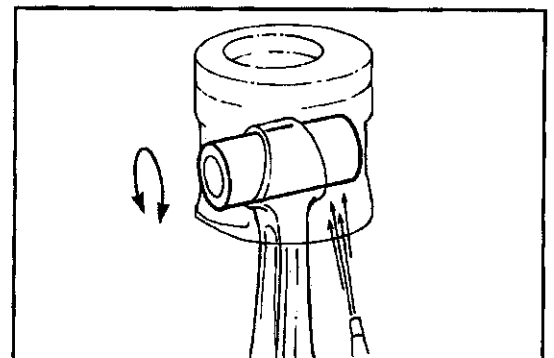
Piston features include: high swirl combustion bowl cast aluminum body and 3 ring grooves. The piston for the turbocharged engines includes a ni-resist insert with a keystone profile for the top piston ring. Always check the part number to be sure the correct configuration is used during piston replacement.



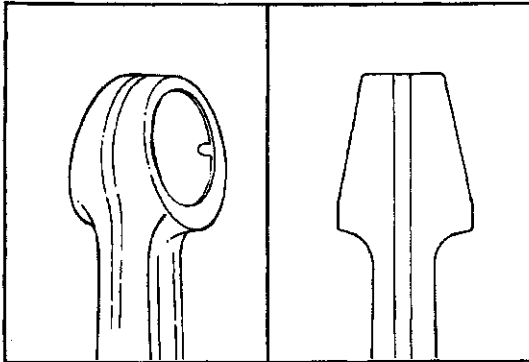
The piston ring sets consist of three rings, the top ring of the set has a keystone profile which operates in a ni-resist insert cast into the piston.



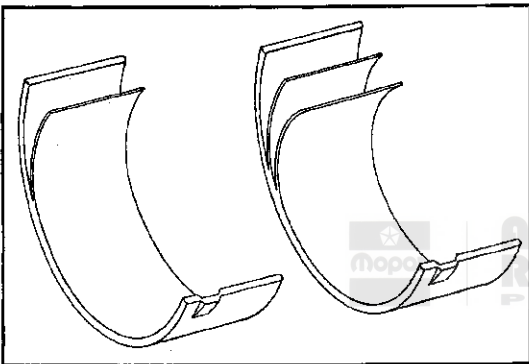
A free floating, hollow piston pin is used to attach the piston to the connecting rod. Lubrication of the pin and journal is accomplished by residual spray from the piston cooling nozzles.



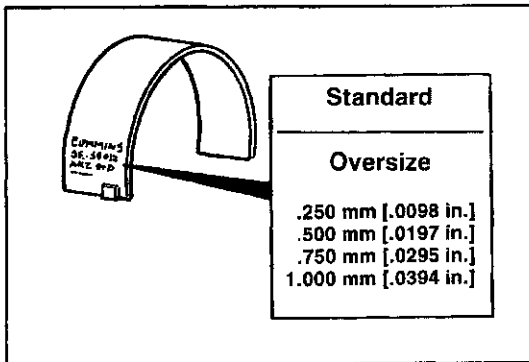




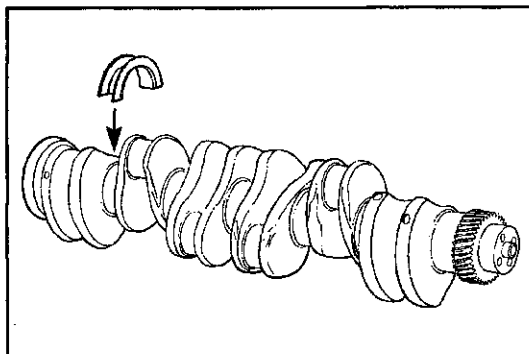
The piston pin end of the connecting rod is angle cut to provide additional bearing surface and is fitted with a bronze bushing.



In production, steel backed aluminum rod bearings and steel backed tri-metal bearings are used.



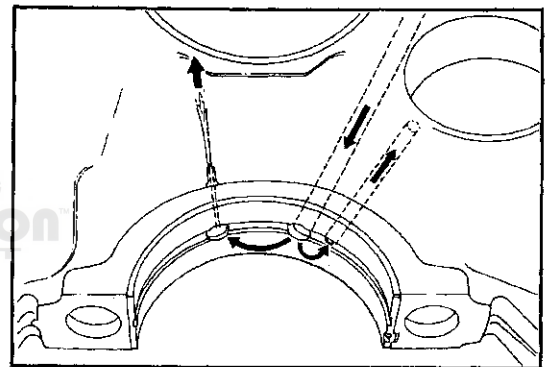
Oversize service rod bearings are available for use with re-ground crankshafts.



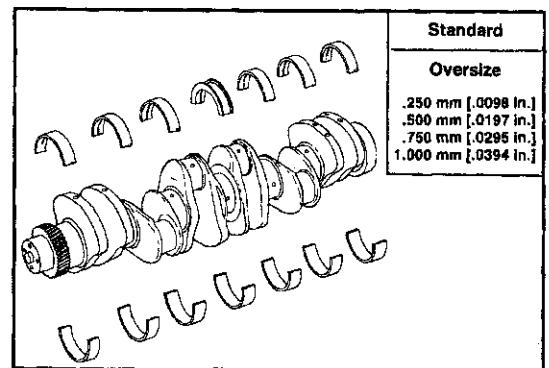
### Crankshaft and Main Bearings Out-of-Chassis Repair

The crankshaft is a balanced, forged steel unit with 7 main bearings. The lower bearing shells are all the same. All of the upper bearing shells are also the same with the exception of the journal adjacent to the rear one. The next to the last journal is fitted with a flanged upper bearing shell. The flanges control the end thrust of the crankshaft.

The upper bearings have three holes in them. The middle hole receives oil from the main oil rifle. One of the adjacent holes is aligned with a drilling to the camshaft journal and serves as an orifice for lubrication flow to the journal. The other adjacent hole supplies oil for piston cooling. The hole does not align perfectly with the cooling nozzle. The hole is off-set to keep the nozzle from dropping into the crankshaft oil supply passage.



**Note:** Oversize service main bearings are available for re-ground crankshafts.





## In-Chassis Repairs - General

### Section 9D

The operations described in the next two sections (9E and 9F) are considered in-chassis procedures and include those service repairs associated with the following engine parts and functions:

**Cylinder Head**  
**Valves, Guides and Seats**  
**Push Rods**  
**Rocker Levers**  
**Camshaft**  
**Tappets**

**Timing**  
**Head Gasket**  
**Front Crankshaft Seal**  
**Vibration Damper**  
**Flywheel Housing and Flywheel**  
**Rear Crankshaft Seal**

The next two Sections, however, do not describe all the service operations that can be done with the engine in-chassis. Those in-chassis operations not appearing in these sections include:

Fuel System (See Section 14)  
Air and Exhaust System (See Section 11)  
Cooling System (See Section 7)  
Oil Pump (See Section 9B)  
Oil Cooler and Cooler Cover Plate (See Section 9B)  
Vacuum and Power Steering Pump (See Section 5)

The condition of the cylinder block and pistons are the limiting criteria for in-chassis repairs. If there is reason to believe that either are severely damaged, the engine should be removed for major overhaul.

Prior to deciding on an in-chassis repair, inspect the air intake for evidence of ingestion of particles that could have severely damaged the cylinder walls. Check the oil and oil filter to be sure the lube system is not thoroughly contaminated with metal. Also check for rust in the coolant. Rust in the coolant can indicate build up in the passages in the cylinder block that will require the block to be removed for cleaning. Also consider the condition of other components, particularly those that are more difficult to replace in-chassis (camshaft, rear seal, etc.).

The in-chassis repairs procedures include prescribed checks of the hardware to determine if continued in-chassis work is practical. If the conditional limits are not met, the engine should be removed for completion of the overhaul.

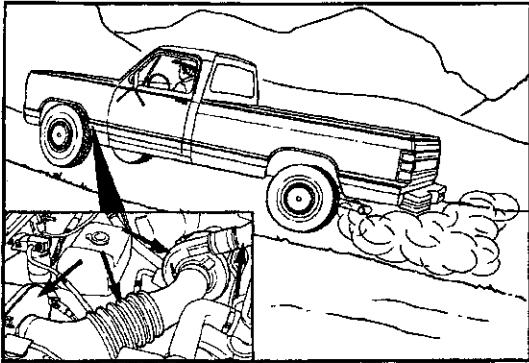


## In-Chassis Diagnostic Procedures

### Section 9E

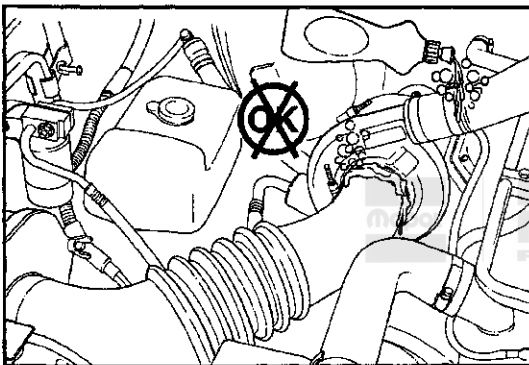
#### Contents

<b>Subject</b>	<b>Page</b>
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Valve Train and Head Assembly .....	9E-2
Valve Adjustment - Check .....	9E-3
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Injector Protrusion .....	9E-4
Rocker Lever, Valve Stem, Push Rod, Tappet and Camshaft .....	9E-5
Front Gear Housing Cover and Gear Train .....	9E-6
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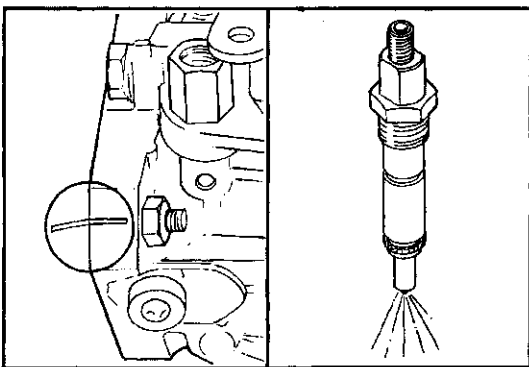
### Air and Fuel Systems – Check

When diagnosing a low power problem, first troubleshoot the air and fuel systems to make sure the engine is receiving adequate intake air and fuel.

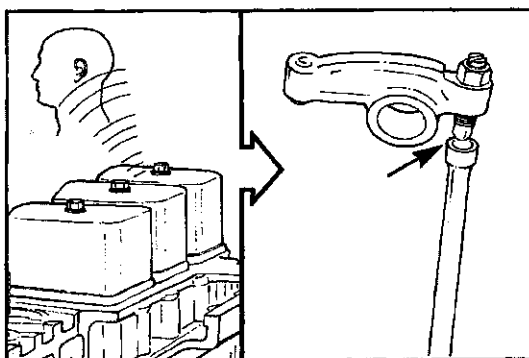


Check the intake air system for leaks. Make sure a sealant is used on the through-hole cap screws which secure manifold cover to the head.

Verify the turbocharger is operating correctly.



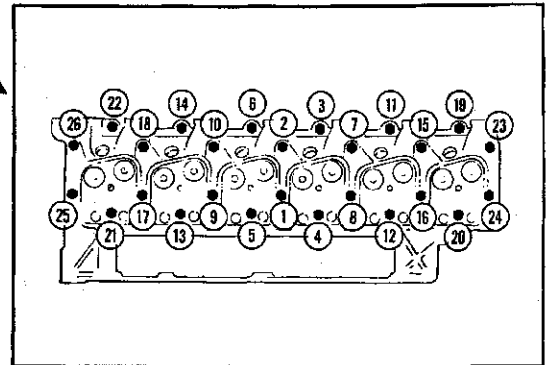
Check the fuel system for correct timing and fuel delivery.



### Valve Train and Head Assembly

The sound emitted from the overhead can indicate a valve train problem. Loose rocker levers will clatter. A squeaking noise can mean lack of lubrication for adjusting screw and the push rod socket.

**Caution:** If one of the individual support pedestals is removed during inspection or repair, all head bolts must be retightened according to the head bolt torque sequence.



### Valve Adjustment - Check

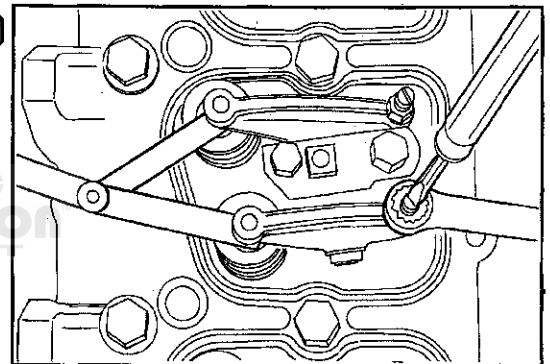
Verify that the valves are adjusted correctly.

### Valve Lash:

Intake .254 mm [.010 in]  
Exhaust .508 mm [.020 in]

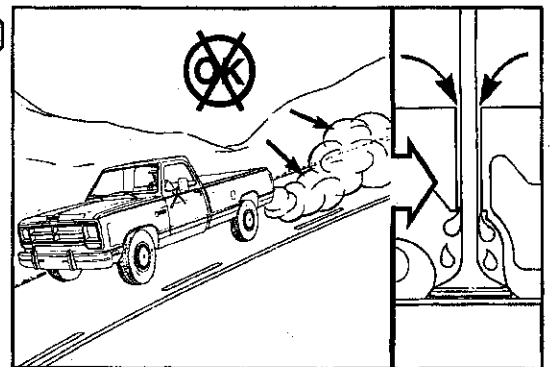


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PRODUCT

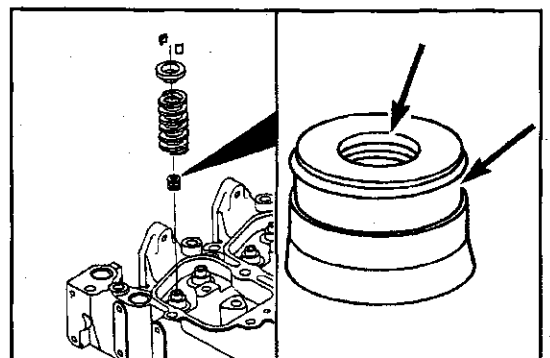


### Valve Seal - Wear

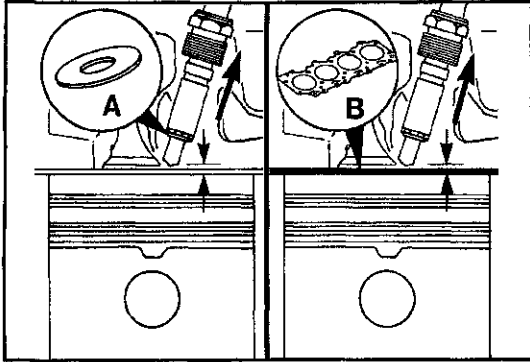
Worn valve seals are typically detected by blue smoke at idle or when the engine is unloaded and going down hill. Verify the condition by removing the valve spring and inspecting the seals.



Hardening of the material and wear or damage to the sealing surface will cause the seal to leak.

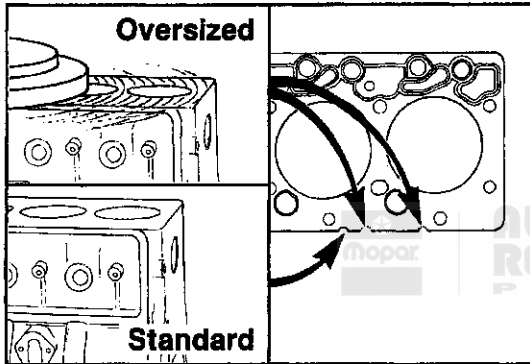




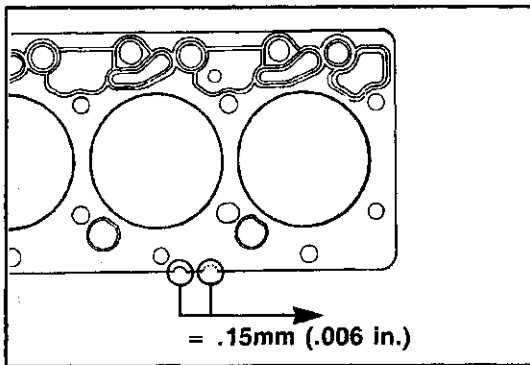


### Injector Protrusion

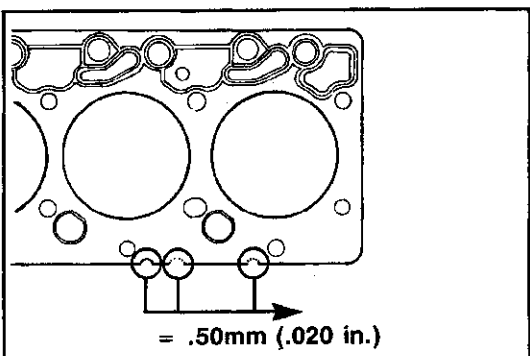
Injector protrusion can affect power from the engine. In addition to a single sealing washer (A) on the injector, the thickness (B) of the head gasket controls injector protrusion.



Oversize service head gaskets are used when the head surface on the block has been refaced. The head gasket is marked to indicate the thickness. One notch means the gasket is standard for use with blocks that have not been refaced.



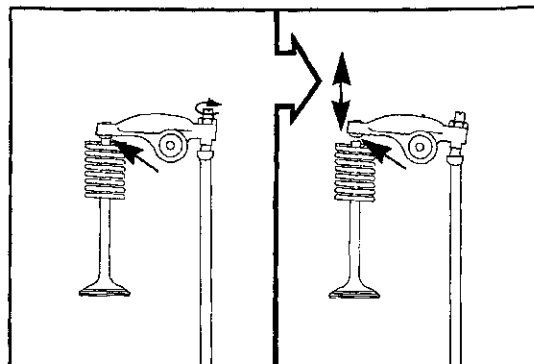
Two notches identify that the gasket is for use with blocks that have been refaced 0.15mm [0.006 inch]. The block should be marked with one X on the rear of the block to indicate the surface has been refaced 0.15mm [0.006 inch].



Three notches indicate the gasket is for use with a block that has been refaced 0.50mm [0.0197 inch]. Two XX's on the rear identifies a block has been refaced 0.50mm [0.0197 inch] resurface.

### Rocker Lever, Valve Stem, Push Rod, Tappet and Camshaft

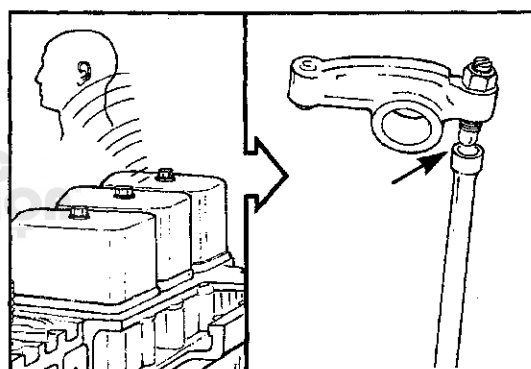
Excessive valve lash can indicate a worn valve stem or rocker lever.



Loose rocker levers and the need to re-set the valve clearance frequently, can also indicate cam lobe or tappet wear. If an inspection of the levers, valve stems and push rods does not show wear, tappet and/or cam lobe wear can be suspected.

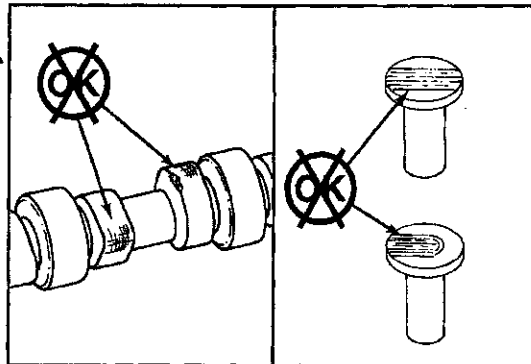


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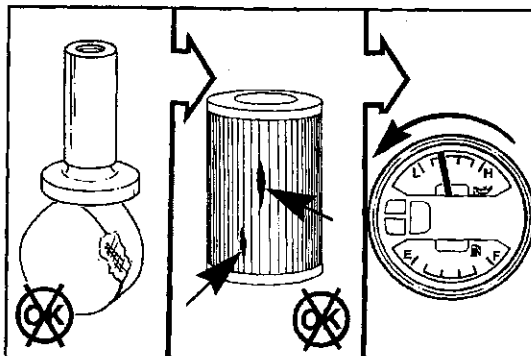


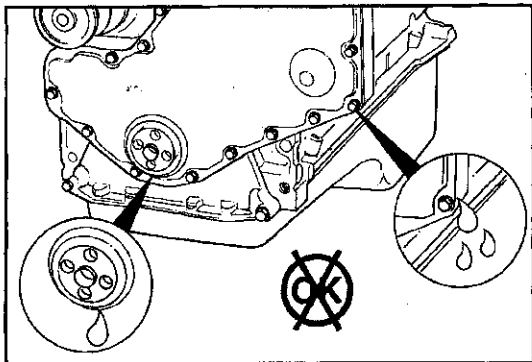
**Caution: Anytime a new camshaft is installed, new tappets must also be installed.**

The camshaft should be removed from the block to properly inspect the lobes. Tappets must also be removed to inspect the faces.



A severely damaged camshaft journal(s) can generate metal chips which will be found in the pan and filter. As the clearance in the journal(s) increases, a small reduction in oil pressure may be detected.

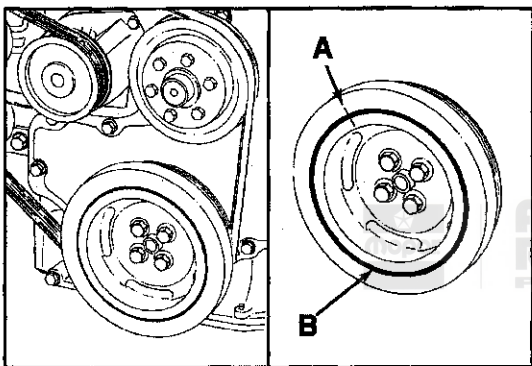




### Front Gear Housing Cover and Gear Train

Troubleshooting the front gear housing cover and gear train consists of:

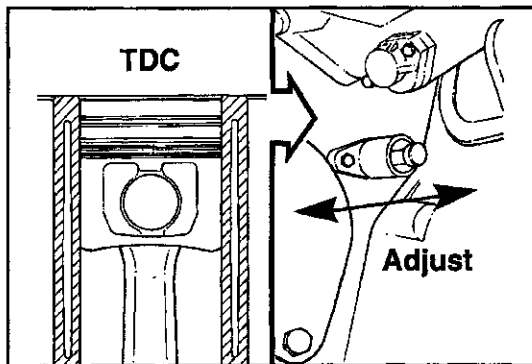
- Checking for leaks at the front cover, timing pin assembly, injection pump and the front crankshaft oil seal.
- Inspecting the gears and measuring backlash when required.



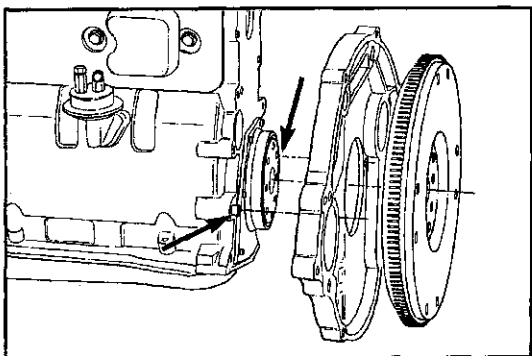
A vibration damper is located on the front of the engine crankshaft. When diagnosing a vibration problem, check the damper for visible wobble when rotating.

Verify that the index lines (A) are aligned. If the lines are more than 1.59mm [1/16 inch] out of alignment, replace the damper.

Inspect the rubber member (B) for deterioration and missing pieces.



As previously discussed in the fuel system, replacement of the gear housing or the timing pin assembly necessitates a realignment of the pin assembly. The pin must be aligned to correspond to TDC for Cylinder Number 1.



### Flywheel Housing and Flywheel

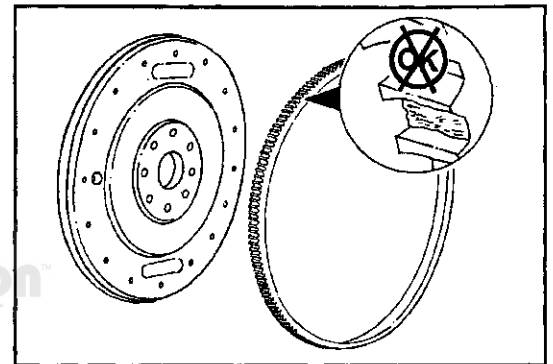
Diagnostics of the flywheel housing and flywheel is normally limited to a visual inspection of the parts for damage or wear.

The flywheel and housing are precision made and aligned per SAE J1033 standard.

### Ring Gear

Occasional failure of a starter to engage can be caused by damaged teeth on the ring gear. Service ring gears are available for repairing flywheels.

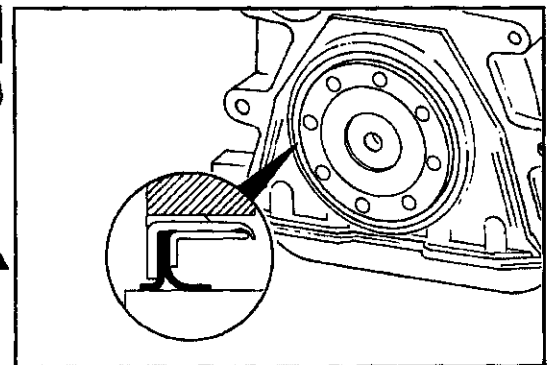
If a ring gear is damaged on an automatic transmission drive plate, the drive plate must be replaced.



### Rear Crankshaft Seal

The rear crankshaft seal is mounted in a housing that bolts to the rear of the block. Double-lipped Teflon seals are used. The Sealing surface on the crankshaft must be clean, dry and free of oil during installation of the seal.

**Caution:** If any oil gets on the crank surface or seal during installation, the seal will leak.





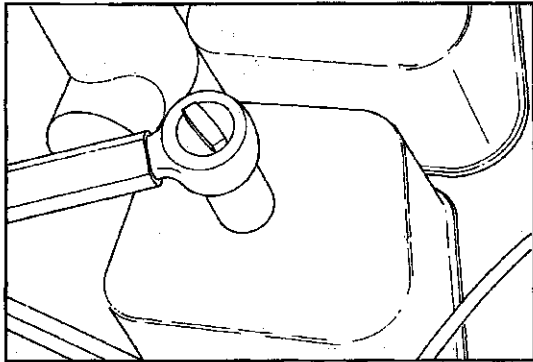
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## In-Chassis Repairs

### Section 9F

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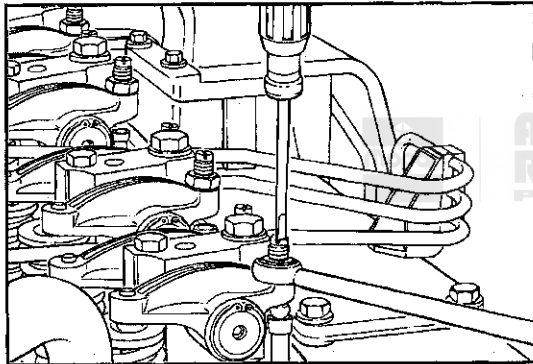
### Rocker Levers and Push Rods - Replacement



15mm

#### Preparatory Step:

- Remove the valve covers.

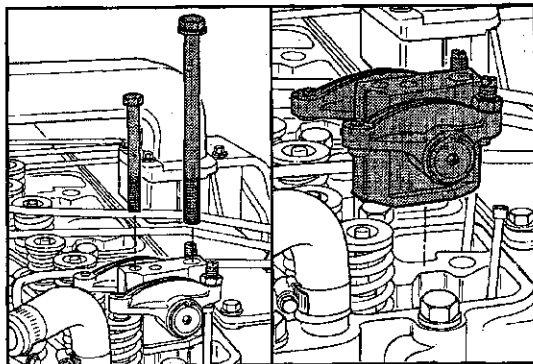


#### Removal



14mm, Screwdriver

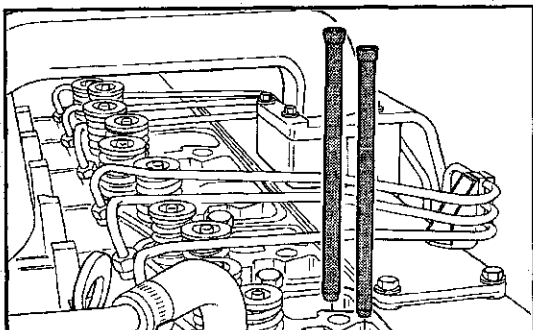
Loosen the adjusting screw locknuts. Loosen the adjusting screws until they stop.



13mm, 18mm



Remove the 8mm and 12mm cap screws from the rocker lever pedestals. Remove the pedestals and rocker lever assemblies.

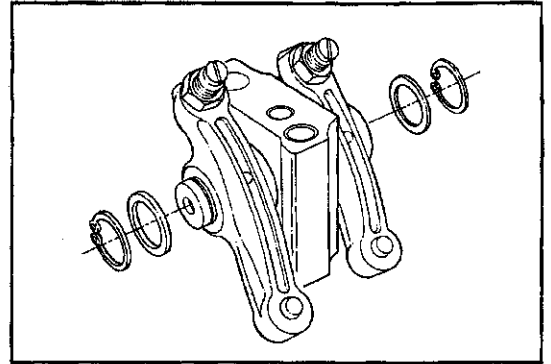


Remove the push rods.

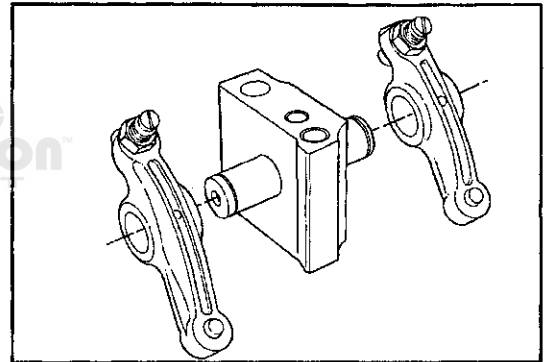
### Rocker Levers - Disassembly

If the rocker lever and push rods are to be inspected for reuse, follow these steps.

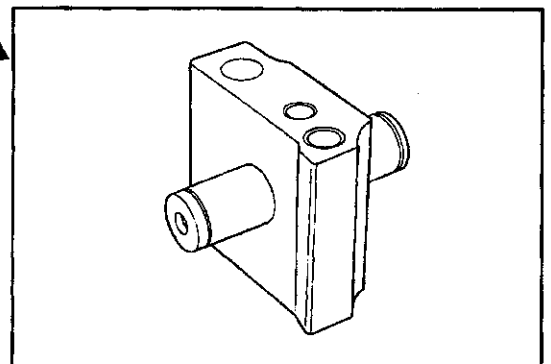
Remove the retaining rings and thrust washers.



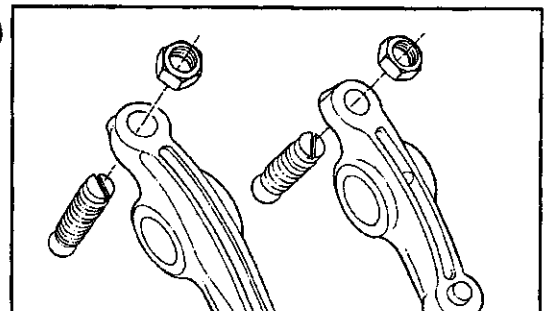
Remove the rocker levers.



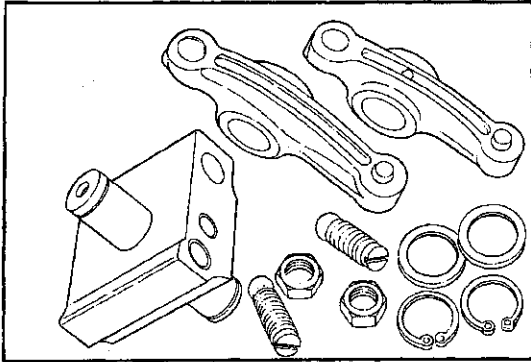
**Caution:** Do not disassemble the rocker lever shaft and pedestal. The pedestal and shaft must be replaced as an assembly.



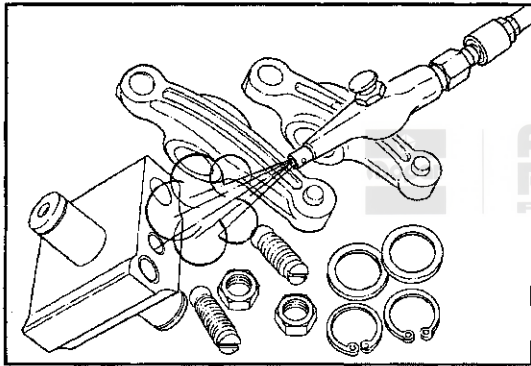
Remove the lock nut and adjusting screw.





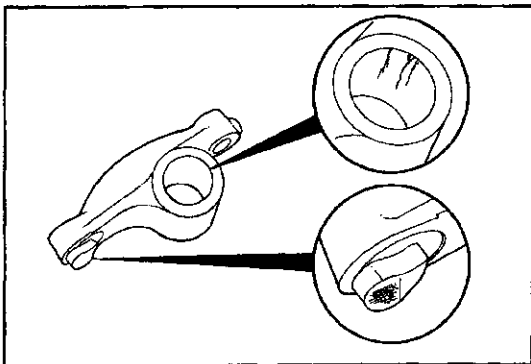


Clean all parts in a strong solution of laundry detergent in hot water.

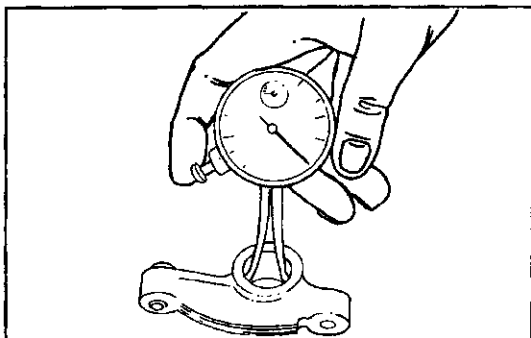


Use compressed air to dry the parts after rinsing in clean hot water.

**Note:** The pedestals are made from powdered metal and may continue to show wetness after they have been cleaned and dried.



Inspect for excessive wear in the bore and the contact surface for the valve stem.



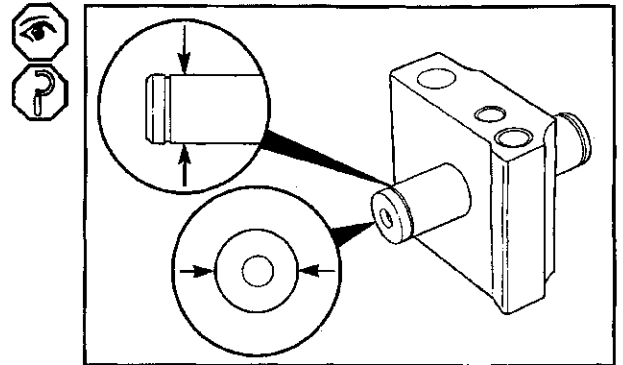
Measure the rocker lever bore.

**Diameter (Maximum):** 19.05mm [0.75 inch]

Inspect the pedestal and shaft.

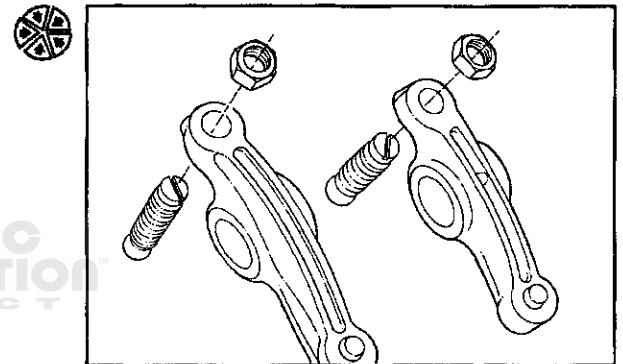
Measure the shaft diameter.

**Minimum Diameter: 18.94mm [0.746 Inch]**

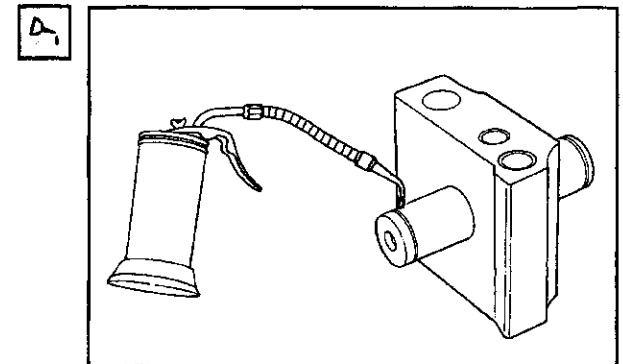


### Rocker Levers - Assembly

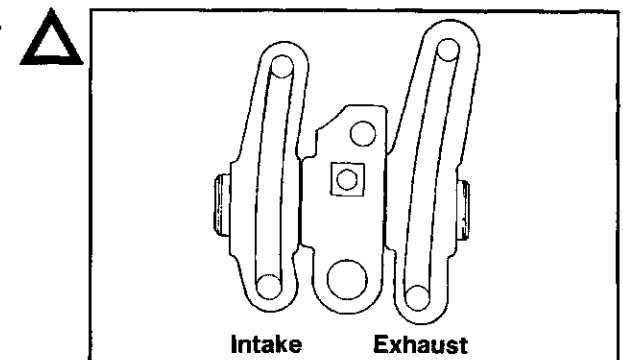
Install the adjusting screw and lock nut.

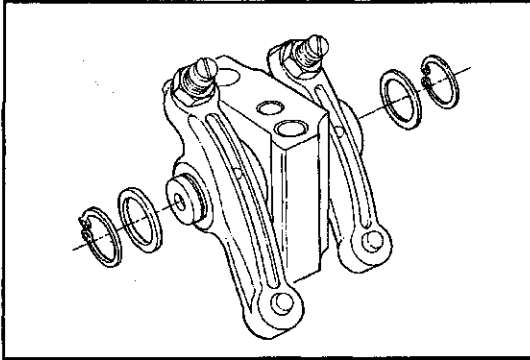



Lubricate the shaft with engine oil.

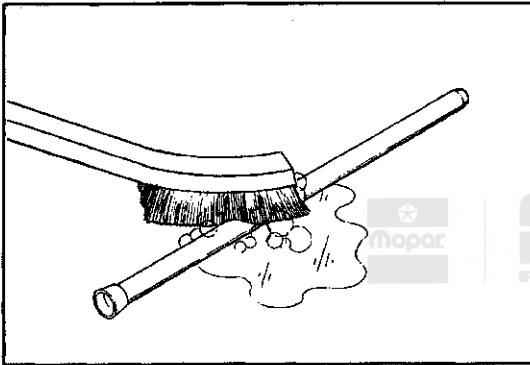


**Caution: Be sure to assemble the intake and exhaust rocker levers in the correct location.**

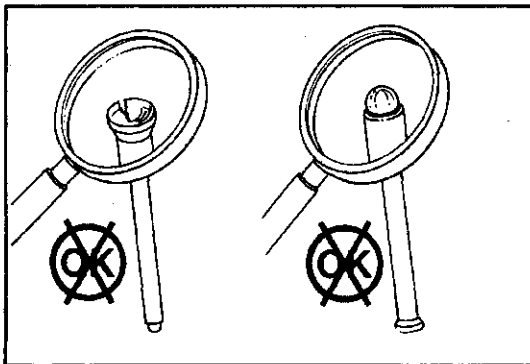





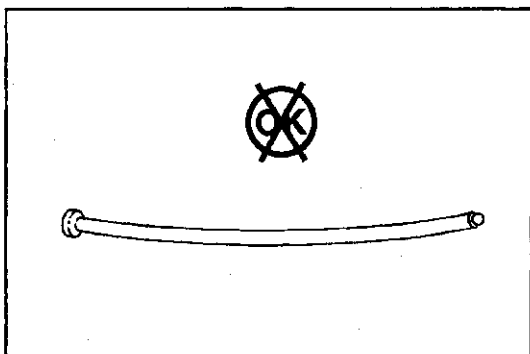
-  Position the levers on the rocker shaft.  
Install the thrust washers.



-  Clean the push rods in hot soapy water.



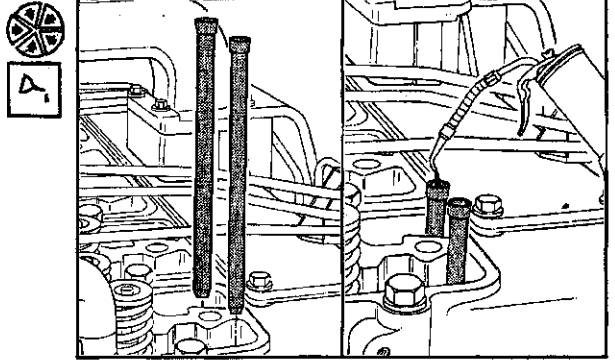
-  Inspect the push rod ball and socket for signs of scoring or cracks where the ball and the socket are pressed into the tube.



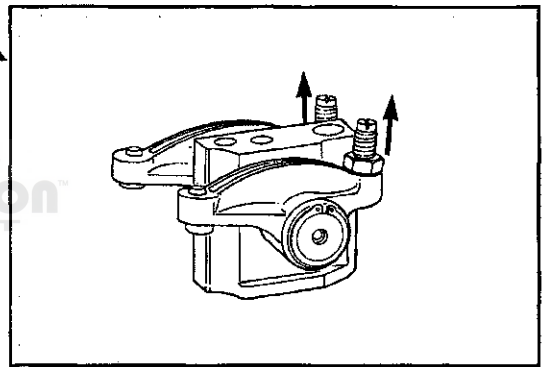
-  Check the push rods for roundness and straightness.

Install the push rods into the sockets of the valve tappets.

Lubricate the push rod sockets with clean engine oil.



**Caution:** Make sure the rocker lever adjusting screws are completely backed out.

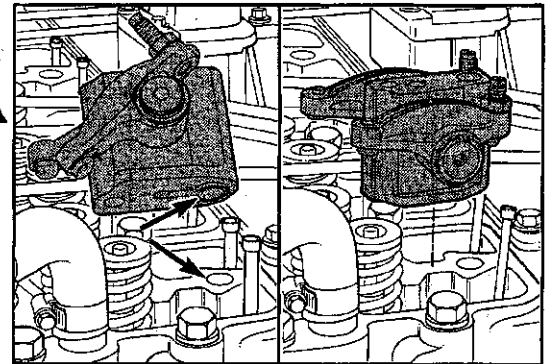


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#### Rocker Lever Assembly - Installation

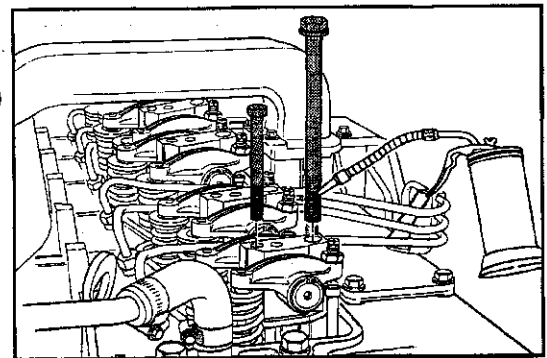
**Caution:** Make sure the dowel rings in the pedestals are installed into the dowel bores in the cylinder head.

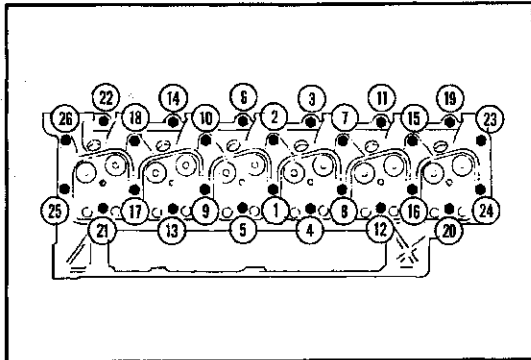
**Note:** If the push rod is holding the pedestal off of the cylinder head, bar the engine until the pedestal will set on the head surface without interference.



Use clean engine oil to lubricate the threads and under the heads of the 8mm and 12mm capscrews.

Install the capscrews into the pedestals.





18mm



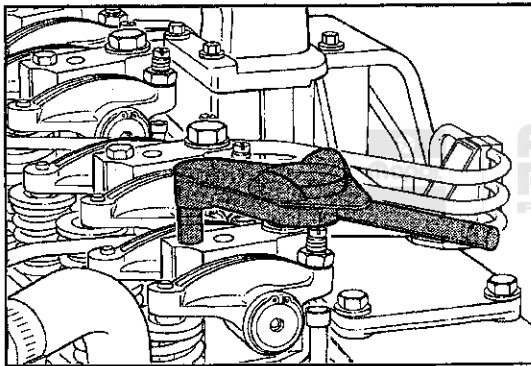
Use the sequence shown to tighten **ALL** of the 12mm cylinder head capscrews.

**Torque Value:**

Step 1 - 40 N·m [29 ft-lbs]

Step 2 - 85 N·m [62 ft-lbs]

Step 3 - 126 N·m [93 ft-lbs]

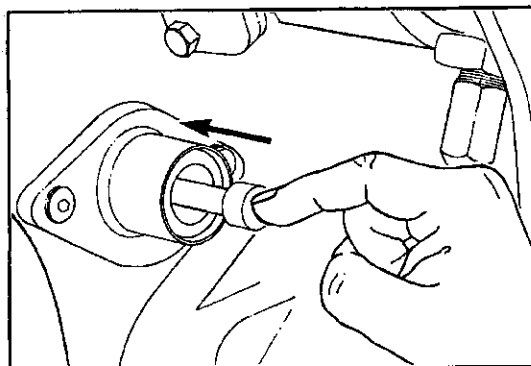


13mm



Tighten the 8mm pedestal capscrews.

**Torque Value:** 24 N·m [18 ft-lbs]

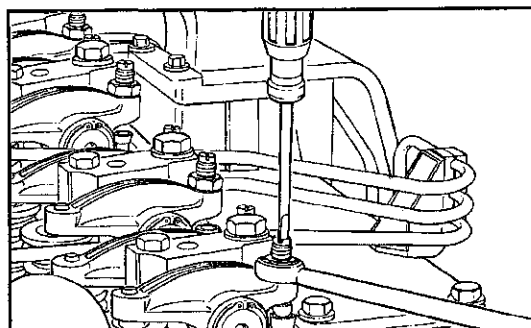


**Valve Clearance Adjustment**



**Caution:** Be sure to disengage the timing pin after locating top dead center.

Use the timing pin to locate Top Dead Center for Cylinder Number 1.



**Caution:** Adjust the valves when the engine is cold - below 60°C [140°F].

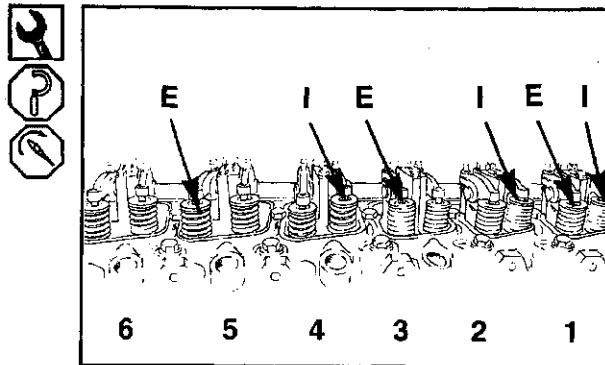
**Step A**

14mm

Adjust the clearance for the valves shown in the illustration.

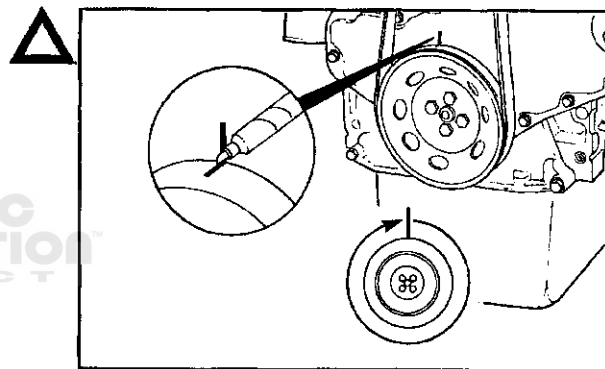
Intake: 0.254mm [0.10 Inch]  
Exhaust: 0.508mm [0.20 inch]

**Torque Value:** 24 N·m [18 ft-lbs]



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

Mark the pulley and rotate the crankshaft 360 degrees.



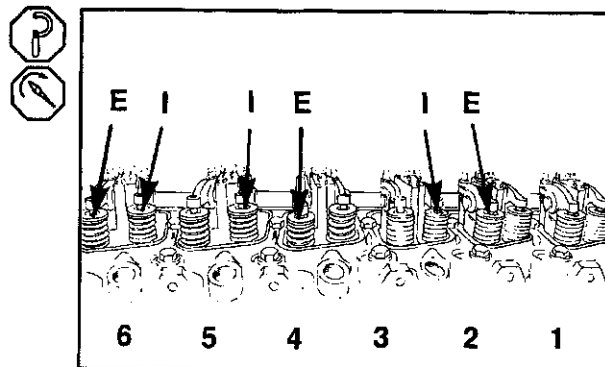
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**Step B**

Adjust the clearance for the valves shown in the illustration.

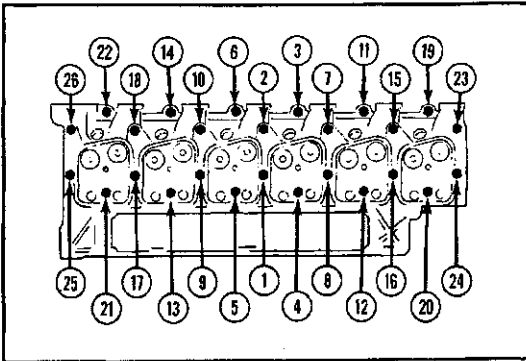
Intake: 0.254mm [0.010 inch]  
Exhaust: 0.508mm [0.020 inch]

**Torque Value:** 24 N·m [18 ft-lbs]



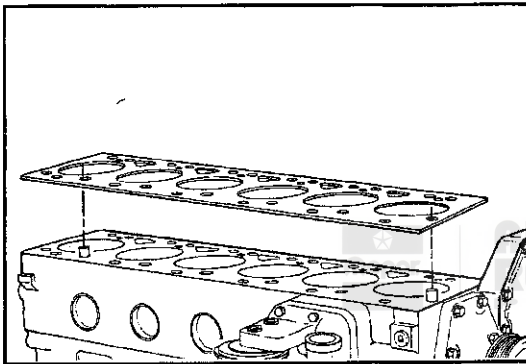
**Cylinder Head Removal**

- Drain the coolant and oil
- Disconnect the radiator and heater hoses
- Remove the turbocharger and air crossover
- Remove the exhaust manifold
- Remove the fuel lines and injector nozzles
- Remove the valve covers
- Remove the rocker levers and push rod
- Remove the fuel filter



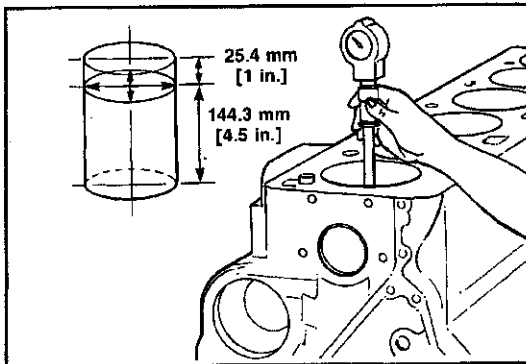
**18 mm**

If engine is hot, remove the cylinder head capscrews in the sequence shown. The removal sequence is not important if the engine is cold.



Remove the cylinder head and gasket from the cylinder block.

**Note:** Inspect the coolant passages. A large build up of rust and lime will require removal of the cylinder block for cleaning in a hot tank.



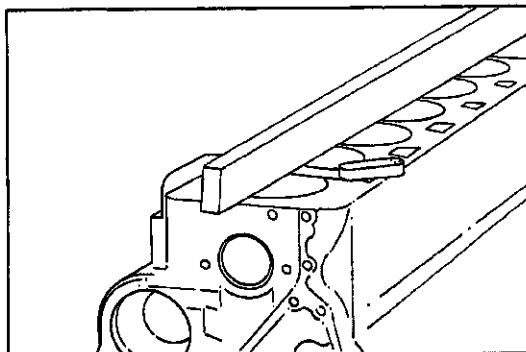
Inspect the cylinder bores for damage or excessive wear. Rotate the crankshaft so the piston is at BDC to inspect the bores.

Measure the cylinder bores.

**Limit:**

- **Maximum Diameter:** 102.116 mm [4.0203 inch]
- **Out-of-Roundness:** .038 mm [.0015 inch]
- **Taper:** .076 mm [.003 inch] Refer to the limits for the oversize cylinder bores.

**Note:** Do not proceed with in-chassis repair if the bores are damaged or worn beyond the above limits.



Check the top surface for damage caused by the cylinder head gasket leaking between cylinders.

Check the top surface for flatness between each cylinder.

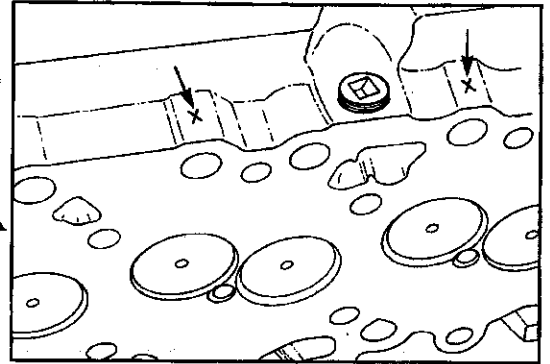
- **Top surface flatness (Maximum overall variation)**
  - 0.075 mm [0.003 inch] (Maximum variation within any 50.00 mm [2.0 inch] diameter area) 0.01 mm [0.0004 inch].

**Note:** Do not proceed with the in-chassis overhaul if the cylinder head surface is damaged or not flat.

### Cylinder Head Overhaul

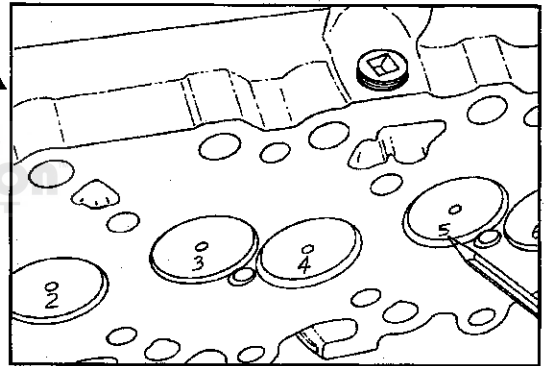
The cylinder heads have integral valve guides and valve seats. The seats can be re-ground. Seats that have been previously re-ground can be replaced with service seats. Service valve guides are also available to replace worn valve guide bores.

**Caution:** Seats that have been previously re-ground should be marked as illustrated.



### Disassembly of the Cylinder Head

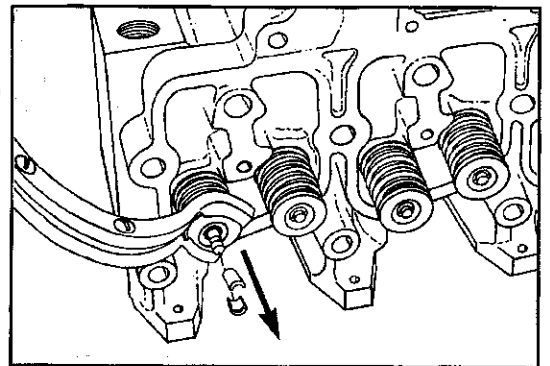
**Caution:** Mark the valves to identify their position.



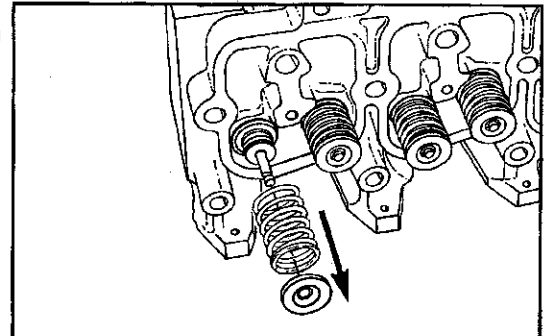
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### Valve Spring Compressor

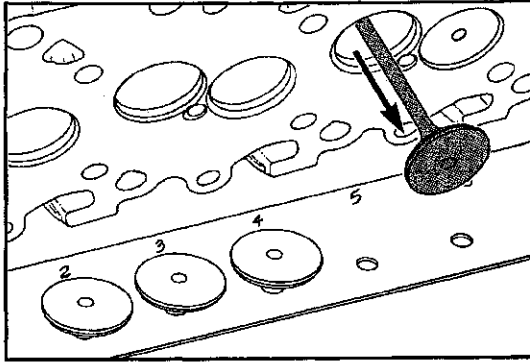
Compress the valve springs and remove the valve stem collets.



Release valve spring and remove the retainer and spring.



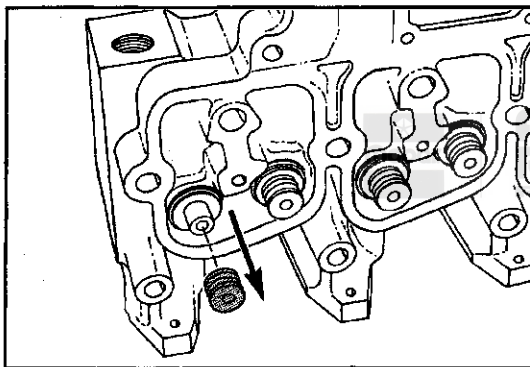




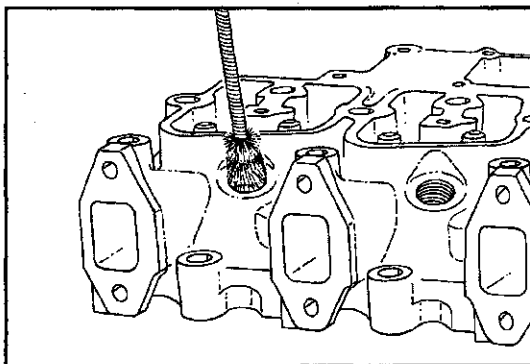
Remove the remaining collets, retainers, springs and valves.



Caution: Keep the valves in a labeled rack.

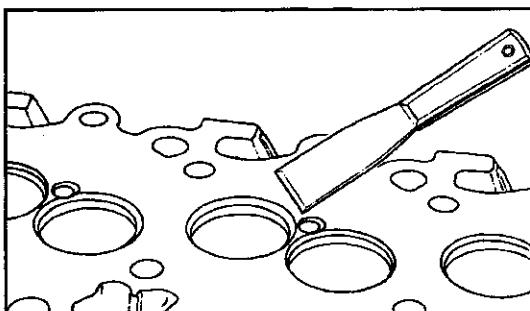


Remove the valve stem seals.



**Cleaning and Inspecting the Cylinder Head**

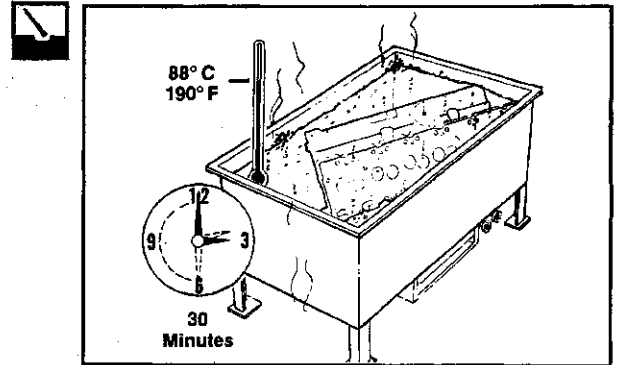
Clean the carbon from the injector nozzle seat with a nylon or brass brush.



Scrape the gasket residue from all gasket surfaces.

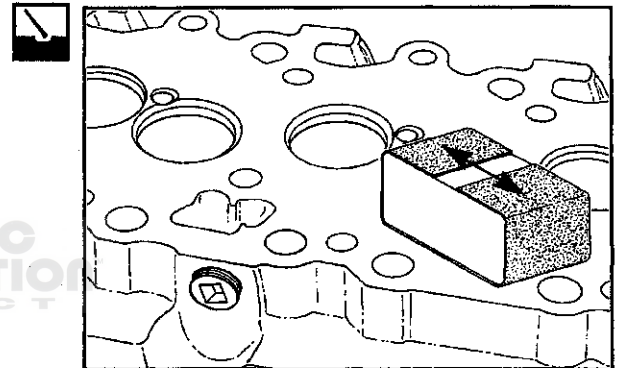
Wash the cylinder head in hot soapy water solution.

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



Polish the gasket surfaces with 400 grit paper.

Use an orbital sander or sanding block to maintain a flat surface.

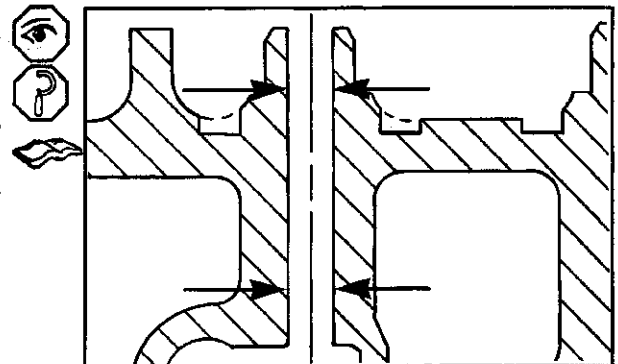


Inspect the valve guides for scuffing or scoring.

Measure the valve guide bore.

mm	Diameter		in
	MIN	MAX	
8.019	MIN		0.3157
8.089	MAX		0.3185

**Note:** If the valve guide bore is over the maximum limit, refer to engine Alternative Repair Section 9K.

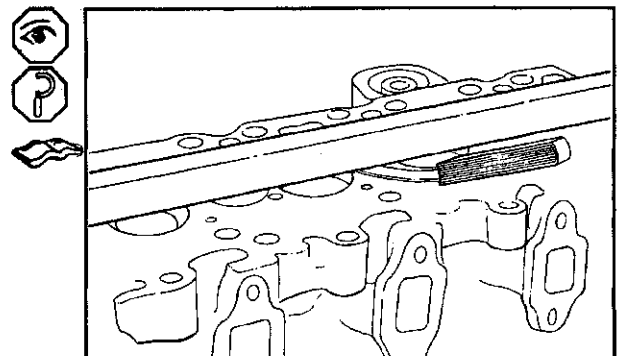


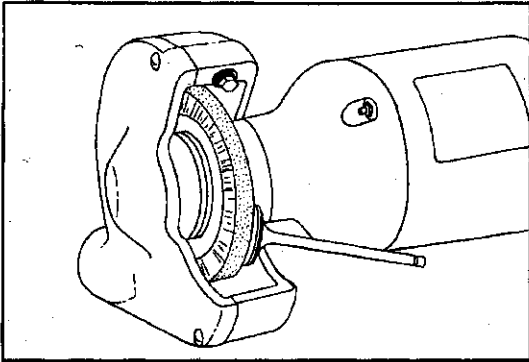
Inspect the head surface for nicks, erosion, etc. Check for head distortion as illustrated.

**Variation:**

**Limit**  
0.010mm [.0004 inch] within a  
50.8mm [2.0 inch] diameter area  
0.30 [0.012 inch] overall end  
to end or side to side.

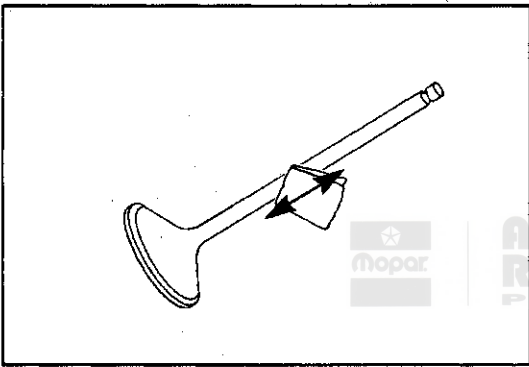
**Note:** If the cylinder head deck surface is out of specification, refer to engine Alternative Repair Section 9K.



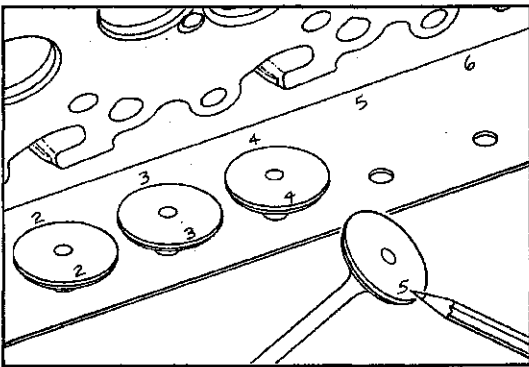


**Cleaning and Inspecting the Valves**

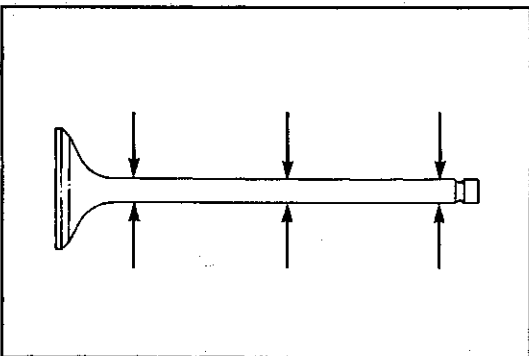
Clean the valve heads with a soft wire wheel.



Polish the valve stems with crocus cloth.



**Caution: Re-mark the valves according to head location.**



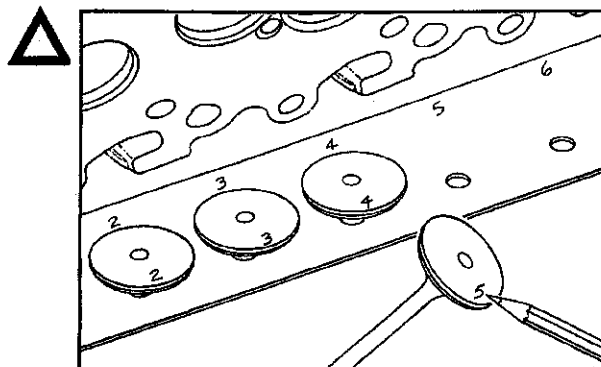
Inspect for abnormal wear on the valve heads and stems.



Measure the valve stem diameter.

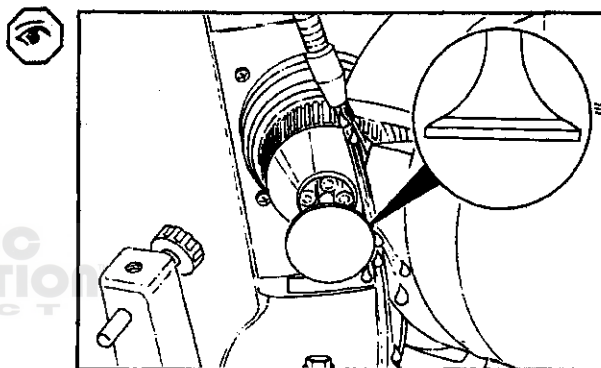
Diameter		
mm		in
7.935	MIN	0.3126
7.960	MAX	0.3134

**Caution:** Mark the new valves, if required, for the replacement location.



### Grinding the Valves

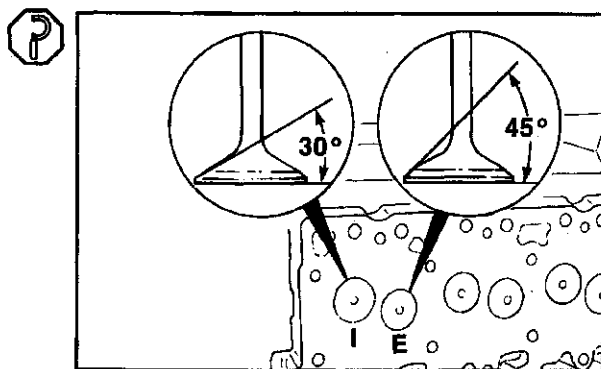
Grind the face of valves to be reused. Check for and replace bent valves.



### Seat Angle:

**Intake:** 30 Degrees

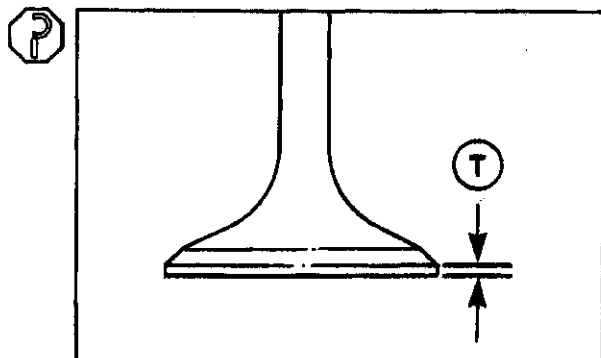
**Exhaust:** 45 Degrees

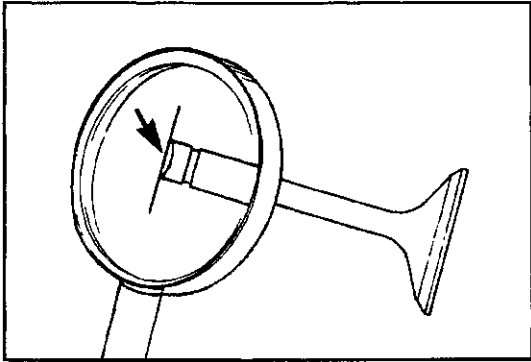


Measure rim thickness.

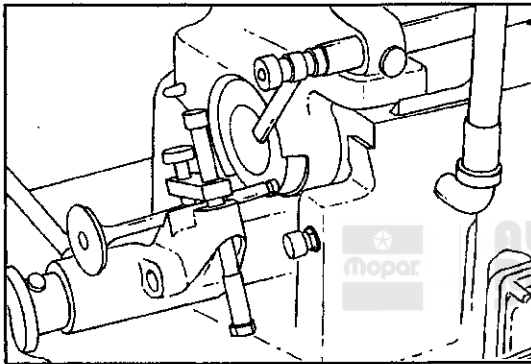
**Limit:**

**Minimum (T):** 0.79mm [0.031 inch]

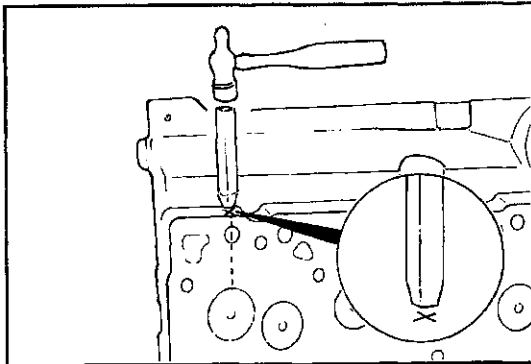




Check the valve stem tip for flatness.



If required, re-surface the tip.

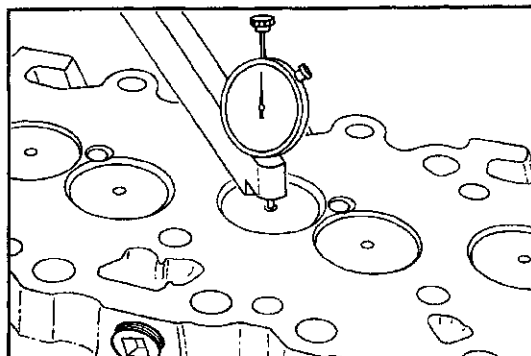


### Grinding the Seats



**Caution:** The illustrated marks indicate valve seats have been ground previously.

Replacement valve seat inserts must be installed if the valve seats have been ground previously.



### Calculating the Grinding Depth

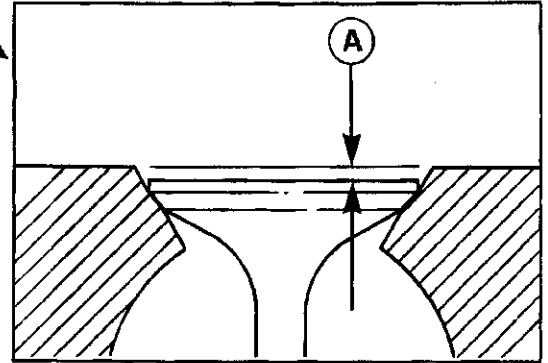
Install the valves in their designated location and measure the valve depth.

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



Record the depth of each valve as (A).

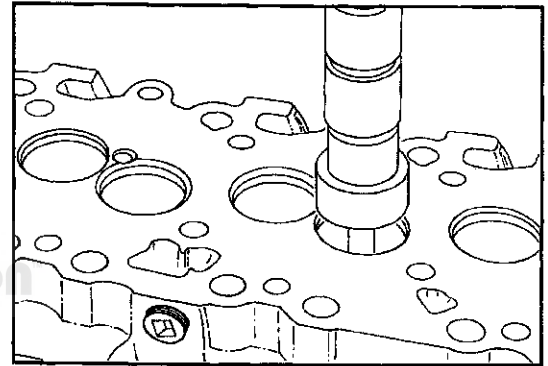
Valve Depth		
mm		in
0.99	MIN	0.039
1.52	MAX	0.060



Grind the valve seats to remove scores, scratches and burns.



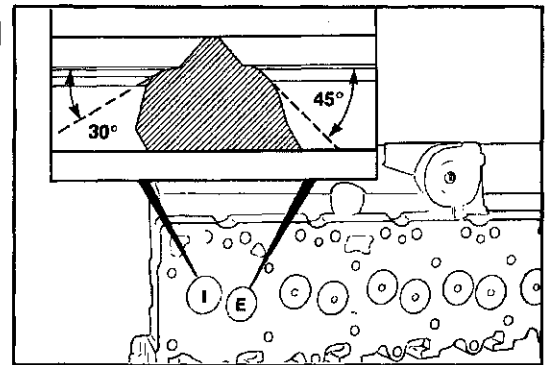
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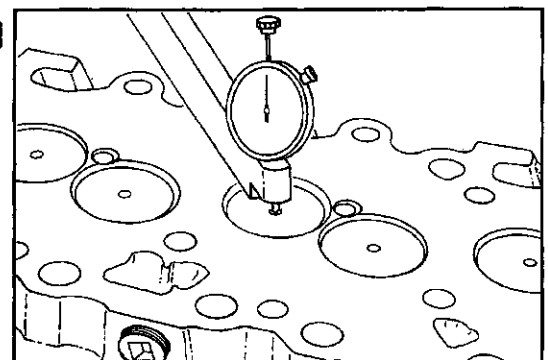
**Seat Angle:**

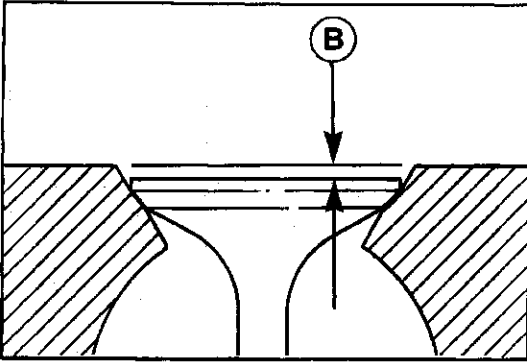
**Intake: 30 Degrees**

**Exhaust: 45 Degrees**



Install the valves in their respective bores and measure the depth again.

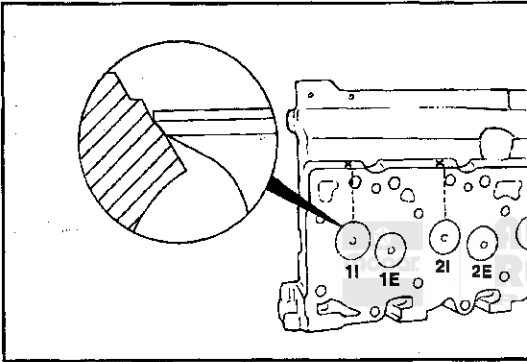




Record the depth of each valve as (B).

Calculate grinding depth (GD) as follows:

$$GD = (B) - (A)$$

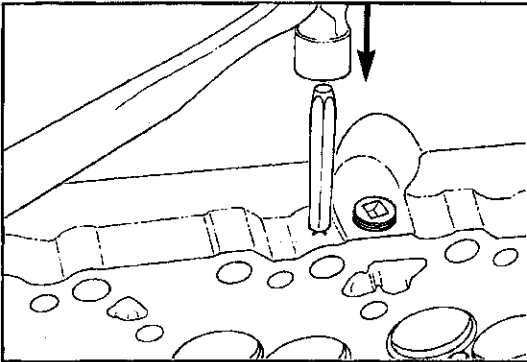


Limit:

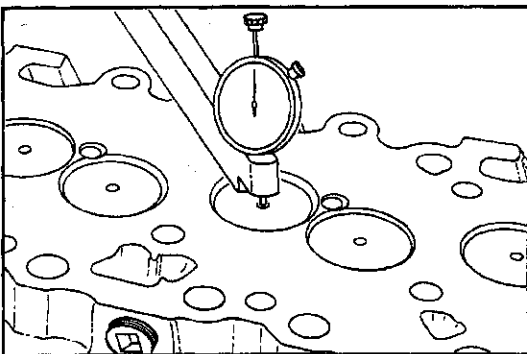


GD: 0.254mm [0.010 inch]

**Note:** Service valve seats are available for seats that are over the limit. Refer to the Engine Alternative Repair Section 9K.



**Caution:** Mark the cylinder head to identify the re-ground valve seats.

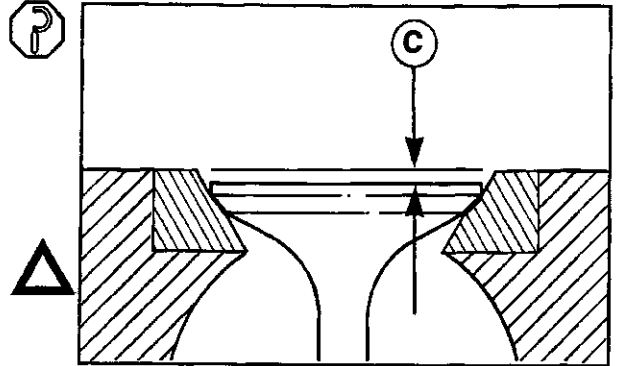


Install the valves in their designated location and measure the depth.

Check valve depth (C) (Integral and insert valve seats).

Valve Depth		
mm		in
0.99	MIN	0.039
1.52	MAX	0.060

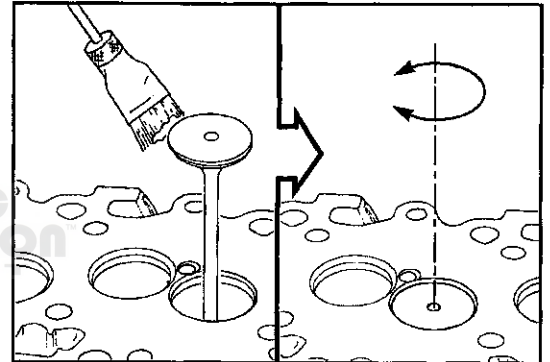
Caution: Replace the valve if the depth is over the limit.



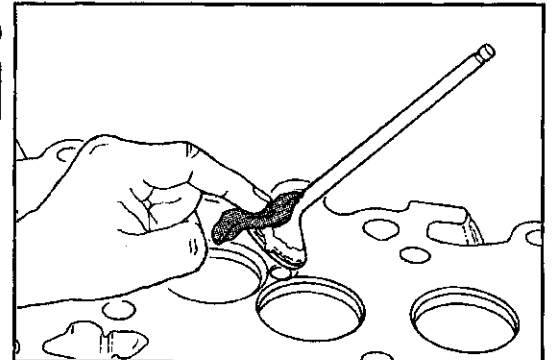
Apply a light coat of valve lapping compound to each valve and lap each valve to its companion seat.



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



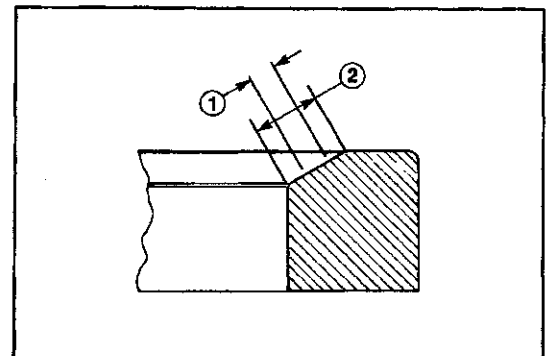
Measure the valve seat width indicated by the lapped surface.



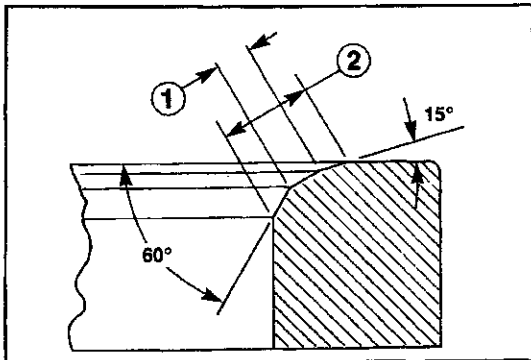
**Valve Seat Width Limit:**

Minimum (1): 1.5mm [0.060 inch]

Maximum (2): 2.0mm [0.080 inch]



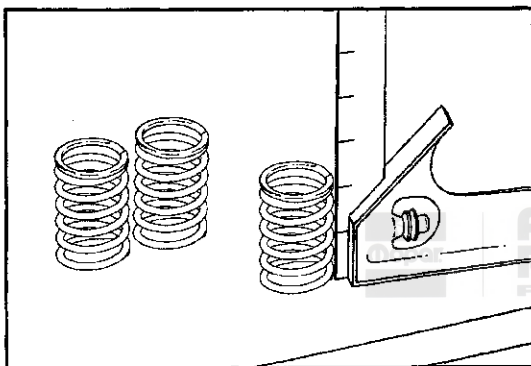




If required, grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face. Maintain the valve seat width limits.

Minimum (1): 1.5mm [0.060 inch]

Maximum (2): 2.0mm [0.080 inch]



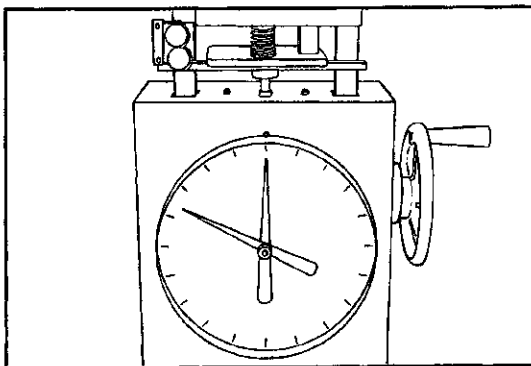
### Inspect the Valve Springs

Measure the valve spring.

Limits:

Approximate Free Length (L): 55.63mm [2.190 inch]

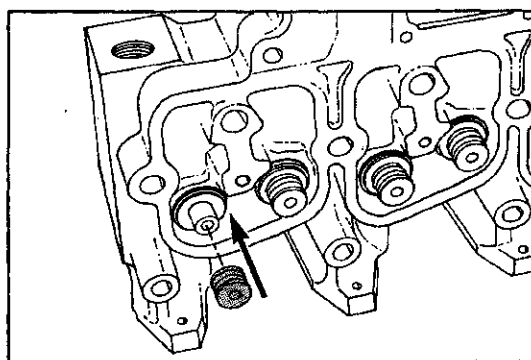
Maximum Inclination: 1.0mm [0.039 inch]



### Measure Valve Spring Force

Force Required:

289.32 N [65 lbs] is the minimum acceptable load required to compress the spring to a height of 49.25 mm [1.94 inch].



### Assembly of the Cylinder Head

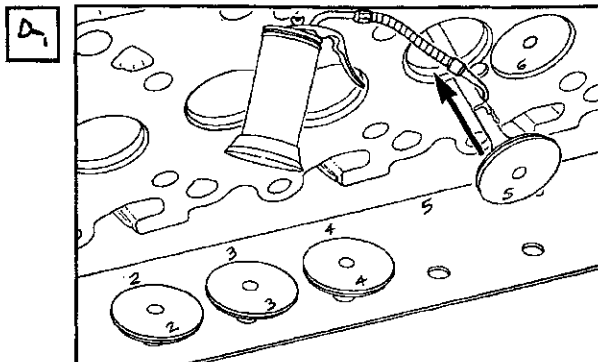


Note: Clean all cylinder head components before assembling.

Install the valve stem seals.

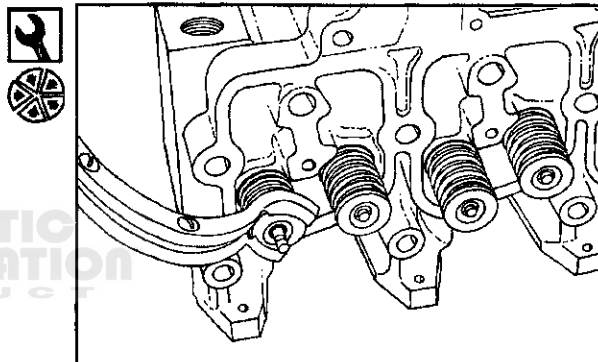
Note: The intake and exhaust seals are the same.

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

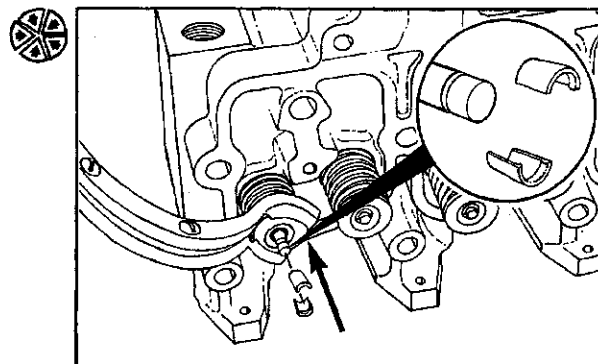


### Valve Spring Compressor

Compress the valve spring after assembling the spring and retainer.



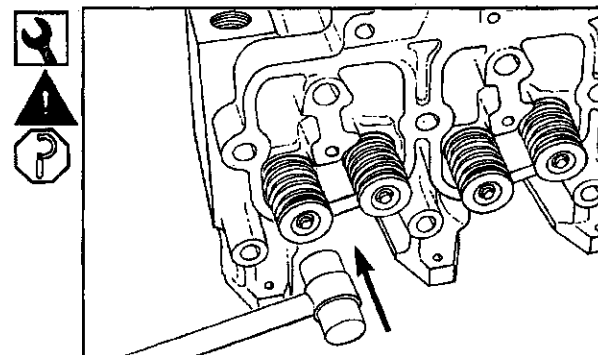
Install new valve collets and release the spring tension.



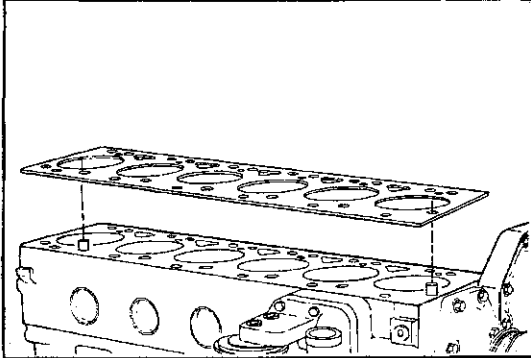
### Plastic Hammer

**Warning: Wear protective equipment and do not stand in line with the valve stem when tapping the valve.**

After assembly, tap the valve stems to verify the collets are seated.



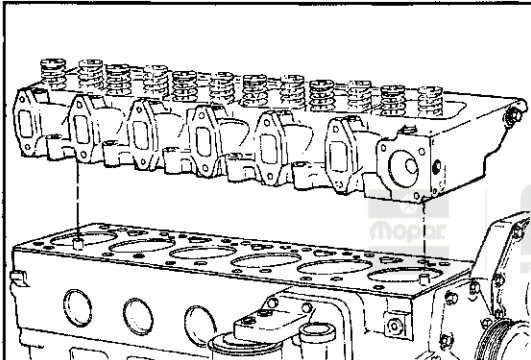
### Cylinder Head and Gasket - Installation



**Caution:** Make sure the gasket is correctly aligned with the holes in the cylinder block.

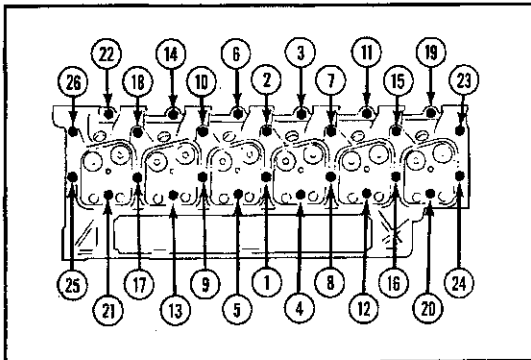
The cylinder block and head must be clean and dry.

Position the gasket onto the dowels.



Carefully put the cylinder head onto the gasket and cylinder block.

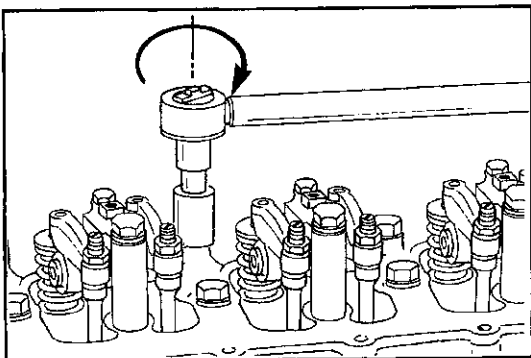
**Note:** Make sure the cylinder head is installed onto the dowels in the cylinder block.



Install the push rods and levers.



Lubricate the cylinder head capscrews. Use the illustrated torque sequence.



18mm



**Torque Value:**

Step 1 - 40 N·m [29 ft-lbs]

Step 2 - 85 N·m [62 ft-lbs]

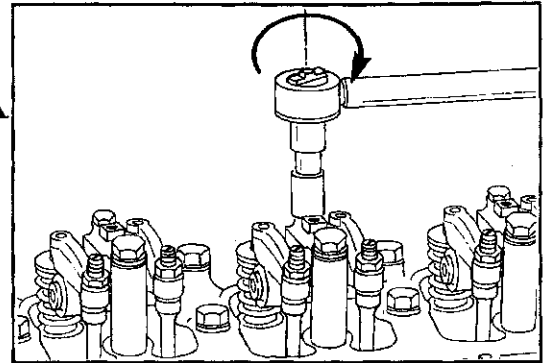
Step 3 - 126 N·m [93 ft-lbs]

13mm

**Caution:** Be sure to lubricate the push rod sockets with clean engine oil.

Install the rocker lever pedestal capscrews.

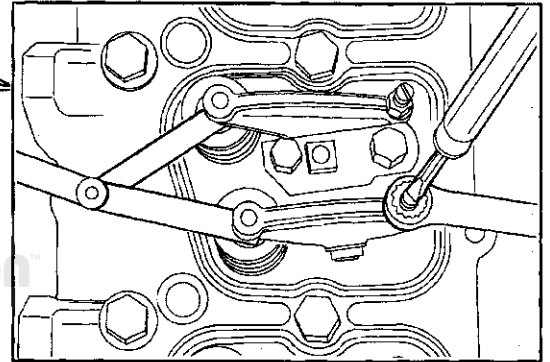
**Torque Value:** 24N·m [18 ft-lbs]



14mm, Screwdriver

Adjust the valve clearance.

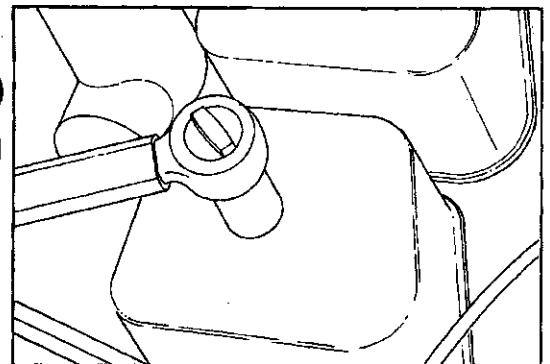
**Note:** Refer to Valve Clearance Adjustment Section for valve set procedure.



15mm

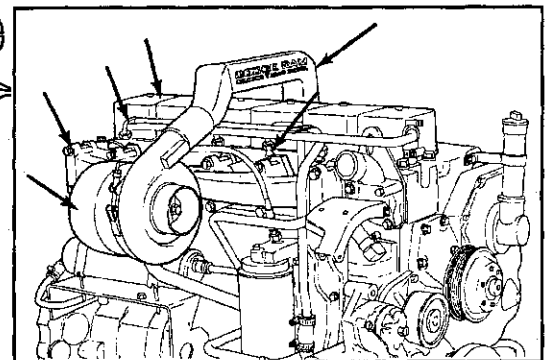
Install the valve covers.

**Torque Value:** 24 N·m [18 ft-lbs]

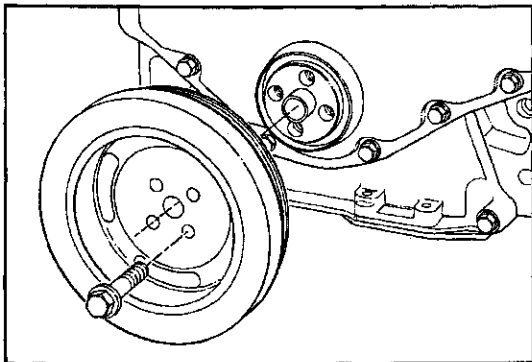


Install the parts previously removed:

- Valve covers
- Injector Nozzles
- Fuel lines
- Fuel filter
- Exhaust manifold
- Turbocharger and air crossover
- Connect the radiator and heater hoses
- Fill the engine with new coolant and oil



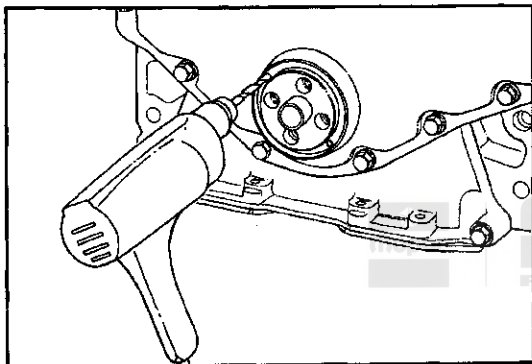
### Front Crankshaft Seal - Replacement



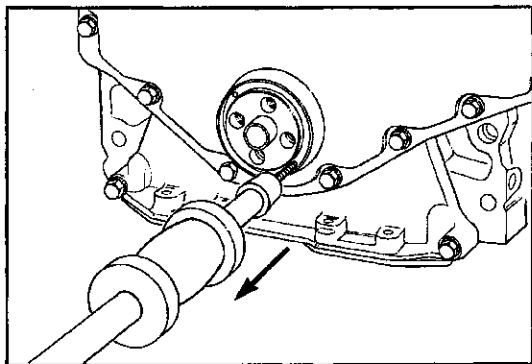
15mm

#### Preparatory Step:

- Remove the drive belt
- Remove the vibration damper



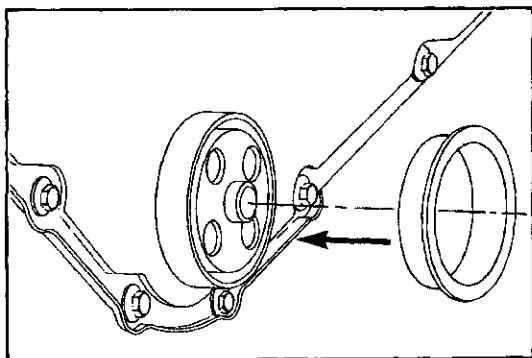
Drill two [1/8 inch] holes into the seal face, 180 degrees apart as shown.



#### No. 10 Sheet Metal Screw, Slide Hammer Dent Puller



Use a slide hammer tool with a #10 metal screw as shown. Pull alternating from side-to-side until the seal is free.



#### Install



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



If the gear cover has been recently removed and replaced, use the alignment tool from the seal kit to make sure the cover is aligned with the crankshaft.

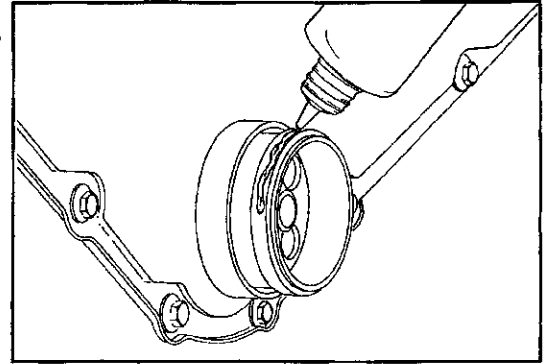
Apply a bead of Loctite 277 to the outside diameter of the seal.



Install the pilot from the seal kit onto the crankshaft.

Install the seal onto the pilot and start it into the front cover seal bore.

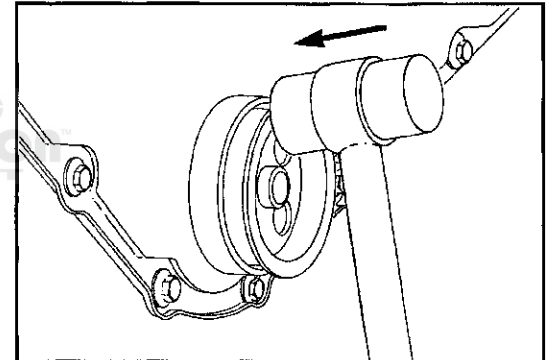
Remove the pilot.



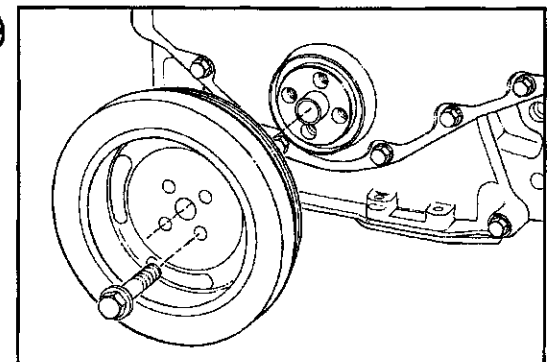
**Alignment/Installation Tool, Plastic Hammer**



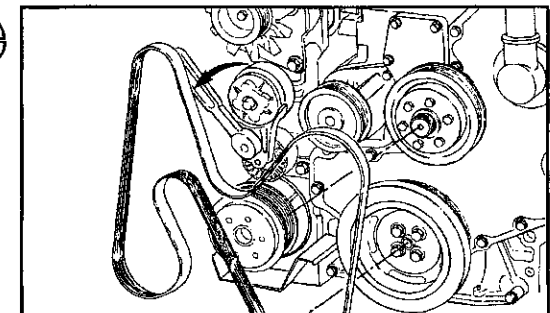
Use the alignment/installation tool and a plastic hammer to install the seal to the correct depth.

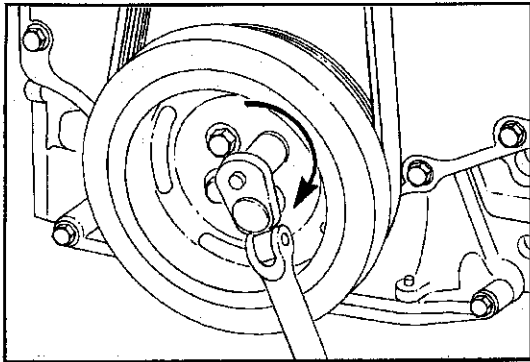


Install the vibration damper but do not tighten the damper cap screws until the belt is installed.



Install the drive belt.



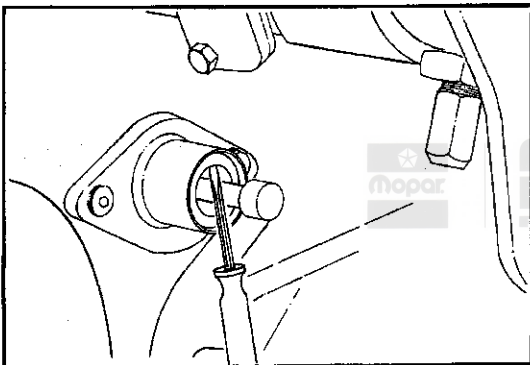


15mm

Tighten the vibration damper capscrews.

**Torque Value:** 125 N·m [92 ft-lbs]

**Note:** Use the engine barring tool to keep the engine from rotating during torquing operation.



### Replacing the Timing Pin

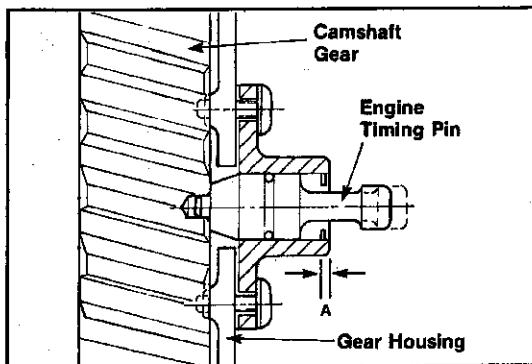


Screwdriver



The timing pin can be replaced without removing the assembly from the gear housing.

Remove the timing pin by prying the retaining ring out with a small screwdriver. Replace the retaining ring if it is damaged during removal.



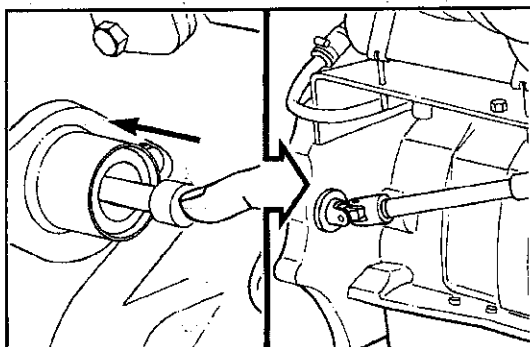
**Note:** If the timing pin assembly is removed from the gear housing, it must be precisely reset to obtain exact TDC. Refer to the Timing Pin Housing Assembly - Installation (With Head On) in this section of the manual.



Install a new o-ring, lubricate the pin and position in the housing. Install the new retaining ring.

A = 1.5mm [.059 inch]

**Torque Value:** 5 N·m [44 in-lbs]

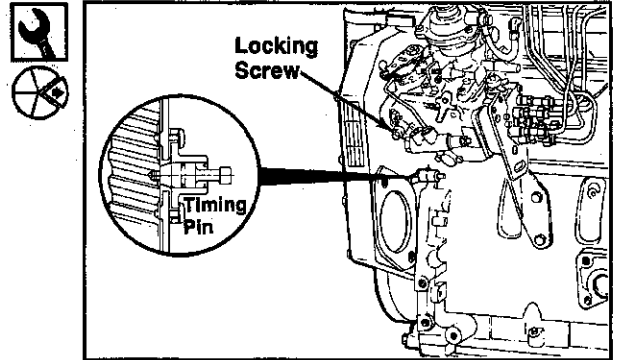


### Timing Pin Assembly or Gasket - Replacement

Locate TDC for Cylinder No. 1.

### T-25 Torx

Remove the timing pin assembly and gasket.

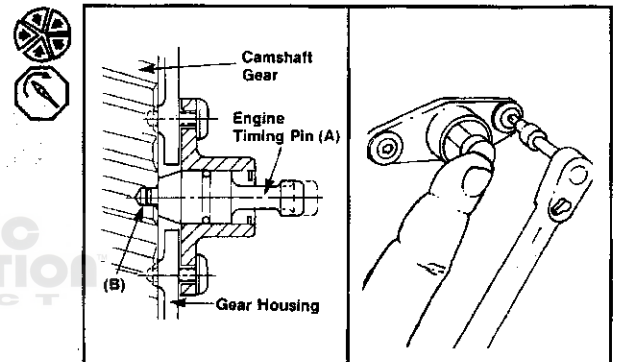


Install a new gasket and, if required, a new timing pin assembly.

Apply a coat of Loctite 59241 liquid Teflon to the threads of the Torx head screws.

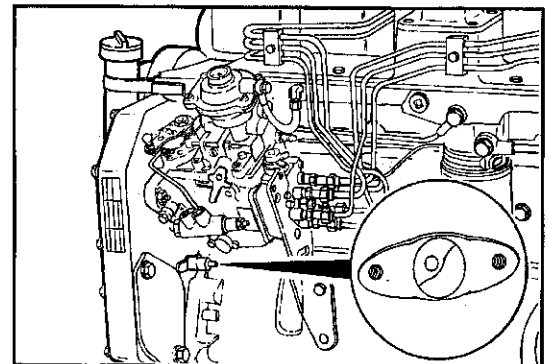
Hold the pin (A) in the hole (B) in the camshaft gear to align the housing.

**Torque Value:** 5 N·m [44 in-lbs]

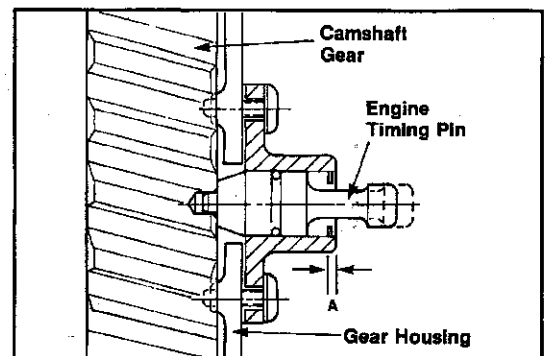


### Timing Pin Housing Assembly - Installation (With Head On)

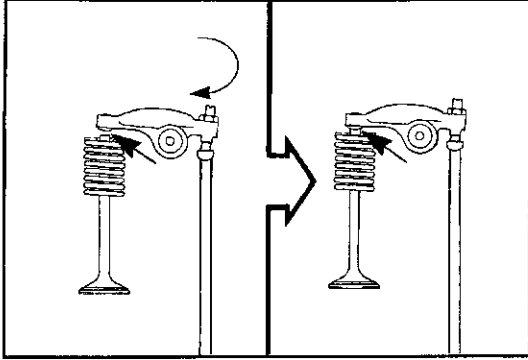
The location of the timing pin assembly on the gear housing is critical for correct engine adjustments. Follow this procedure to install the assembly so that it corresponds to Top Dead Center (TDC) for Cylinder Number 1.



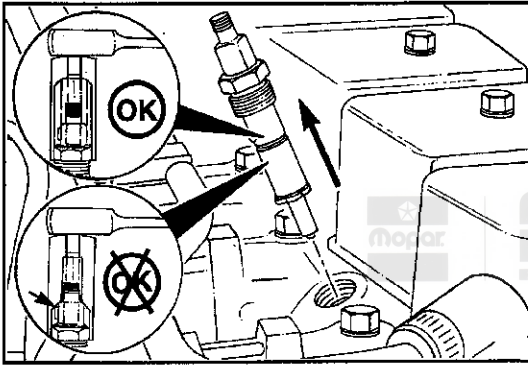
Looking through the hole in the gear housing, rotate the engine until the hole in the camgear can be seen.







Adjust the exhaust rocker lever to have zero (0) valve clearance.

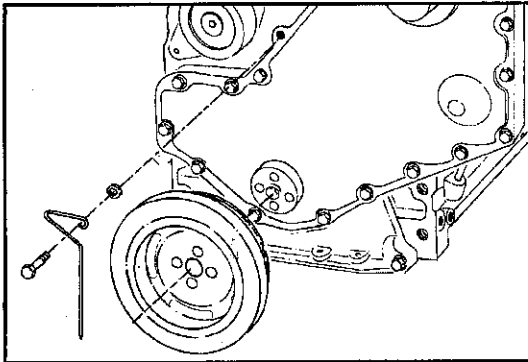


24mm



Remove the injector nozzles from all of the cylinders.

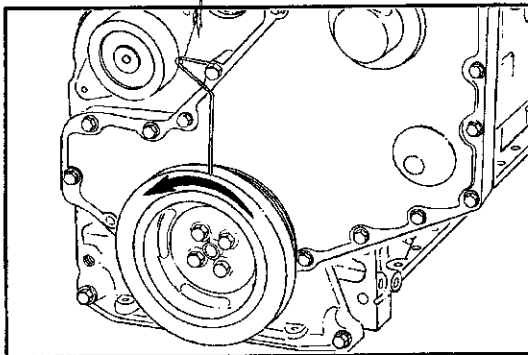
**Note:** This step is important to vent the cylinders so the crankshaft can be rotated smoothly to locate TDC for Cylinder Number 1.



10mm, 15mm

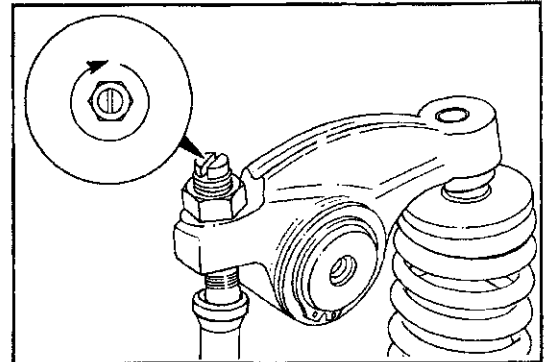


Temporarily install the vibration damper. Fabricate and install a wire pointer as shown.



Rotate the crankshaft one-quarter rotation in the direction opposite engine rotation.

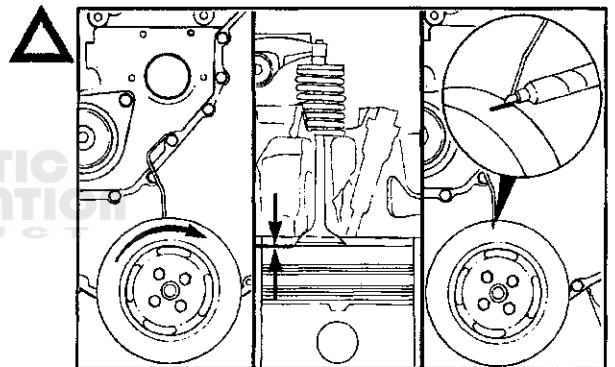
Tighten the adjusting screw for the exhaust valve two complete turns of the screw. Tighten the locknut.



**Caution:** Use extreme care that the piston does not push against the exhaust valve with so much force that it bends the push rod.

Rotate the crankshaft slowly in the direction of engine rotation until the piston touches the exhaust valve.

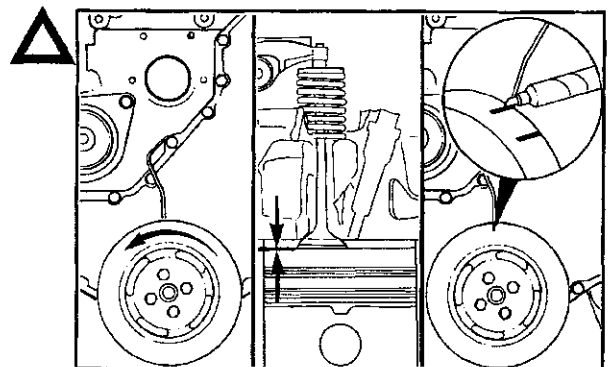
Mark the vibration damper corresponding to the wire pointer.



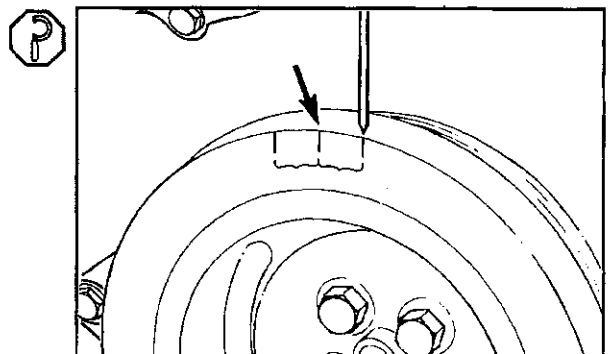
**Caution:** Make sure that the piston touches the valve with approximately the same amount of force as in the previous step.

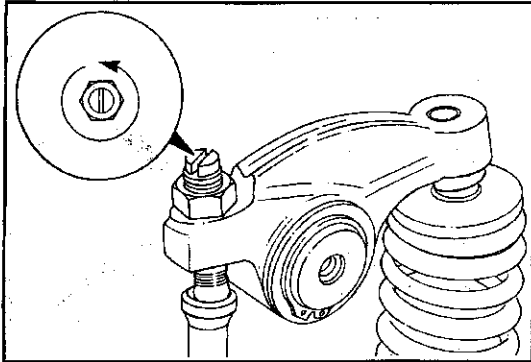
Rotate the crankshaft in the opposite direction until the piston touches the valve.

Mark the vibration damper again.

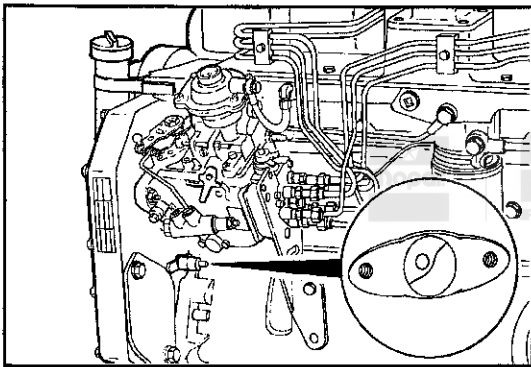


Measure the distance and mark the pulley at one-half the distance between the two marks. This mark is the TDC mark.



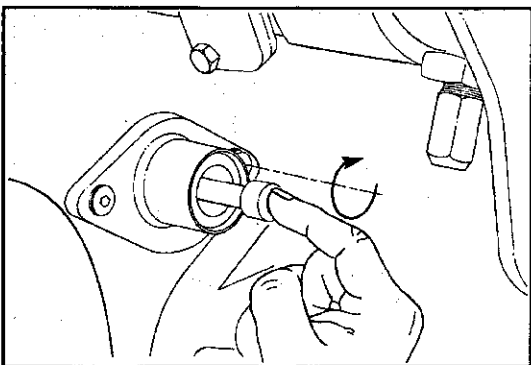


Completely loosen the exhaust valve adjusting screw.



Rotate the crankshaft approximately 180° in the direction of engine rotation until the pointer is aligned with the TDC mark. Look through the back side of the gear housing for the timing pin hole in the camshaft gear.

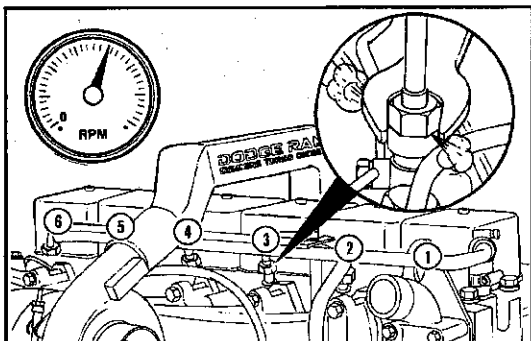
Reset valves on No. 1 cylinder and install cover.



T-25 Torx

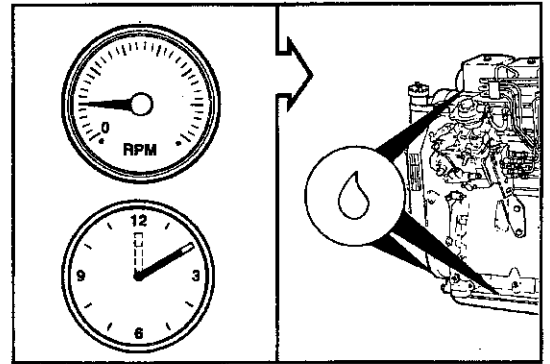
Apply a coat of Loctite 59241 Liquid Teflon to the threads of the torx headscrews. Hold the timing pin in the hole to align the housing.

Torque Value: 5 N·m [44 in-lbs]



Install the injectors and bleed the fuel system. Refer to the Fuel System Section 14.

Operate the engine at idle for 5 to 10 minutes and check for leaks and loose parts.



### Gear Cover - Removal

Preparatory steps:

- Remove Fan Drive Assembly
- Remove Fan Belt
- Remove Belt Tensioner
- Remove Oil Fill Tube and Adapter
- Remove Vibration Damper

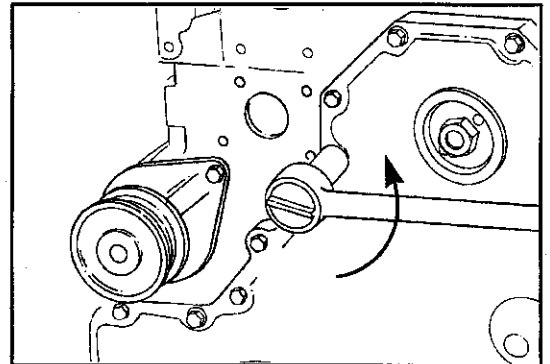


AUTHENTIC  
RESTORATION  
PRODUCT

10mm



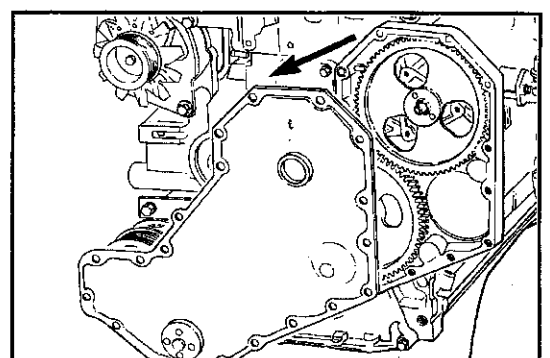
Remove the capscrews that hold the gear cover to the gear housing.

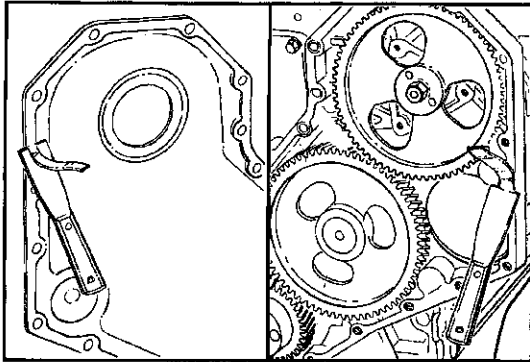


Gently pry the cover away from the housing, taking care not to mar the gasket surfaces.

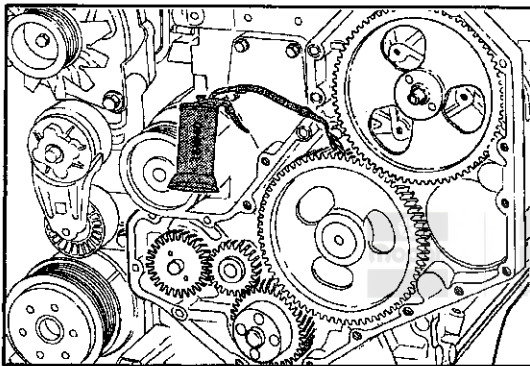


Remove the cover from the engine.



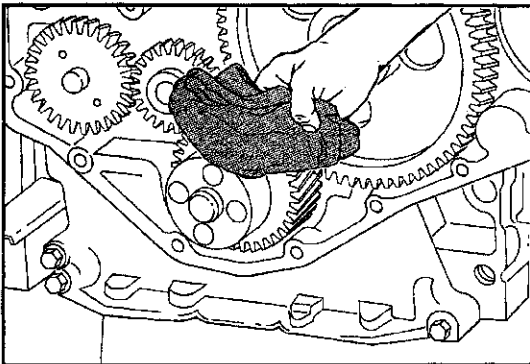


Clean all old gasket residue from the back of the gear cover and front of the gear housing.



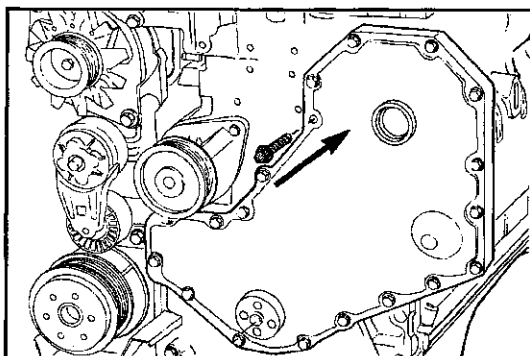
### Gear Cover - Installation

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 the front seal area of the crankshaft.



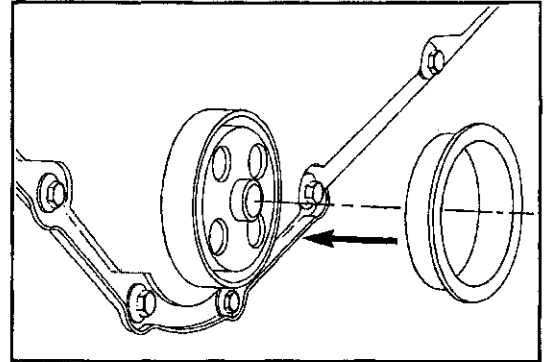
10mm



Install the front cover and gasket.

**Note:** Install the capscrews but do not tighten them at this time.

Use the alignment/installation tool from the seal kit to align the cover to the crankshaft.

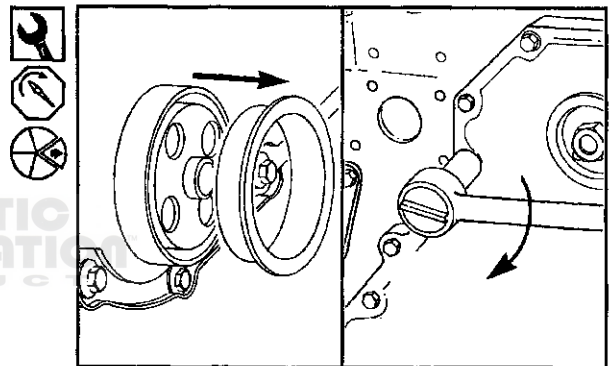


10mm

Tighten the gear cover capscrews.

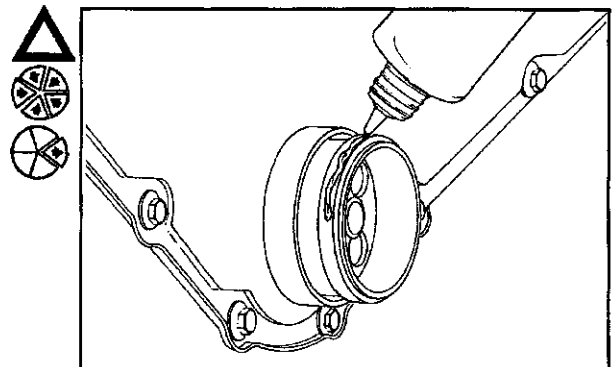
Torque Value: 24 N.m [18 ft-lbs]

Remove the alignment/installation tool.



**Caution:** Always use a seal pilot when you install a seal.

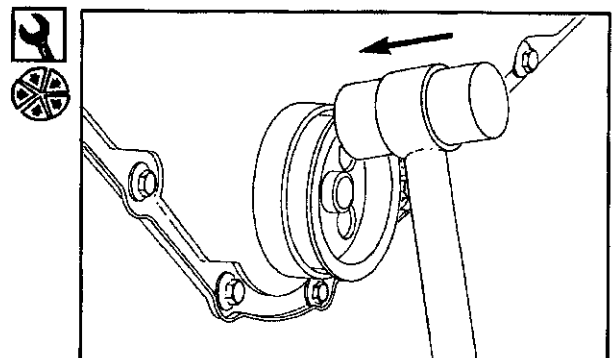
Apply a bead of Loctite 277 to the outside diameter of the seal. Install the pilot from the seal kit onto the crankshaft. Install the seal onto the pilot and start into the front cover. Remove the pilot.

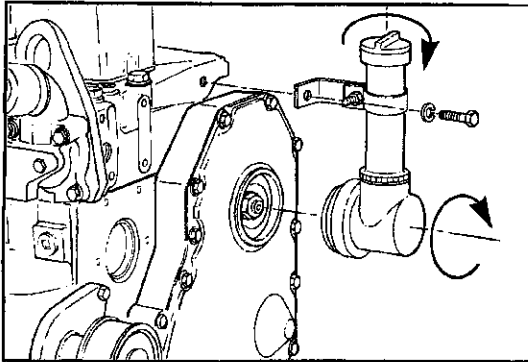


**Alignment/Installation Tool, Plastic Hammer**


**Note:** To prevent damage to the seal carrier, hit the alignment/installation tool alternately at the 12, 3, 6 and 9 o'clock positions.

Use the alignment/installation tool and a plastic hammer to install the seal to the correct depth.

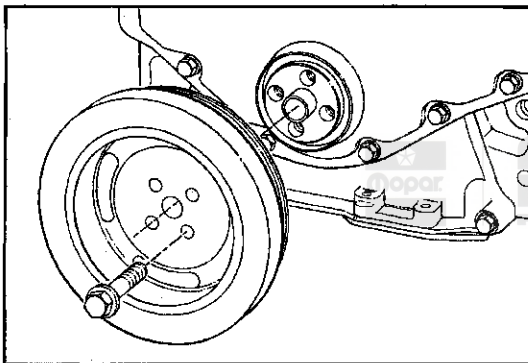






 17mm

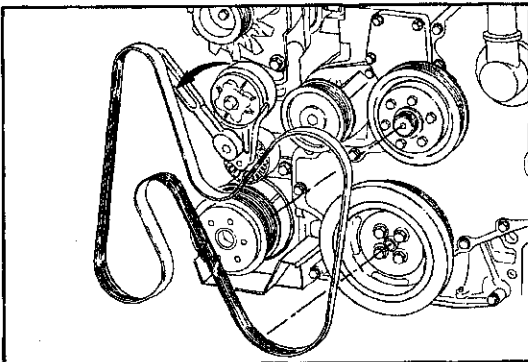
 Install the oil fill tube and mounting capscrow.

**Torque Value: 43 N·m [32 ft-lbs]**



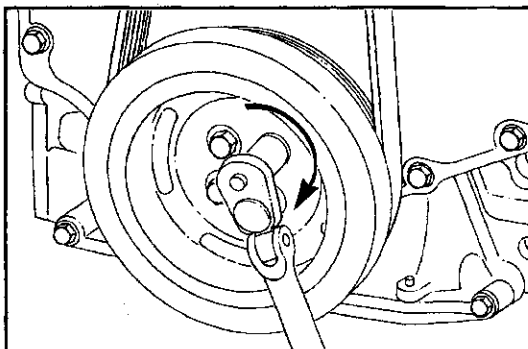
 15mm


 Install the vibration damper. Do not tighten the capscrow to the correct torque value at this time.



 3/8 inch Square Drive

 Raise the belt tensioner to install the belt.



 15mm

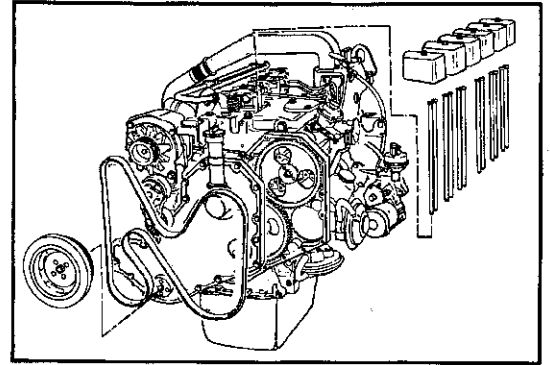
 Torque value: 125 N.m [92 ft-lbs]



## Camshaft, Gear and Tappet - Replacement

### Preparatory Steps:

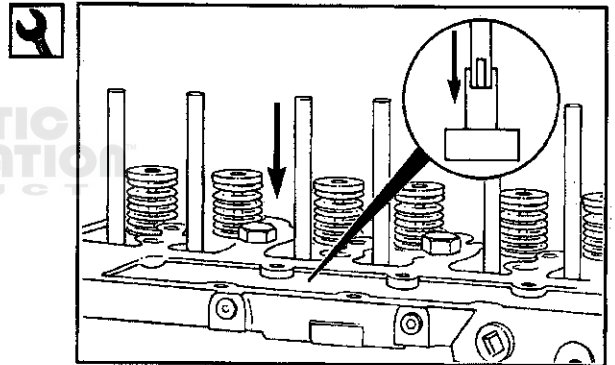
- Remove the valve covers
- Remove rocker lever assemblies
- Remove the push rods
- Remove the drive belt
- Remove fan hub assembly
- Remove the vibration damper
- Remove the gear cover
- Remove the lift pump



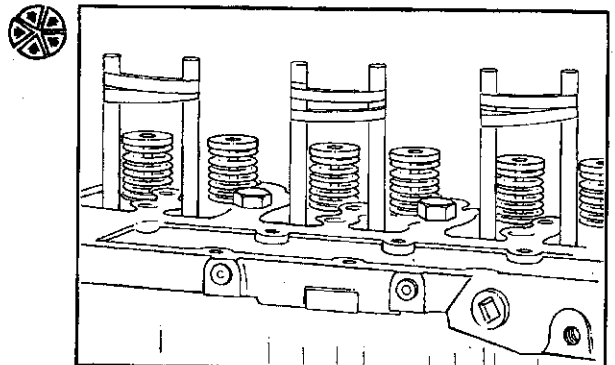
### Camshaft Removal

#### Camshaft Removal Service Tool, Plastic Hammer

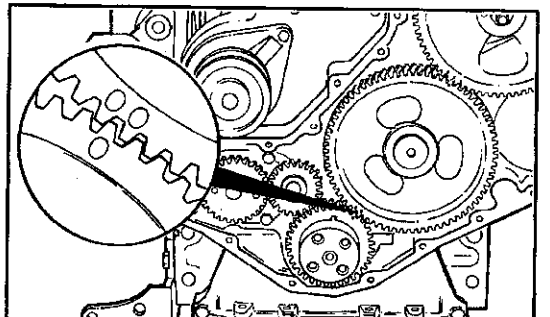
Insert the dowels through the push tube holes and into the top of each tappet securely. When properly installed, the dowels can be used to pull the tappets up and should not be able to be pulled out without considerable effort.



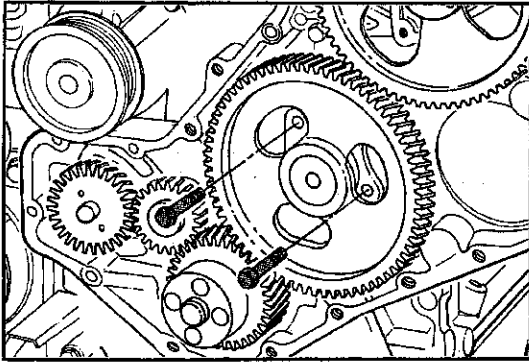
Pull the tappets up and wrap a rubber band around the top of the dowel rods. This will prevent the tappets from dropping down.



Rotate the crankshaft to align the crankshaft to camshaft timing marks.



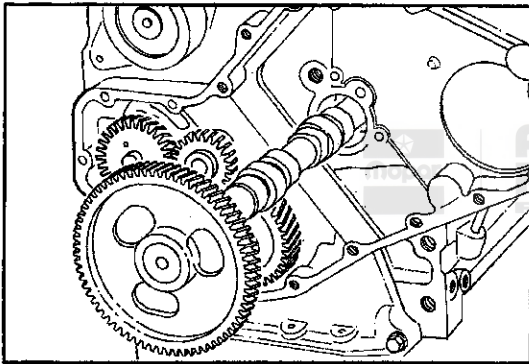




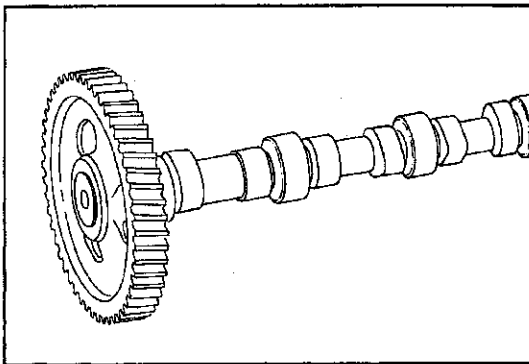
13mm



Remove the capscrews from the thrust plate.

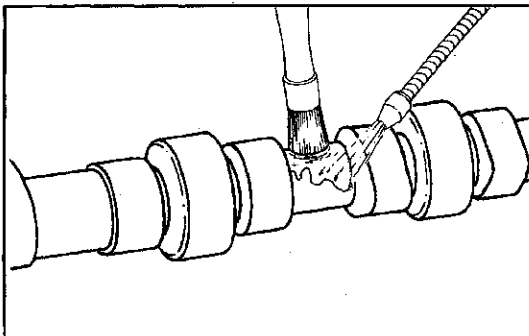


Remove the camshaft and thrust plate.



### Camshaft Inspection

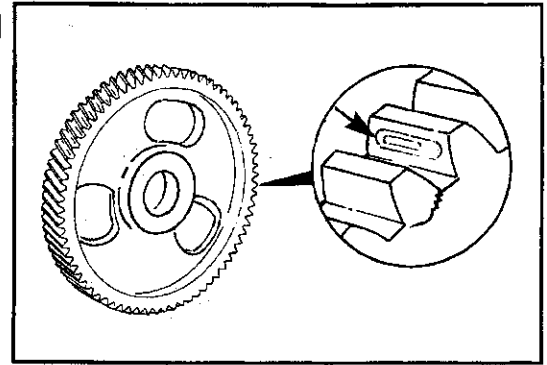
Inspect the lift pump lobe, valve lobes and bearing journals for wear, cracking, pitting and other damage.



### Inspection of the Camshaft and Gear

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

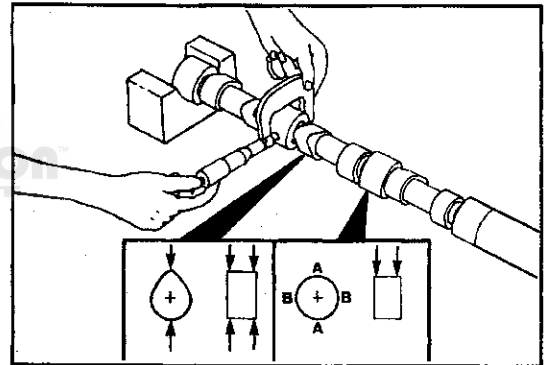
Inspect the gear teeth for wear and damage. Look for cracks at the root of the teeth.



Measure the bearing journals and valve lobes.

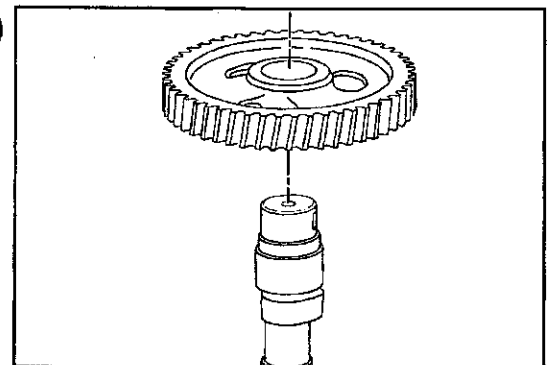
Limits

- **Journal**
- **Minimum Diameter: 53.962mm [2.1245 inch]**
- **Valve Lobes: (Minimum Diameter at Peak of Lobe)**
- **Intake Minimum Height: 47.040mm [1.852 inch]**
- **Exhaust Minimum Height: 46.770mm [1.841 inch]**
- **Lift Pump Lobe Diameter Minimum: 35.5mm [1.398 inch]**

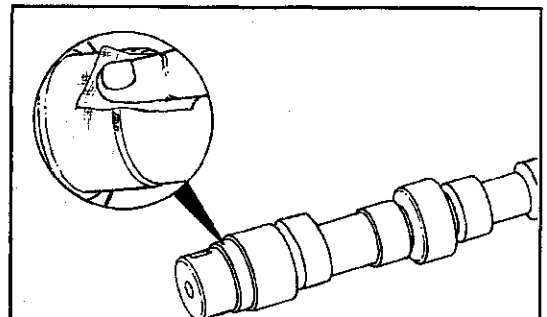


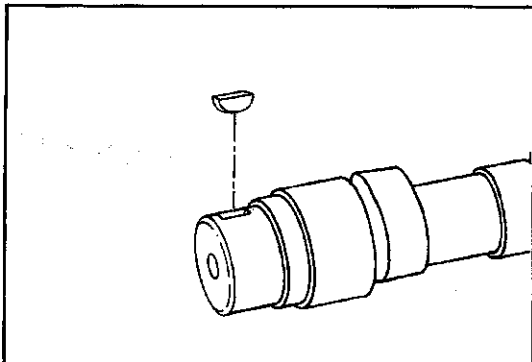
Camshaft Gear - Replacement

Press the camshaft out of the gear.

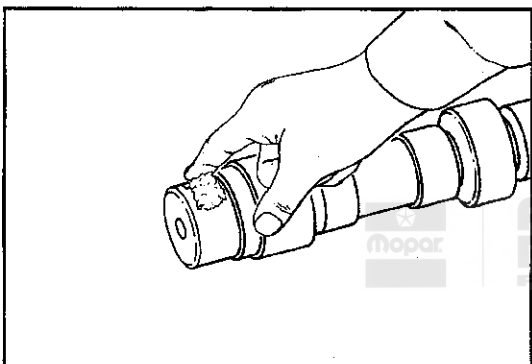


Remove all burrs and smooth any rough surfaces caused by removing the gear.

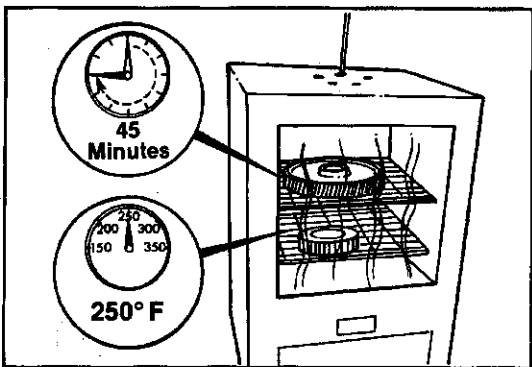




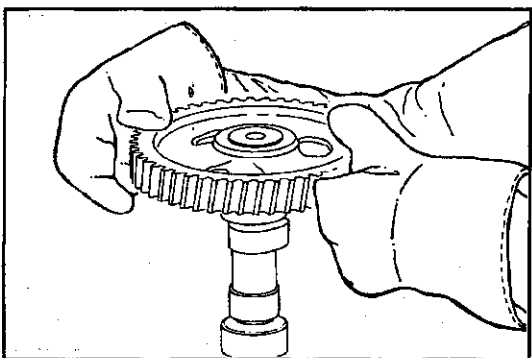
 Install the key.






 Lubricate the camshaft surface with Lubriplate 105.

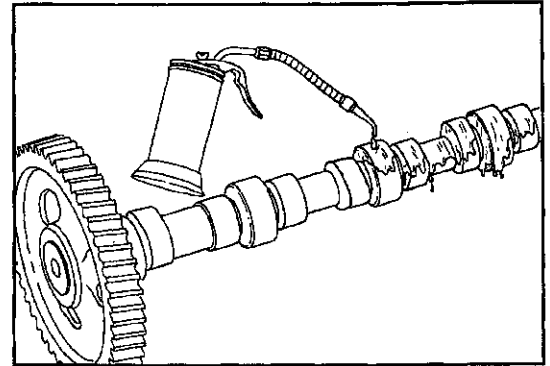


Heat the gear in an oven at 121°C [250°F] for 45 minutes.



-  Wear protective gloves to handle the hot gear.
-  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 Bushing - Inspection

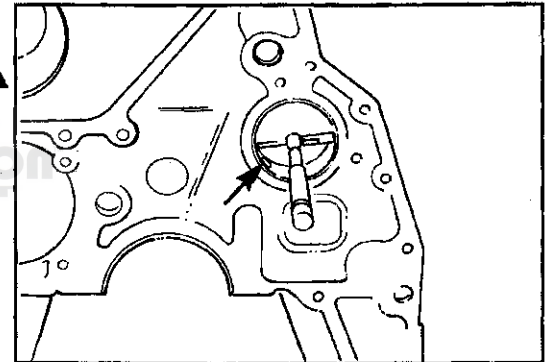
**Caution:** If the camshaft bore for the first cam bushing is worn beyond the limit, install a new service bushing.



Inspect the rest of the camshaft bores for damage or excessive wear.

Measure the diameter of each bore. (The limit for the bushing in the No. 1 bore is the same as for the other bores without bushings.)

Limit

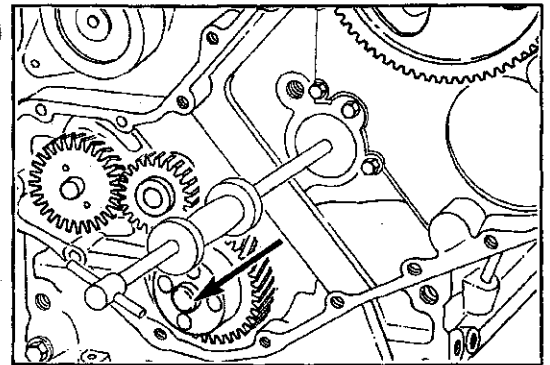


**Inside Diameter:** 54.133mm [2.1312 inch]

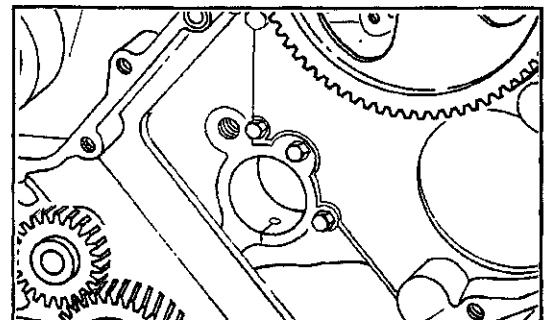
**Note:** If the bores without a bushing are worn beyond the limit, the engine must be removed for machining and installation of service bushings or replacement of the cylinder block.

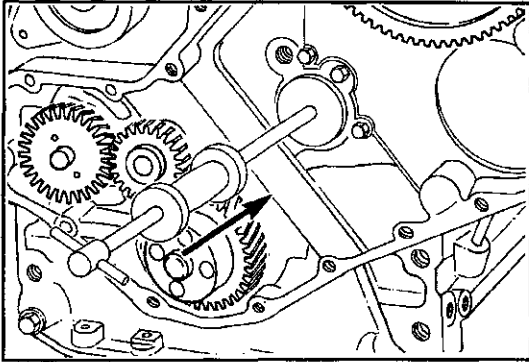



Remove the bushing from the Number 1 bore, using a universal cam bushing tool.

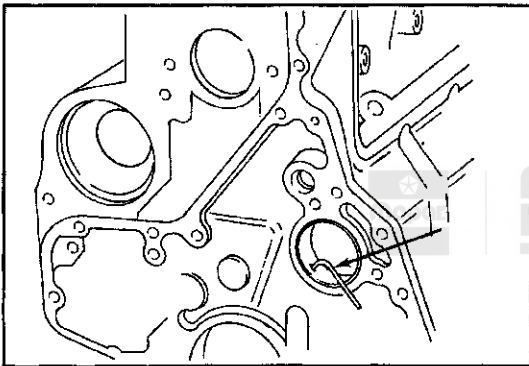




**Note:** Mark the cylinder block so you can align the oil hole in the cylinder block with the oil hole in the bushing.

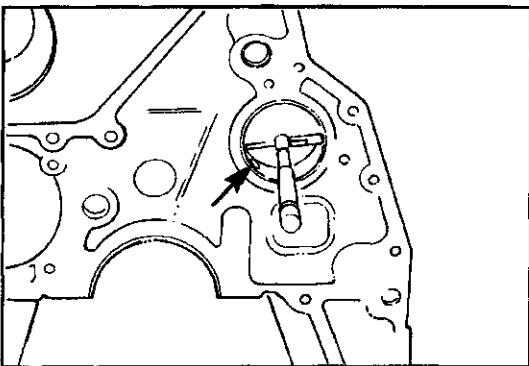





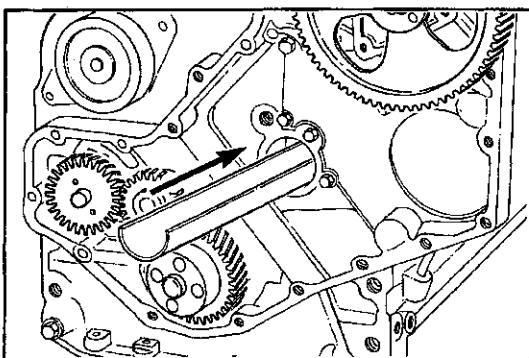
 Install the bushing so that it is even with the front face of the cylinder block, using a universal cam bushing installation tool.




 **Caution: The oil hole must be aligned.**  
 A 3.2mm [0.128 inch] diameter rod must be able to pass through the hole.

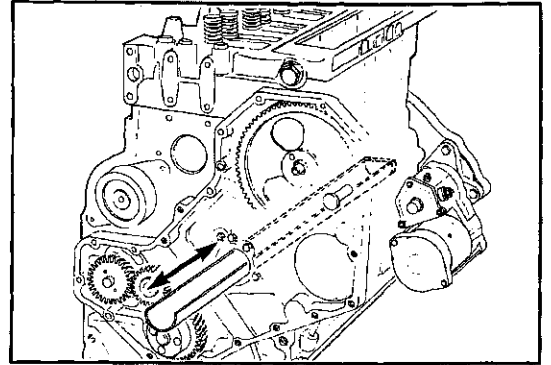


 Measure the installed bushing.  
Limits  
**Inside Diameter: 54.133mm [2.1312 inch]**



 **Tappet – Removal**  
**Tappet Removal Service Tool**  
Insert the trough to the full length of the cam bore.

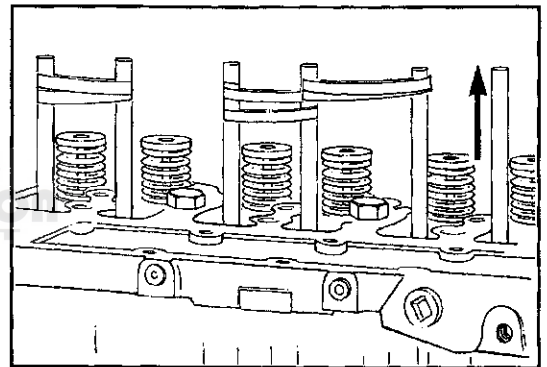
Make sure the trough is positioned so it will catch the tappet when the wooden dowel is removed.



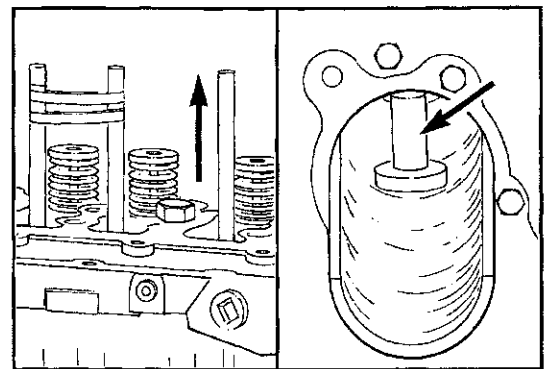
**Note:** Identify the location of each tappet as it is removed. The tappets must be installed in their original locations.



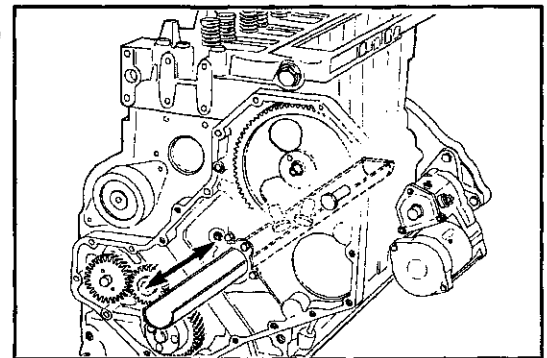
**Only remove one tappet at a time.** Remove the rubber band from the two companion tappets, securing the tappet not to be removed with the rubber band.

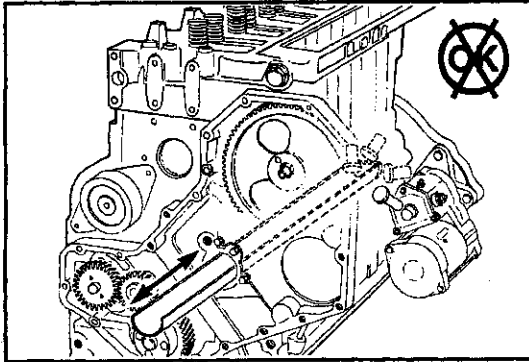


Pull the wooden dowel from the tappet bore allowing the tappet to fall into the trough.

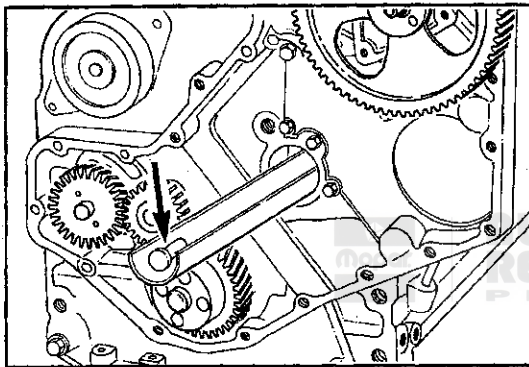


Normally the tappet will fall over when it drops into the trough. Use a flashlight to determine this. If the tappet does not fall over, shake the trough gently to get it to do so.

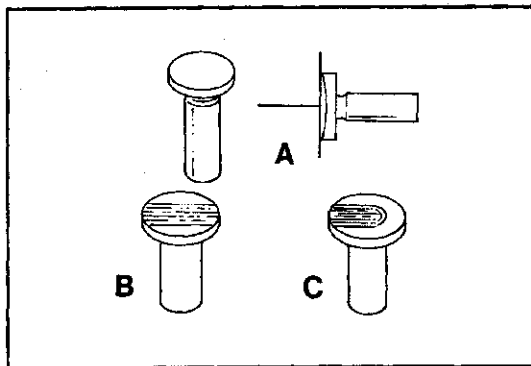




**Note:** Special care should be taken, when removing the Number 6 Cylinder tappets, not to knock or shake the tappet over the end barrier of the trough.



Carefully pull the trough and tappet from the cam bore and remove the tappet. Repeat the process until all tappets are removed.

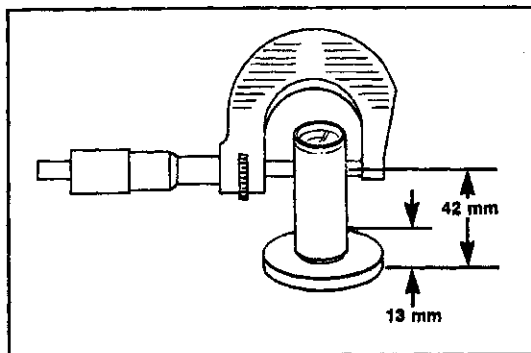


**Tappet Inspection**

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

Limits

- (A) - Normal wear
- (B) and (C) - Abnormal wear - Do not reuse



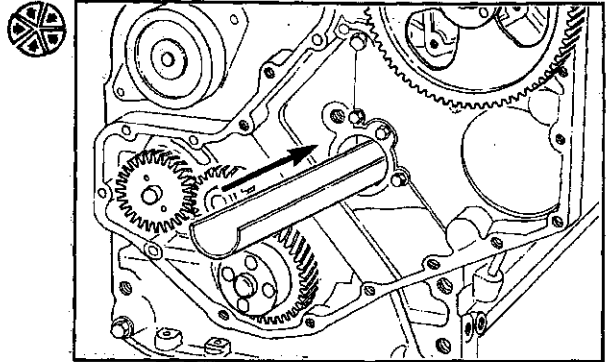
**Tappet stem specifications**

Limits

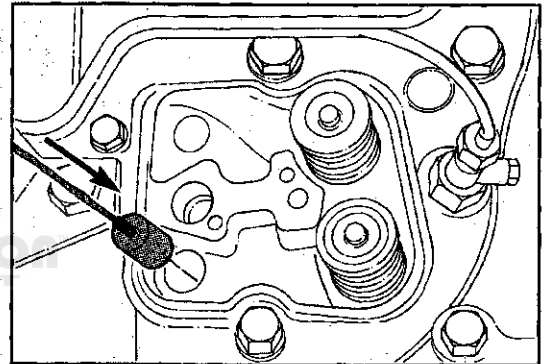
Minimum Diameter: 15.925mm [0.627 inch]

### Tappet Installation

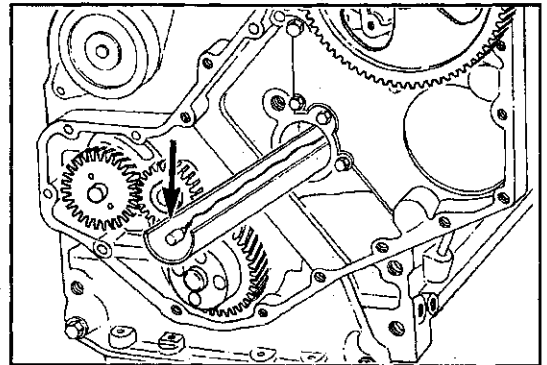
Insert the trough the full length of the cam bore:



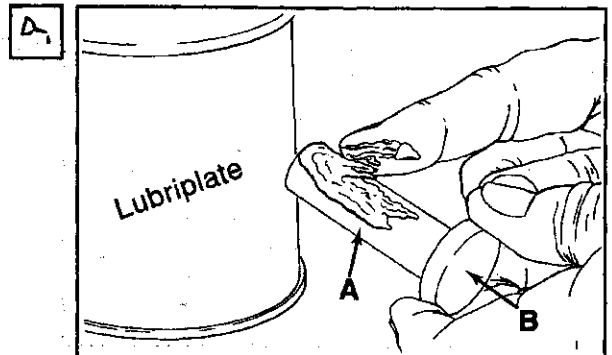
Feed the installation tool down the tappet bore and into the trough.



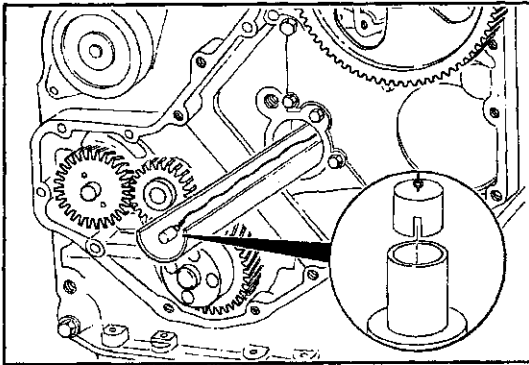
Feed the installation tool through the cam bores by carefully pulling the trough/installation tool out the front. The barrier at the rear of the trough will assure the tool will be pulled out with it.



Lubricate the tappets at locations A and B with Lubriplate 105.

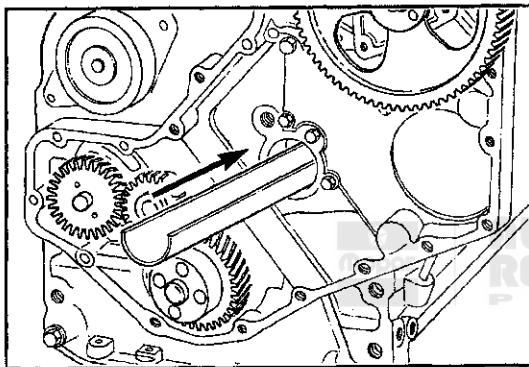




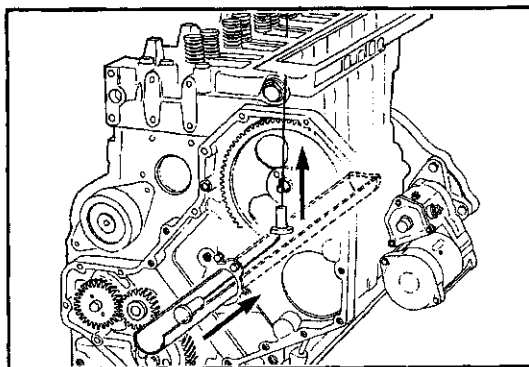


Insert the installation tool into the tappet.

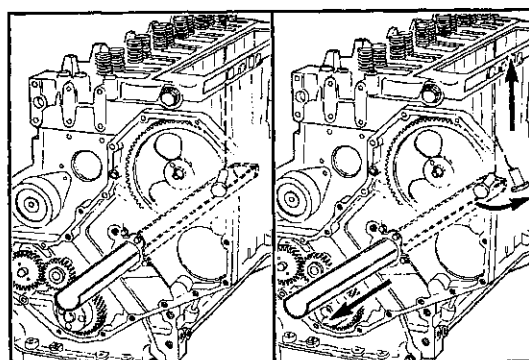
**Note:** To aid in removing the installation tool after the tappet is installed, work the tool in and out of the tappet several times before installing the tappets.



Place the tappet and tool in the trough and slide the trough back into the cam bore.

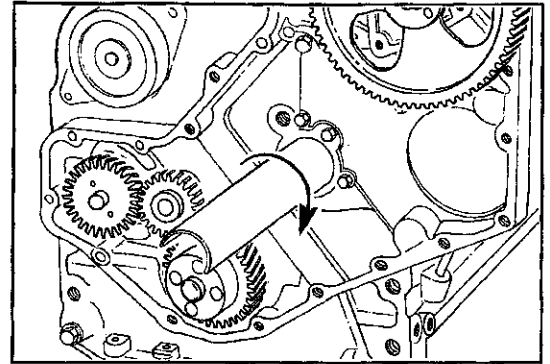


Pull the tool/tappet through the cam bore and up into the tappet bore.



**Note:** If difficulty is experienced in getting the tappet to make the bend from the trough up to the tappet bore (due to the webbing of the block), pull the trough out enough to allow the tappet to drop down and align itself, then pull the tappet up into the bore carefully.

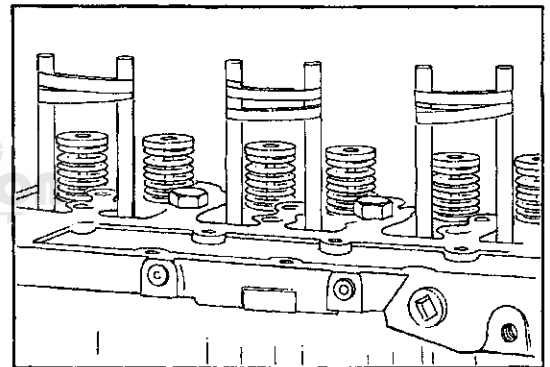
After the tappet has been pulled up into position, slide the trough back into the cam bore and rotate it 1/2 turn. This will position the round side of the trough up, which will hold the tappet in place.



Remove the installation tool from the tappet.

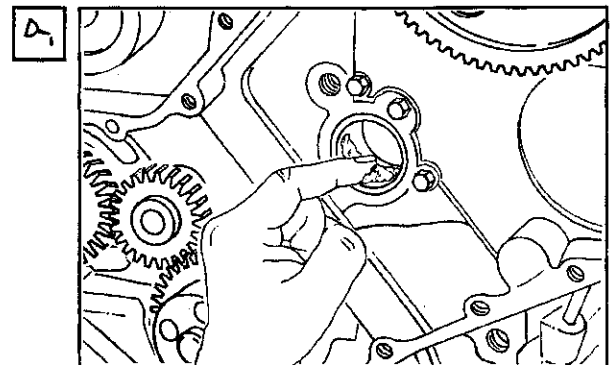
Install a wooden dowel into the top of the tappet and secure it with a rubber band.

Repeat this process until all tappets have been installed.

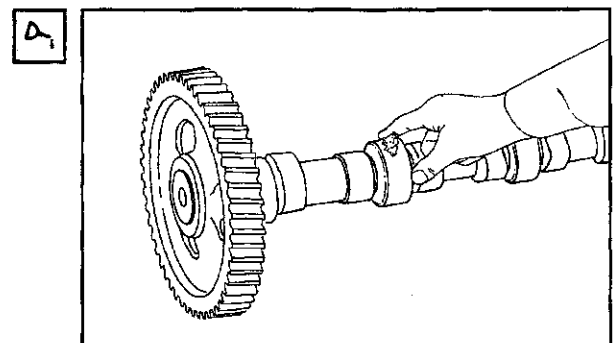


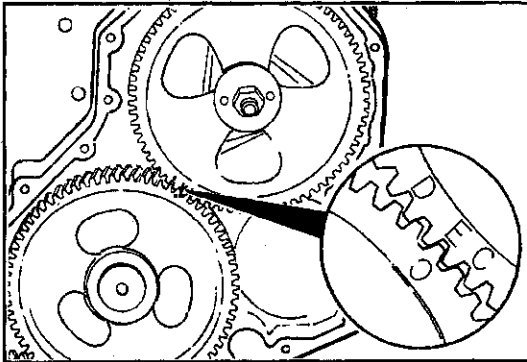
### Camshaft Installation

Apply a coat of Lubriplate 105 to the camshaft bores.



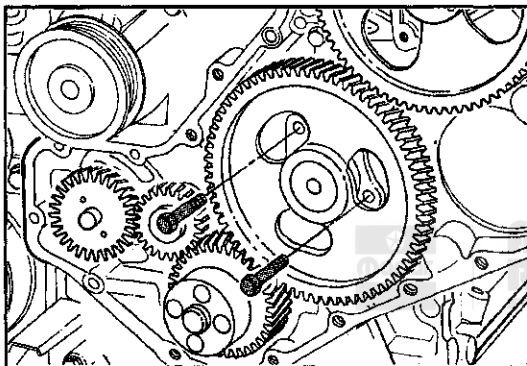
Lubricate the camshaft lobes, journals and thrust washer with Lubriplate 105.





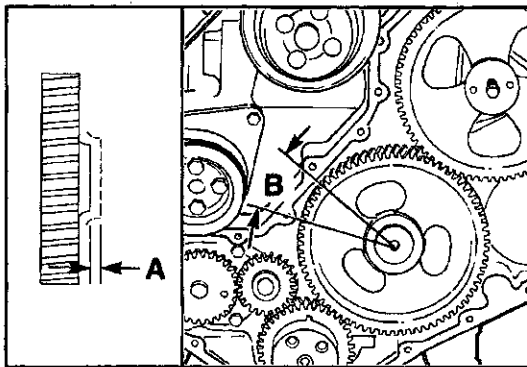
**Caution:** When installing the camshaft, do not push it in farther than it will go with the thrust washer in place. Pushing it too far can dislodge the plug in the rear of the cam bore and cause an oil leak.

Install the camshaft/thrust washer. Align the timing marks as illustrated.



13mm

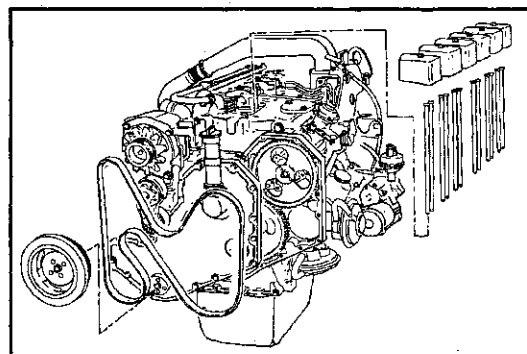
Install the thrust washer cap screws and tighten to 24 N·m [18 ft-lbs].



Verify the camshaft has the correct amount of back lash and end clearance.

A = 0.152 to 0.254mm [0.006 to 0.010 inch]

B = 0.08 to 0.33mm [0.003 to 0.013 inch]



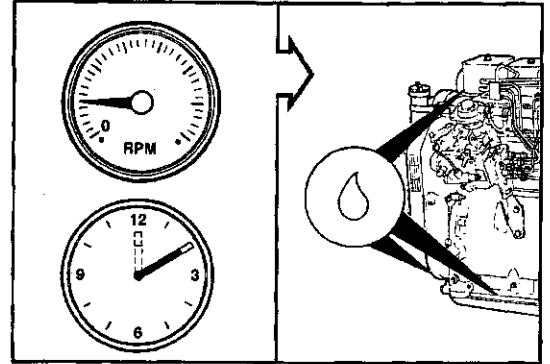
Install the following parts.



Refer to appropriate sections of this manual for torque sequence and values and for clearance specifications.

- Gear cover
- Vibration damper
- Rocker levers and valve cover
- Lift pump

- Operate the engine at idle for 5 to 10 minutes and check for leaks and loose parts.



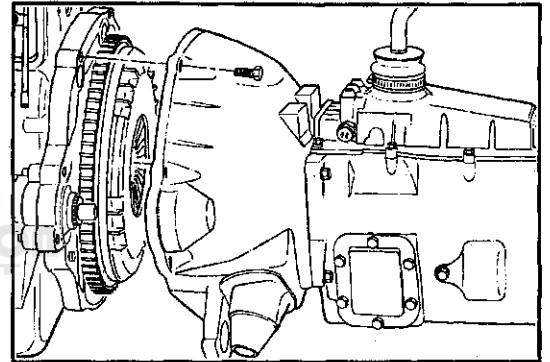
### Flywheel Ring Gear - Replacement

**Preparatory Step:**

- Remove the transmission.
- Remove the clutch cover.
- Remove the clutch plate.

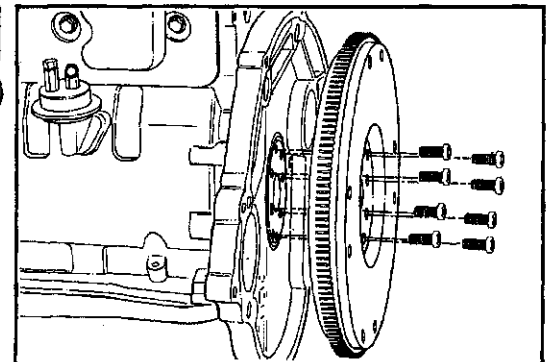


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19mm

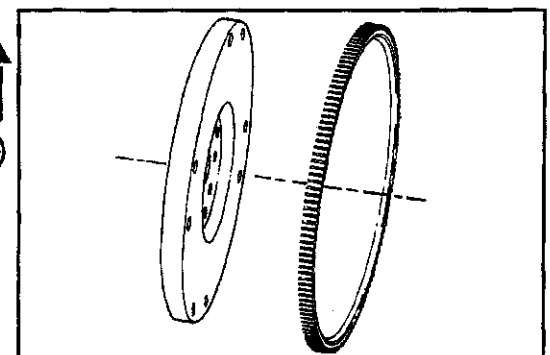
Remove the flywheel.

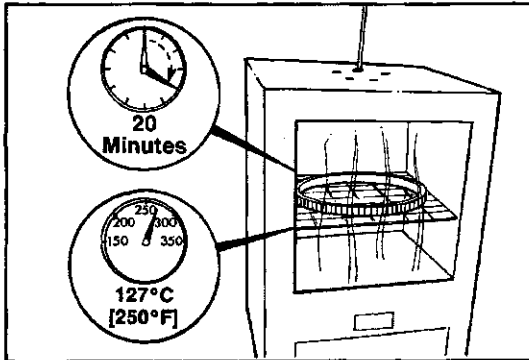


### Brass Drift Pin

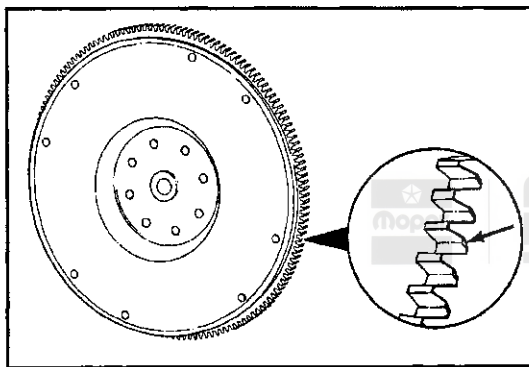
**Warning:** Wear eye protection when you drive the gear from the flywheel. Do not use a steel drift pin.

Use a drift pin to drive the ring gear from the flywheel. Strike the gear at several points around the wheel until it is off.



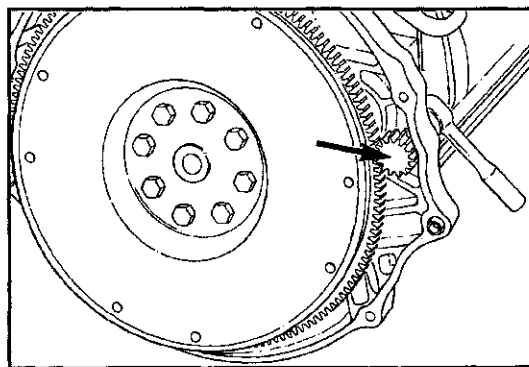


Heat the new ring gear for 20 minutes in an oven preheated to 127°C [250°F].



**Warning:** Wear protective gloves when you install the heated gear.

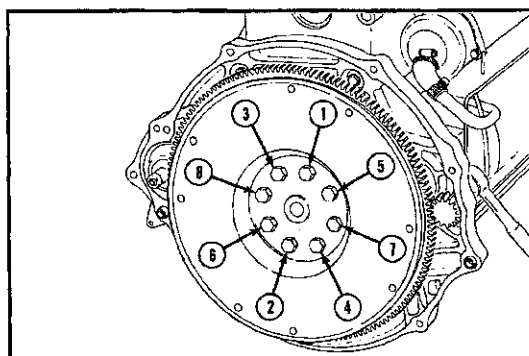
Install the gear. The gear must be installed so the bevel on the teeth is towards the crankshaft side of the flywheel.



### Flywheel - Installation

**Caution:** Never use the timing pin to hold the crankshaft in position.

Use the engine barring tool to hold the crankshaft when the flywheel capscrews are being tightened.



19mm Socket, Torque Wrench



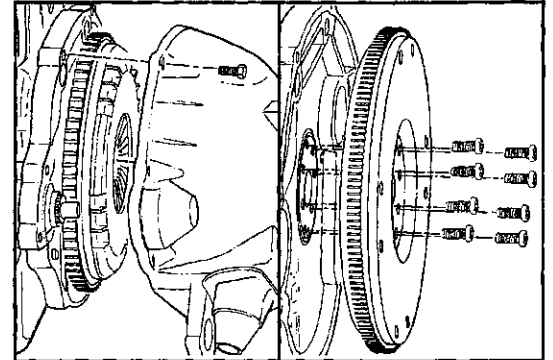
Tighten the capscrews in the sequence shown.

**Torque Value:** 137 N·m [101 ft-lbs]

## Rear Seal - Replacement

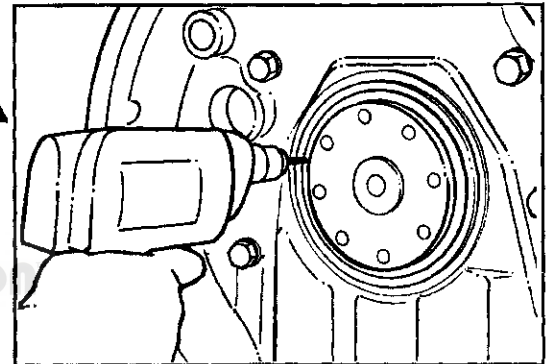
### Preparatory Step:

- Remove the transmission.
- Remove the clutch cover.
- Remove the clutch plate.
- Remove the flywheel.



### 1/8 Inch Drill

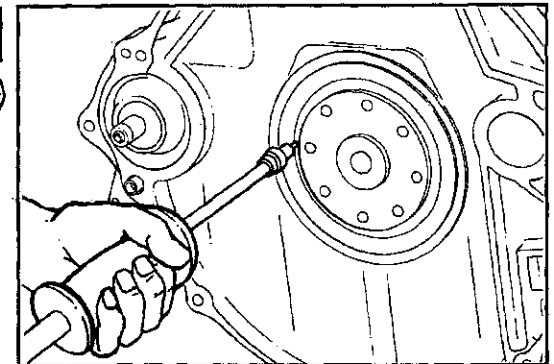
Drill holes 180 degrees apart into the seal. Be careful not to get the drill against the crankshaft.



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### No. 10 Sheet Metal Screw, Slide Hammer Dent Puller

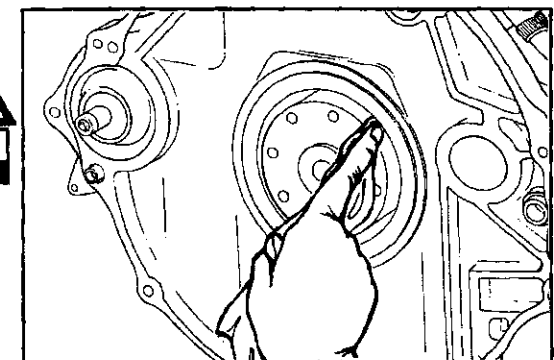
Remove the rear seal.

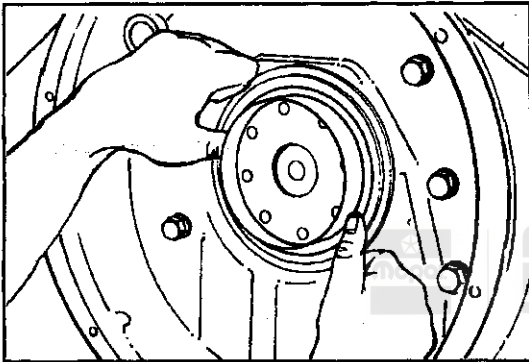


### Rear Seal - Installation

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

The crankshaft and seal must be dry when the seal is installed.



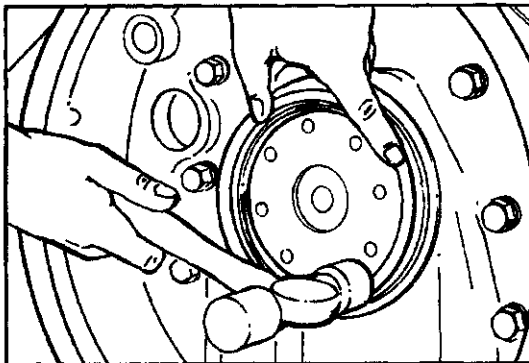


Install the seal pilot, provided in the replacement kit, on the crankshaft. Push the seal on the pilot and crankshaft.

Remove the seal pilot.

**Note:** Seal O.D. lubricant/sealant:

- Rubber O.D. rear crankshaft seals are lubricated with soapy water.
- Seals without rubber O.D. use Loctite 277, 11264 or no. 2654422 sealant.



Use the alignment tool to install the seal to the correct depth in the housing. Use a hammer to drive the seal into the housing until the alignment tool stops against the housing.

Hit the tool at the 12, 3, 6 and 9 o'clock positions to drive the seal evenly and prevent bending the seal housing.

## Out-of-Chassis Repairs - General

### Section 9G

The operations described in the next two Sections (9H and 9I) are considered out-of-chassis procedures and include those service repairs associated with the following engine parts and functions:

**Oil Pan**  
**Suction Tube**  
**Piston and Rod**  
**Cylinder Block and Bores**  
**Bearings**



**Crankshaft**  
**Crankshaft Gear**  
**Rear Crankshaft Seal Housing**  
**Gear Housing**  
**Timing Pin Installation (Head Off)**



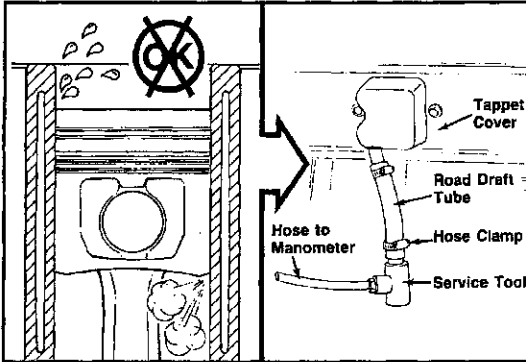


## Out-of-Chassis Diagnostic Procedures

### Section 9H

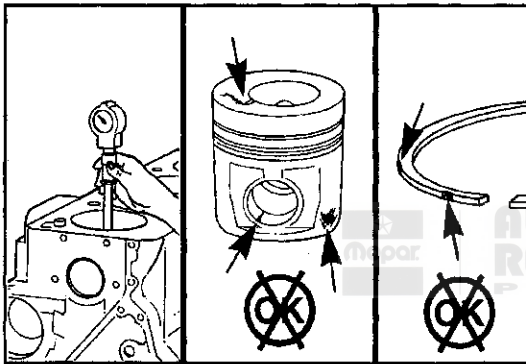
#### Contents

Subject	Page
Piston and Rod Assembly .....	9H-2
Crankshaft and Main Bearings .....	9H-4
Cylinder Block .....	9H-5

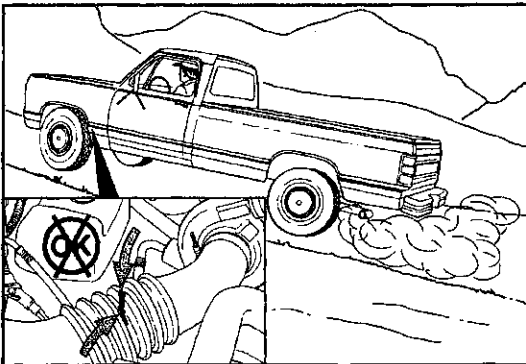


### Piston and Rod Assembly

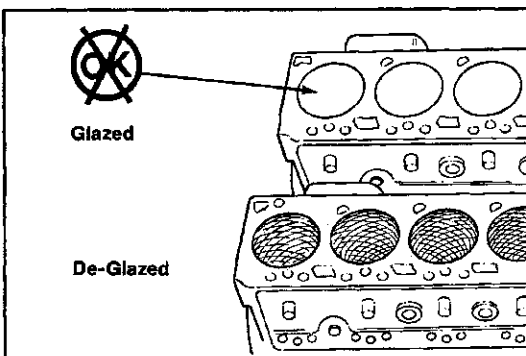
There are a number of power related problems including excessive oil consumption, smoke, blow-by and poor performance that can be caused by inadequate sealing between the piston rings and the cylinder walls. A blowby measurement can help detect the problem.



Verification of the damaged or worn component requires visual/dimensional inspection of rings, pistons and cylinder walls.

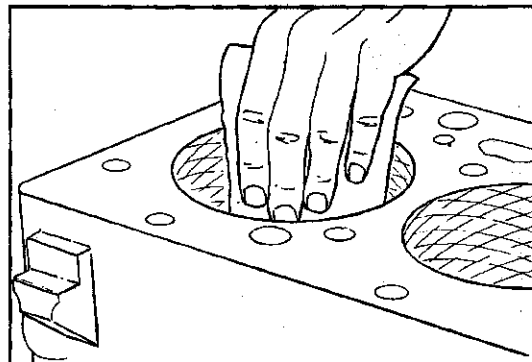


The cause of piston ring wear can range from wear over a long period of service to a dust-out in a short period of time because of poor maintenance of the air intake system.



During repair it is essential that the cylinder wall be de-glazed so that new rings will seat against the cylinder wall. Failure of the rings to seat can result in high blow-by and excessive oil consumption.

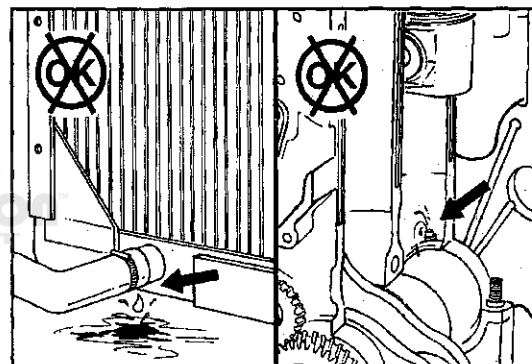
However, it is also critical that the cylinder walls be thoroughly cleaned after the de-glazing. Grit left in the cylinder wall will cause rapid wear out of the new rings leading to the previously discussed power problems.



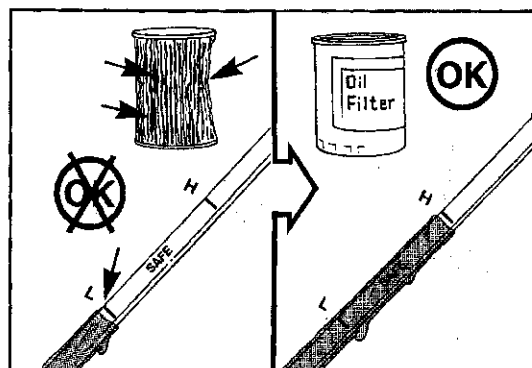
Overheating of the engine from a loss of coolant will cause the cylinder to overheat resulting in seizure of the piston.



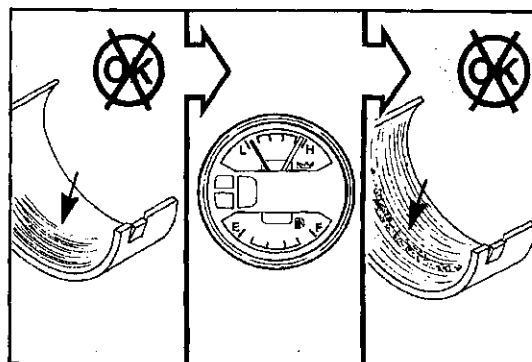
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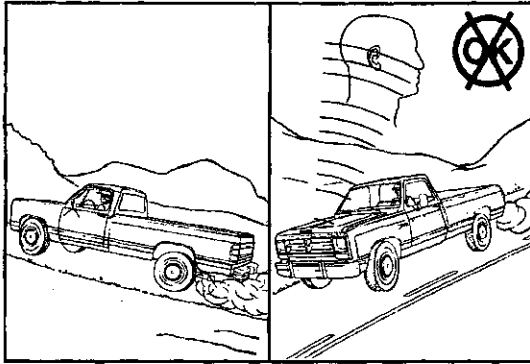



Improper maintenance of the lubrication system is the primary cause of reduced main bearing life.

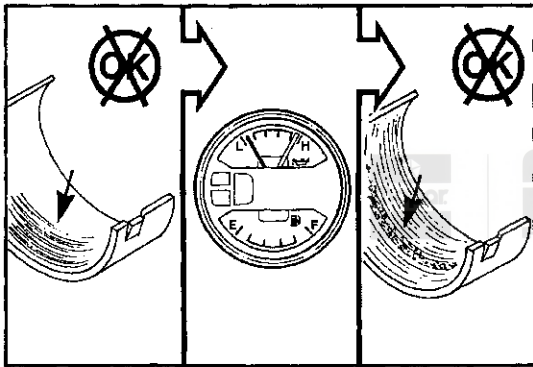


Reduced oil pressure may be an indication that bearings are wearing. If wear is allowed to continue, bearing clearances become excessive and the crankshaft will hammer on the bearings, causing a knocking sound.





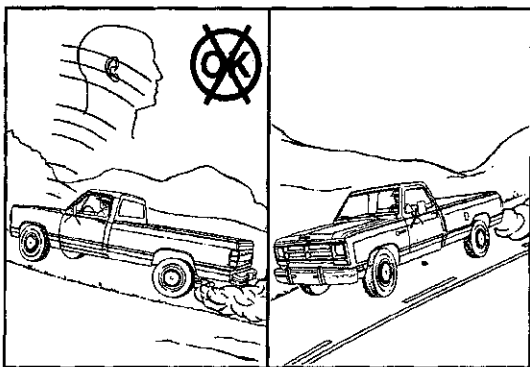
 A rod knock occurs when the engine is not loaded. Verify by first applying load and then unloading and listening for the knock.




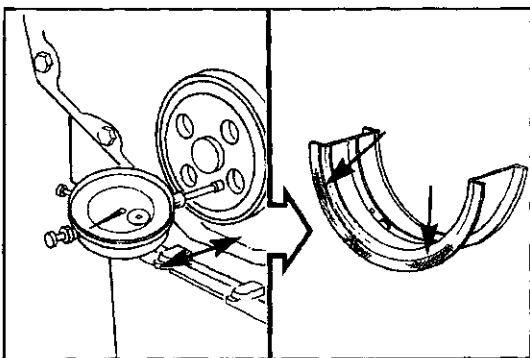
### Crankshaft and Main Bearings


Improper maintenance of the lubrication system is the primary cause of reduced main bearing life.

A malfunction of the crankshaft main bearing will usually be detected by reduced oil pressure. As with rod bearings, continued operation with low oil pressure will lead to a rapid deterioration of the bearings and eventually will produce a knocking sound.

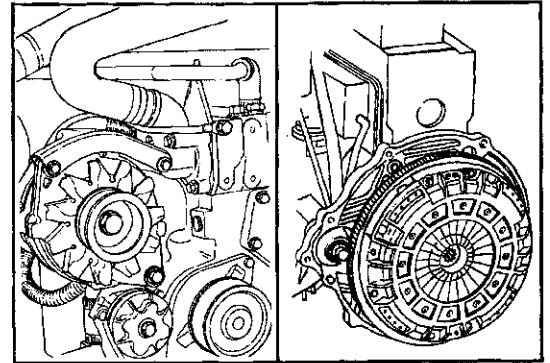


 An excessively worn main bearing will be heard when the engine is loaded.



 A damaged or worn thrust bearing flange of the upper main bearing shell can be detected by measuring the end play of the crankshaft.

Failures of driven units at the front or rear of the engine which increase the end loading can damage the thrust bearing.

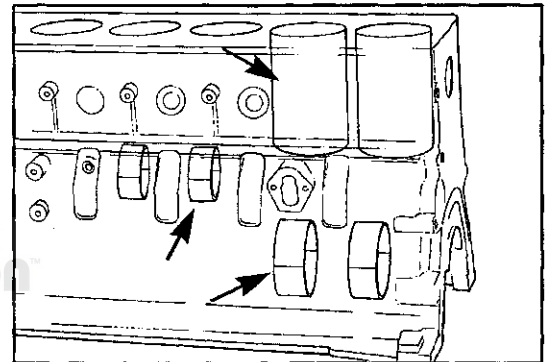


### Cylinder Block

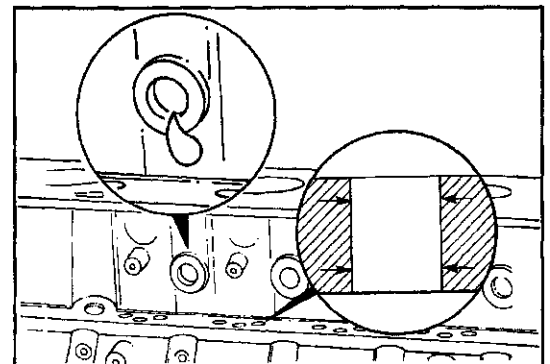
Diagnosis of cylinder block malfunctions relative to cooling and lubrication have been discussed in those respective system Sections. The potential problems with the cylinders, the camshaft bore and the crankshaft main journals have also been discussed in this section.



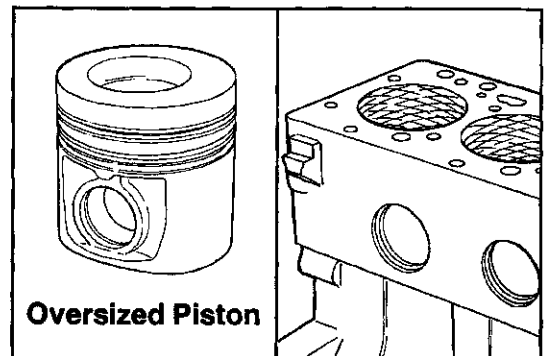
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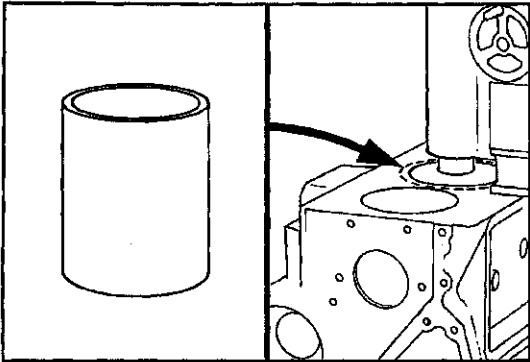



Malfunctions of the block such as leaks, tappet bore wear, etc. require a visual or dimensional inspection to isolate the problem.



The cylinder bores are machined directly into the block during production. The size and condition of the bore is critical to engine performance and life. During repair, be sure to inspect the bore carefully. It may also be necessary to de-glaze the cylinder walls before reassembly.



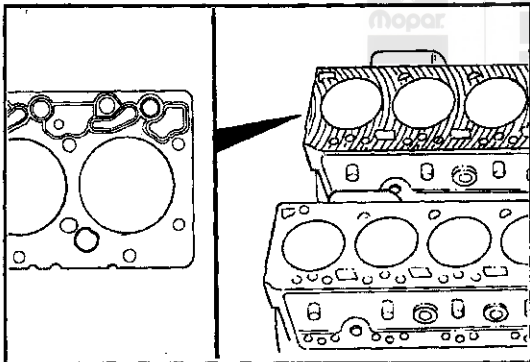



 The cylinder bores can be rebored in a machine shop and fitted with oversize service pistons.

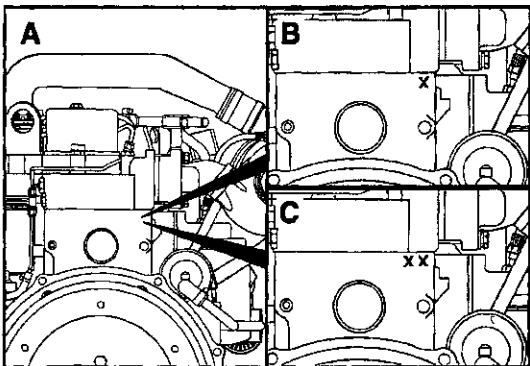
There are two oversize pistons: .50mm [0.020 inch]  
1.00mm [0.040 inch]

There is also a sleeve available for salvage.

**Note:** Refer to Section 9K - Alternative Repair for procedures.



 **Note:** The head surface of the block is also critical to sealing the bores. Inspect the surface carefully during repair before assembly. The head deck can be resurfaced in a machine shop and a thicker surface head gasket installed to keep the piston-to-head clearance the same.



After machining, mark the block as follows:



Machining	Mark
A - Standard	None
B - 0.15mm [0.006 inch]	X
C - 0.50mm [0.020 inch]	XX

**Note:** Refer to Section 9K - Alternative Repair for procedures.

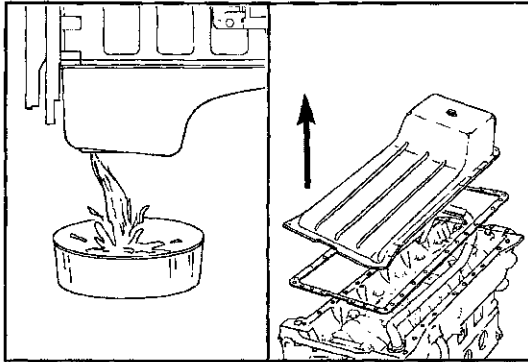
## Out-of-Chassis Repairs

### Section 9I

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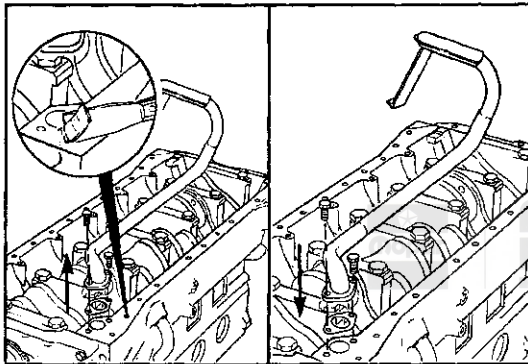


### Oil Pan, Suction Tube and/or Gasket - Replacement

17mm, 10mm

**Note:** This operation will require engine removal.

Drain the oil and remove the pan and gasket.



10mm, 13mm



**Caution:** Be sure to connect the support bracket.



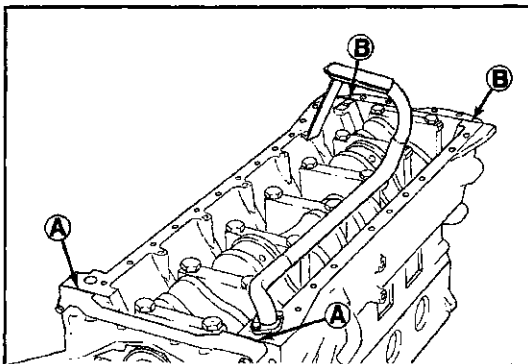
If required, remove the suction tube and gasket.



Clean the sealing surface.



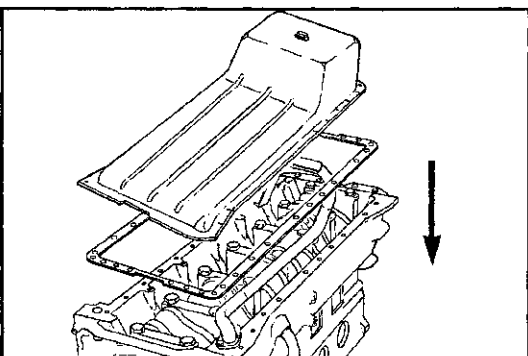
**Torque Value:** 24 N·m [18 ft-lbs]



**Caution:** Be sure to fill the joint between the pan rail, gear housing and rear cover with sealant. Use Three Bond 1207-C.

**Sealing Area:**

- A - Pan rail to gear housing
- B - Pan rail to rear cover



10mm



Install the pan and gasket.

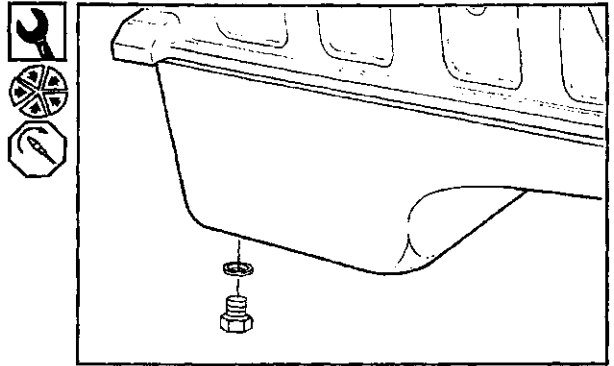


**Torque Value:** 24 N·m [18 ft-lbs]

17mm

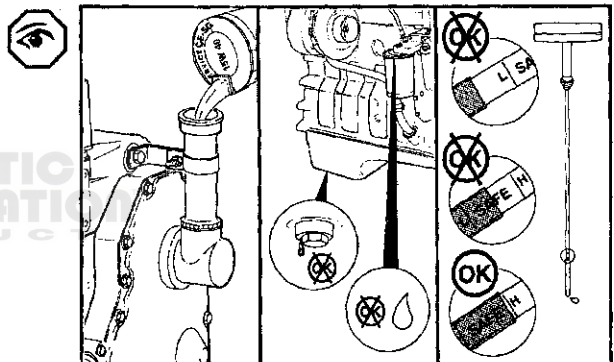
Install the drain plug.

Torque Value: 80 N-m [60 ft-lbs]



Fill the engine with oil. Run the engine and check for leaks.

Stop the engine and let it set for five minutes. Check the oil level with the dipstick.

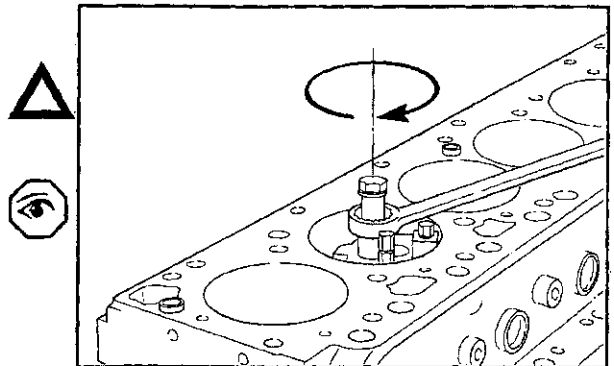


### Piston and Rod Assembly – Removal

**Caution:** Make sure the ridge reamer does not make a deep cut into the bore. Do not remove more metal than is necessary to remove the ridge.

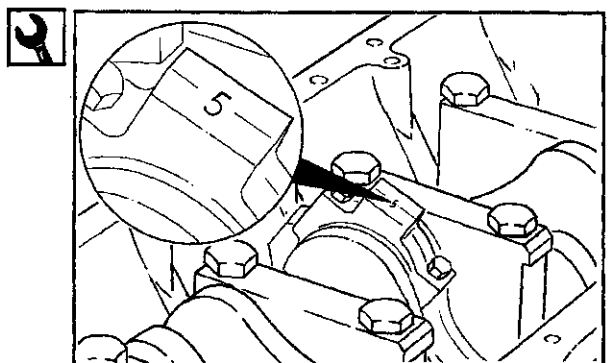
If the cylinder bores have ridges, use a ridge reamer to cut the ridge from the top of the cylinder bore before removing the piston.

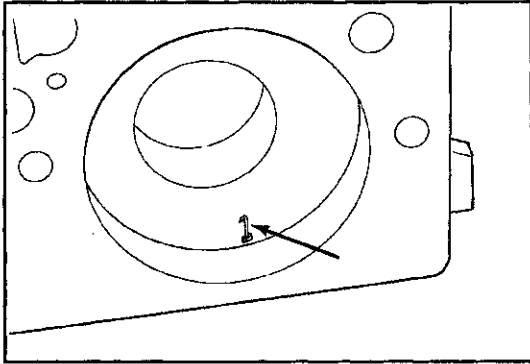
**Note:** If cylinders have ridges, the cylinders are oversize and will need reboring.



### Hammer, Steel Number Stamps

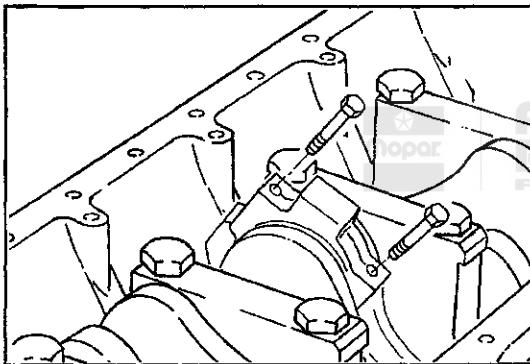
Mark the cylinder number onto each connecting rod cap.





**Hammer, Steel Number Stamps**

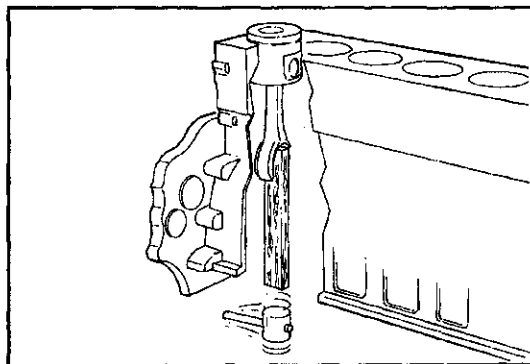
Mark the cylinder number onto the top of each piston.



**12mm**



Remove the connecting rod capscrews and rod caps.

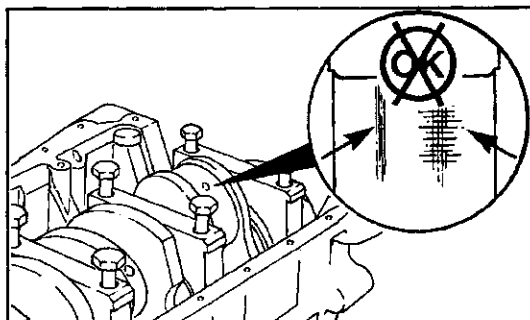


**Caution: Use care so the cylinder bores and connecting rods are not damaged.**



Use a hammer handle or similar object to push the piston and connecting rod through the cylinder bore.

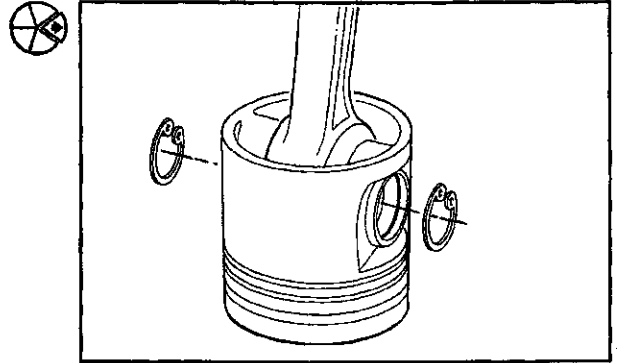
Store the piston/rod assemblies in a rack.



Inspect the rod journals for deep scratches, indications of overheating and other damage.

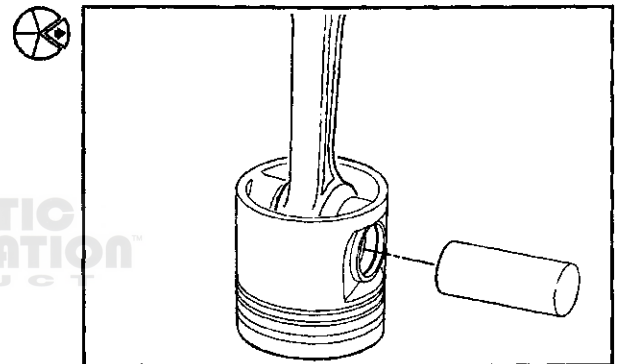
### Piston and Rod - Disassembly

Remove the retainer rings from the piston.

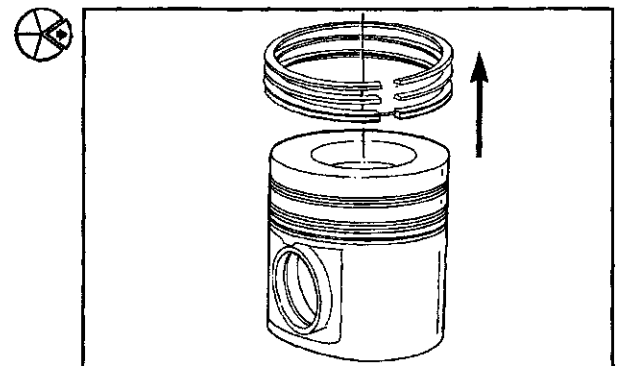


Remove the piston pin.

**Note:** Heating the piston is not required.



Remove the piston rings.

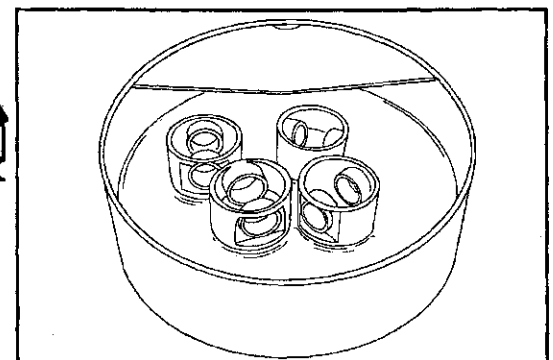


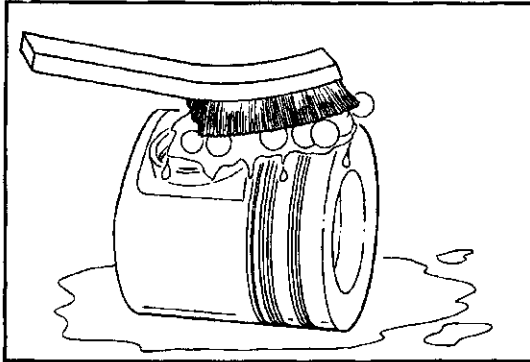
### Piston, Pin and Connecting Rod - Clean

**Caution:** Do not use bead blast to clean the pistons.

Soak the pistons in cold parts cleaner.

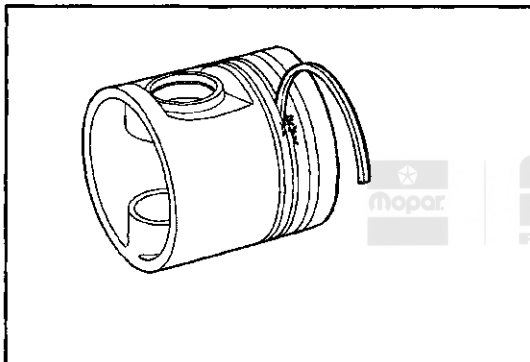
Soaking the pistons overnight will usually loosen the carbon deposits.





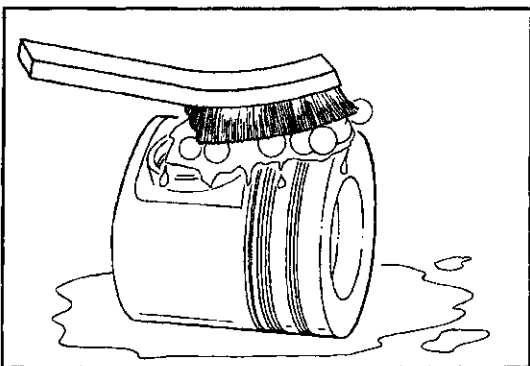
**Caution: Do not clean the pistons and rods in an acid tank.**

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



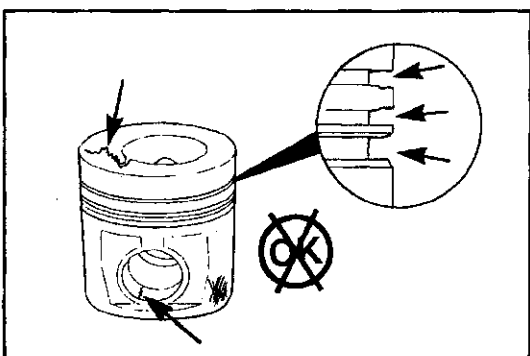
**Caution: Do not use a ring groove cleaner and be sure not to scratch the ring sealing surface in the piston groove.**

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

Rinse the pistons. Use compressed air to dry.



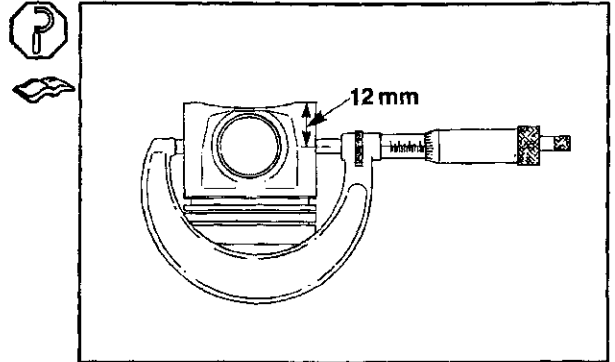
**Piston, Pin and Rod - Inspection**

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

Measure the piston skirt diameter as illustrated.

**Minimum Diameter:** 101.823mm [4.0088 inch]

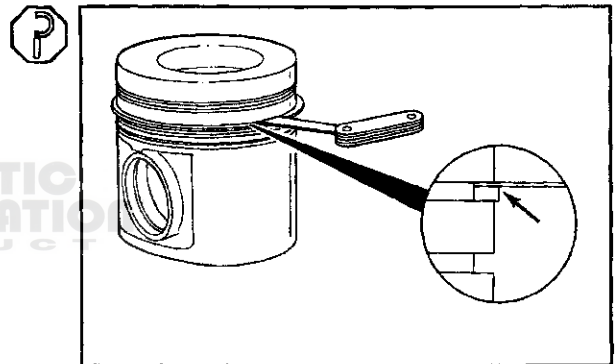
**Note:** Refer to the limits for the oversize pistons.



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

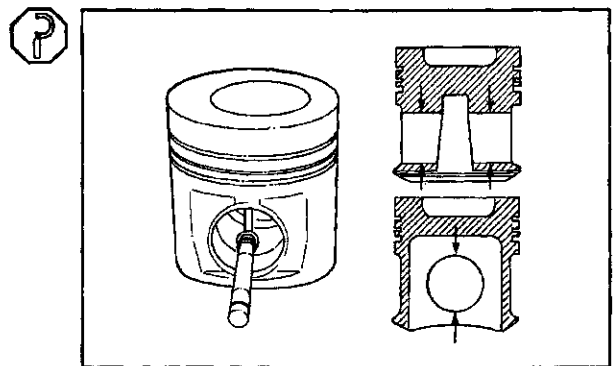
**Maximum Clearance** - The upper groove only needs to be inspected for damage. Check the clearance as shown with a new ring and feeler gauge. If the clearance of the intermediate ring exceeds .150mm [0.006 inch] replace the piston.

If the clearance in oil groove exceeds .130mm [.005 inch], replace the piston.



Measure the pin bore.

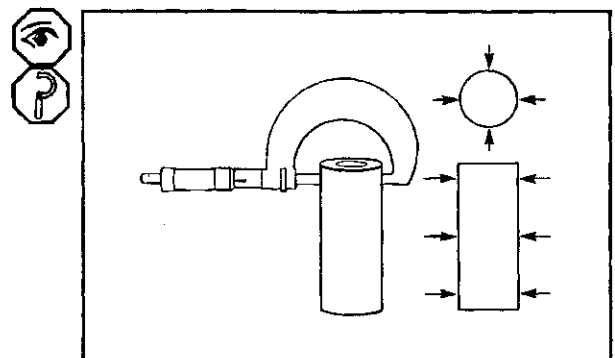
**Maximum Diameter** - 40.025mm [1.5758 inch]

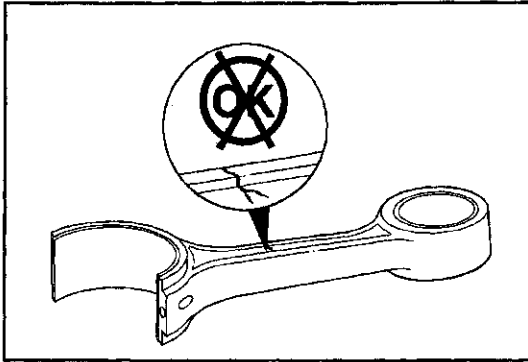


Inspect the piston pin for nicks, gouges and excessive wear.

Measure the pin diameter.

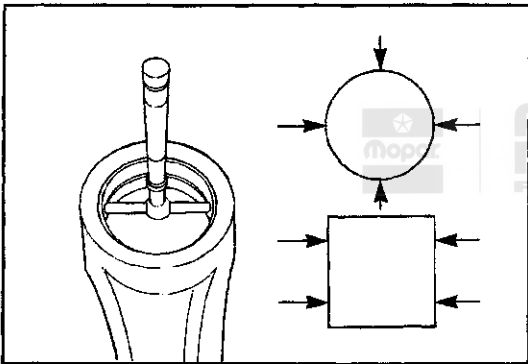
**Minimum Diameter** - 39.990mm [1.5744 inch]





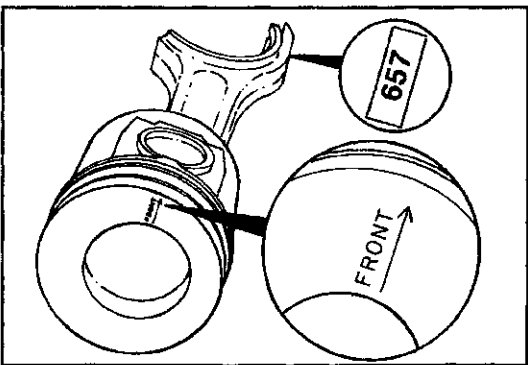
**Caution:** The I-Beam section of the connecting rod cannot have dents or other damage. Damage to this part can cause stress risers which will progress to breakage.

Inspect the rod for damage and wear.



Measure the pin bore.

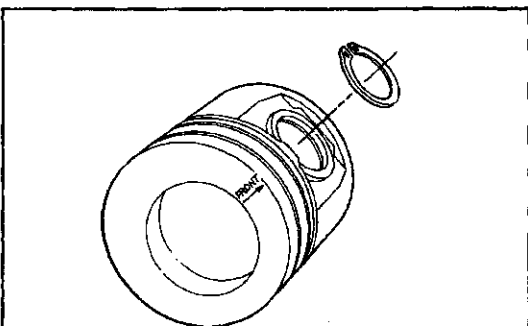
**Maximum Diameter - 40.053mm [1.5769 inch]**



### Piston and Rod - Assembling

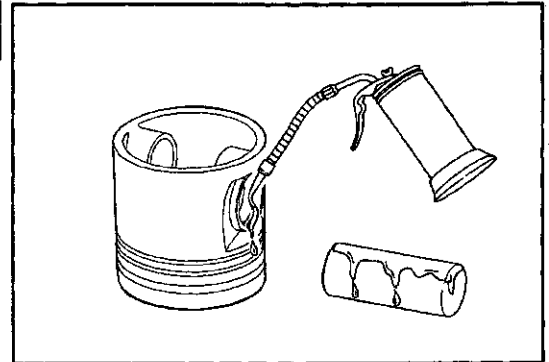


**Caution:** Be sure the "Front" marking on the piston and the numbers on the rod and cap are oriented as illustrated.



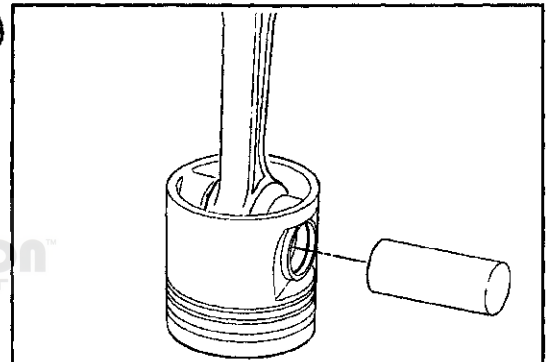
Install the retaining ring into the pin groove on the "Front" side of the piston.

Lubricate the pin and bore with engine oil.



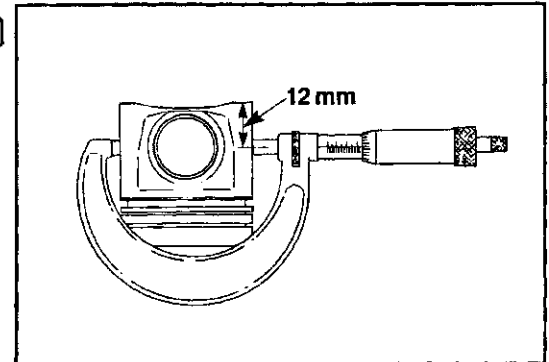
Install the pin.

**Note:** Pistons do not require heating to install the pin, however, the piston does need to be at room temperature or above.



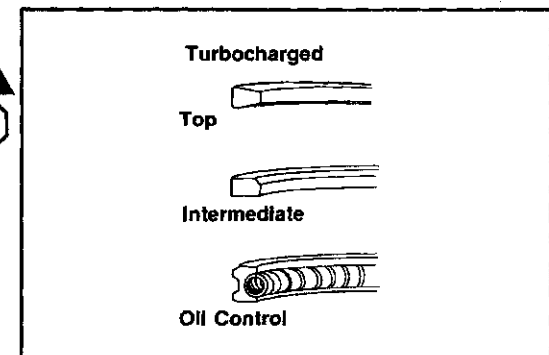
AUTHENTIC  
RESTORATION  
PRODUCT

Determine the piston diameter and obtain the appropriate ring set.

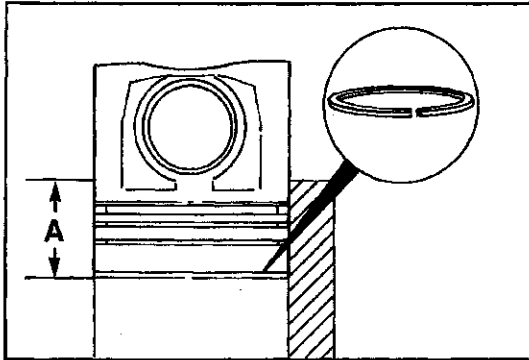



Piston Ring Gap - Check

**Caution:** Be sure the rings look like the illustration.

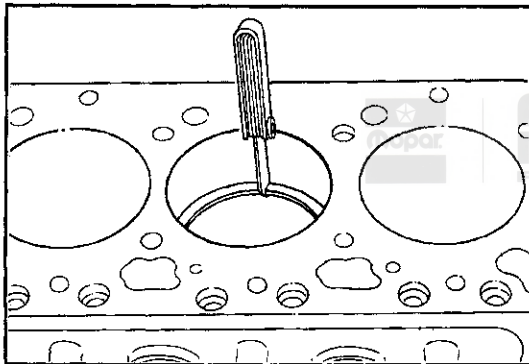






 Position each ring in the cylinder and use a piston to square it with the bore.

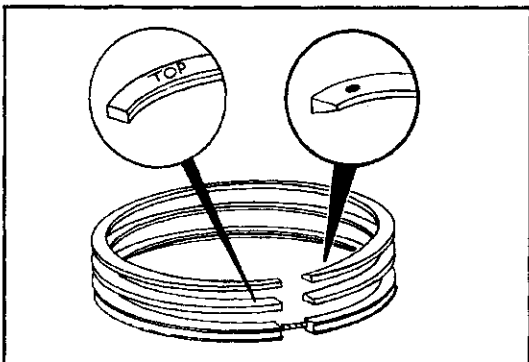
A = 89mm [3.5 inch]



 Use a feeler gauge to measure the gap.

Limits:

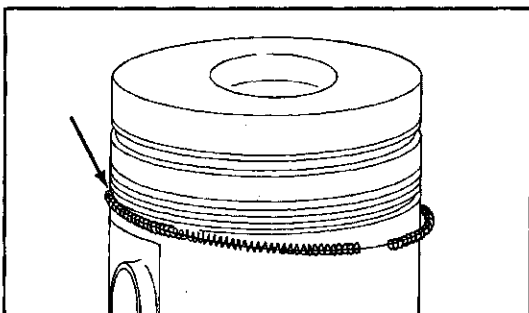
Ring	Minimum	Maximum
Top	0.4mm [0.0160 inch]	0.70mm [0.0275 inch]
Intermediate	0.25mm [0.0100 inch]	0.55mm [0.0215 inch]
Oil Control	0.25mm [0.0100 inch]	0.55mm [0.0215 inch]



 **Piston Rings – Installation**

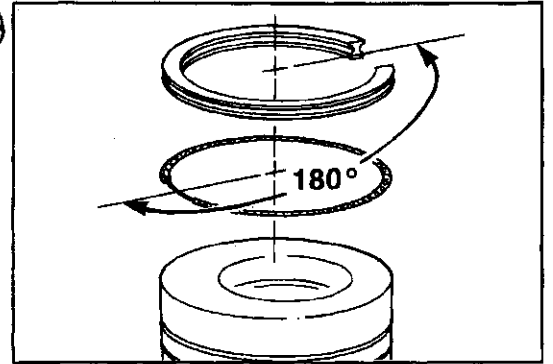
**Note:** The top surface of all of the rings are identified with the word "Top" or the suppliers "Mark".

Assemble the rings with the word "Top" or "Mark" up.

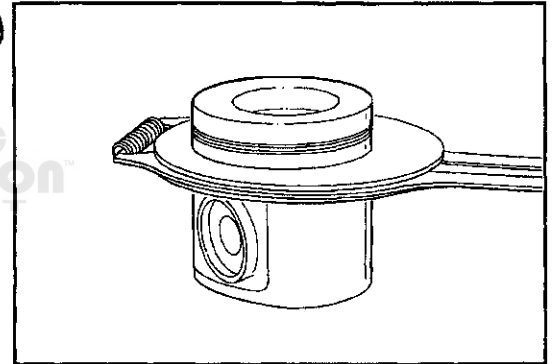


 Position the oil ring expander in the oil control ring groove.

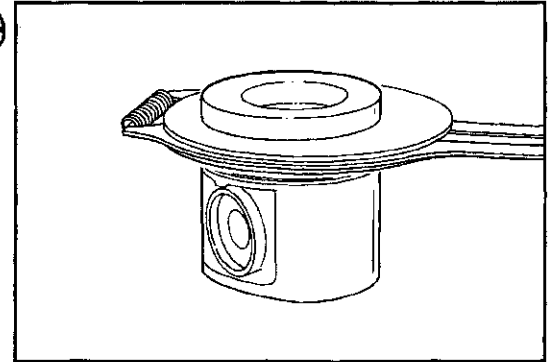
Install the oil control ring with the end gap opposite the ends on the expander.



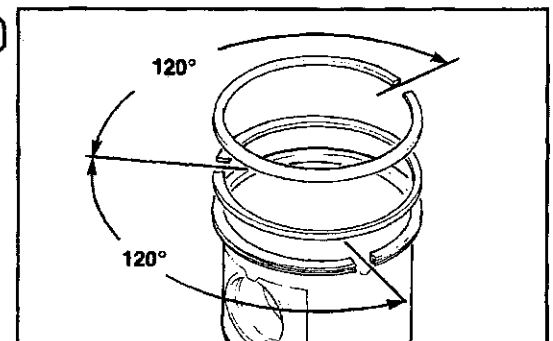
Install the intermediate ring.



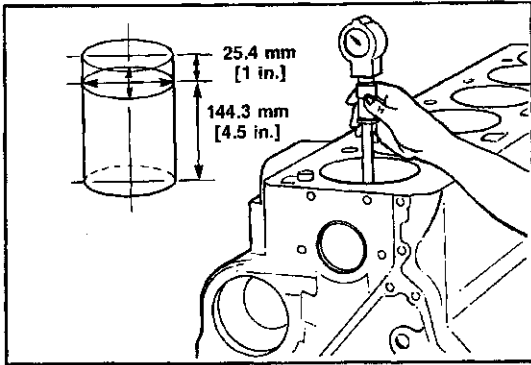
Install the top ring.



Position the rings as shown in the illustration.



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### Cylinder Block - Inspect



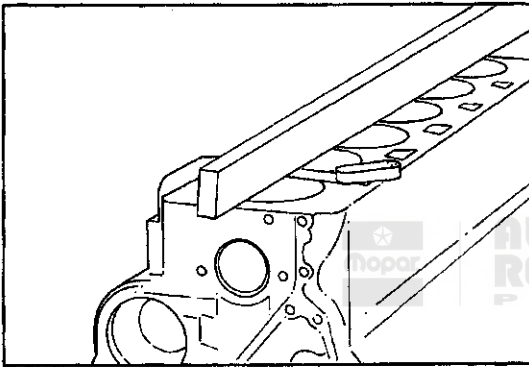
Inspect the cylinder bores for damage or excessive wear.

Measure the cylinder bores.

Diameter		
mm		in
102.000	MIN	4.0157
102.116	MAX	4.0203

**Out-of-Roundness:** .038mm [.0015 inch] **Taper:** 0.76mm [.003 inch]

**Note:** Oversize pistons and rings are available for re-bored cylinder blocks.

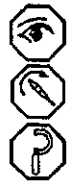
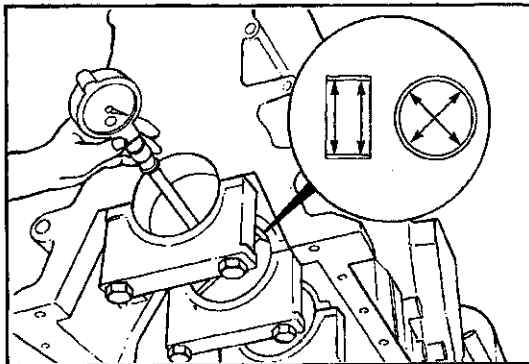


### Straight Edge, Feeler Gauge



The distortion of the combustion deck face is not to exceed 0.010mm [.0004 inch] in any 50.00mm [2.0 inch] diameter. Overall variation end to end or side to side .075mm [.003 inch].

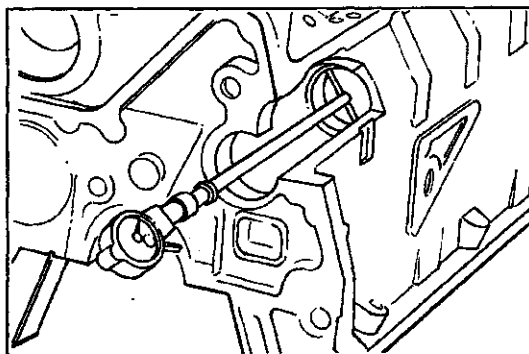
If the surface exceeds the limit, refer to the Alternative Repair section of this manual.



Inspect the main bearing bores for damage or abnormal wear.

If required, install the main bearings and measure main bearing bore diameter with main bolts tightened to 176 N·m [130 ft-lbs]. Record the measurement for later reference.

Standard Bearing Diameter		
	MAX	
83.106		3.2719



Inspect the camshaft bores for scoring or excessive wear.

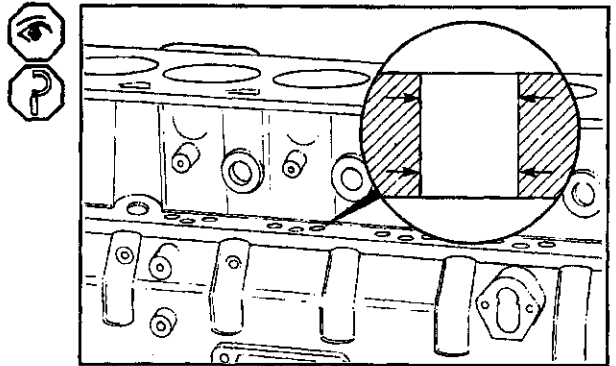
Measure the camshaft bores. The limit for the No. 1 bore applies to the ID of the bushing.

Diameter		
	MAX	
54.133		2.1312

**Note:** If a bore exceeds the limit, refer to Alternative Repair Section of this manual.

Inspect the tappet bores for scoring or excessive wear.

Diameter		
mm		In
16.055	MAX	0.632

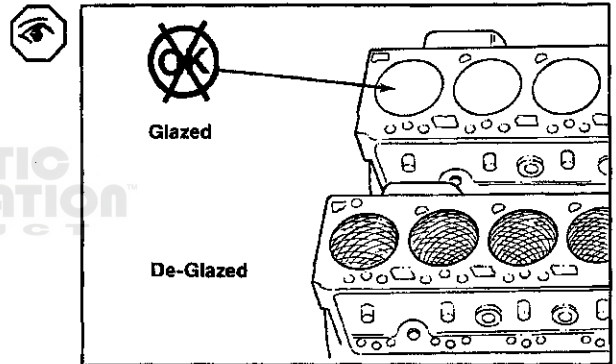


### Cylinder Bores - De-Glaze

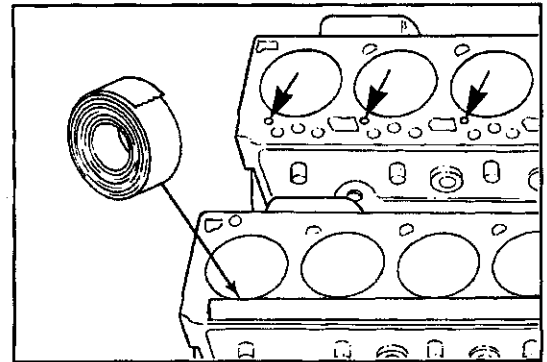
**Note:** New piston rings may not seat in glazed cylinder bores.

De-glazing gives the bore the correct surface finish required to seat the rings. The size of the bore is not changed by proper de-glazing.

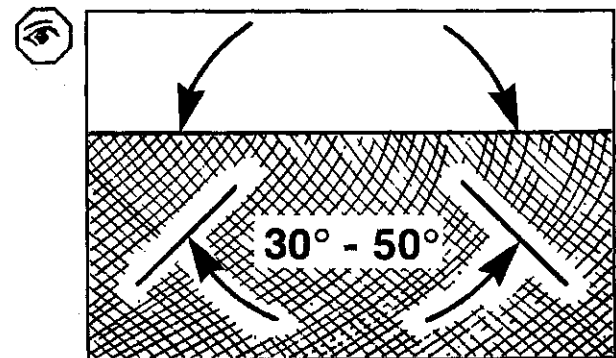
**Note:** Completely disassemble engine before de-glazing cylinders.

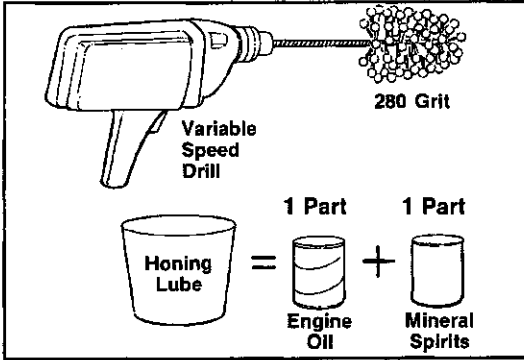


Cover the lube holes in the top of the block with waterproof tape.

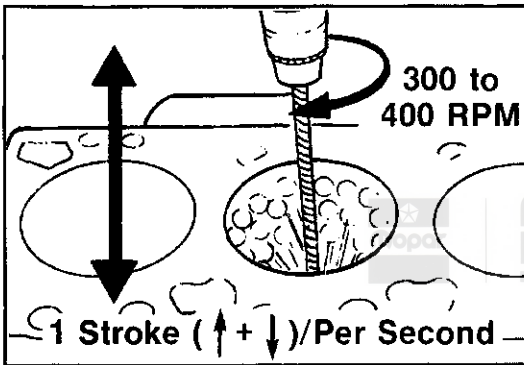


A correctly de-glazed surface will have a crosshatch appearance with the lines at 15 to 25 degree angles with the top of the cylinder block. 30 to 50 degrees indicates angles on crosshatch.

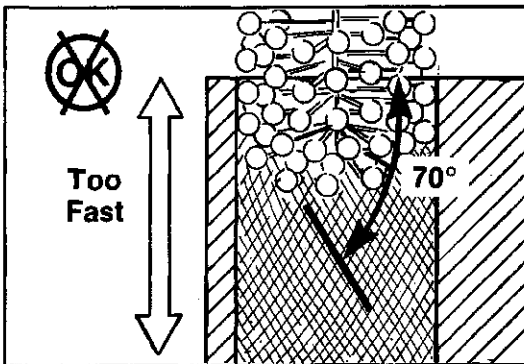




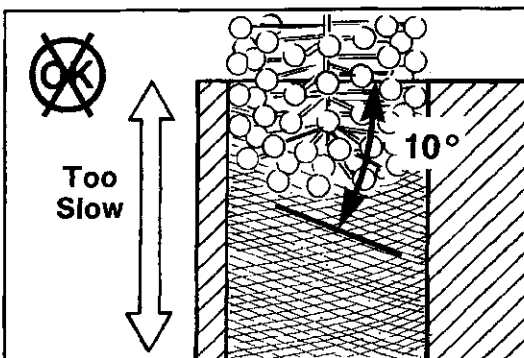
Use a drill, a fine grit Flexi-Hone and a mixture of equal parts of mineral spirits and SAE 30W engine oil to de-glaze the bores.



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



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

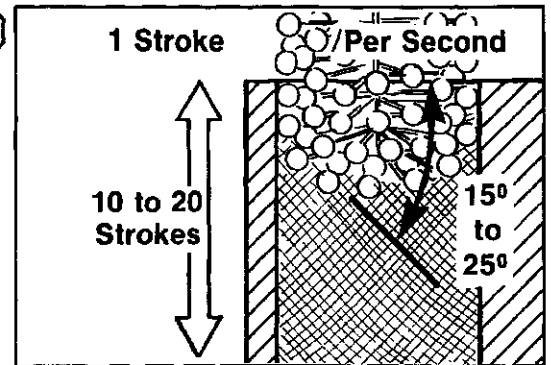


This illustration shows the result of the drill speed **too fast** or the vertical stroke **too slow**.

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



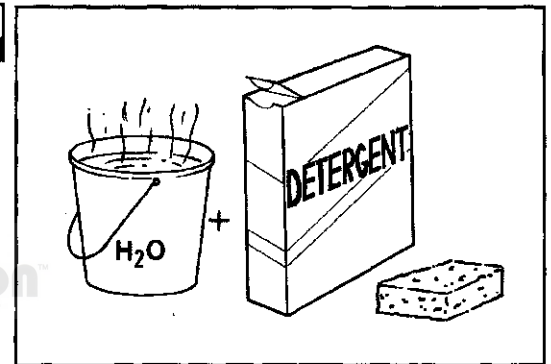
Inspect the bore after 10 strokes.



Use a strong solution of hot water and laundry detergent to clean the bores.



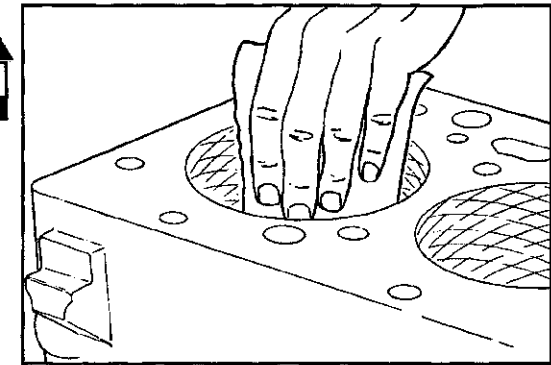
Since a large volume of water must be used to rinse the bores, position the block over or close to a floor drain.



**Caution:** Clean the cylinder bores immediately after deglazing.



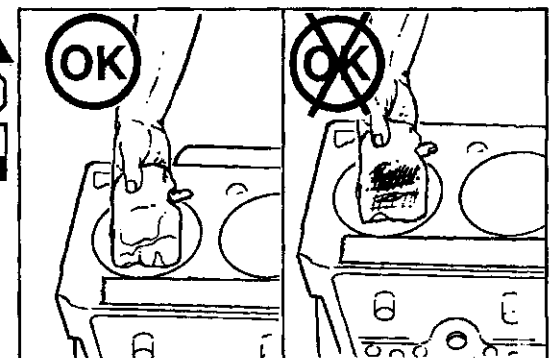
Rinse the bores until the detergent is removed and blow the block dry with compressed air.

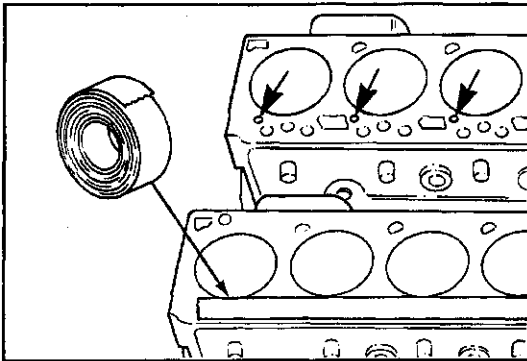


**Caution:** Be sure to remove the tape covering the lube holes after the cleaning process is complete.

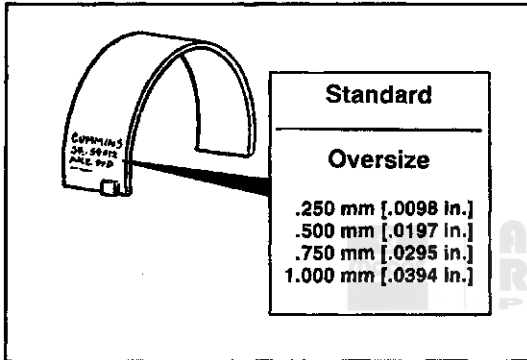


Check the bore cleanliness by wiping with a white, lint free, lightly oiled cloth. If grit residue is still present, repeat the cleaning process until all residue is removed. Wash the bores and the complete block assembly with solvent and dry with compressed air.





Remove the protective tape from the block surface.

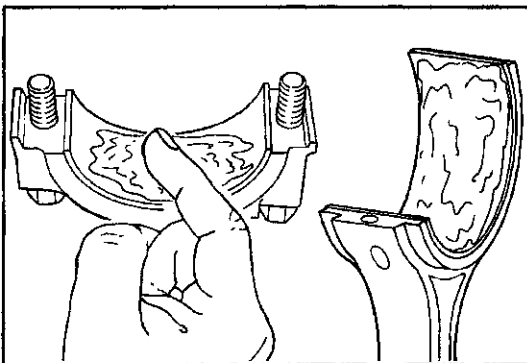


### Connecting Rod Bearing - Install



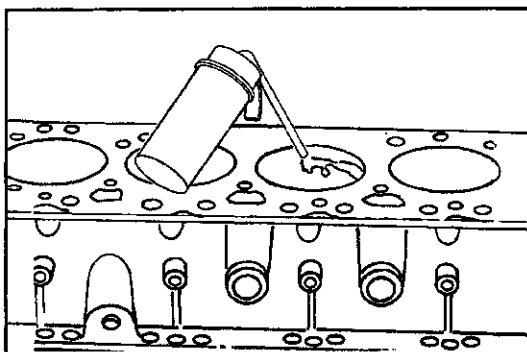
Determine the size of the bearing removed and obtain the same size bearing for installation.

Refer to the dimensions of the standard and undersize connecting rod bearing journals.



**Caution:** Do not lubricate the side of the bearing that is against the connecting rod or cap.

Apply a coat of Lubriplate 105 to the new upper and lower connecting rod bearings.



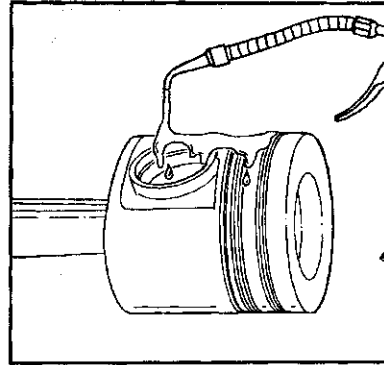
### Piston and Rod Assembly - Installation

Lubricate the cylinder bore with clean engine oil.

Base Engine Components  
DODGE Turbo Diesel

Out-of-C

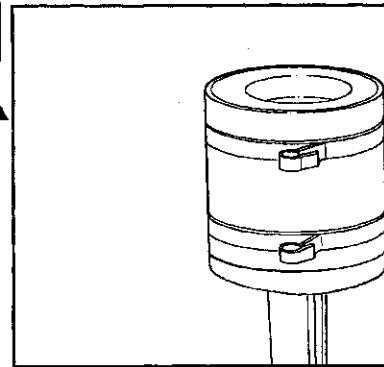
Generously lubricate the rings and piston skirts with clean engine oil.



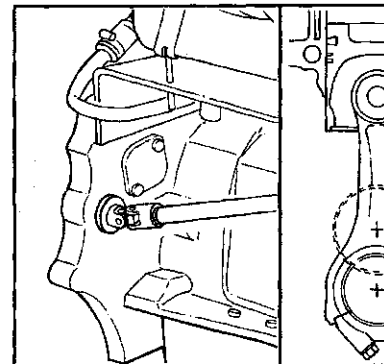
75 to 125mm Ring Compressor

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.

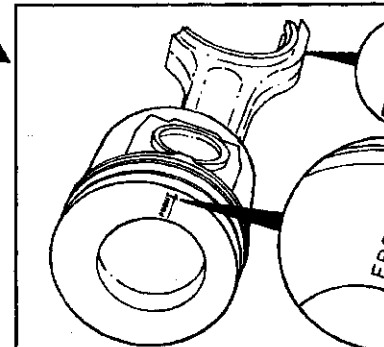
Compress the rings.



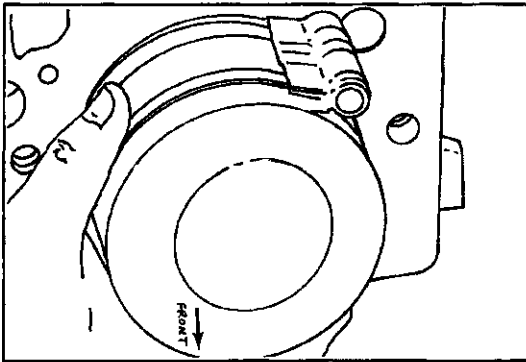
Bar the crankshaft so the rod journal for the piston to be installed is at BDC (Bottom Dead Center).




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

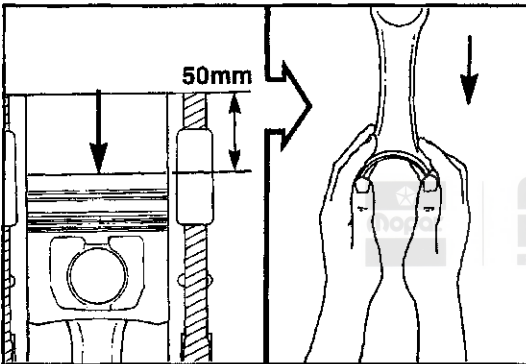





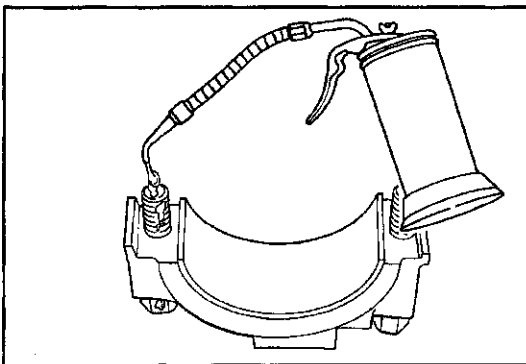



 **Caution:** Use care when you install the piston and connecting rod so the cylinder bore is not damaged.

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

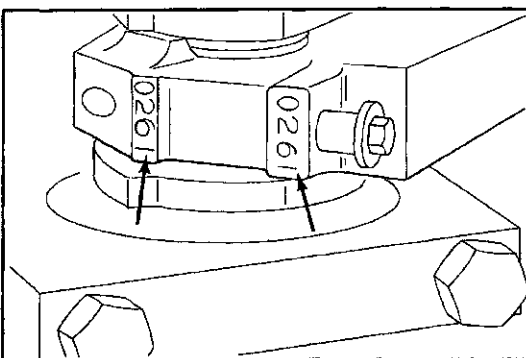



 Push the piston into the bore until the top of the piston is approximately 50mm [2 inch] below the top of the block. Carefully pull the connecting rod onto the crankshaft journal.



 **Note:** The following series of illustrations show the engine in a vertical position. This is for clarity of illustration only.

Use clean engine oil to lubricate the threads and under the heads of the connecting rod capscrews.



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

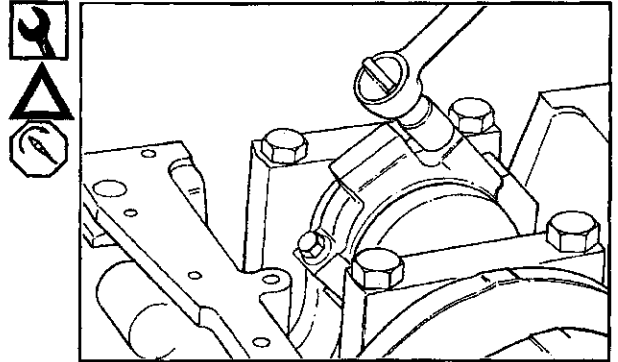
Install the rod cap and capscrews to the connecting rod.

12mm Socket, Torque Wrench

**Caution:** Tighten the connecting rod and capscrew evenly.

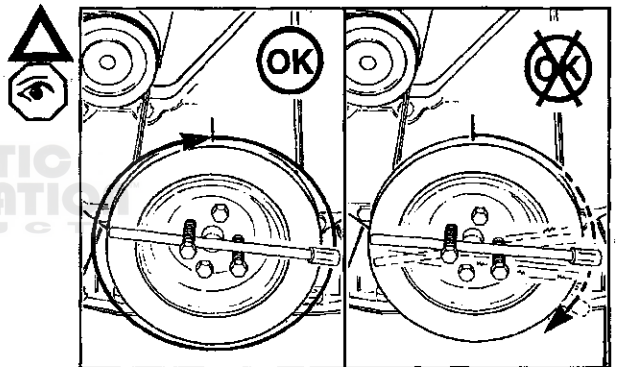
**Torque Value:**

Step 1 - 35 N·m [26 ft-lbs]  
Step 2 - 70 N·m [51 ft-lbs]  
Step 3 - 100 N·m [73 ft-lbs]



**Caution:** The crankshaft must rotate freely.

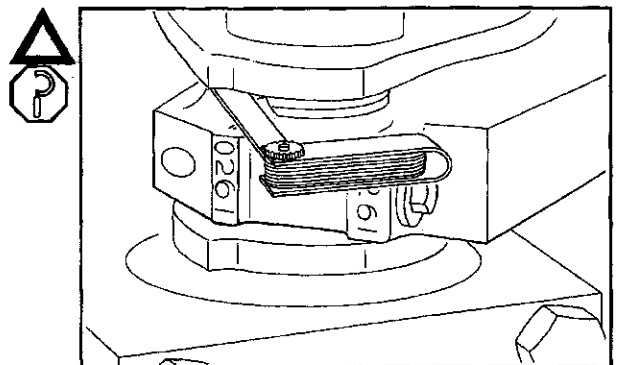
Check for freedom of rotation as the caps are installed. If the crankshaft does not rotate freely, check the installation of the rod bearing and the bearing size.



**Caution:** Do not measure the clearance between the cap and crankshaft.

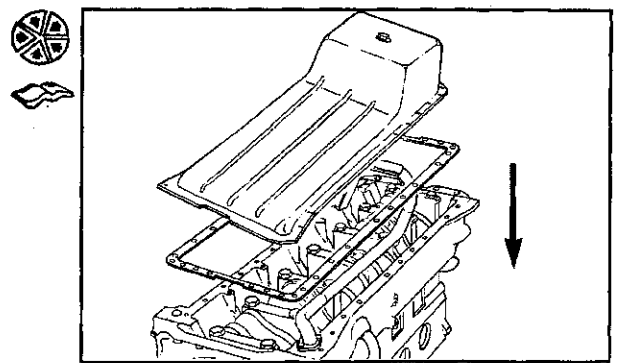
Measure the side clearance between the connecting rod and the crankshaft.

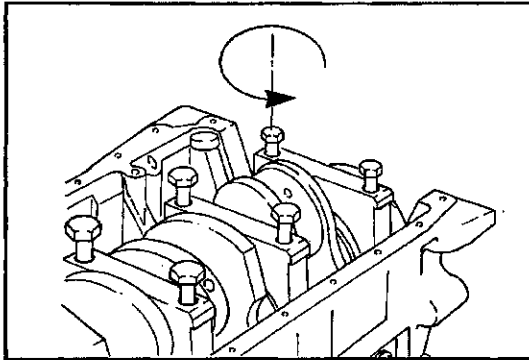
Side Clearance Limits		
mm		In
0.10	MIN	0.004
0.30	MAX	0.012



Install the suction tube and oil pan.

**Note:** Refer to Oil Pan Suction Tube or Gasket Replacement Section.



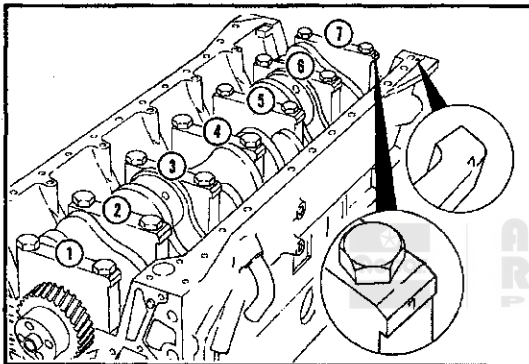


### Crankshaft - Removal

- Remove the rear crankshaft seal housing.
- Remove the gear housing.

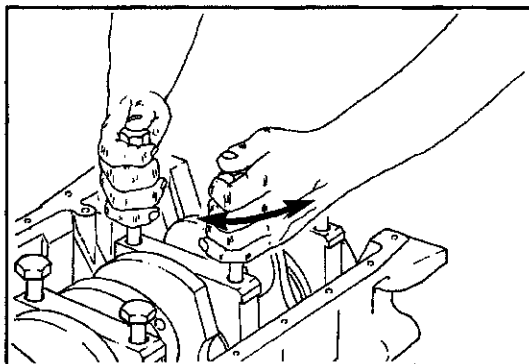
23mm

Rotate the engine to a horizontal position and remove the main bearing cap capscrews.



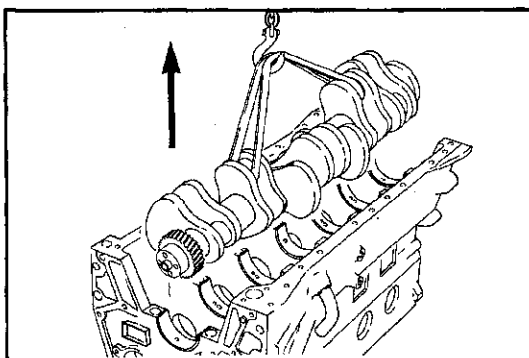
The main caps should be numbered. If they are not, be sure to mark them, beginning with number one at the front and ending with number seven at the rear.

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**Caution:** 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. Remove the caps.



**Warning:** Use a hoist to avoid injury.



Lift the crankshaft and gear from the cylinder block.

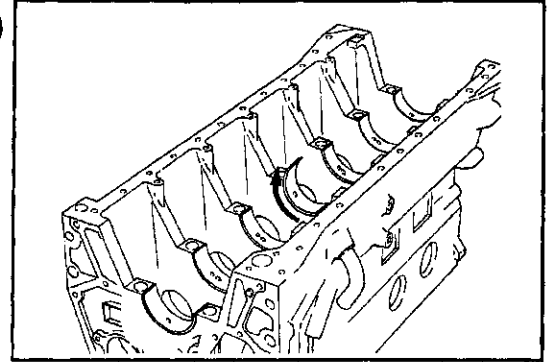


**Crankshaft Weight:** 55.3 Kg [123 lb]



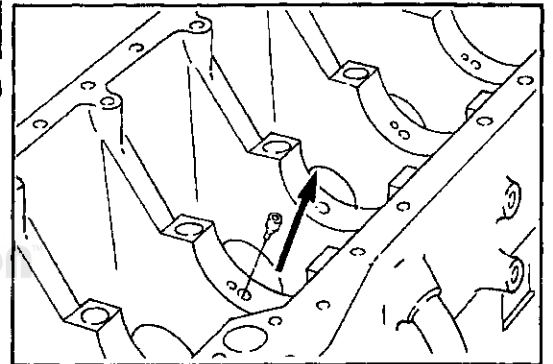
**Caution:** Crankshaft must be lifted straight off the bearings to prevent damage to the thrust bearings.

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



### 3/16 inch Pin Punch

Remove the piston cooling nozzles by using the pin punch to push them out of the drillings.



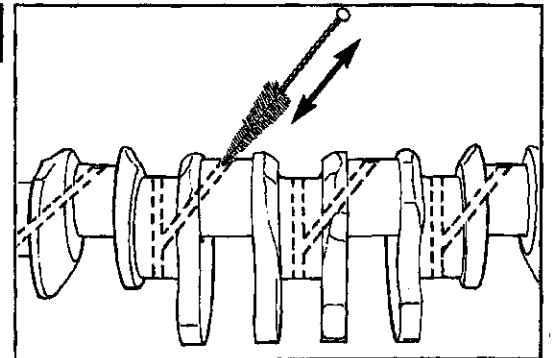
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## Crankshaft – Cleaning and Inspection

### Cleaning the Crankshaft

Clean the crankshaft oil drillings with a nylon brush.

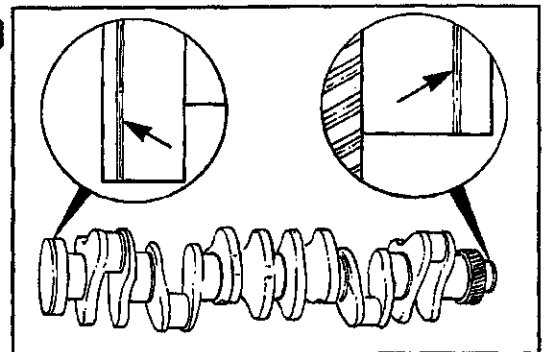
Rinse in clean solvent and dry with compressed air.

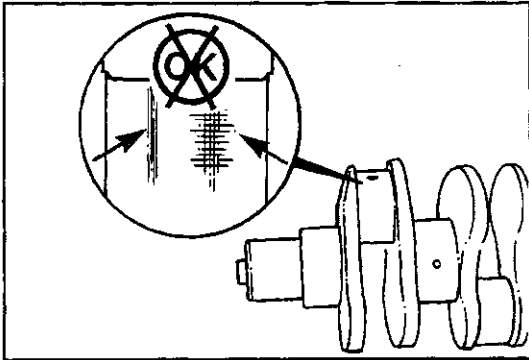


### Inspecting the Crankshaft

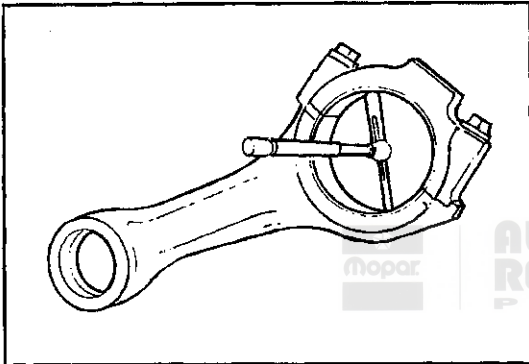
Inspect the front and rear seal contact areas of the crankshaft for scratches or grooving.

The service seal kit will position the seal slightly deeper into the seal bore so it will contact the crankshaft at a different location. If this has already been done and the crankshaft has two worn areas, install a wear sleeve to provide a new contact surface for the seal.





Inspect the rod and main journals for deep scores, signs of overheating and other abnormal marks.

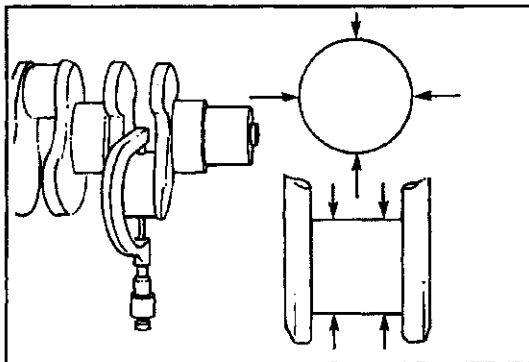


### Determine Rod Bearing Clearance



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

Record the smaller diameter.

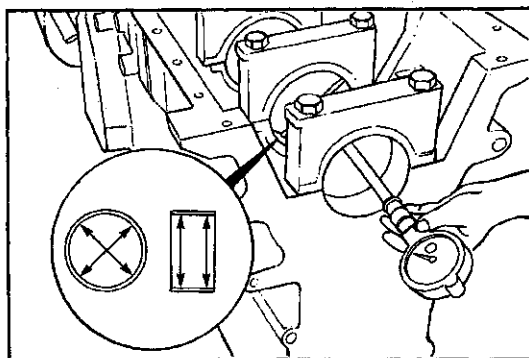


Measure the diameter of the rod journal at the location shown. Calculate the average diameter for each side of the journal.



Rod Journal Diameter Limits		
mm		in
68.962	MIN	2.7150
69.013	MAX	2.7170

- **Out-of-Roundness:** 0.050mm [0.002 inch] Maximum
- **Taper:** 0.013mm [.0005 inch] Maximum
- **Bearing Clearance:** 0.089mm [0.0035 inch] Maximum (Rod inside diameter with bearings installed - Crankshaft journal diameter.)



### Determine Main Bearing Clearance



Install the main bearings and measure main bearing bore diameter with main bolts tightened to 176 N·m [130 ft-lbs]. Record for later reference.

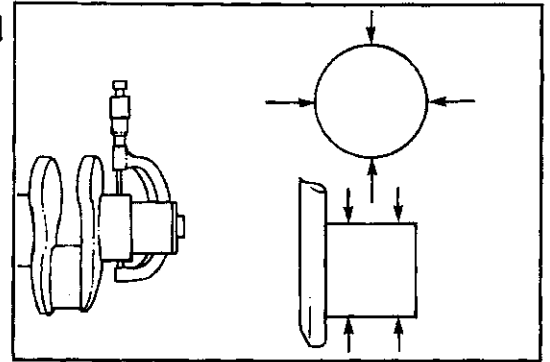
Diameter		
mm		in
83.106	MAX	3.2719

Measure the diameter of the main journal at the locations shown. Calculate the average diameter for each side of the journal.



Main Journal Diameter Limits		
mm		In
82.962	MIN	3.2662
83.013	MAX	3.2682

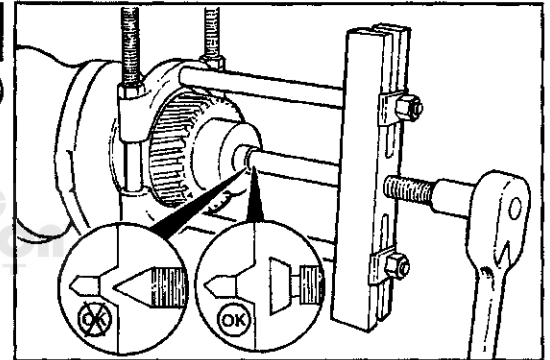
- **Out-of-Roundness:** 0.050mm [0.002 inch] Maximum
- **Taper:** 0.013mm [.0005 inch] Maximum
- **Bearing Clearance:** 0.119mm [0.0047 inch] Maximum (Main bore diameter with bearings installed - Crankshaft main journal diameter.)



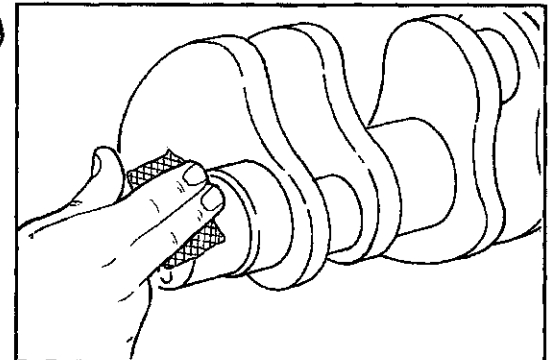
## Crankshaft Gear - Replacement

### Heavy Duty Gear Puller

Remove the crankshaft gear using a heavy duty puller.

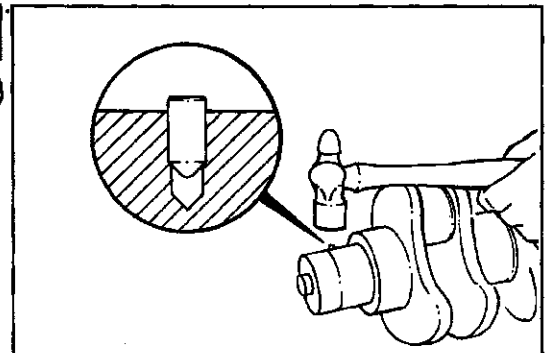


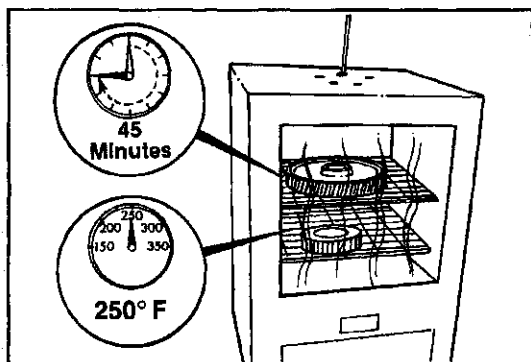
Remove all burrs and make sure the gear surface on the end of the crankshaft is smooth.



### Ballpeen Hammer

If removed, install a new alignment pin. Drive in the pin, leaving it protruding 1.60mm [0.063 inch] to 2.39mm [0.094 inch] above the crankshaft.

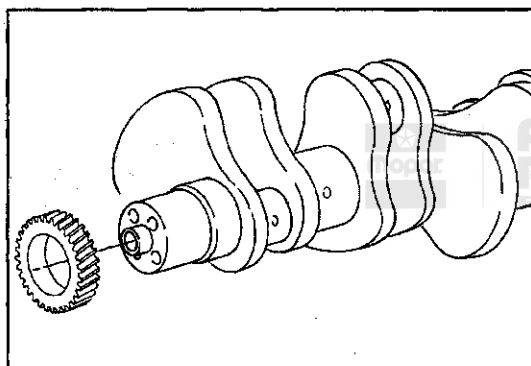




Heat the crankshaft gear for 45 minutes at a temperature of 121°C [250°F].



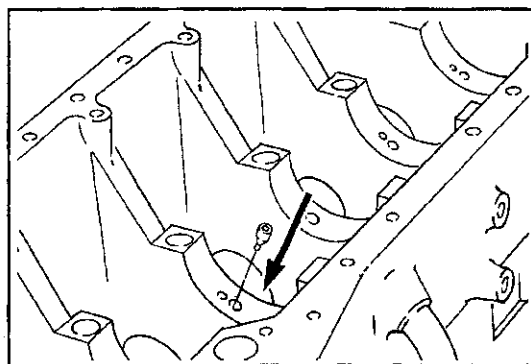
**Caution:** Do not heat the gear longer than 45 minutes.



**Warning:** Wear protective gloves to prevent injury.



Position the gear with the timing mark out and install it on the crankshaft, making sure it contacts the shoulder.



**Crankshaft - Installation**



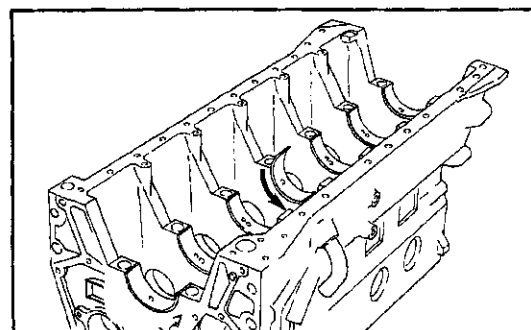
**Center Punch**



**Caution:** Use only hand force to push the nozzle in place. If driven with a hammer the nozzle will be damaged.

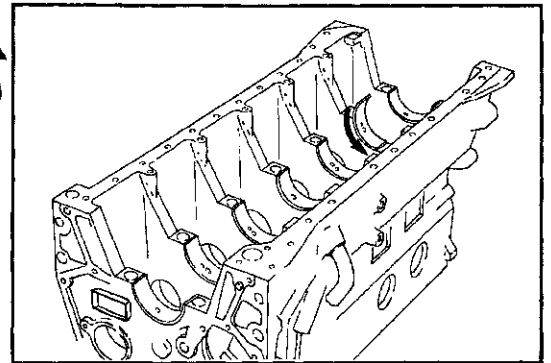


Use a center punch to push the piston cooling nozzle into place. Install nozzles so they are even with or slightly below the saddle surface.

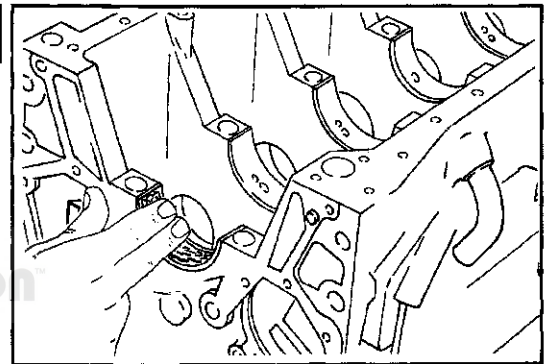


Make sure the saddle surface is clean and dry. Install the upper main bearings.

Install the combination thrust/main bearing in the number six main bearing location.



Lubricate the bearings with Lubriplate 105.



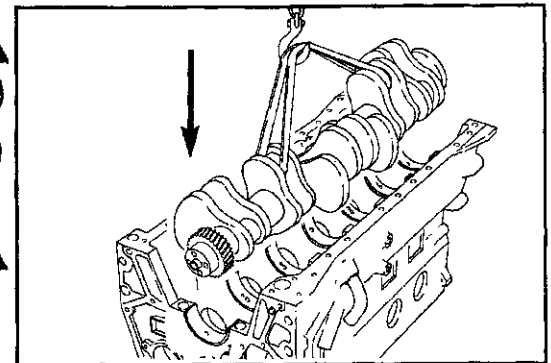
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**Warning: Use a hoist to install the crankshaft to avoid injury.**

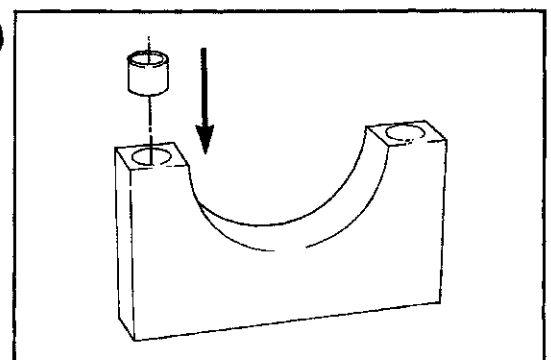
Install the crankshaft.

**Crankshaft Weight: 55.3 Kg [123 lb]**

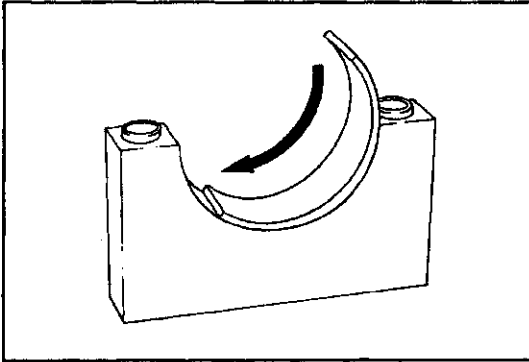
**Caution: Crankshaft must be lowered onto the bearings straight to prevent damage to thrust bearings.**



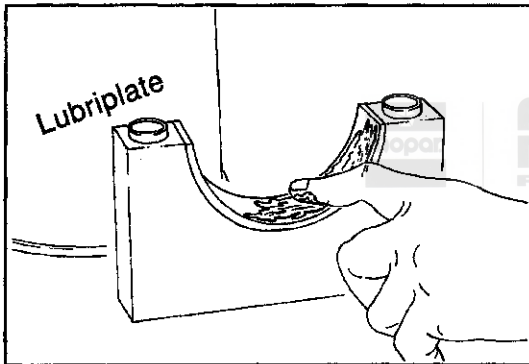
Install the ring dowels in the main bearing caps.



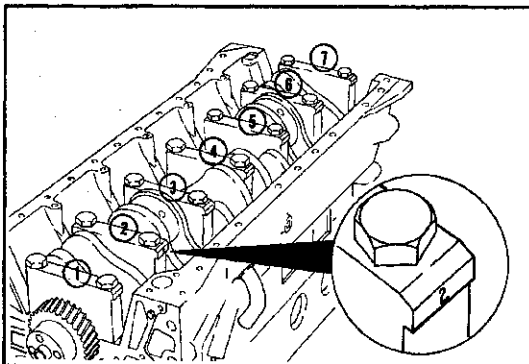





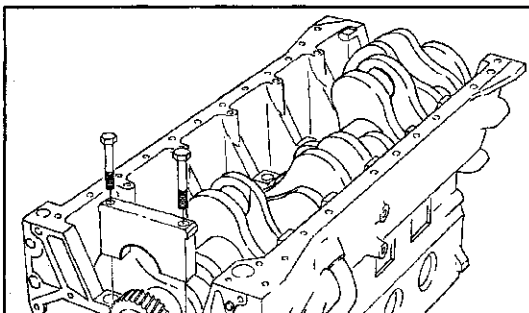
 Install the lower main bearing in the caps.





 Lubricate the bearings with Lubriplate 105.

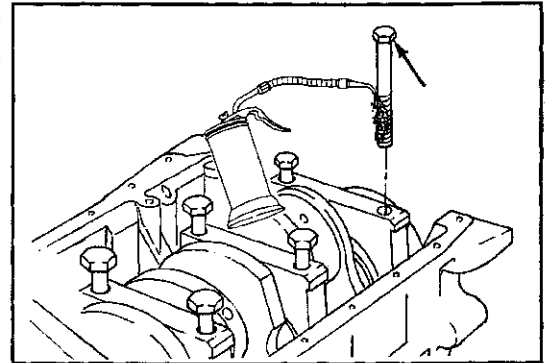


 Numbers on the main bearings caps face the oil cooler side of the engine with number one at the front of the engine.



 Place the caps in their respective positions.  


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



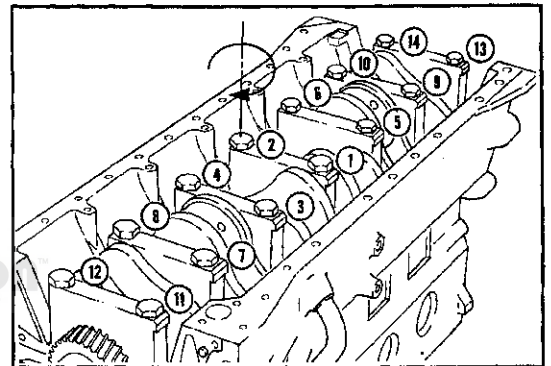
Tighten the capscrews evenly in the sequence shown using the following torque steps.



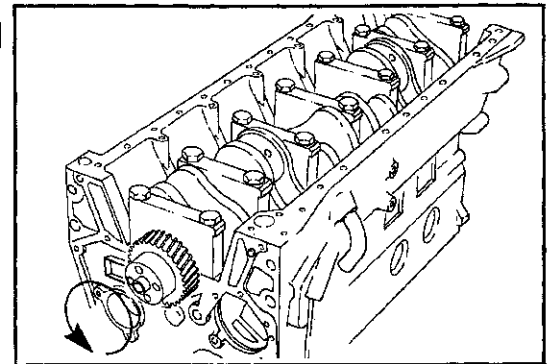
Step	Torque Value
1	60 N·m [45 ft-lbs]
2	119 N·m [88 ft-lbs]
3	176 N·m [129 ft-lbs]



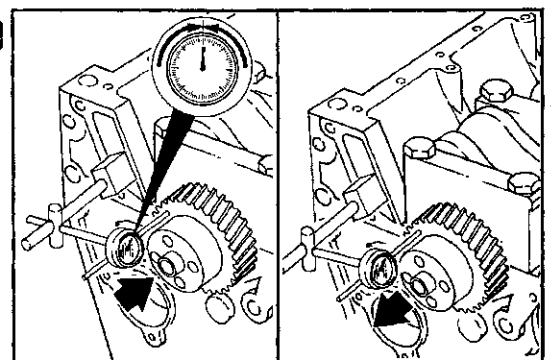
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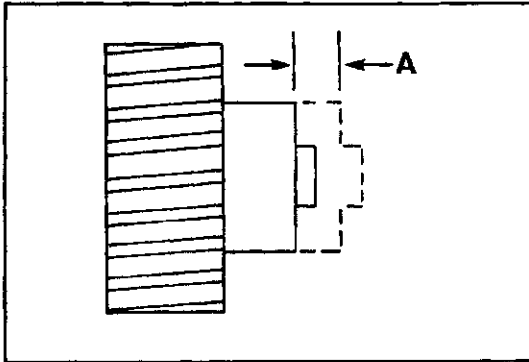


Turn the crankshaft to determine that it will rotate freely all 360 degrees. Check the main bearing cap installations and/or the bearing sizes if the shaft does not turn easily.



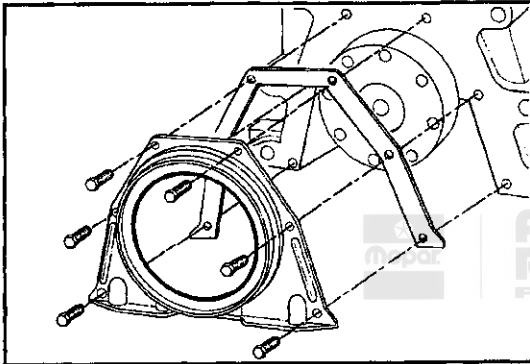
Push the crankshaft towards one end of its thrust and place a dial indicator as shown. Zero the indicator needle and push the crankshaft towards the other end of its thrust and record the indicator reading.





The crankshaft end clearance limits are:

Crankshaft End Clearance		
mm		in
0.13	<b>MIN</b>	0.005
0.30	<b>MAX</b>	0.012

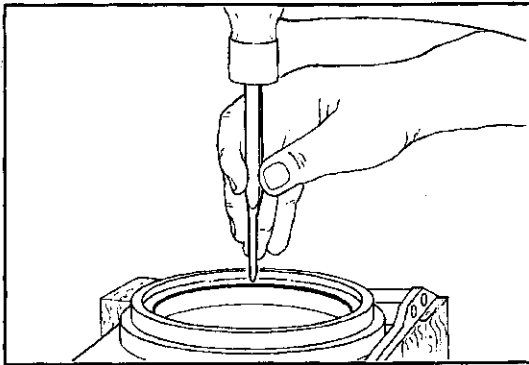


### Rear Crankshaft Seal Housing and Seal - Replacement



8mm

Remove the rear seal housing and gasket.



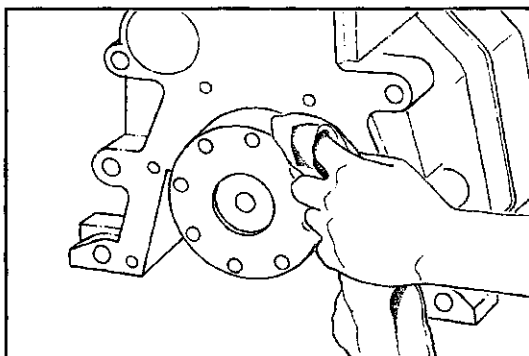
Hammer, Pin Punch



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



Clean the rear seal housing.

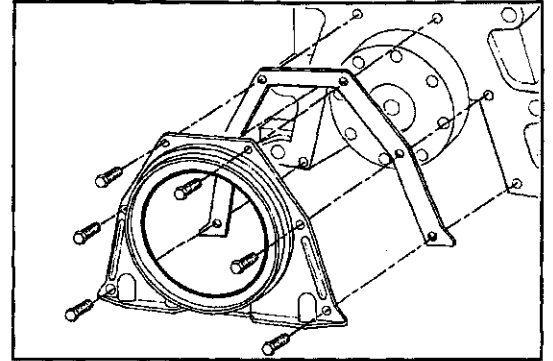


### Rear Seal Housing - Installation

Clean and dry the rear crankshaft sealing surface.

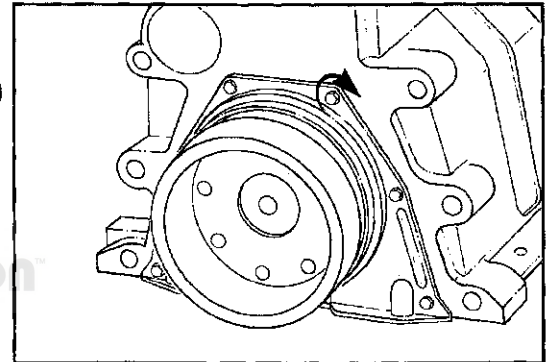
**Note:** The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

Assemble the rear seal housing and gasket to the cylinder block with the capscrews.



8mm

Align the seal housing to the crankshaft with the alignment tool provided in the seal kit. Make sure the seal housing is level with both sides of the block oil pan rail. Tighten the capscrews.

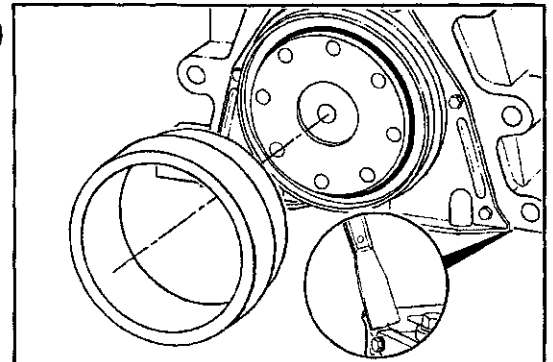


**Torque Value:** 9 N·m [7 ft-lbs]



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Remove the alignment tool and trim the gasket even with the oil pan mounting surface.

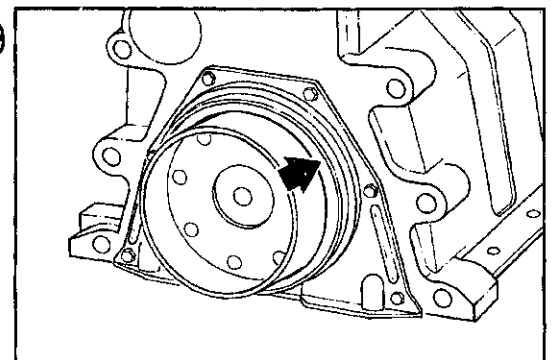


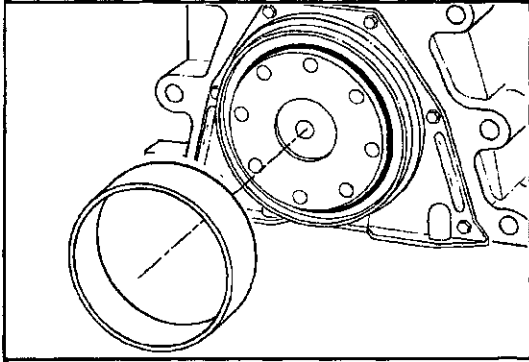
### Rear Crankshaft - Installation

#### Seal O.D. Lubrication/Sealant

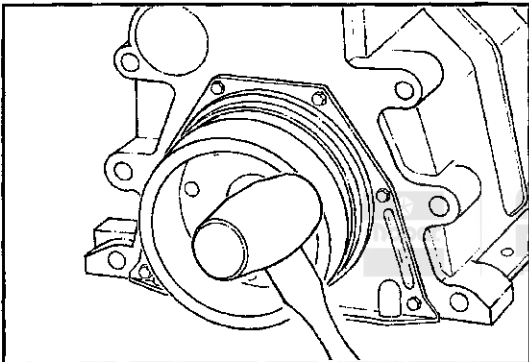
- Rubber O.D. rear crankshaft seals are lubricated with soapy water.
- Seals without rubber O.D. use Loctite 277, 11264 or No. 2654422 Sealant.


Install the seal pilot, provided in the replacement kit, onto the crankshaft. Push the seal onto the crankshaft.



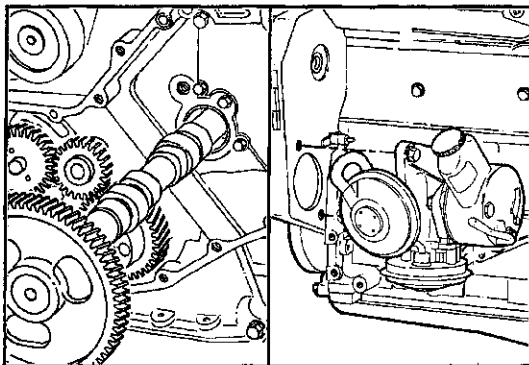


 Remove the seal pilot.



 **Caution: Alternately, drive the seal at the 12, 3, 6 and 9 O'Clock positions to prevent bending the seal carrier during installation.**

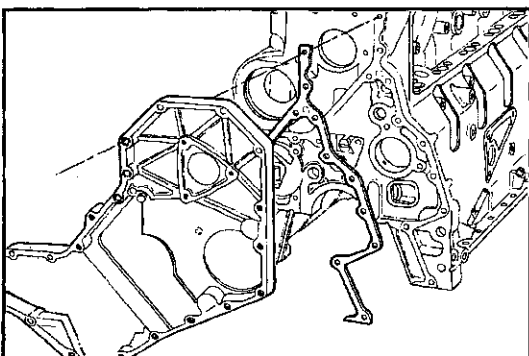
Use the alignment and installation tool packaged in the seal kit. Drive the seal into the housing until the driver bottoms.




 **Gear Housing and Gasket - Replacement**

After removing front end components and the gear cover, remove the following:

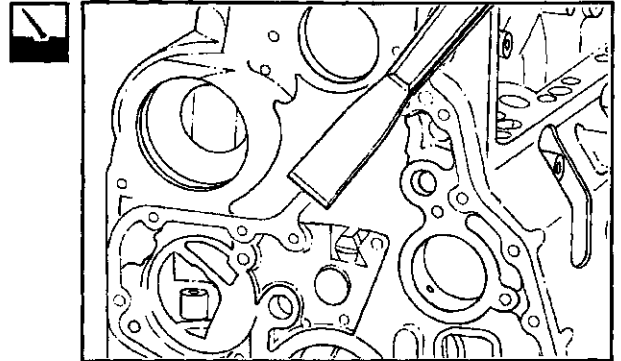
- Camshaft
- Gear driven accessories
- Fuel Pump
- Fan hub assembly



 10mm

 Remove the gear housing and gasket.

Clean the gasket material from the cylinder block.

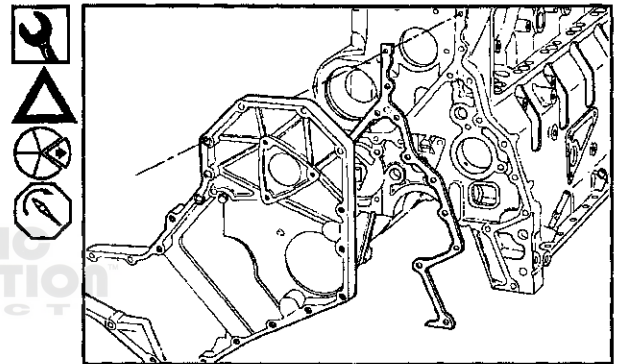


10mm

**Caution:** If a new housing or other than the original housing is installed, the timing pin assembly must be accurately located.

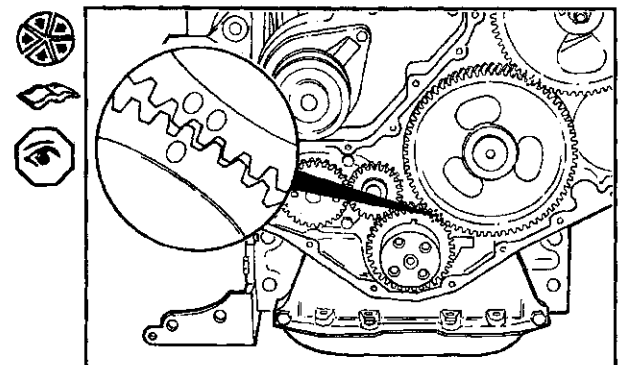
Install a new gasket and gear housing.

**Torque Value:** 24 N·m [18 ft-lbs]



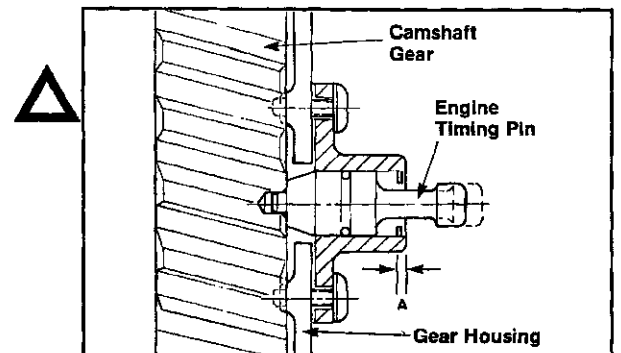
Install the camshaft.

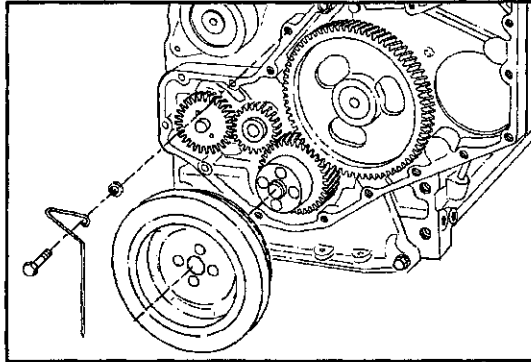
**Note:** Make sure the alignment marks on the camshaft and crankshaft gears are aligned.



### Timing Pin - Installation (Cylinder Head Off)

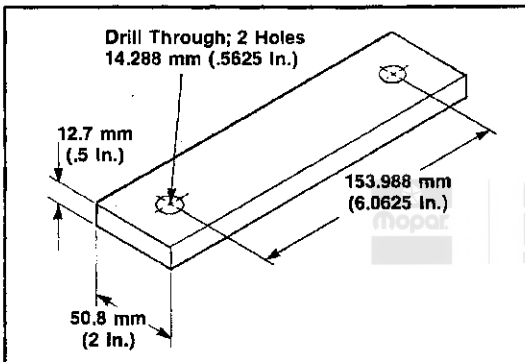
**Caution:** The timing pin assembly is precisely located on the gear housing to correspond to TDC for Cylinder Number 1. The timing pin assembly must be relocated if the gear housing is interchanged.



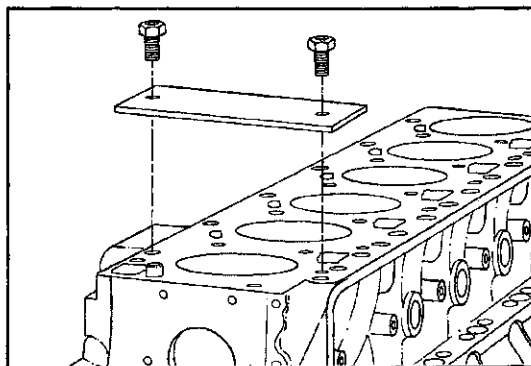


13mm, 15mm

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

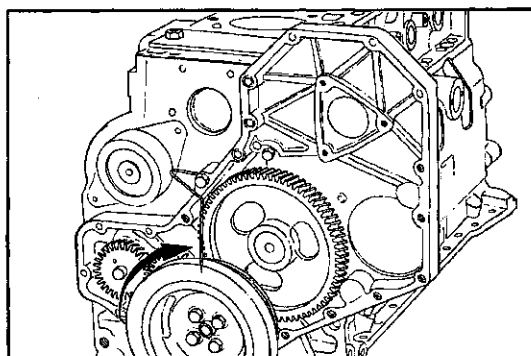


Fabricate a steel plate as shown in the illustration.



19mm

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



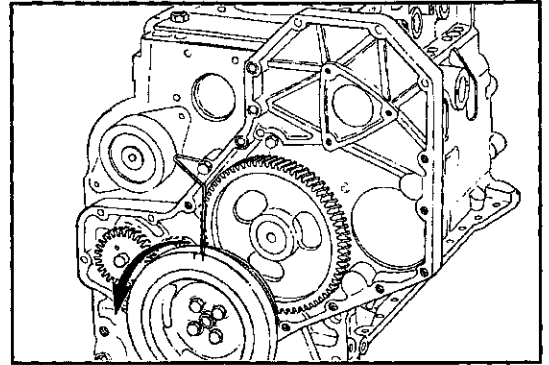
Rotate the crankshaft in the direction of rotation until the piston contacts the plate.

Mark the vibration damper.

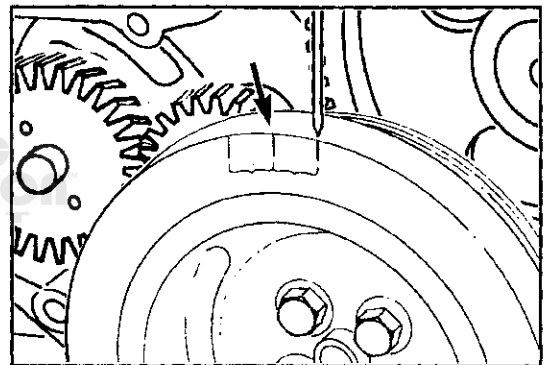


Rotate the engine in the opposite direction until the piston contacts the plate.

Mark the vibration damper.



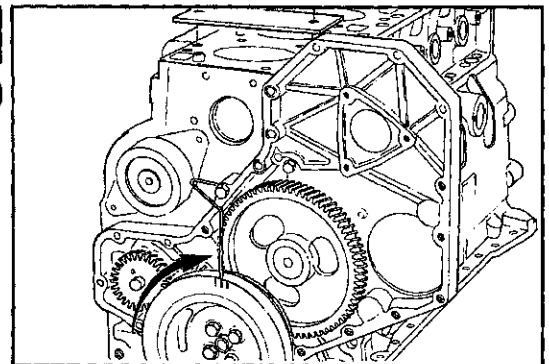
Mark the vibration damper for TDC. TDC will be one-half the distance between the first two marks.



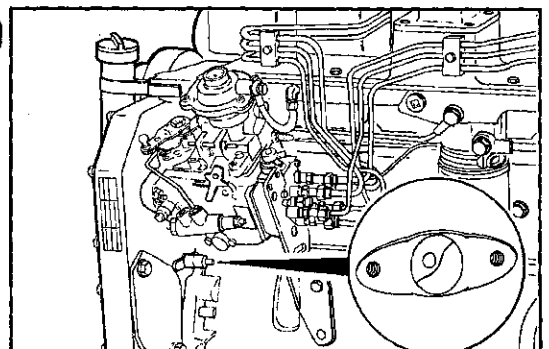
AUTHENTIC  
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PRODUCTS

19mm

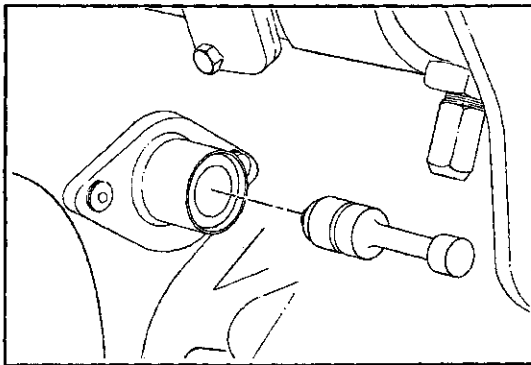
Remove the plate and rotate the engine in the direction of rotation until the pointer aligns with the TDC mark.



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



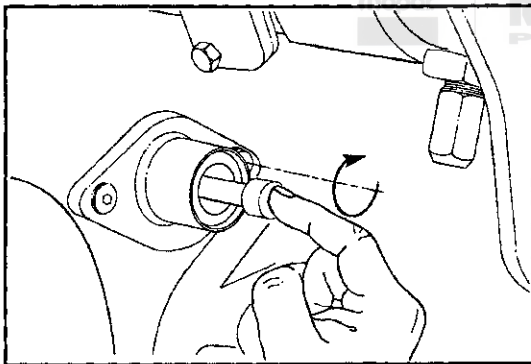




**T-25 Torx**



Install the timing pin assembly. Apply a coat of Loctite 59241 liquid teflon to the threads of the torx headscrews.

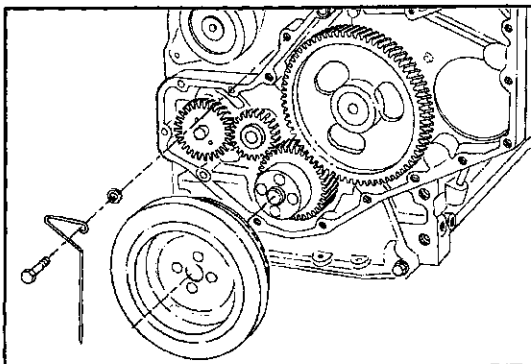


Push the pin into the hole in the cam gear to align the housing.



Hold the pin in while tightening the torx headscrew.

**Torque Value: 5 N·m [44 in-lbs]**



**10mm, 15mm**



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



Remove the vibration damper and wire pointer.

## Engine Removal, Replacement and Testing

### Section 9J

#### Contents

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## Engine Removal

**Caution:** Use the equipment manufacturer's recommendations and precautions for removal of chassis parts to gain access to the engine.

### Preparatory Steps:

- Remove the hood.
- Disconnect the battery.
- Drain the coolant.
- Remove, Fan/Fan Clutch Assembly, Fan Shroud, Radiator.
- Disconnect the air intake and exhaust pipes.
- Disconnect the air conditioner connections.
- Disconnect the alternator.
- Disconnect the accelerator linkage.
- Disconnect throttle linkage from the control lever. **Do not remove control lever from the injection pump.**
- Disconnect the ground cable.
- Disconnect the starter.
- Disconnect all engine driven accessories.
- Disconnect the torque converter.
- Drain the lubricating oil.
- Disconnect the transmission cooler lines.
- Hoist the engine.
- Disconnect the power steering lines.
- Disconnect the fuel lines.
- Remove the motor mounts.
- Remove the transmission bolts.

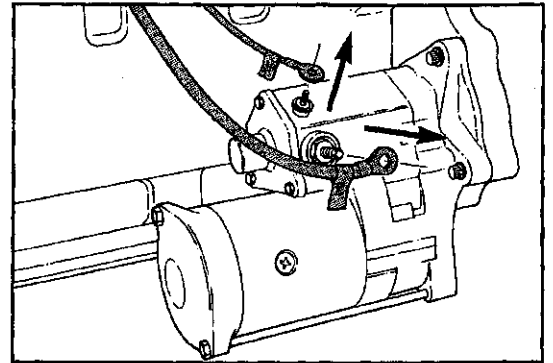
## Engine Replacement

### Listing of Steps:

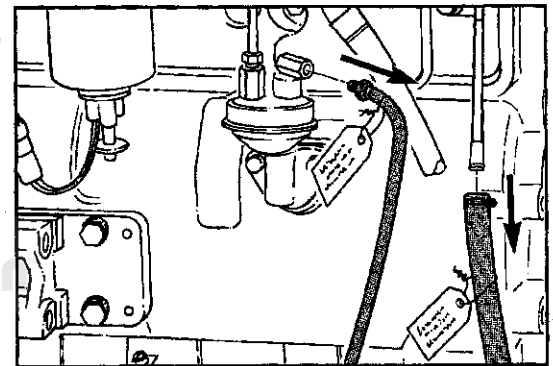
- Hoist engine.
- Install the motor mounts.
- Install the transmission bolts.
- Bolt-up the torque converter.
- Connect the transmission cooler lines.
- Connect power steering lines.
- Connect the fuel lines.
- Connect all engine driven accessories.
- Install the starter.
- Connect the ground cable.
- Connect the accelerator linkage.
- Connect the throttle linkage to the control lever. **Do not remove the control lever from the injection pump.**
- Connect the air conditioner connections.
- Connect the alternator.
- Connect the air intake and exhaust pipes.
- Install fan/fan clutch assembly, fan shroud and radiator.
- Install the lubricating oil.
- Install coolant.
- Install transmission fluid (automatic).
- Connect the battery.
- Test engine assembly.
- Install the hood.

### Engine Removal - Procedure

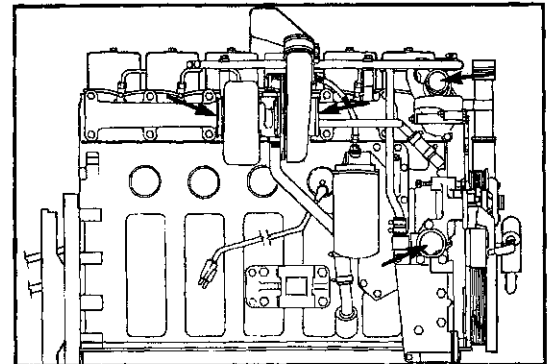
Disconnect all electrical connections. Put tags on the connections to identify their locations.



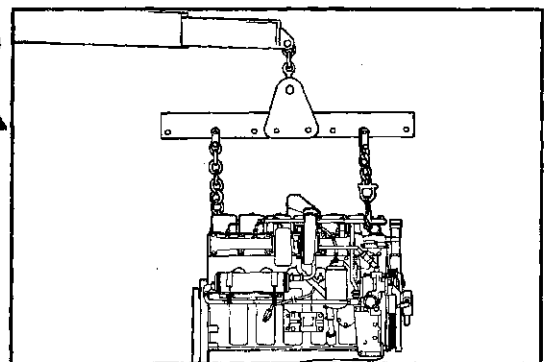
Disconnect all lines including fuel lines to the lift pump and fuel return. Use tags to identify the lines.



Put a cover or tape over all engine openings.



Use the lifting eyes to lift the engine. Apply tension to the hoist to hold the engine while you disconnect the engine mounts from the chassis. Lift the engine from the equipment.

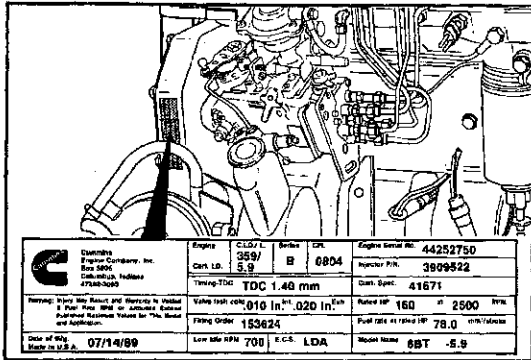


#### Dry Engine Weight:

5.9 Liter Diesel      399 Kg      [880 lb]

**Note:** Remove all accessories and brackets not previously removed to use with the replacement engine.





### Engine Replacement - Procedure

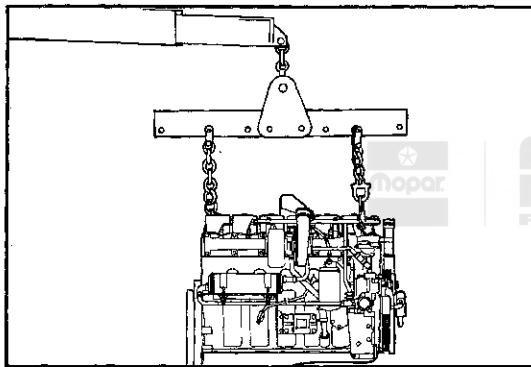


**Caution:** Do not exceed the torque value for the engine supports.

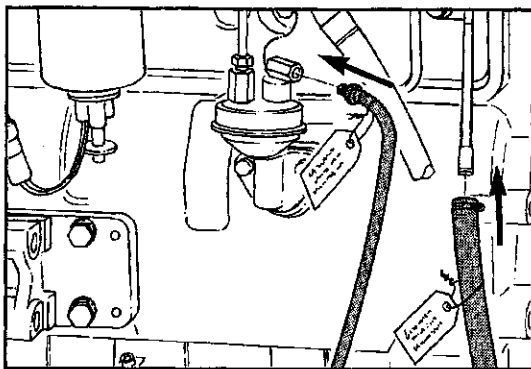
**Torque Value:** 77 N·m [57 ft·lb]

Check the data plate to verify that the replacement engine is the same model and rating as the engine that was removed.

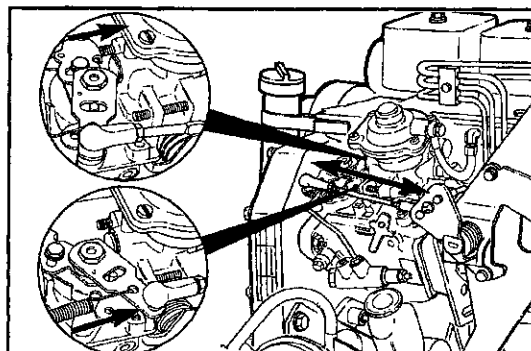
**Note:** Install all accessories and brackets that had been removed from the previous engine.



Use the lifting eyes to lift the engine. Keep tension on the hoist while you align the engine in the chassis and tighten the engine mounts.

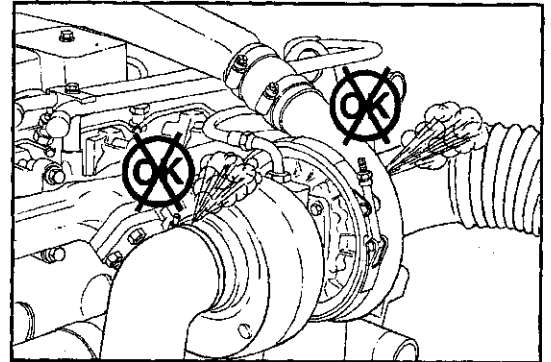


Connect the engine and chassis parts in the reverse order of removal.



When connecting the cable/rod to the control lever, adjust the length so the lever has stop-to-stop movement.

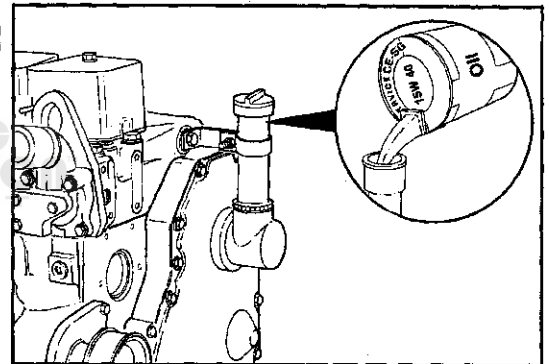
**Note:** Make sure the air intake and exhaust pipe connections are tight and free of leaks.



Fill the engine with the required amount of lubricating oil.

5.9 Liter Diesel-  
10.5 liters [11 - U.S. quarts]  
0.95 liters [1 - U.S. quart] engine oil filter

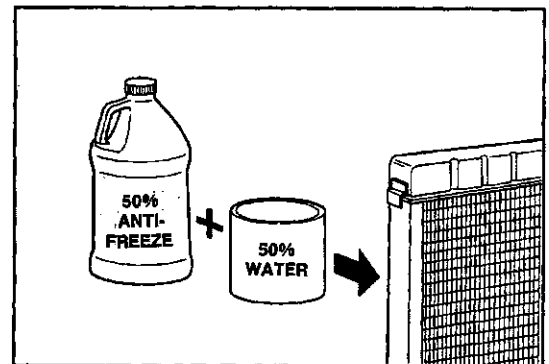
**Note:** Check the oil level after the engine has run for 2 to 3 minutes. Oil held in the oil filter and oil passages will cause the oil level in the oil pan to be lower.



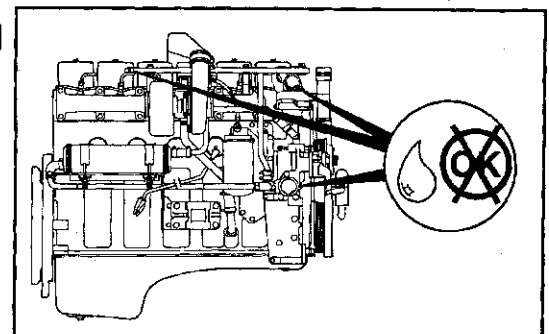
Fill the cooling system with a mixture of 50% water and 50% ethylene-glycol base antifreeze.

	Truck Coolant Capacity	
	Liters	U.S. Quarts
Automatic	15.7	[16.5]*
Manual	14.7	[15.5]*

\*Coolant recovery tank not included.



Operate the engine at idle for 5 to 10 minutes and check for leaks and loose parts.



### Engine Testing

Verify engine performance by performing an in-chassis check.

#### Operating Conditions for Run-In and Test

Measurement	Limit(s)
Coolant Temperature .....	95°C [203°F] Maximum
Lubricating Oil Temperature .....	121°C [250°F] Maximum
Lubricating Oil Pressure .....	241 kPa [35 psi] Minimum
Air Inlet Temperature .....	38°C [100°F] Maximum
Air Inlet Restriction .....	25.4cm [10 in] H <sub>2</sub> O Maximum
Boost Pressure .....	50.8cm [20 in] Hg Minimum 66cm [26 in] Hg Maximum
Exhaust Temperature .....	700°C [1290°F] Maximum
<b>Smoke</b>	
Bosch Smoke Meter .....	2.5 Units Maximum
Celesco Smoke Meter .....	4% Opacity Maximum

### Blowby Limits

The following table gives the values of blow-by that are normal for the Dodge 5.9 Liter Diesel engines. These blow-by values have been calculated on amount of displacement of the engine, volumetric efficiency, cylinder pressure and turbo contribution.

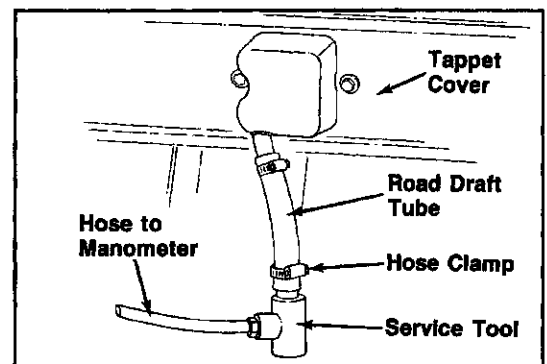
Engine Model	Speed / RPM	New Limit	Worn Limit
5.9 Liter Diesel	2500	76L/Min [7 in H <sub>2</sub> O]	152L/Min [28.5 in H <sub>2</sub> O]

**Note:** The blow-by values are for 100 percent load at the given speed.

### Blowby Measurement

Blowby is generally recorded in Liters/Minute, but a water manometer may be used to measure blowby from the breather tube. Pressure readings in inches of water are measured using a 5.613 mm [0.221 inch] diameter orifice.

Use a service tool with 5.613mm [.221 in.] orifice built in.





**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 Rating

### Dodge 5.9 Liter Diesel Engine

Engine Model	Rating Hp/RPM	Torque ft-lb/RPM	Torque ft-lb/RPM
Dodge 5.9 Liter Diesel	2500	319/2500	400/1500

## Engine Test Check List

- Correct injector for the engine rating used and only one copper sealing washer installed?  
Sealant applied to the capscrews that attach the intake manifold cover?  
Turbocharger pre-lubricated?  
Engine filled with oil; oil filter filled with oil prior to installation so the engine has an immediate supply of oil?  
Fuel filter filled with fuel and the injection pump primed using the lever on the lift pump?

OK

\_\_\_\_\_  
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\_\_\_\_\_

## Engine Run-In

1. Make sure that the fuel solenoid is in the "OFF" position or disconnected.
2. Crank the engine to establish oil pressure on the gauge. Do not engage the starter for more than 30 seconds at a time, wait two (2) minutes between engagements.

Reconnect the fuel solenoid if disconnected and move to the "RUN" position.

**Note:** Bleeding of the fuel system may be required to start the engine.

3. Start the engine and run at 1000-1200 RPM for 30 minutes. Observe the oil pressure and water temperature. If oil pressure drops below 103 kPa [15 psi], stop the engine and troubleshoot the lubrication system. If water temperature exceeds 95°C [203°F], stop the engine and allow to cool. Troubleshoot the cooling system.
4. After completing Step 3, stop the engine and inspect for leaks.
5. Restart the engine and test drive the vehicle at approximately 1/3 throttle in "Drive" or "High" gear. Periodically, open the throttle and accelerate to governed RPM and decelerate rapidly. Repeat this procedure at least 10 times.

The engine should be operated normally, but not at continuous high speeds and loads for the first 500 miles or 20 hours. Occasional quick acceleration followed by quick deceleration during this period is beneficial to engine break in.

Change the oil and filters after 500 miles or 20 hours of operation. Follow oil specifications described in Lubrication and Maintenance, Section 0.



Engine Removal, Replacement and Testing  
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Base Engine Components  
DODGE Turbo Diesel

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## Alternative Repair Procedures

### Section 9K

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### **About this Section**

This section describes and illustrates approved repair procedures for the cylinder block, crankshaft, and cylinder head. Procedures shown are performed in an engine machine shop environment. Shop tools and tool sizes are identified through the section when applicable and all necessary dimensions, angles, and surface finishes are specified.

### **When Should an Alternative Repair Be Performed?**

The following procedures do provide an alternative to replacement of major engine components. Local machine shop expertise is the first criterion. Beyond the technical requirements, availability, price and equipment down time are the considerations that will influence the decision.

### **Inspection**

The procedures assume the component was inspected and the discrepancy noted during repair or overhaul. Only those inspection requirements directly related to the alternative repair procedure are provided in this manual.

### **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. Also, be sure to use good safety practices with tools and equipment.

### **Follow the Cleaning Instructions Specified in the Procedures**

After completing the repair, make sure all machining debris is removed and that the part is thoroughly cleaned.

### **Perform the Inspections Specified in the Procedures**

After the repair, perform the required inspection to make sure the part meets the technical requirements for continued use in an engine.

## Cylinder Block Repair Procedures

### Repair Tools

Camshaft Bore Boring Bar

Camshaft Bushing Driver

Cylinder Boring Bar

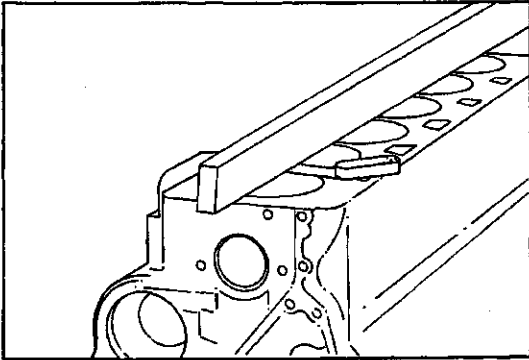
Cylinder Block and Head Surface Grinder

Cylinder Hone Set

**Note:** The repairs can be performed with standard gasoline engine tooling at local automotive engine repair shops.

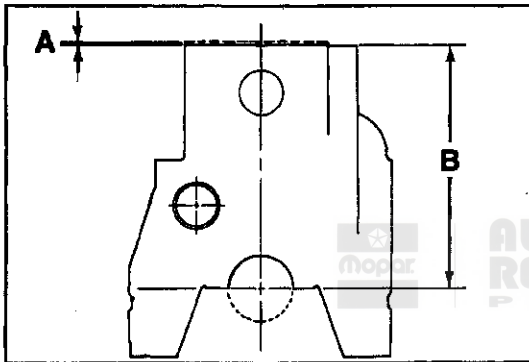


**AUTHENTIC  
RESTORATION™  
PRODUCT**



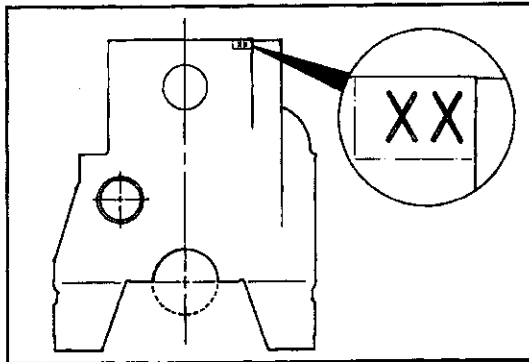
**Combustion Deck**

The distortion of the combustion deck face is not to exceed 0.010mm [.0004 inch] in any 50.00mm [2.0 inch] diameter. Overall variation end to end or side to side .075mm [.003 inch].



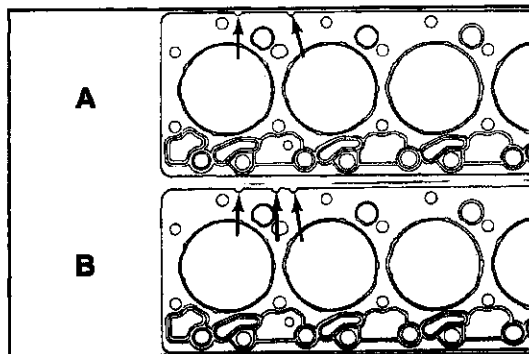
The combustion deck can be refaced twice. The first reface should be 0.15mm [0.0059 inch]. If additional refacing is required, an additional 0.35mm [.0138 inch] can be removed. Total allowed refacing is 0.50mm [.0197 inch].

A = 0.15mm [0.0058 inch]	First reface
0.35mm [0.0138 inch]	Second additional reface
0.50mm [0.0197 inch]	Total Allowed Standard
B = 323.00mm ± 0.10	
[12.7165 inch ± .0039]	
322.85mm ± 0.10	First reface
[12.7106 inch ± .0039]	
322.50mm ± 0.10	Second reface
[12.6968 inch ± .0039]	



Surface finish requirements = 1.5 - 3.2 micrometers [60 -126 microinch]

The upper right corner of the rear face of the block must be stamped with a X when the block is refaced to 0.15mm [0.0059 inch]. A second X must be stamped beside the first when the block is refaced to 0.50mm [0.0197 inch].



Consult the parts catalog for the proper head gaskets which must be used with refaced blocks to insure proper piston-to-valve clearance.



- A = Use where block deck has been refaced 0.15mm [0.0059 inch]. (two notches)
- B = Use where block deck has been refaced 0.50mm [0.0197 inch]. (three notches)

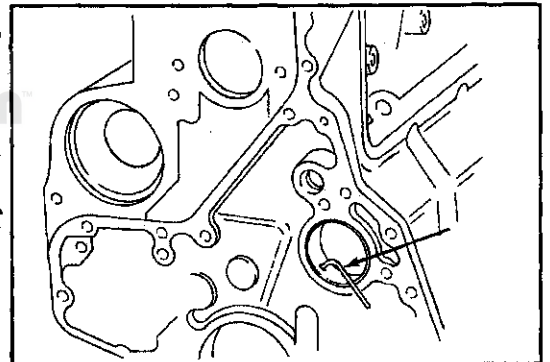
### Cam Bore(s)

The front cam bushing bore can be rebored to  $57.740 \pm 0.018\text{mm}$  [ $2.273 \pm 0.0007$  inch] oversize. **Do not bore the intermediate or rear cam bore to the front cam bore oversize dimensions.** Intermediate and rear cam bores may be rebored to  $57.240 \pm 0.018\text{mm}$  [ $2.253 \pm 0.0007$  inch] oversize. A surface finish of 2.3 micrometers [92 microinch] must be maintained. Not more than 20 percent of area of any one bore may be 3.2 micrometers [126 microinch].

**Note:** Camshaft bores can be repaired individually. It is not necessary to repair undamaged cam bores in order to repair individually damaged cam bores.

Install all cam bushings flush or below the front cam bore surface. The oil hole must align to allow a 3.2 mm [.125 inch] rod to pass through freely.

**Caution:** The standard front bushing cannot be used to repair intermediate or rear bores. Consult the parts manual for correct oversize cam bushing part numbers.



### Cylinder Bore(s) Repair - General

Cylinder bore(s) can be repaired by two methods.

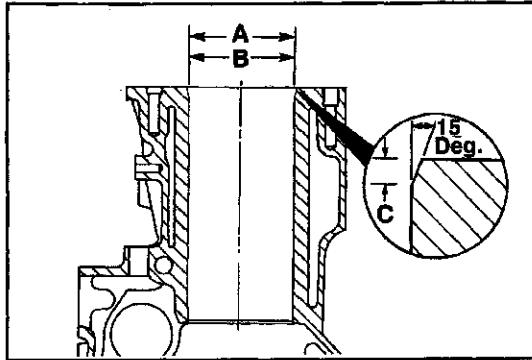
#### Method 1.

- Over boring and using oversize pistons and rings.

#### Method 2.

- Boring and installing a repair sleeve to return the bore to standard dimensions.
- Oversize pistons and rings are available in two sizes: 0.50mm [0.0197 inch] and 1.00mm [0.0393 inch].
- If more than 1.00mm [0.0393 inch] overbore is needed, a repair sleeve is required. It is permissible to install sleeves into individual cylinders as required. Repair sleeves can be replaced by using a boring bar to bore out the old sleeve. Do not cut the cylinder bore beyond the oversize limit. It is also permissible to overbore individual cylinders as required. Any combination of standard, 0.50mm overbore, or 1.00mm overbore may be used in the same engine.





**Cylinder Bore(s)**

Block cylinder bores may be rebored twice before use of a repair sleeve is required. The first rebore is 0.50mm [0.197 inch] oversize. The second rebore is 1.00mm[0.0393 inch] oversize.

**Boring Diameter Dimensions**

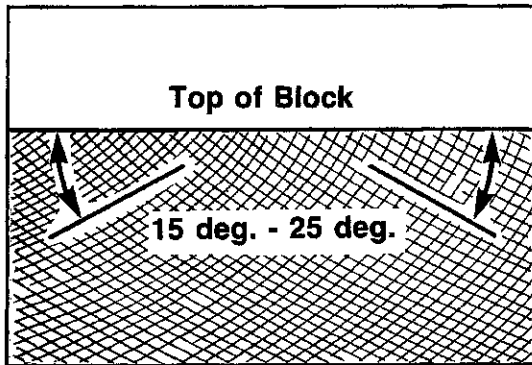
A =	102.469mm [4.0342 inch]	First rebore
	102.969mm [4.0539 inch]	Second rebore

**Honing Diameter Dimensions**

B =	102.020 ± .020mm	Standard bore
	[4.0165 ± .0008 inch]	
	102.520 ± .020mm	First rebore
	[4.0362 ± .008 inch]	
	103.020 ± .020mm	Second rebore
	[4.0559 ± .0008 inch]	

After boring to size, use a honing stone to chamfer the edge of the bore to Dimension C.

C = Approximately 1.25mm  
[.049 inch] X 15 Degrees

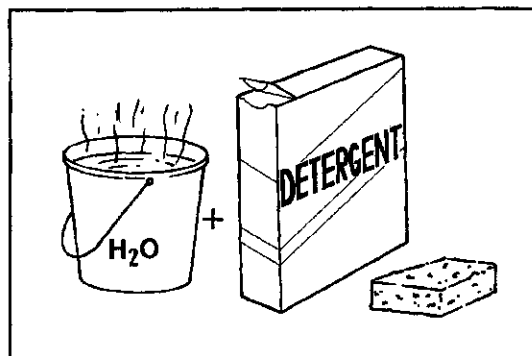


A correctly honed surface will have a cross-hatch appearance with the lines at 15 to 25 degree angles with the top of the cylinder block.

Rough hone: Use 80 grit honing stones.

Finish hone: Use 280 grit honing stones.

A maximum of 1.2 micrometer [48 microlinch] surface finish must be obtained.



**After finish honing is complete:**

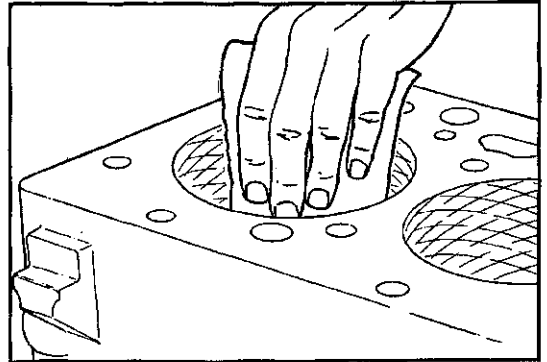
Immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, blow the block dry.

Check the bore cleanliness by wiping with a white, lint-free, lightly-oiled cloth. There should be no grit residue present.

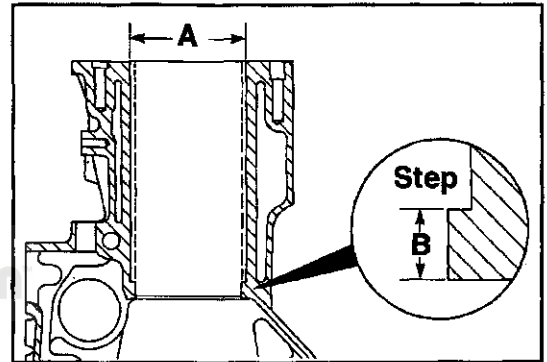


If the block is not to be used right away, coat it with a rust-preventing compound.



### Repair Sleeve Installation

If more than a 1.00mm [.03937 inch] diameter oversize bore is required, the block must be rebored and a repair sleeve installed. The repair sleeve must be bored and honed to a finished size of  $102.020 \pm .020\text{mm}$  [ $4.0165 \pm .0008$  inch] diameter. A standard diameter piston and a service piston ring set must be used.



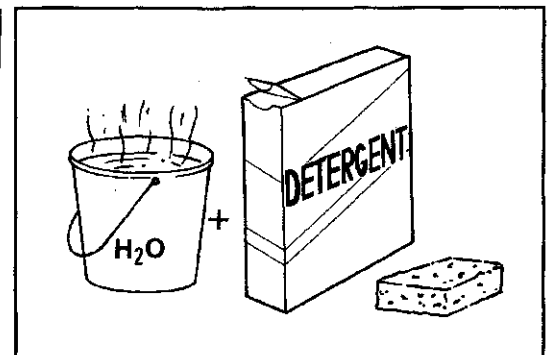
### Block Rebore for Repair Sleeve

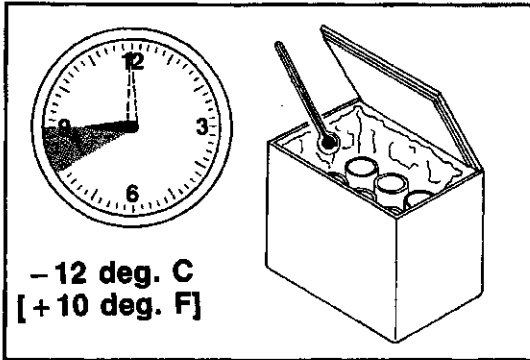
$$A = 104.500 \quad + .015\text{mm} [4.1142 + .0006 \text{ inch}] \\ \quad \quad \quad - .000\text{mm} \quad \quad \quad - .000$$


$$B = 6.35\text{mm} [0.250 \text{ inch}]$$

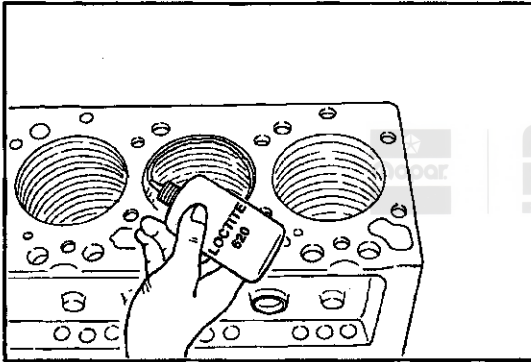
Repair Sleeve Part No. 4429166


After machining the block for the new repair sleeve, thoroughly clean the bore of all metal chips, debris, and oil residue before installing the sleeve.

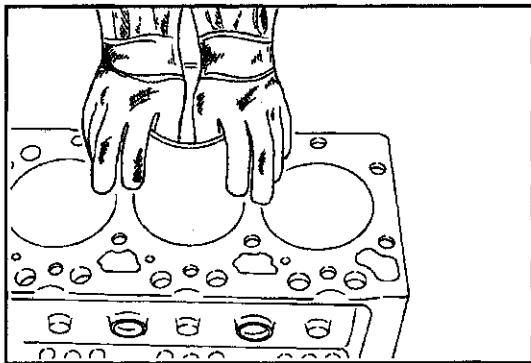





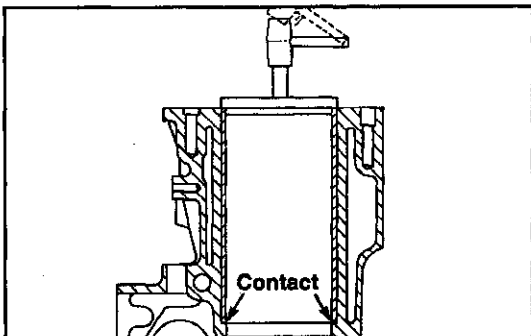
 Cool the repair sleeve(s) to a temperature of  $-12^{\circ}\text{C}$  [ $10^{\circ}\text{F}$ ] or below for a minimum of one hour. Be ready to install a sleeve immediately after removing it from the freezer.




 Apply a coat of Loctite 620 to the bore that is to be sleeved.



 Wear protective gloves. Push the cold sleeve into the bore as far as possible.

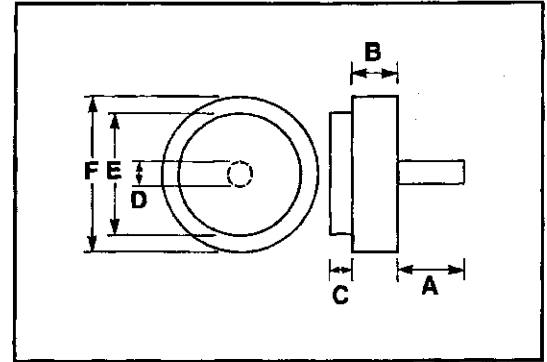


 Using a sleeve driver, drive the sleeve downward until it contacts the step at the bottom of the bore.

**Driver Construction**

Driver - aluminum  
Handle - steel

- A = 127mm [5 inch]
- B = 38mm [1.5 inch]
- C = 6.35mm [0.250 inch]
- D = 25.4mm [1.00 inch]
- E = 101mm [3.976 inch]
- F = 107.343mm [4.226 inch]

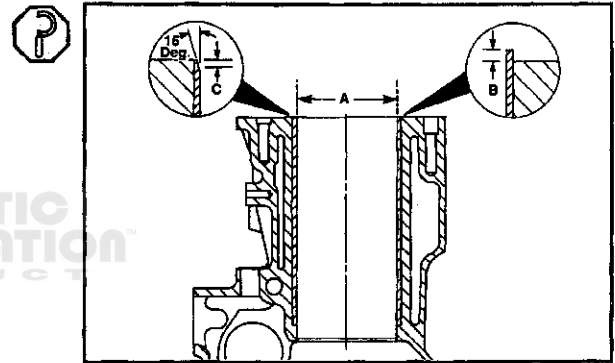


Set up a boring bar and machine to the following dimensions.

- A = 101.956mm [4.014 inch]
- B = Minimum - flush with block  
Maximum - .05mm [.0019 inch] protrusion

After removing the boring bar, use a honing stone to chamfer the corner of the repair sleeve(s) to dimension C.

C = Approximately 1.25mm [.049 inch] X 15 Degrees

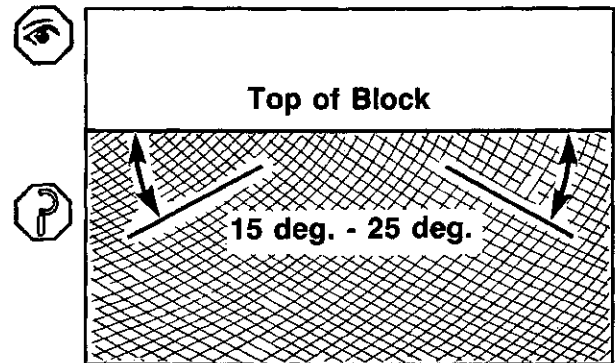


A correctly honed surface will have a cross-hatch appearance with the lines at 15 to 25 degree angles with the top of the cylinder block.

- Rough hone: use 80 grit honing stones.
- Finish hone: use 280 grit honing stones.

Finished bore inside dimension: 102.020 ± .020mm [4.0165 ± .0008 inch]

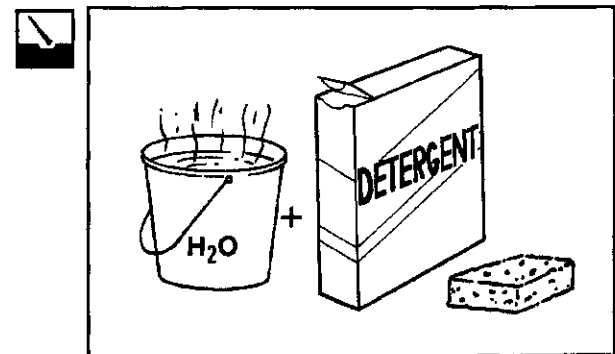
A maximum of 1.2 micrometer [48 microinch] surface finish must be obtained.

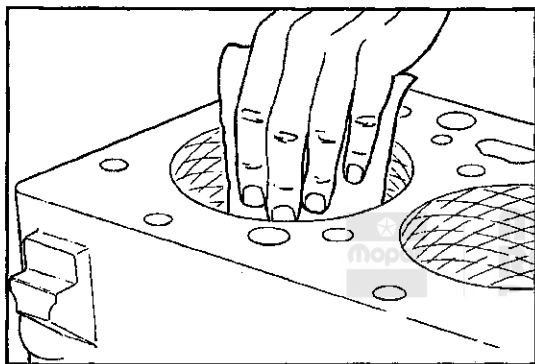


**After finish honing is complete:**

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

After rinsing, blow the block dry with compressed air.





Wipe the bore with a white, lint-free, lightly oiled cloth. Make sure there is no grit residue present.



Apply a rust-preventing compound if the block will not be used right away.

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## Crankshaft Repair Tools

### Crankshaft Regrinding Lathe

**Note:** The repairs can be performed with standard automotive engine tooling at local automotive engine repair shops.

### Crankshaft Grinding - General

Crankshaft main and rod journals may be reground in increments of 0.25mm [0.0098 inch] up to four times for a total of 1.00mm [0.0394 inch]. The only exception is the main journal thrust width surface which must be reground in two increments of 0.50mm [0.0197 inch] and 1.00mm [0.0394 inch]. The thrust surface is located on the number six main bearing. When the thrust surface requires regrinding, the main journal must be reground to the same undersize dimension.

Two procedures, a preferred and an optional, will be given for regrinding all crankshaft journals except when the thrust width surface requires regrinding. Then the preferred procedure is the only accepted procedure.



### Crankshaft Main Journal Regrind Specifications

**Standard main journal size:** 83.000 ± .013mm [3.2677 ± .0005 inch]

**Worn Limit:** 82.962mm [3.2662 inch]

#### Undersizes: All Main Journals

Available Undersize	Regrind To
0.25mm [.0098 inch]	82.750 ± .013mm [3.2579 ± .0005 inch]
0.50mm [.0197 inch]	82.500 ± .013mm [3.2480 ± .0005 inch]
0.75mm [.0295 inch]	82.250 ± .013mm [3.2381 ± .0005 inch]
1.00mm [.0394 inch]	82.000 ± .013mm [3.2283 ± .0005 inch]

All main journals are to be parallel to the front and rear mains within 0.03mm [0.001 inch]

Out of roundness: 0.005mm [0.0002 inch] maximum

Taper: 0.005mm [0.0002 inch] maximum

All main journals are to be ground in the opposite direction of engine rotation (clockwise as viewed from the front of crankshaft). Polish the journals in the same direction as engine rotation.

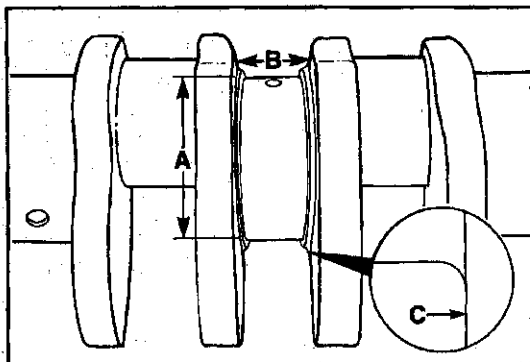
### Thrust Journal/Thrust Surface Width Regrinding

Thrust journals can be reground in the same increments and using the same specifications as all other main journals. The main journal radius may be reground using either the preferred or the optional procedure providing the thrust surface width is not being reground. Then the preferred procedure must be used. When the thrust surface width requires regrounding, the main journal must be reground to the same undersize dimension.

Available Undersize Thrust Journal/Thrust Surface	A = Diameter	Regrind To	B = Width
0.50mm [.0197inch]	82.500 ± .013mm [3.2480 ± .0005inch]		38.000 ± .025mm [1.4961 ± .001inch]
1.00mm [.0394inch]	82.000 ± .013mm [3.2283 ± .0005inch]		38.500 ± .025mm [1.5158 ± .001inch]



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The thrust surface (C) is to be ground on center within 0.10mm [.004 inch] and must be perpendicular to the front and rear mains within .0015mm [.00006 inch] per radial inch on the thrust area. The surface finish requirement is .04 micrometer [16 microinch].

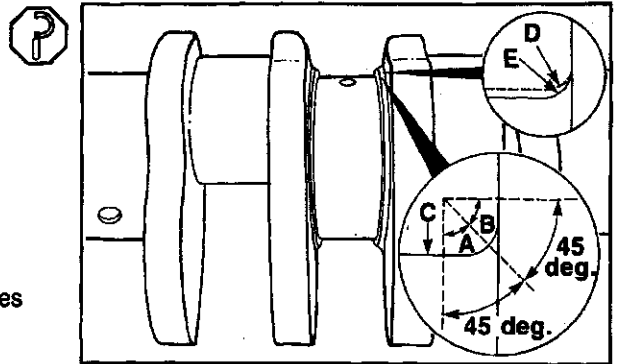
### Crankshaft Main Journal Radius - Regrind

#### Preferred Procedure - All Main Journals

Smoothly blend a  $4.20 \pm .020\text{mm}$  [ $.1654 \pm .0008$  inch] radius to the reground diameters.

#### Surface finish

- A = 0.8 micrometer [32 microinch] for a minimum of 45 degrees the fillet beyond the journal surface.
- B = 1.6 micrometer [64 microinch] for the remainder of the fillet.
- C = 0.4 micrometer [16 microinch] journal surface.
- D = Original radius
- E = New undercut radius



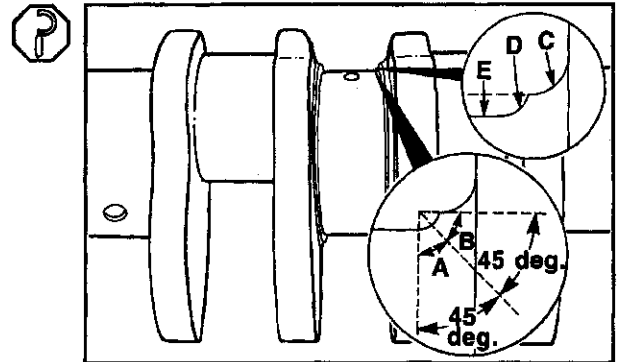
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#### Optional Procedure - Not to be Used when Thrust Surface Width is Reground

Smoothly blend a  $1.25 \pm .020\text{mm}$  [ $0.0492 \pm .0008$  inch] radius to the reground diameters.

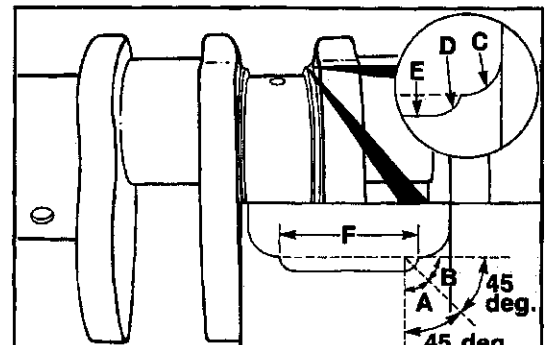
#### Surface finish:

- A = 0.8 micrometer [32 microinch] for a minimum of 45 degrees into the fillet beyond the journal surface.
- B = 1.6 micrometer [64 microinch] for the remainder of the fillet.
- C = Original radius
- D = New undercut radius
- E = 0.4 micrometer [16 microinch] journal surface.



#### Width of regrind for undercut radius

- F =  $34.500 \pm .025\text{mm}$  [ $1.358 \pm .001$  inch]





### Crankshaft Rod Journal Regrind Specifications

**Standard rod journal size:** 69.000 ± .013mm [2.7165 ± .0005 inch]

**Worn limit:** 68.962mm [2.7150 inch]

**Available Undersize**

- 0.25mm [.0098 inch]
- 0.50mm [.0197 inch]
- 0.75mm [.0295 inch]
- 1.00mm [.0394 inch]

**Regrind To:**

- 68.750 ± 0.013mm [2.7067 ± .0005 inch]
- 68.500 ± 0.013mm [2.6969 ± .0005 inch]
- 68.250 ± 0.013mm [2.6870 ± .0005 inch]
- 68.000 ± 0.013mm [2.6772 ± .0005 inch]

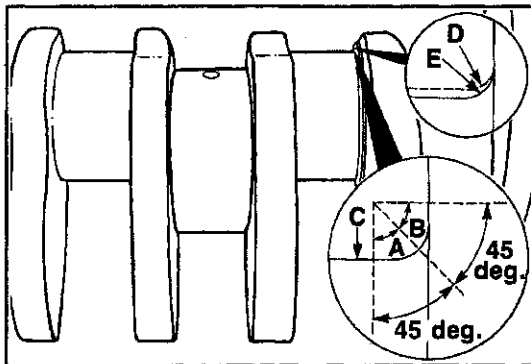
All rod journals to be parallel to front and rear main journals within ..... 0.03mm [0.001 inch]

Out of roundness ..... 0.005mm [0.0002 inch] maximum

Taper ..... 0.005mm [0.0002 inch] maximum

Journals are to be ground in the opposite direction of rotation (clockwise as viewed from the front of the crankshaft).

Journals are to be polished in the same direction as engine rotation.



### Crankshaft Rod Journal Radius - Regrind

**Preferred Procedure**

Smoothly blend a 4.00 ± 0.20mm [.1575 ± .0008 inch] radius to the reground diameters and side faces.

**Surface finish:**

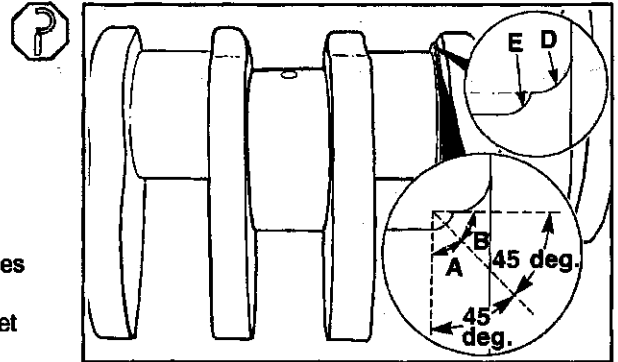
- A = 0.8 micrometer [32 microinch] for a minimum of 45 degrees into the fillet beyond the journal surface
- B = 1.6 micrometers [64 microinch] for the remainder of the fillet
- C = Journal surface 0.4 micrometer [16 microinch]
- D = Original radius
- E = New undercut radius

**Optional Procedure**

Smoothly blend a  $1.25 \pm .020\text{mm}$  [ $.0492 \pm .0008$  inch] radius to the reground journal.

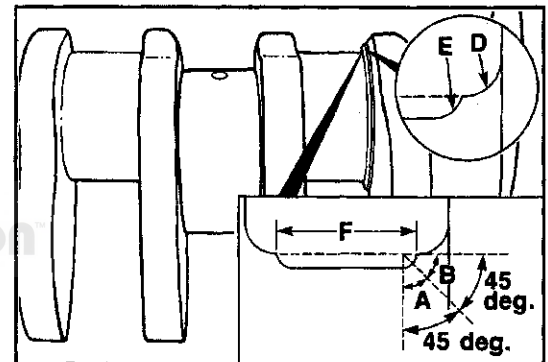
**Surface finish**

- A = 0.4 micrometer [16 microinch] journal surface
- B = 0.8 micrometer [32 microinch] for a minimum of 45 degrees into the fillet beyond the journal surface
- C = 1.6 micrometer [64 microinch] for the remainder of the fillet
- D = Original radius
- E = New undercut radius



**Width of regrind for undercut radius**

F =  $34.790 \pm .025\text{mm}$  [ $1.369 \pm .001$  inch]



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## Cylinder Head Repair Tools

Valve Refacer

Valve Seat Grinder

Valve Guide Installation Tool

Valve Seat Installation Tool



**Note:** The repairs can be performed with standard gasoline engine tooling at local automotive repair shops.

## Cylinder Head Combustion Deck Inspection and Refacing



Inspect the head surface for nicks, erosion, etc.

Check for head distortion as illustrated.

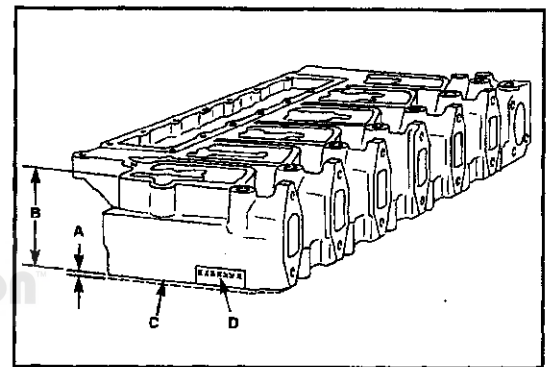
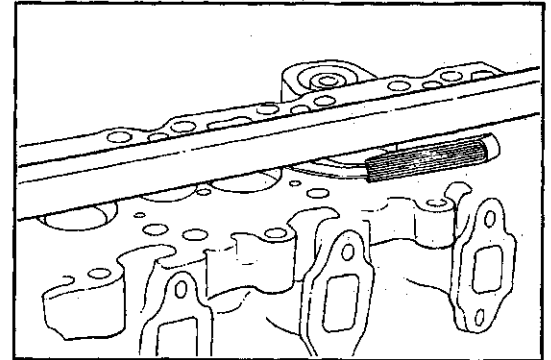
### Limit

**Variation:** .010mm [0.0004 inch] in any given 50.8mm [2.0 inch] diameter area. The overall end or side-to-side variation limit is:

- 0.30mm [0.012 inch]

The combustion deck may be refaced in whatever increments necessary to clean up the surface and maintain the surface finish and flatness tolerancing, as long as the combined total of stock removed does not exceed 1.00mm [.0393 inch]. The amount of stock removed each time must be steel stamped just above the edge of the combustion deck on the lower right hand corner of the rear face.

- A = 1.00mm [.03937 inch] total
- B =  $94.00 \pm 0.25$ mm [3.7008  $\pm$  .0010 Inch] minimum (reference only)
- C = Surface finish 1.5 to 3.2 micrometers [60 to 128 microinches]
- D = Identification area for stamping amounts of stock removed



## Valve Guides: Inspection and Installation

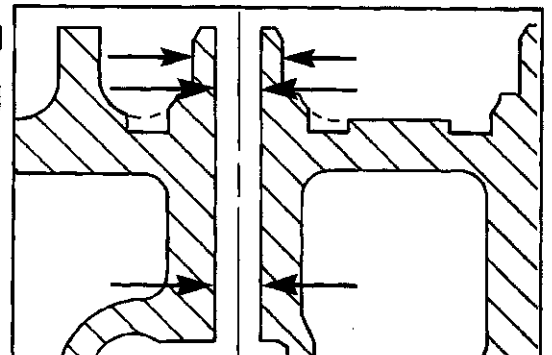
Inspect the valve guides for scuffing or scoring.

Measure the valve guide bore.

### Diameter Limits

New Minimum: 8.019mm [0.3157 inch]  
New Maximum: 8.029mm [0.3165 inch]

**Worn Limit:** 8.090mm [0.3185 inch]

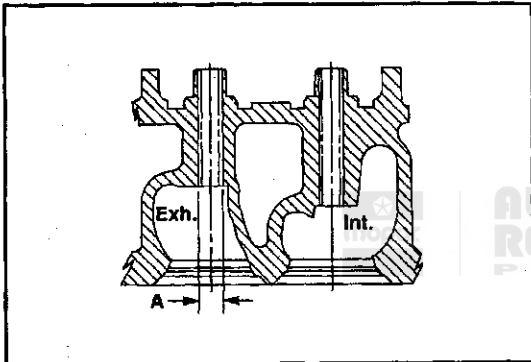


If the valve guide bores are larger than the worn limit, the cylinder head must be machined for service valve guides. New valve guides must be reamed to size after they are installed.

**Note:** If the cylinder head needs service valve guides and valve seat inserts, the valve guides should be installed first.

### Valve Guides

- Intake (Thick wall)
- Exhaust (Thick wall)
- Intake and Exhaust (Thin wall)

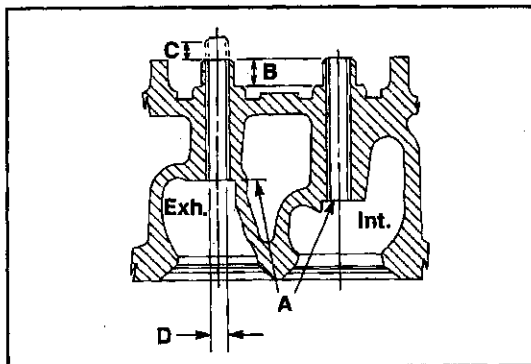


### Service Valve Guides - Thin Wall

Machine the cylinder head valve guide bores to Dimension A.

A =  $11.125 \pm 0.013\text{mm}$  [ $.4380 \pm .0005$ ] in diameter

Service valve guides must be centered with valve seats within  $0.35\text{mm}$  [ $.01378$  inch] diameter and are to be square with the combustion face within  $0.10\text{mm}$  [ $.0004$  inch] at  $50.0\text{mm}$  [ $1.9685$  inch] radius.



Install the valve guides as illustrated.

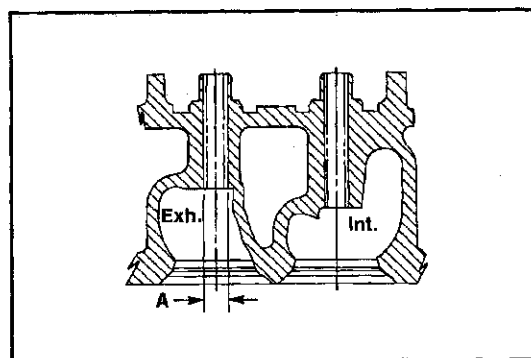
A = Lubricate with oil and press the guides flush to the bottom of the bosses.

B =  $12.00 \pm 0.75\text{mm}$  [ $.4724 \pm .0295$  inch] reference

C = Trim off flush to top of guide bosses if necessary.

D =  $8.029 \pm 0.010\text{mm}$  [ $.3161 \pm .0004$  inch]

**Note:** The valve guide bore must be centered with the valve seat within  $0.35\text{mm}$  [ $0.0138$  inch] diameter and must be square with the combustion face within  $.010\text{mm}$  [ $0.004$  inch] at  $50.0\text{mm}$  [ $2.0$  inch] radius.



### Service Valve Guides - Thick Wall

Machine the cylinder head valve guide bores to Dimension A.

A =  $14.000 \pm 0.013\text{mm}$  [ $0.5512 \pm .0005$  inch] diameter

Valve guides must be centered with valve seats within  $0.35\text{mm}$  [ $.01378$  inch] diameter and must be square with the combustion face within  $0.10\text{mm}$  [ $.0004$  inch] at  $50.0\text{mm}$  [ $1.9685$  inch] radius.

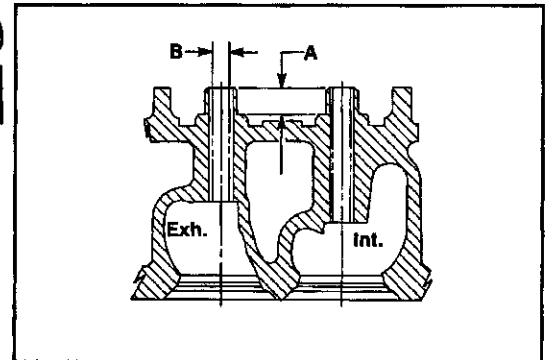
Install the valve guides as illustrated.

Lubricate with oil and press in the guides to dimension A protrusion above the cylinder head.

Ream the bores to the dimension B size.

A =  $12.25 \pm 0.50\text{mm}$  [ $0.4823 \pm 0.020$  inch]

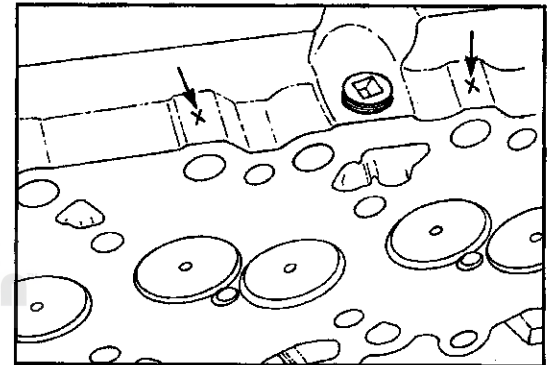
B =  $8.029 \pm 0.010\text{mm}$  [ $0.3161 \pm 0.0004$  inch]



### Valve Seats - General

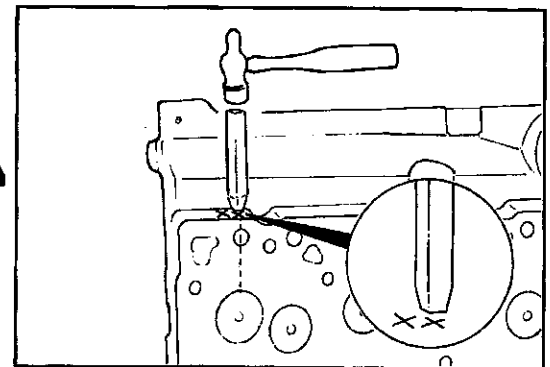
On cylinder head which have integral valve seats, the seats can be reground once only. Integral seats that have been previously reground must be replaced with service seats.

Seats that have been previously reground should have been identified with one X stamped into the head casting as shown.



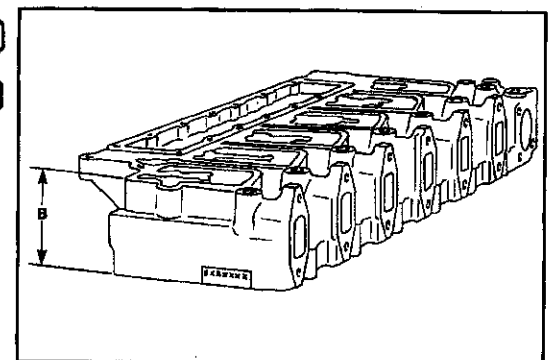
Two X's stamped on the head indicate service seats have been installed. Service seats can be reground.

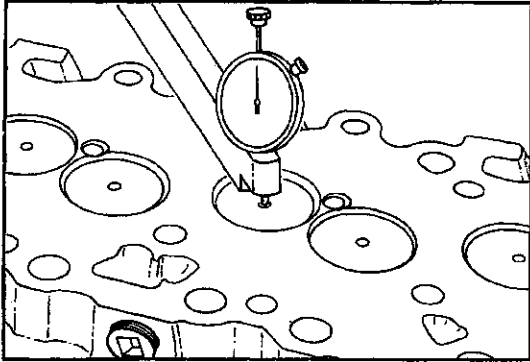
**Caution:** On the integral seat head, if 0.254mm [.010 inch] or more has been removed from the head combustion surface, service seats must be installed.



**Note:** To determine if the head has been previously resurfaced, before calculating valve depth, proceed as follows:

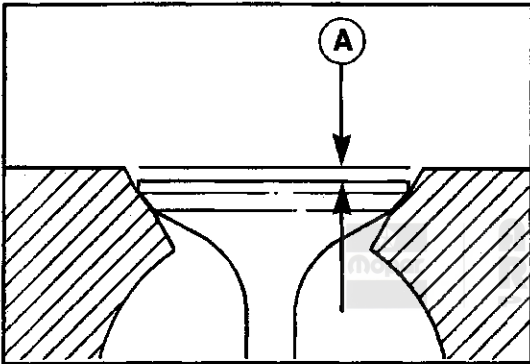
1. Check the rear lower right corner of the head for a stamping that would indicate previous resurfacing (e.g. .003).
2. To verify the information, or if no amount is indicated, measure the head height (B).
3. If the head height is 94.75mm [3.730 inch] or greater, the valve seats may be reground if they have not been reground previously.





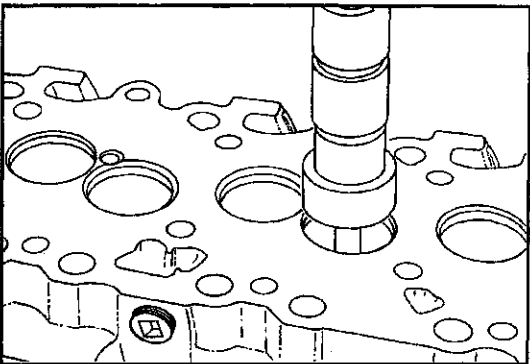
### Calculating the Grinding Depth (Integral seats only)

After resurfacing the valves and determining that all values meet specifications, install the valves in their designated locations and measure valve depth.



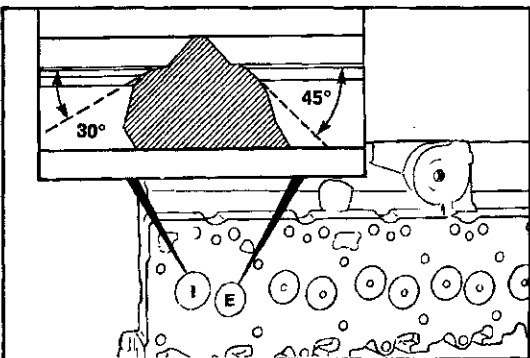
**Note:** The valve depth is the distance from the valve face to the head deck.

Record the depth of each valve (A).



### Grinding the Valve Seats

Grind the valve seats to remove scores, scratches and burns.

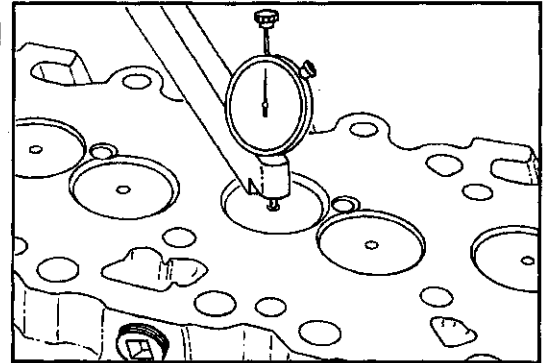


### Seat Angle

Intake: ..... 30 degrees

Exhaust: ..... 45 degrees

Install the valves in their respective bores and measure the depth again.



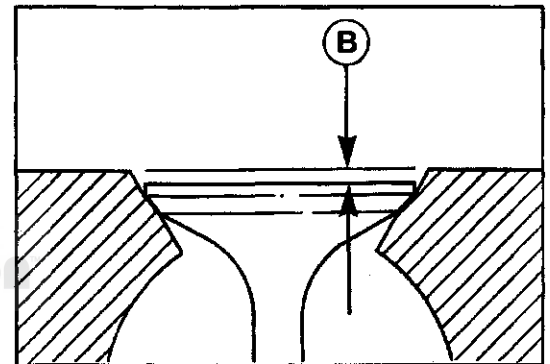
Record the depth of each valve (B).

Calculate the grinding depth (GD) as follows:

$$GD = (B) - (A)$$



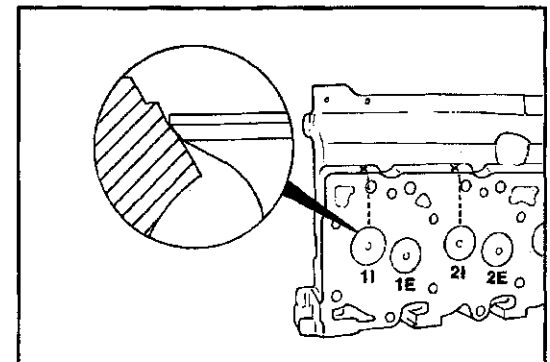
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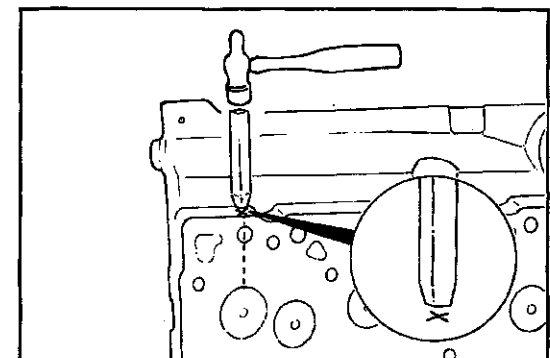
**Grinding Depth Maximum Limit (Integral Seats Only)**

$$GD = .254\text{mm} [.010 \text{ inch}]$$

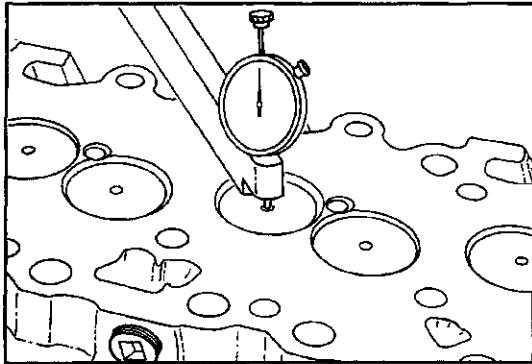
**Note:** Service valve seats are available for over the limit seats.



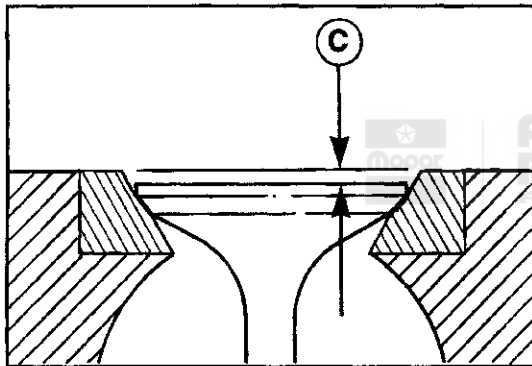
Identify reground valve seats.







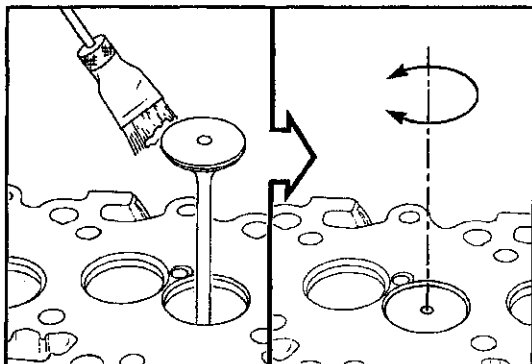
Install the valves in their designated locations and measure the depth of each.



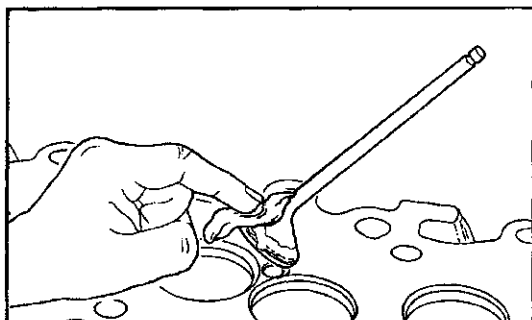
**Valve Depth Limit (Integral and Inserted Seats)**

C = 0.99mm to 1.52mm [.039 to .060 inch]

**Note:** Replace the valve if the depth is over the limit.



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



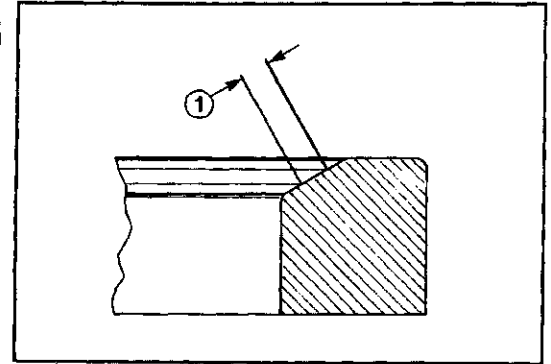
Remove the valves and clean lapping compound from the valves and seats.

Measure to valve seat width indicated by the lapped surface.



**Valve Seat Width Limit**

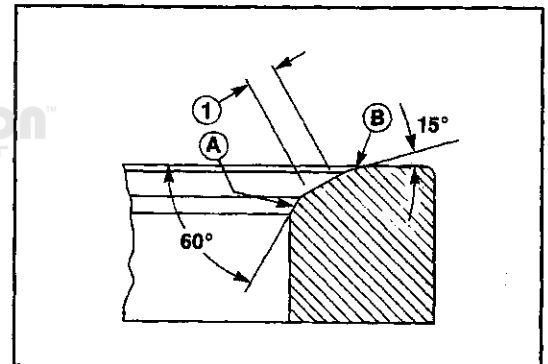
1.50mm Minimum [.060 inch] 2.0mm Maximum [.080 inch]



If required, grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face. Maintain the valve seat width limits.

**Valve Seat Width Limits (1)**

1.5mm Minimum [.060 inch] 2.0mm Maximum [.080 inch]



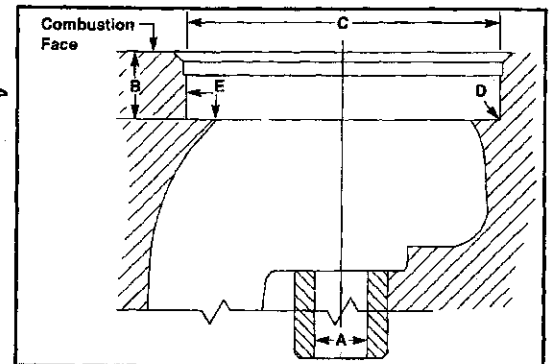
**Installing Service Valve Seats**

Inspect the valve guide bores as described in the valve guide section of this manual. If it is necessary to install valve guides, install the guides before installing the service seats.

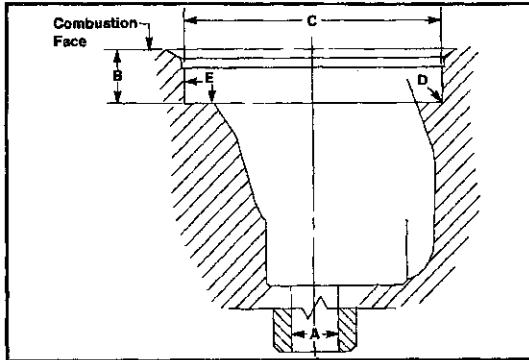


**Valve Seat Insert - Pocket Machining Dimensions, Intake Seat**

- A = 8.029 ± 0.010mm [.3161 ± .0004 inch]
- B = 10.40 ± 0.10mm [.4094 ± .004 inch]
- C = 47.00 ± 0.013mm [1.8504 ± .0005 inch] diameter
- D = 0.40mm [.0157 inch] maximum radius
- E = 3.2 micrometers [128 microinch] surface finish



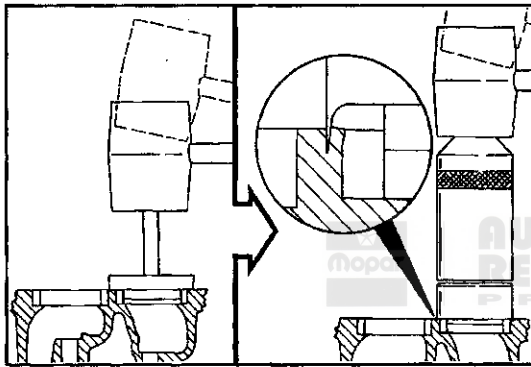
(Valve Seat Insert Part Number 4429854)



**Valve Seat Insert - Pocket Machining Dimensions, Exhaust Seat**

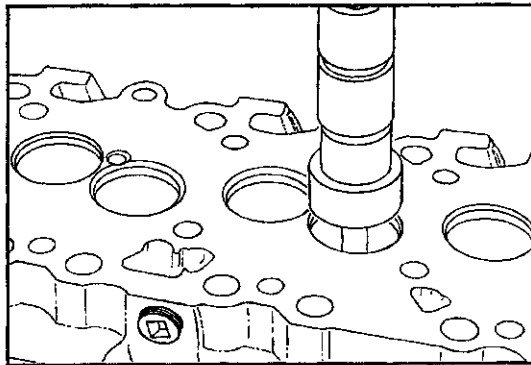
- A = 8.029 ± 0.010mm [.3161 ± .0004 inch] diameter
- B = 10.20 ± 0.10mm [.4015 ± .004 inch]
- C = 43.650 ± 0.013mm [1.7185 ± .0005 inch] diameter
- D = 0.40mm [.0157 inch] maximum radius
- E = 3.2 micrometers [128 microinch] surface finish

(Valve Seat Insert Part Number 4429111)

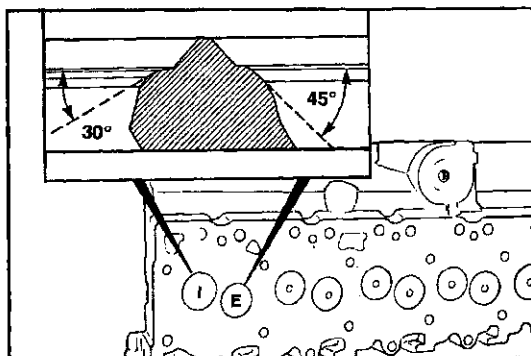


**Valve Seat Insert Staking Tool**

Press service seats into the machined pockets. Stake the valve seats into the pockets.



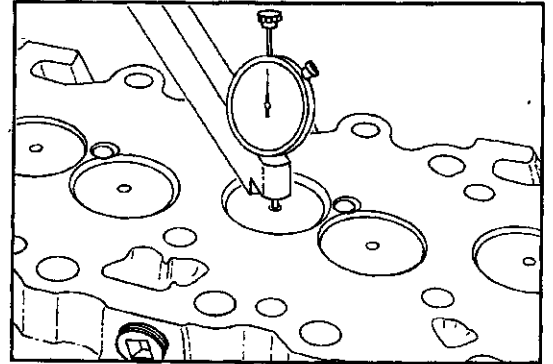
Grind the valve seats lightly to ensure proper seat angle.



**Seat Angle**

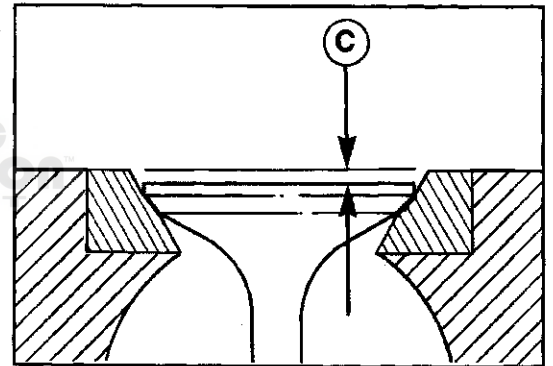
- Intake: ..... 30 degrees
- Exhaust: ..... 45 degrees

Install the valves in their respective locations and measure the depth.

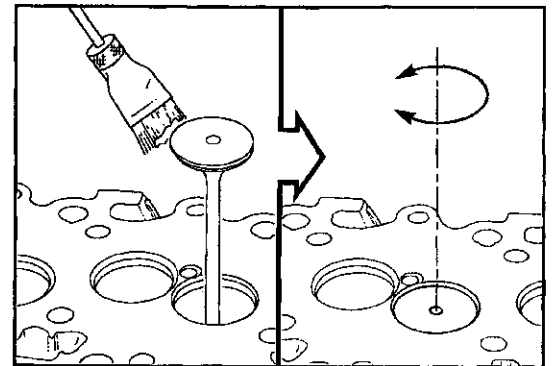


**Valve Depth Limit**

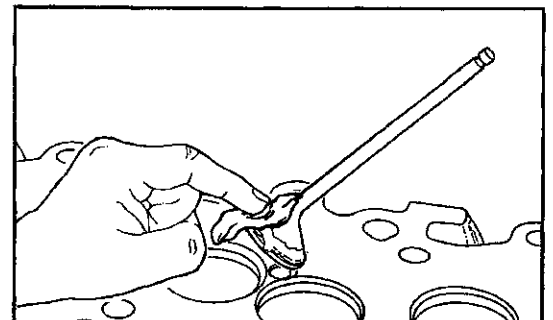
C = 0.99mm to 1.52mm [.039 to .060 inch]

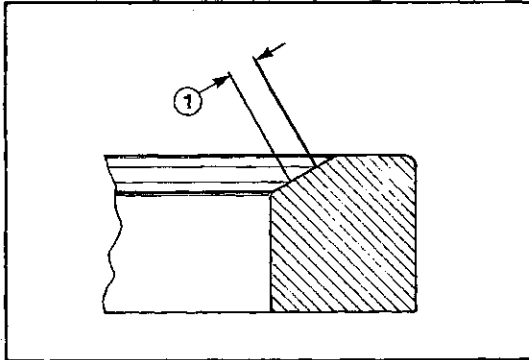


Apply a light coat of valve lapping compound to each valve and lap each valve to its mating seat.



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

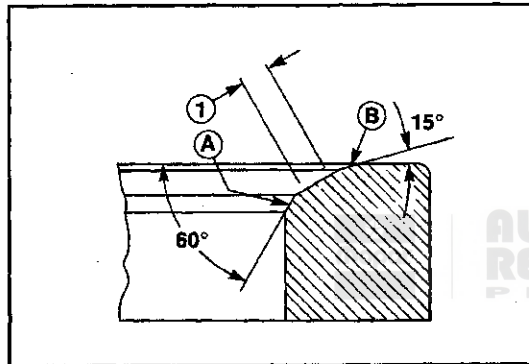




Measure the valve seat width indicated by the lapped surface.

**Valve Seat Width Limit**

1.50mm Minimum [.060 inch] 2.0mm Maximum [.080 inch]



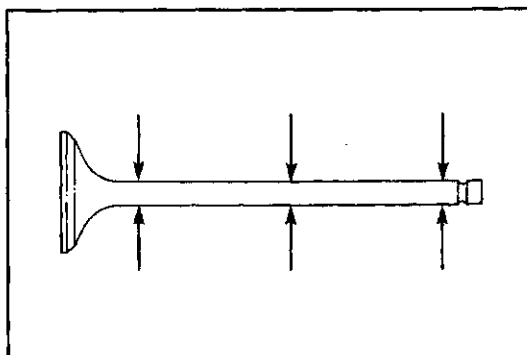
If required, grind area (A) with a 60 degree stone and (B) with a 15 degree stone to center the seat on the valve face. Maintain the valve seat width limits.

1.5mm Minimum [.060 inch] 2.0mm Maximum [.080 inch]

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**Replacing Service Seats**

To replace service seat inserts, machine the insert in the same manner as if machining out the integral seat. Hold the same tolerances and follow the same installation procedures.



**Grinding the Valves**



Inspect for abnormal wear on the valve heads and stems.

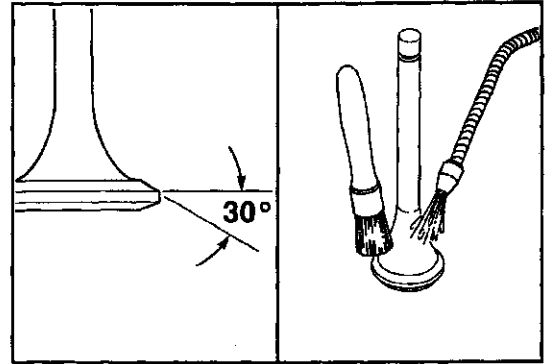
Measure the valve stem diameter.

**Valve Stem Diameter Limits**

- 7.935mm Minimum [.3126 inch]
- 7.960mm Maximum [.3134 inch]

Resurface all reused valves.

Replace bent valves.

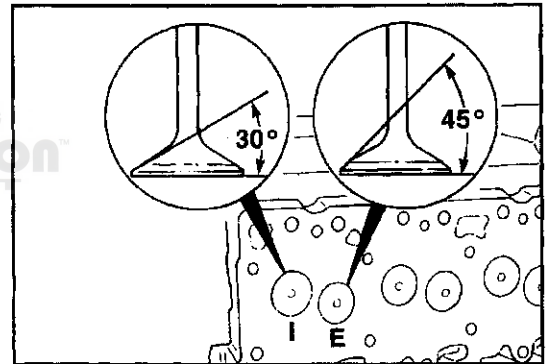


**Seat Angle**

Intake: ..... 30 degrees  
Exhaust: ..... 45 degrees



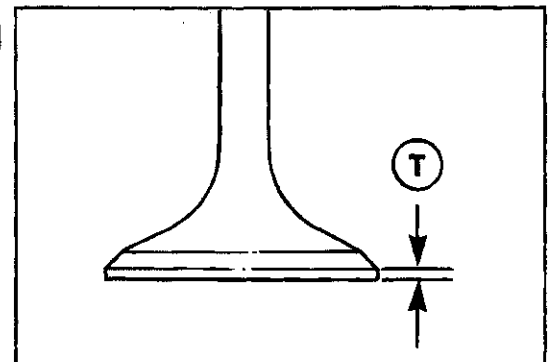
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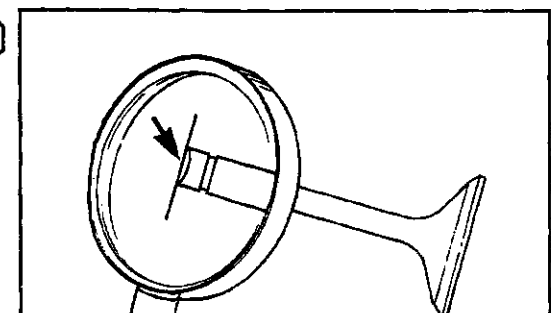
Measure the rim thickness.

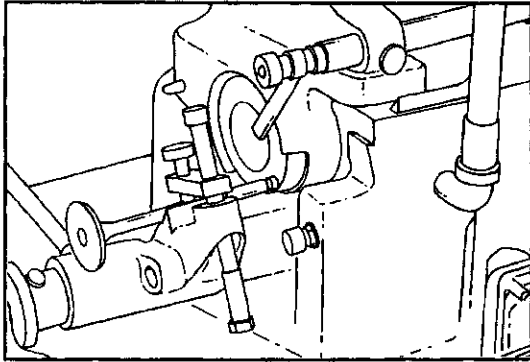
**Valve Rim Thickness Limit**

T = .79mm Minimum [.031 inch]

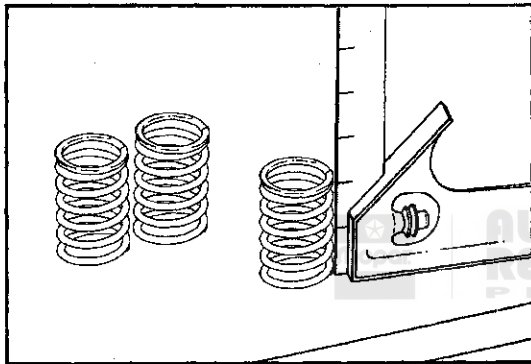


Inspect the end of the valve stem for flatness.





If required, resurface valve end.



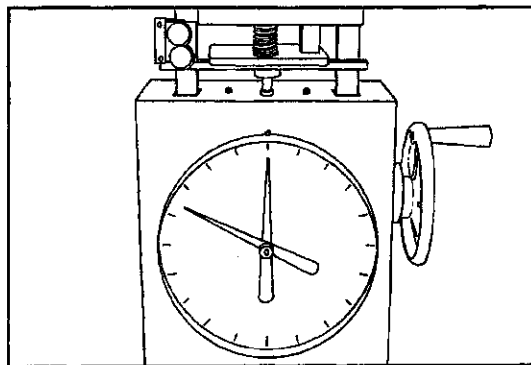
**Inspect the valve springs.**

Measure the valve spring length.

**Valve Spring Dimensional Limits**

Approximate Free Length: 55.63mm [2.190 inch]

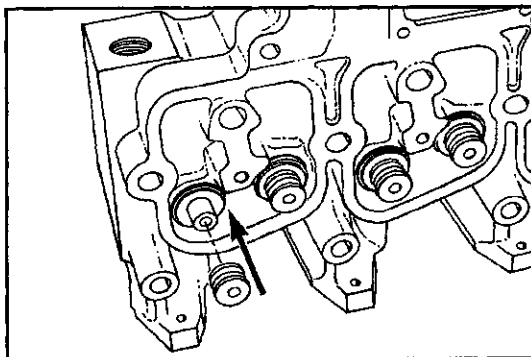
Maximum Inclination: 1.0mm [.039 inch]



Measure the valve spring force.

**Valve Spring Minimum Load Limit**

Minimum Load: 289.32 N [65 lb] is the minimum acceptable load required to compress the spring to a height of 49.25mm [1.94 inch].



**Assembly of the Cylinder Head**

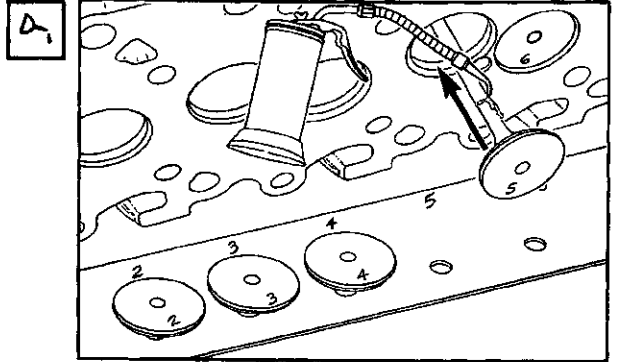
**Note:** Clean all cylinder head components before assembling.



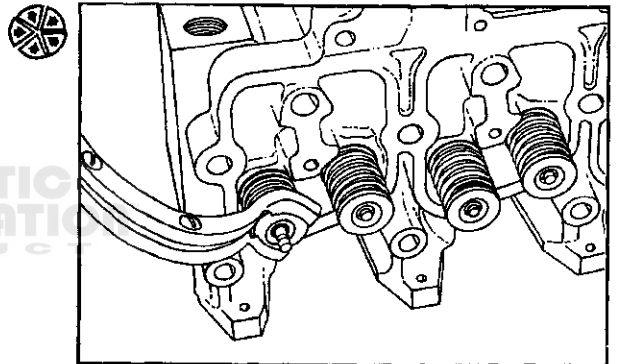
Install the valve stem seals.

**Note:** The intake and exhaust valve seals are the same.

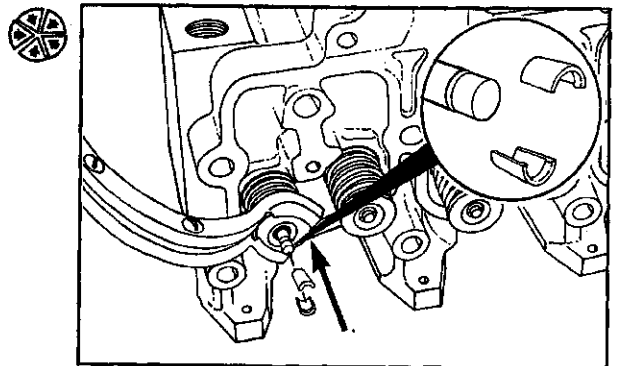
Lubricate the stems with SAE 90W oil before installing the valves.



Compress the valve spring after installing the spring and retainer.

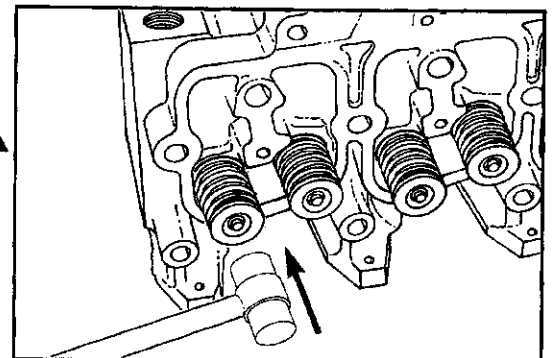


Install new valve collets and release the spring tension.



Tap the ends of the valve stems with a mallet to verify the collets are seated.

**Warning:** Wear protective equipment and do not stand in line with the valve stem when tapping valve.







## Specifications

### Section 9L

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<b>Subject</b>	<b>Page</b>
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Pipe Plugs, Fittings, and Adapters .....	9L-4
Engine Component Torque Value .....	9L-5
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Cylinder Bores .....	9L-17

### Tools Required

Sockets	Combination Wrenches	Other
6mm 6 point	6mm	Crankcase Blowby Tool (.221 inch orifice)
7mm 6 point	7mm	Water Manometer
8mm 6 point	8mm	Breaker Bar (3/8 and 1/2 in. Square Drive)
10mm 6 point	10mm	Flat Screwdriver
12mm 6 point	12mm	Ratchet (3/8 in. Square Drive)
13mm 6 point	13mm	Ratchet (1/2 in. Square Drive)
14mm 6 point	14mm (open end)	Filter Wrenches (75-80mm and 90-95mm)
15mm 6 point	15mm (open end)	Drill Motor (1/4 inch)
16mm 6 point	16mm	Drill Bit (3mm)
17mm 6 point	17mm	Slide Hammer
18mm 6 point	18mm	Flat Chisel
19mm 6 point	19mm	T-Bar Puller (75mm)
21mm 6 point	21mm	Sheet Metal Screw (#10)
22mm 6 point	22mm	Torque Wrench
24mm (deep well)	24mm	Pliers
1/2 inch 6 point	5/8 inch	Injector Bore Cleaning Brush
9/16 inch 6 point		Tappet Removal/Installation Tool
1 1/16 inch (deep well)		#20 Torx
		#25 Torx
		36mm Fan Wrench
		Clutch Disc Guide Tool
		Oil Pressure Sending Unit Socket
		Screwdriver Adapter (1/2 in. Square Drive)
		5mm Allen Drive Adapter (3/8 in. Square Drive)
		Snap Ring Pliers
		Cam Bushing Removal/Installation Tool
		75-125mm Piston Ring Compressor

## Capscrew Markings and Torque Values - Metric

Metric capscrews are identified by the grade number stamped on the head of the capscrew or on the surface of metric nuts. The higher the number, the greater the strength of the capscrew.

### Commercial Steel Class

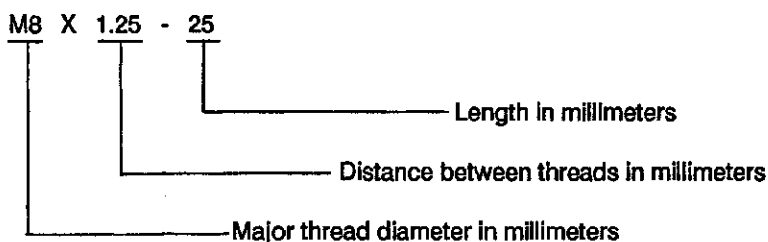


Thread Diameter mm	Torque		Torque		Torque	
	N·m	[ft-lb]	N·m	[ft-lb]	N·m	[ft-lb]
5	6	[5]	8	[6]	8	[6]
6	9	[7]	14	[10]	15	[11]
8	24	[18]	34	[25]	38	[28]
10	43	[32]	64	[47]	77	[57]
12	77	[57]	112	[83]	137	[101]
14	127	[94]	180	[133]	216	[159]
16	195	[144]	266	[196]	319	[235]

### Notes:

1. Do not use these values when the torque values are specified in another section of the manual.
2. These values are based on clean, dry threads. Reduce the value by 10% when a lubricant is used. Reduce the value by 20% if new plated capscrews are used.
3. Always use caution to be sure that capscrews from the engine are put back in their proper locations.
4. When replacing capscrews, always use a capscrew of the same dimensions and strength as the capscrew being replaced. Incorrect capscrews can result in engine damage.

### Metric Capscrew Nomenclature



### Pipe Plugs, Fittings, and Adapters

- When installing directional fittings, tees or elbows, first tighten it to the appropriate torque value and then continue to turn it in the tightening direction until it is aligned. Do not turn it in the loosening direction, and do not turn it more than one revolution past the specified torque value.
- Apply liquid Teflon to all pipe fittings and plugs.

#### Torque For Pipe Plugs

Pipe Plug Size	Torque (Into Aluminum Or Cast Iron)	
	N-m	[ft-lb]
1/16"	6	[4]
1/8"	8	[6]
1/4"	12	[9]
3/8"	15	[11]
1/2"	24	[18]
3/4"	36	[27]
1"	45	[33]



### Engine Component Torque Value

Socket Or Wrench Size mm [inch]		Torque		
		N-m	[ft-lbs]	
12	Air Fuel Control Banjo Screw (In Pump)	12	[9]	
[1/2]	Air Fuel Control Fitting (In Head)	8	[6]	
13	Alternator Ground Cable Mtg to Block	24	[18]	
13,15	Alternator Mtg to Water Pump Inlet	41	[30]	
[15/16]	Alternator Pulley	80	[60]	
10	Alternator Support (Upper)	24	[18]	
18	Battery Cable (Negative) Mtg to Block	77	[57]	
13	Belt Tensioner Mounting	43	[32]	
5 (Allen)	Block Heater Mounting	12	[9]	
[5/16]	Cab Heater Hose Clamp	4	[35 in-lbs]	
10	Cab Heater Tubing Clamp Mtg.	24	[18]	
13	Cam Thrust Plate	24	[18]	
[1/2]	Clutch Cover Mtg to Flywheel	23	[17]	
12	Connecting Rod	35	[26]	
	(Alternately Tighten	Step 2	70	[51]
	in three Steps)	Step 3	100	[73]
[1/2]	Cooling Fan Mtg to Fan Clutch	20	[15]	
[5/16]	Crossover Clamp (Air)	5	[44 in-lbs]	
18	Cylinder Head Mounting	Step 1	40	[29]
		Step 2	85	[62]
		Step 3	126	[93]

### Engine Component Torque Value

Socket Or Wrench Size mm [inch]		Torque	
		N·m	[ft-lb]
13	Exhaust Manifold	43	[32]
[7/16]	Exhaust Outlet Pipe, V Band Clamp	8	[6]
[9/16]	Exhaust Pipe Clamp Mtg	27	[20]
[9/16]	Exhaust Pipe Steady Rest Mtg to Transmission	68	[50]
36	Fan Clutch Mtg to Fan Hub (Left Hand Threads)	57	[42]
10	Fan Hub Bracket Mounting	24	[18]
15	Fan Hub Bearing Retaining Capscrew	77	[57]
10	Fan Pulley to Fan Hub	9	[7]
10	Fan Pulley C/S	9	[7]
	Fan Shroud Mounting Nuts	11	[95 in-lbs]
19	Flywheel	137	[101]
15	Flywheel Housing - Adapter	60	[44]
[3/4]	Front Engine Mount Isolator Mtg to Mount	109	[80]
[9/16]	Front Engine Mount Mtg to Mount Pad (Through Bolt & Nut)	41	[30]
15	Front Engine Mount to Block	60	[44]
--	Front Oil Filler Pipe / Access Cover	---Hand Tighten	
17	Fuel Banjo Screw (In Fuel Pump)	32	[24]
17	Fuel Banjo Screw (In Head)	24	[18]
10	Fuel Banjo Screw (In Injector)	8	[6]
80-95	Fuel Filter	1/2 Turn After Contact	
	Fuel Heater Assembly Mounting	32	[24]
[3/8]	Fuel Heater Ground Mtg to Intake Manifold	12	[9]
17	Fuel Line Fitting (High Press)	24	[18]
14	Fuel Low Pressure Supply	24	[18]
22	Fuel Pump Drive Gear (With Pump Unlocked)	65	[48]
10	Fuel Pump Lock (Bosch)	30	[22]
13	Fuel Pump Mounting Nut	24	[18]
24	Fuel Pump Solenoid	43	[32]
10	Fuel Pump Support Bracket	24	[18]
10	Fuel Pump Unlock (Bosch)	13	[10]
10	Fuel Vent Screw (In Banjo)	8	[6]
10	Gear Cover	24	[18]
10	Gear Housing-to-Block	24	[18]
24	Injector Retaining Nut	60	[44]
10	Intake Manifold Cover	24	[18]
10	Lift Pump Mounting	24	[18]
18	Lifting Bracket (Rear)	77	[57]
23	Main Bearing Cap	60	[45]
		Step 1	
		Step 2	119 [88]
		Step 3	176 [129]
10	Oil Cooler Assembly	24	[18]
17	Oil Fill Tube Bracket	43	[32]
75-85	Oil Filter	3/4 Turn After Contact	
17	Oil Pan Drain Plug	80	[60]
10	Oil Pan Mounting	24	[18]
19	Oil Pressure Regulator Plug	80	[60]
	Oil Pressure Sender/Switch	16	[12]
13	Oil Pump Mounting	24	[18]
13	Oil Suction Tube (Flange)	24	[18]
10	Oil Suction Tube Brace	24	[18]
15	Power Steering Pump to Vacuum Pump Mounting	24	[18]

### Engine Component Torque Value

Socket Or Wrench Size mm [inch]		Torque	
		N·m	[ft-lb] [in-lbs]
[5/16]	Radiator Hose Clamp / Upper	4	[35 in-lbs]
	Radiator Mounting Nuts	11	[95 in-lbs]
8	Rear Seal Mounting	9	[7]
10	Refrigerant Compressor Lines - Flange Mtg.	20	[15]
[9/16]	Refrigerant Compressor Mtg.	47	[35]
14	Rocker Lever Nut	24	[18]
13	Rocker Support	24	[18]
10	Starter Mounting	43	[32]
15	Starter Positive Battery Cable Nut	22	[16]
8	Starter Solenoid Nut	5	[44 in-lbs]
10	Tappet Cover/Fuel Drain Line Supports	24	[18]
[1 1/16]	Thermistor	24	[18]
10	Thermostat Housing	24	[18]
10	Throttle Bracket Mtg to Mtg Bracket	24	[18]
10	Throttle Rod Mtg to Throttle Lever Nut	10	[7.5]
T-25 Torx	Timing Pin Flange Mounting	5	[44 in-lbs]
13	Torque Converter Access Cover Plate Mtg	4	[35 in-lbs]
	Transfer Case Linkage Bracket Mtg to Transmission	41	[30]
	Transfer Case Mtg to Transmission	47	[35]
13	Transmission Cooler Tubing Mtg to Oil Pan Flange	24	[18]
[11/16]	Transmission Kick Down Cable Bracket Mtg to Transmission	68	[50]
	Transmission Mount Mtg to Transmission (Manual)	68	[50]
	Transmission Mount Through Bolt Mtg (Manual)	68	[50]
[9/16]	Transmission Mtg to Engine	41	[30]
	Transmission Oil Cooler Line Connection	54	[40]
	Transmission Oil Cooler Line Fittings	6	[50 in-lbs]
	Transmission Oil to Air Cooler Hose Clamps	2	[18 in-lbs]
[9/16]	Transmission to Clutch Housing Mtg.	47	[35]
	Transmission Torque Converter Mtg	47	[35]
13	Turbine Housing	11	[8]
[7/16]	Turbo Compressor Housing Clamp	8	[6]
15	Turbo Mounting Nut	32	[24]
10	Turbo Oil Drain Tube	24	[18]
[5/8]	Turbo Oil Supply (Both Ends)	15	[11]
10	Vacuum Pump Mounting	9	[7]
18	Vacuum Pump to Gear Housing Mtg.	77	[57]
15	Valve Cover	24	[18]
15	Vibration Damper Mounting	125	[92]
[5/16]	Water Hose Clamps	4	[35 in-lbs]
13	Water Inlet Connection	43	[32]
13	Water Pump Mounting	24	[18]
[1 1/16]	Water Temperature Sensor	50	[37]

## Engine Sealants

Use the sealants listed below or sealants containing equivalent properties.

Description	Sealing Method
Pipe Plugs	Precoated teflon, or Loctite 59,241 liquid teflon,
Gaskets	
a. Oil Pan	Apply Three Bond 1207-C (or Permatex #2C) to the four "T" joints and smear into the joints with finger until full.
b. Tappet Cover (6 cylinder)	Self-adhesive tappet cover side. K&W Copper Coat #1504 - block side.
c. All Other Gaskets	No sealant required.
Cup Plugs	Loctite 277, 11,264, or #2654427 MS CD 96 Type A.
O-Rings	No sealant required.
Rear Camshaft Expansion Plug	Loctite 277, 11,264, or #2654427 MS CD 96 Type A.
Intake Cover Capscrews	Precoated or Loctite 59,241 liquid teflon.
Fuel Pump Studs	Loctite 601.
Turbo Drain in Block	Loctite 277, 11,264 or #2654427 MS CD 96 Type A.
Dipstick Tube in Block	Loctite 277, 11,264 or #2654427 MS CD 96 Type A.
Front Seal in Gear Cover	Loctite 277, 11,264 or #2654427 MS CD 96 Type A.
Rear Seal in Rear Cover	No sealant on seal with rubber O.D. Loctite 277, 11,264 or #2654427 MS CD 96 Type A, on seal with Aluminum Housing.
Timing Pin Housing Capscrews	Loctite 59,241 liquid teflon or precoated.



## Engine Lubricants

Use the lubricants listed below or lubricants containing equivalent properties when assembling or installing parts.

Part	Lubricant Required
Rod Bearings	Lubriplate 105
Main Bearings	Lubriplate 105
Cam Lobes and Journals	Lubriplate 105
Tappets	Lubriplate 105
Pistons	15W40 Engine Oil
Piston Rings	15W40 Engine Oil
Piston Pin	15W40 Engine Oil
Rocker Assemblies	15W40 Engine Oil
Push Tubes	15W40 Engine Oil
	Lubriplate 105 in Cup

Capscrews - under head and on threads - as follows:

Main Capscrews	15W40 Engine Oil
Cylinder Head Capscrews	15W40 Engine Oil
Connecting Rod Capscrews	15W40 Engine Oil
Flywheel Mounting Capscrews	15W40 Engine Oil
Damper Mounting Capscrews	15W40 Engine Oil
All Other Capscrews	15W40 Engine Oil
Valve Stems	90W 140W Oil
Front and Rear Seals to Crankshaft	Dry - use no lubricants
Rear Seal in Seal Housing	Soapy water to install seal in housing (seal with rubber O.D) Aluminum O.D. requires sealant.
Lube Oil Pressure Regulator	15W40 Engine Oil

## Engine Specifications

Description	Specification	
<b>General Engine Data</b>		
Bore - mm [inch]	102	[4.02]
Stroke - mm [inch]	120	[4.72]
Displacement - liter [in. <sup>3</sup> ]	5.88	[359]
Engine Weight (Dry) Less Flywheel and Electric kg.. [lbs.]	399	[880]
Firing Order	1,5,3,6,2,4	
Valve Clearance - Intake - mm [inch]	.25	[.010]
Valve Clearance - Exhaust - mm [inch]	.51	[.020]
Compression Ratio	17.5:1	
Rotation, viewed from front of engine	Clockwise	
Aspiration	Turbocharged	
<b>Lubrication System</b>		
Oil Pressure at Idle - (Minimum Allowable) kPa [PSI]	69	[10]
Oil Pressure at Rated - (Minimum Allowable) kPa [PSI]	207	[30]
Regulating Valve Opening Pressure kPa [PSI]	414	[60]
Differential Pressure to Open the Filter Bypass Valve - kPa [PSI]	138	[20]
Oil Capacity of Pan - Liter [U.S. Quarts] <b>High Mark</b>	10.5	[11]
Oil Capacity of Pan - Liter [U.S. Quarts] <b>Low Mark</b>	8.6	[9]
Oil Capacity of Oil Filter - Liter [U.S. Quarts]	.95	[1]
<b>Cooling System</b>		
Total Cooling System Capacity* (Manual) Liter [U.S. Quarts]	14.7	[15.5]
Total Cooling System Capacity* (Automatic) Liter [U.S. Quarts]	15.7	[16.5]
Coolant Recovery Tank Liter [U.S. Quarts]	.95	[1]
Cooling Capacity (Engine only) Liter [U.S. Quarts]	10.5	[11.1]
Modulating Thermostat Range - Start Max. to Fully Open Max. - °C [°F]	83°C [181°F] to 95°C [203°F]	
Pressure Cap - kPa [PSI] 110°C [230°F] System	103	[15]
<b>Intake Air, Exhaust Systems</b>		
Maximum Allowable Intake Restriction at Rated Speed and Load with Dirty Air Filter Element - mm H <sub>2</sub> O [in. H <sub>2</sub> O]	635	[25]
Maximum Allowable Exhaust Restriction at Rated Speed and Load - mm Hg [in. Hg]	177.8	[7]
<b>Fuel System</b>		
Maximum Allowable Restriction to Fuel Lift Pump - mm Hg [in. Hg]	95	[3.75]
Maximum Allowable Fuel Return line Restriction - mm Hg [in. Hg]	518	[20.4]
<b>Electrical System</b>		
Minimum Recommended Battery Capacity with Accessories - 12V Starter	1025CCA	
Maximum Allowable Resistance of Starting Circuit - with 12V Starter - Ohms	.0012	

\* Coolant Recovery Tank not included in Total Cooling System Capacity.

### Coolant Specifications

Use antifreeze during all seasons to protect the engine cooling system from corrosion as well as freezing damage. The antifreeze should be changed every two years.

A mixture of 50% water and 50% ethylene-glycol base antifreeze is required for operation of the engine in temperature environments above -37°C [-34°F]. A mixture of 40% water and 60% antifreeze is recommended for temperatures below -37°C [-34°F].

**Note:** In Tropical climates where antifreeze availability may be limited, use a corrosion inhibitor (Cummins liquid DCA) or equivalent to protect the engine cooling system.

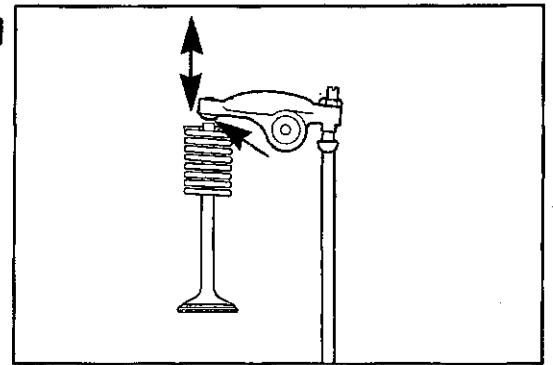
### Fuel Specifications

The Cummins Turbo Diesel engine has been developed to take advantage of the high energy content and generally lower cost No. 2 Diesel Fuels. Experience has shown that it also operates satisfactorily on No. 1 Diesel Fuels or other fuels within the following specifications.

Fuel Property	Specification	Lab Test Method
Viscosity .....	(ASTM D-445) .....	1.3 to 5.8 CentiStroke [1.3 to 5.8 mm <sub>2</sub> per Second] at 40°C [104°F]
Cetane Number .....	(ASTM D-613) .....	40 Minimum except in cold weather or in service with prolonged low loads, a higher cetane number is desirable.
Sulfur Content .....	(ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment .....	(ASTM D-1796) .....	Not to exceed 1% by weight.
Carbon Residue .....	(Ramsbottom ASTM D-524 or 189)	Not to exceed 1% by weight on 10% residue.
Flash Point .....	(ASTM D-93) .....	52°C [125°F] Minimum. Certain marine registries require higher flash points.
Density .....	(ASTM D-287) .....	-1 to 6°C [30 to 42°F] A.P.I. at 16°C [60°F] 0.816 to 0.876 Sp. Gr.
Cloud Point .....	(ASTM D-97) .....	-12°C [10°F] below lowest temperature expected to operate at.
Active Sulfur Copper Strip Corrosion .....	(ASTM D-130) .....	Not to exceed No. 2 rating after 3 hours at 50°C [122°F].
Ash .....	(ASTM D-482) .....	Not to exceed 0.02% by weight.
Distillation .....	(ASTM D-86) .....	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 360°C [680°F]. All of the fuel should evaporate at less than 385°C [725°F].

\*No. 1 Diesel Fuel should be used only where extended arctic conditions -23° [-10°F] exist.

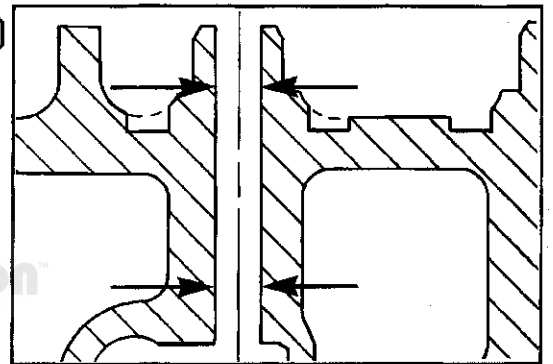
## Base Engine Components Specifications



### Valve Train

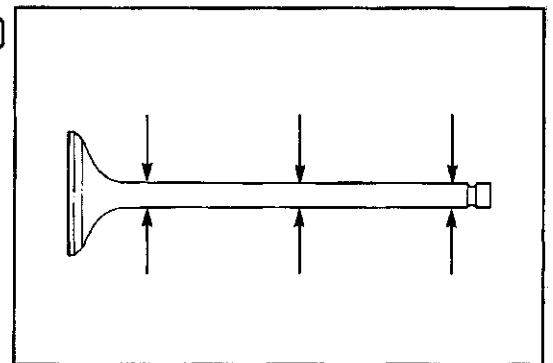
- **Valve Clearance**
  - Intake - 0.25mm [0.010 inch]
  - Exhaust - 0.51mm [0.020 inch]

Valve Guide Diameter		
mm		In
8.019	<b>MIN</b>	0.3157
8.089	<b>MAX</b>	0.3185



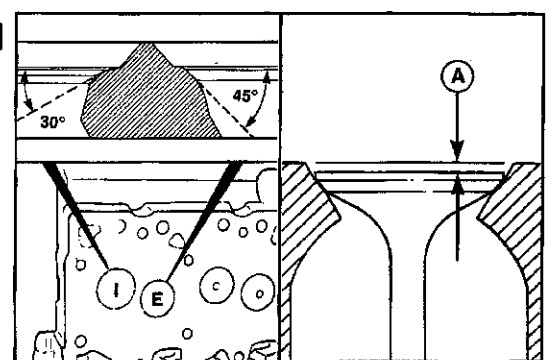
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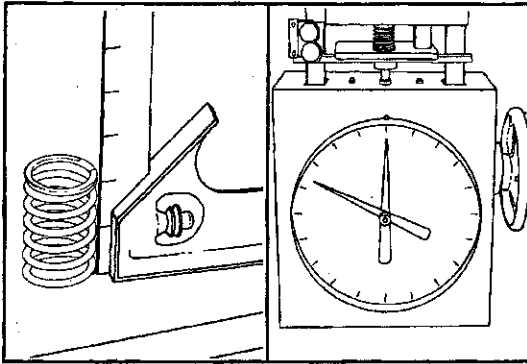
Valve Stem Diameter		
mm		In
7.935	<b>MIN</b>	0.3126
7.960	<b>MAX</b>	0.3134



- **Valve Seat Angle**
  - Intake - 30 degrees
  - Exhaust - 45 degrees

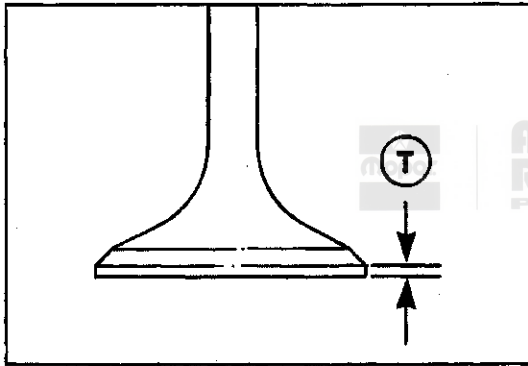
Valve Depth (Installed)		
mm		In
0.99	<b>MIN</b>	0.039
1.52	<b>MAX</b>	0.060





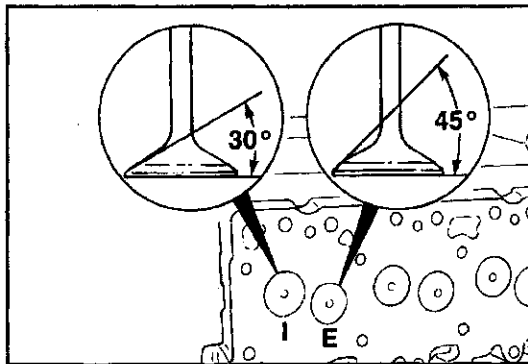
• **Valve Spring**

- Free Standing Length - 55.63mm [2.19 inch]
- Inclination (Maximum) - 1.0mm [.039 inch]
- Minimum acceptable load at 49.25mm [1.94 inch] - 289.32 N [65 lb]



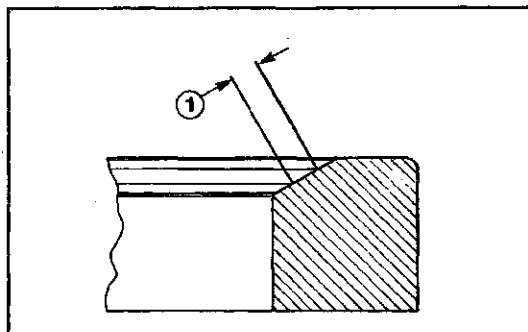
• **Valve Rim Thickness**

- Minimum .79mm [.031 Inch]



• **Valve Seating Angle of Face**

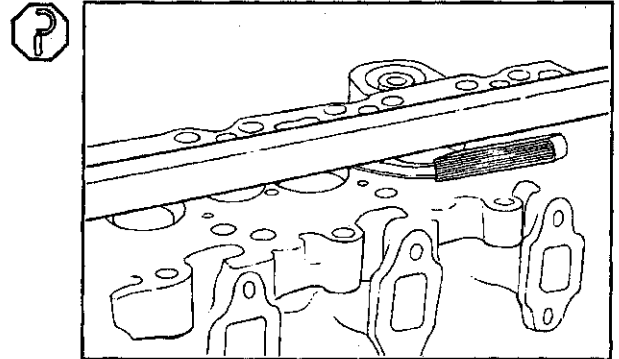
- Intake - 30 degrees
- Exhaust - 45 degrees



• **Valve Seat Width**

- Minimum - 1.5mm [.060 inch]
- Maximum - 2.0mm [.080 inch]

- **Cylinder Head Flatness Total**
  - Maximum Overall
    - 0.030mm [0.012 inch]
- **Incremental**
  - Maximum variation within 0.01mm [.0004 inch] any 50.8 [2.0 inch] diameter area

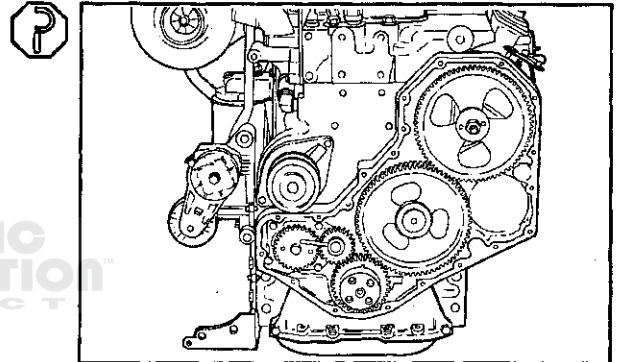


### Gear Train

- **Gear Backlash (all gears)**
  - 0.08 to 0.33mm [0.003 to 0.013 inch]
- **Camshaft End Clearance**
  - 0.152 to 0.254mm [0.006 to 0.010 inch]

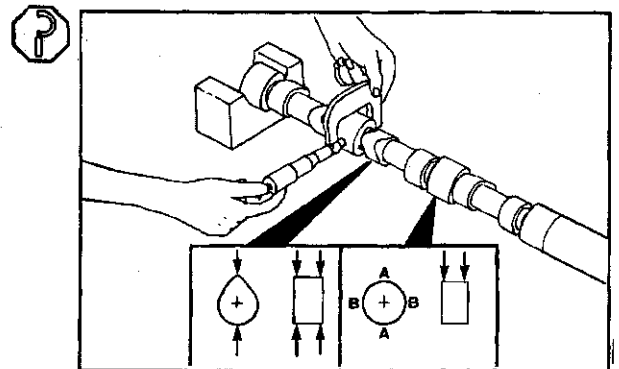


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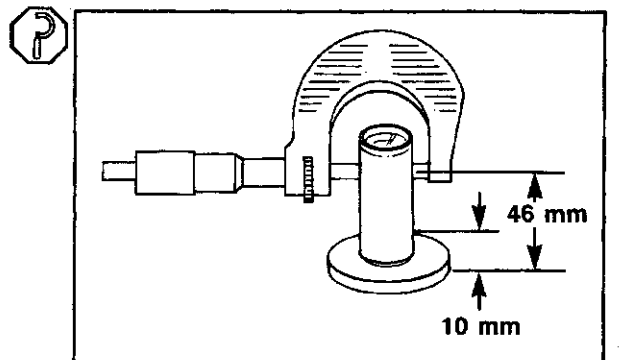
### Camshaft

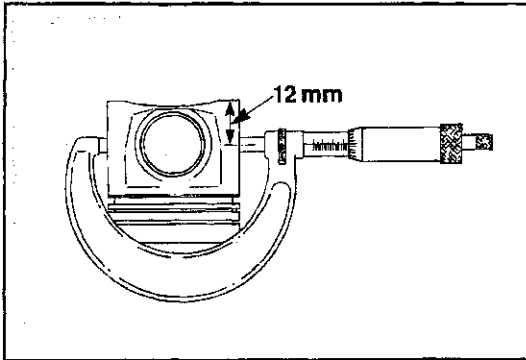
- **Journal Diameter (Minimum)**
  - 53.962mm [2.1245 inch]
- **Valve Lobes (Min. Dia. at Peak of Lobe)**
  - Intake - 47.040mm [1.852 inch]
  - Exhaust - 46.770mm [1.841 inch]
- **Lift Pump Lobe (Min. Dia. at Peak of Lobe)**
  - 35.5mm [1.398 inch]



### Tappets

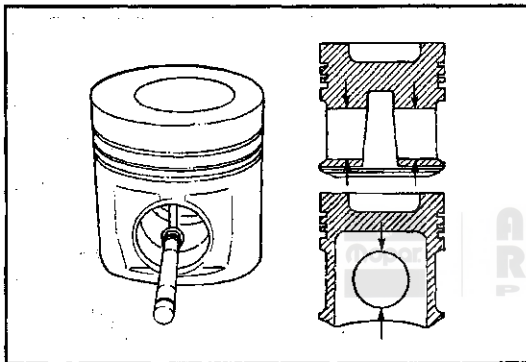
- **Stem Diameter (Minimum at 10mm and 46mm height)**
  - 15.925mm [0.627 inch]





### Pistons

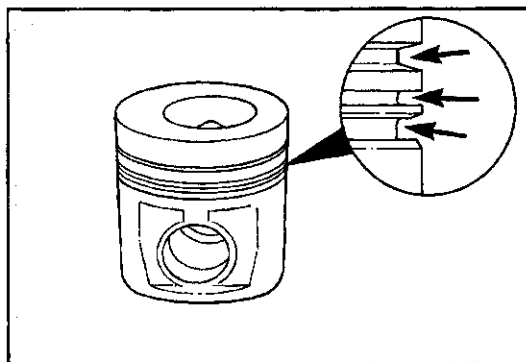
- **Skirt Diameter (Minimum)**
  - Nominal - 101.880mm [4.011 inch]
  - Worn Limit - 101.823mm [4.0088 inch]



### 

- **Pin Bore Diameter (Maximum)**
  - 40.025mm [1.5758 inch]

**Note:** Measure the diameter on a vertical axis only.

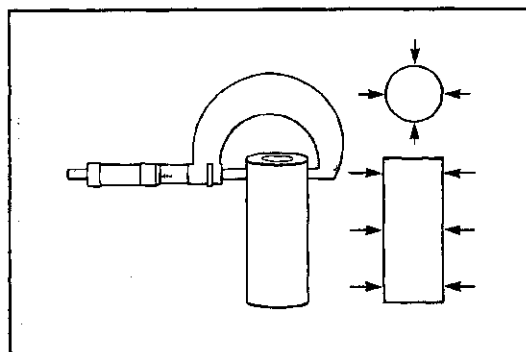


### 

- **Ring Groove**

Check wear by inserting a new ring into the groove and inserting a feeler gauge between the ring and the top side of the ring groove. If maximum feeler gauge limits are exceeded, replace the piston.

- **Top-Ni Resist - No check-Will not normally wear**
  - Intermediate (Maximum) - .150mm [0.006 inch]
  - Oil Control Groove (Maximum) - .130mm [0.005 inch]



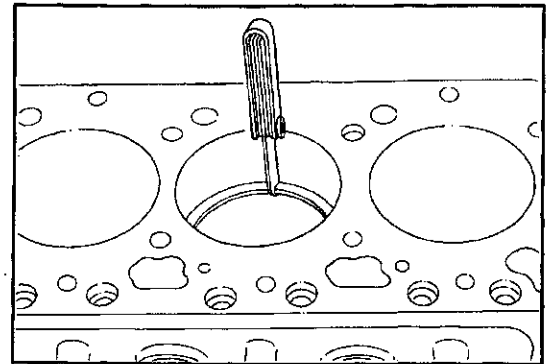
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- **Piston Pin Diameter (Minimum)**
  - 39.990mm [1.5744 inch]

• Rings

• End Gap

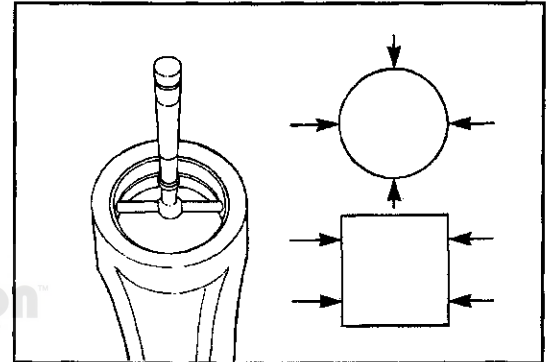
- Top - 0.40 - 0.70mm [0.0160 - 0.0275 inch]
- Intermediate - 0.25 - 0.55mm [0.010 - 0.0215 inch]
- Oil Control - 0.25 - 0.55mm [0.010 - 0.0215 inch]



Connecting Rod

• Pin Bore Diameter (Maximum)

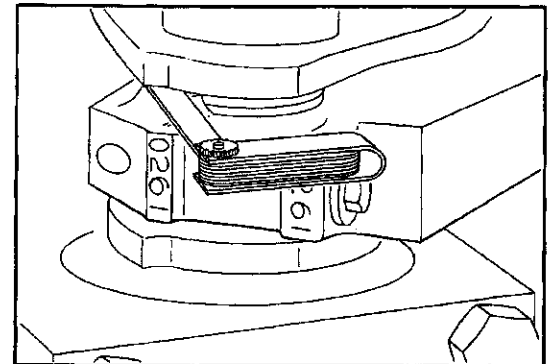
- 40.053mm [1.5769 inch]



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• Side Clearance

- 0.10 to 0.30mm [0.004 to 0.012 inch]



Crankshaft

• Main Bearing Journal Diameter

	Minimum (Wear Limit)
Standard	82.962mm [3.2662 inch]
Machined 0.25mm	82.712mm [3.2564 inch]
Machined 0.50mm	82.462mm [3.2465 inch]
Machined 0.75mm	82.212mm [3.2367 inch]
Machined 1.00mm	81.962mm [3.2269 inch]

• Journal Out of Round (Maximum)

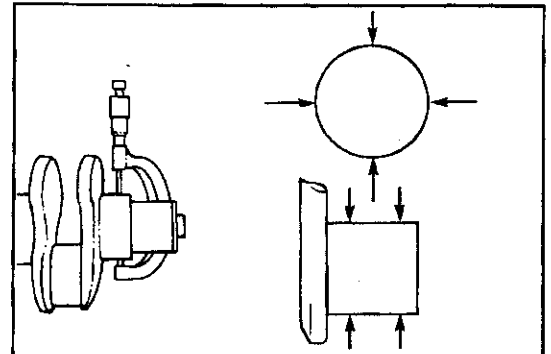
- 0.050mm [0.002 inch]

• Journal Taper (Maximum)

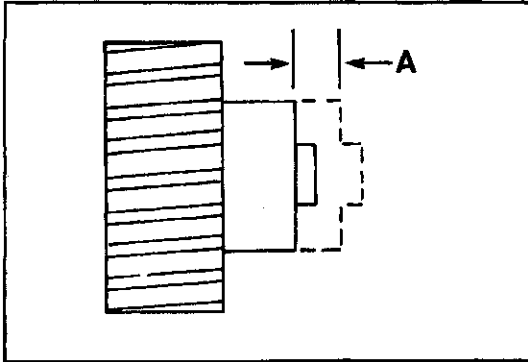
- 0.013mm [0.0005 inch]

• Oil Clearance (Maximum)

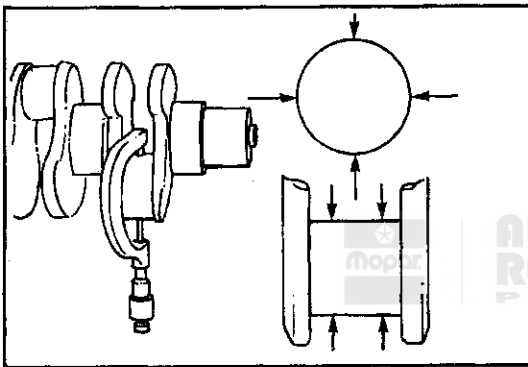
- 0.119mm [0.0047 inch]







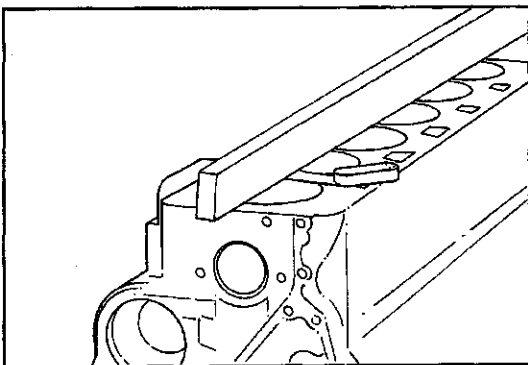
- **End Clearance**
  - 0.13 to 0.30mm [0.005 to 0.012 inch]



- **Connecting Rod Journal**

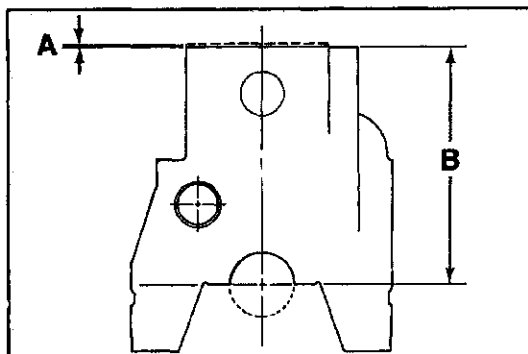
	<b>Minimum (Wear Limit)</b>
Standard	68.962mm [2.7150 inch]
Machined 0.25mm	68.712mm [2.7052 inch]
Machined 0.50mm	68.462mm [2.6954 inch]
Machined 0.75mm	68.212mm [2.6855 inch]
Machined 1.00mm	67.962mm [2.6757 inch]

  - **Journal Out of Round (Maximum)**
    - 0.050mm [0.002 inch]
  - **Journal Taper (Maximum)**
    - 0.013mm [0.0005 inch]
  - **Oil Clearance (Maximum)**
    - 0.089mm [0.0035 inch]



**Cylinder Block**

- **Top Surface Flatness (Maximum overall variation)**
  - 0.075mm [0.003 inch]
- **(Maximum Variation within any 50.0mm [2.0 inch] diameter area)**
  - 0.010mm [0.0004 inch]

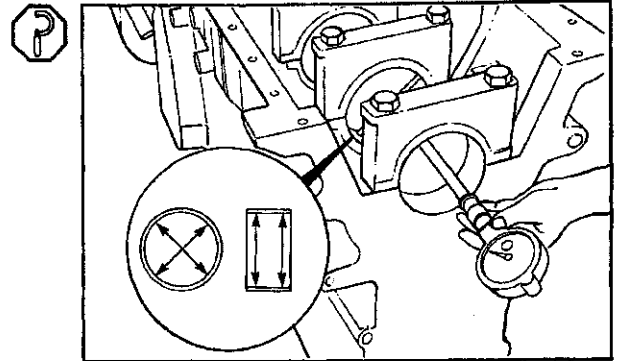


- **Refacing Combustion Deck**

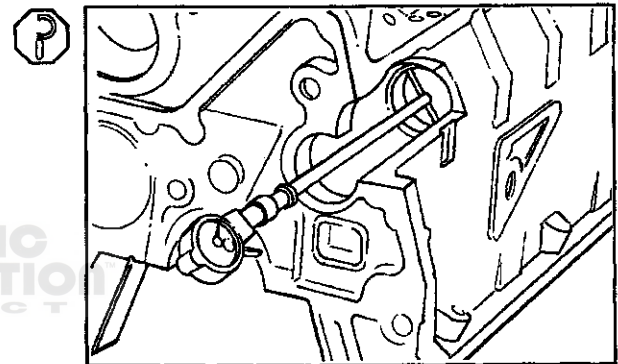
A =	0.15mm [0.0058 inch]	First reface
	0.35mm [0.0138 inch]	Second additional reface
	0.50mm [0.0197 inch]	Total Allowed
B =	323.00mm ± 0.10	Standard
	[12.7165 inch ± .0039]	
	322.85mm ± 0.10	First reface
	[12.7106 inch ± .0039]	
	322.50mm ± 0.10	Second reface
	[12.6968 inch ± .0039]	

Surface finish requirements = 1.5 - 3.2 micrometers [60 - 126 microinch]

- **Main Bearing Bore Diameter (Maximum)**
  - 83.106mm [3.2719 inch] (with bearing installed)

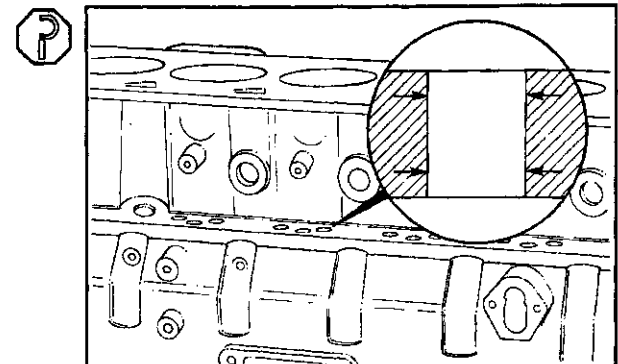


- **Camshaft Bore Diameter (Maximum)**
  - 57.258mm [2.2543 inch] (without bushing) No. 1 only
  - 54.133mm [2.1312 inch] No. 1 with bushing
  - 54.133mm [2.1312 inch] No. 2 through No. 7



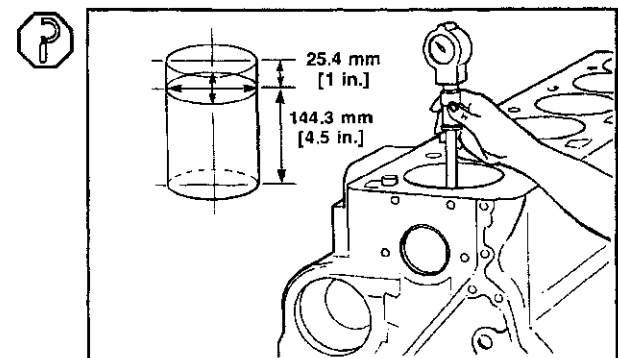
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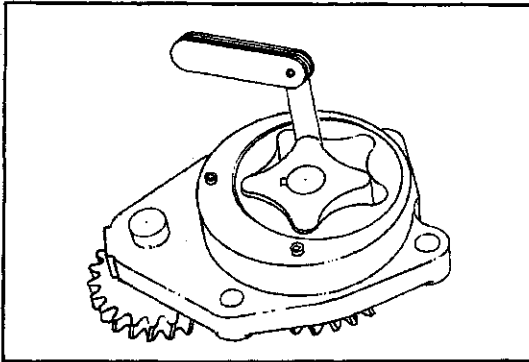
- **Tappet Bore Diameter (Maximum)**
  - 16.055mm [0.632 inch]



## Cylinder Bores

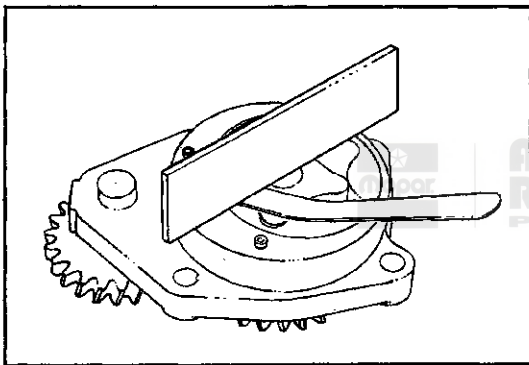
- **Cylinder Bore Diameter (Maximum)**
  - 102.116mm [4.0203 inch]
- **Out of Round (Maximum)**
  - 0.038mm [0.0015 inch]
- **Taper (Maximum)**
  - 0.076mm [0.003 inch]



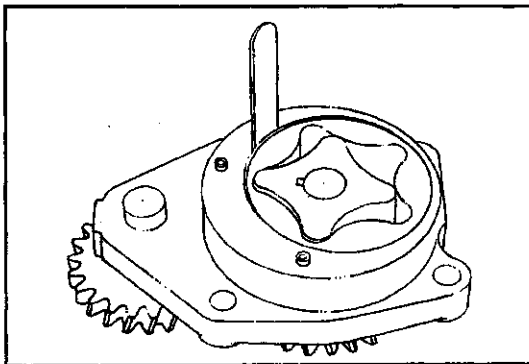


### Oil Pump Specifications

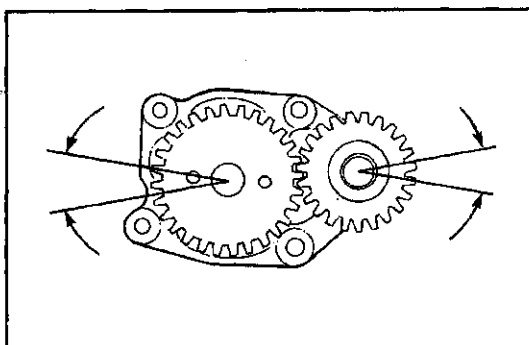
- **Tip Clearance (Maximum)**
  - 0.1778mm [0.007 Inch]



- **Gerotor Drive/Gerotor Planetary to Port Plate Clearance (Maximum)**
  - 0.127mm [0.005 Inch]



- **Gerotor Planetary to Body Bore Clearance (Maximum)**
  - 0.381mm [0.015 Inch]



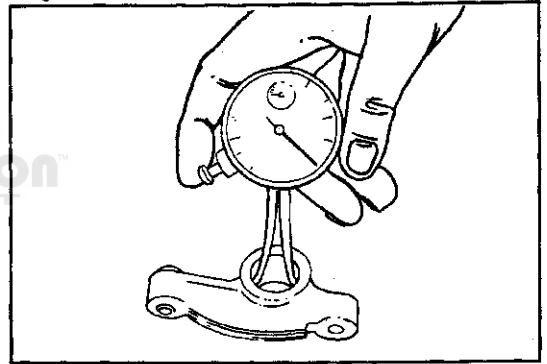
- **Gear Backlash (Used Pump)**
  - 0.08 to 0.38mm
  - [0.003 to 0.015 Inch]

### Rocker Lever Specifications

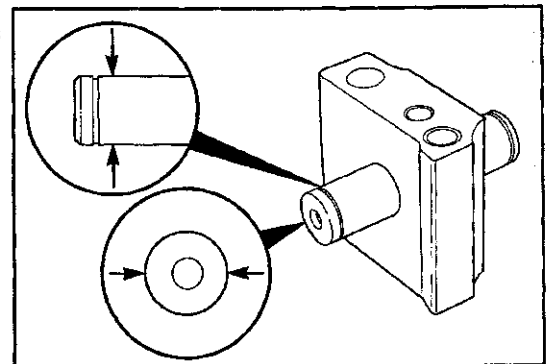
- **Rocker Lever Bore (Maximum)**
  - 19.05mm [0.75 inch]



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- **Shaft Diameter (Minimum)**
  - 18.94mm [0.746 inch]





# Exhaust System and Intake Manifold

## Section 11

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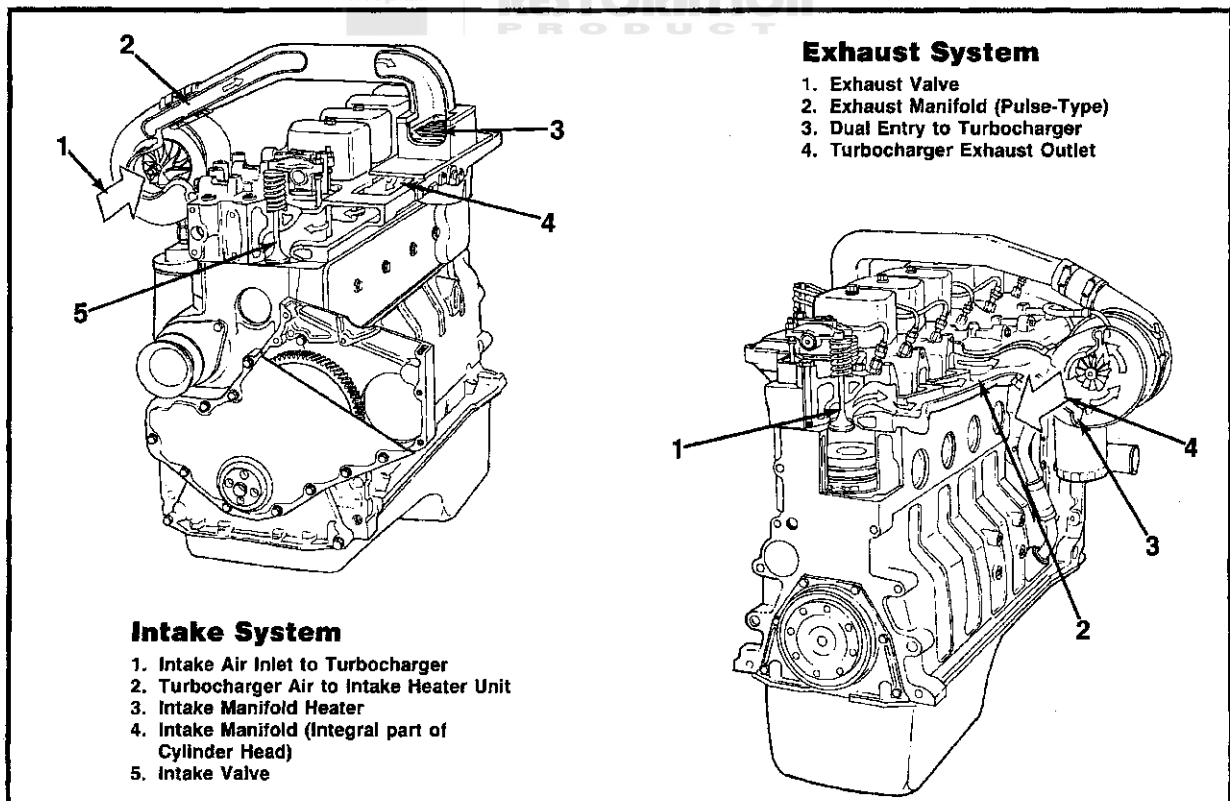
## Air System

### Air System Flow

Air is pulled into the engine from an air filter. Clean air is very important to the life of the engine. Ingested dust and dirt can damage the cylinders very quickly.

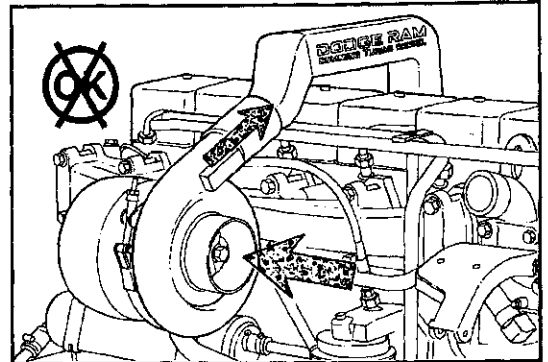
- **Caution:** Make sure that a quality air cleaner is used and that it is periodically replaced.

On turbocharged engines the flow is from the filter to the turbocharger, and then through the air crossover to the manifold. From the intake manifold, air is forced into the cylinder and used for combustion. The exhaust gases flow through the turbocharger to rotate the turbine and impeller, thereby utilizing exhaust energy to force more air into the cylinders. The additional air provided by the turbocharger allows more fuel to be injected to increase the power output from the engine. Thus, the power-to-weight ratio for the engine is increased significantly with the addition of the turbocharger.



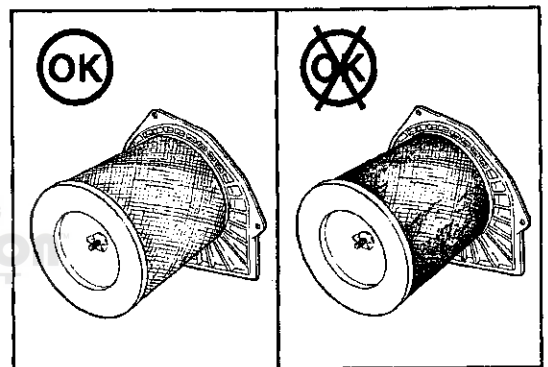
### Diagnosing Air System Malfunctions

The correct amount of clean air to the cylinders is required for good performance. As discussed earlier in System Air Flow, ingested dust and dirt will damage the engine cylinders. Dust and dirt can also damage the valve stems and guides. Larger debris can damage the blades of the turbocharger.

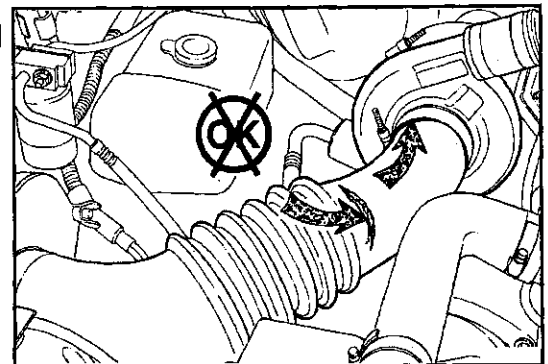


### Air Flow Restriction Results in Excess Smoke and Low Power

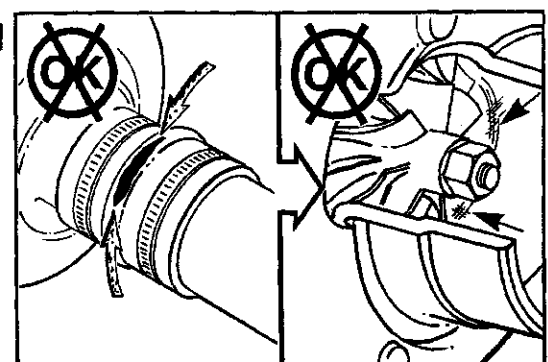
Restriction increases as the filter removes contaminants from the intake air. Restricted air flow changes the air-to-fuel ratio, reducing power and increasing smoke from the engine. Verify that the air cleaner is being maintained correctly.



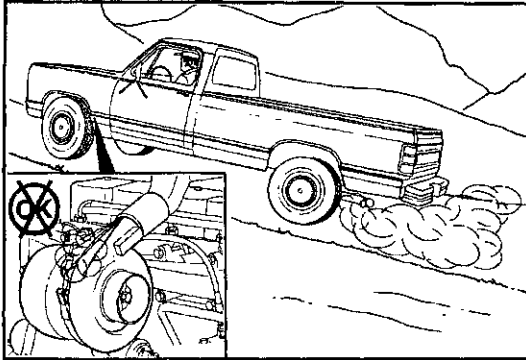
Loose connections or cracks in the suction side of the intake pipe on turbocharged engines can allow debris to be ingested into the turbocharger compressor and forced into the engine.



Debris drawn into the air suction side can damage the compressor blades causing an imbalance resulting in a bearing failure. To verify a bearing failure or damaged compressor, remove the intake and exhaust piping and check for contact. The rotor assembly must rotate freely. Measurement of axial and radial clearance is described in this Section.

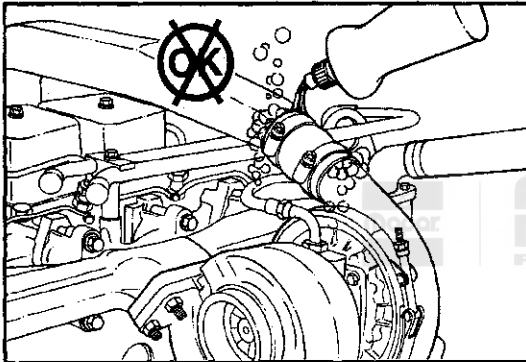




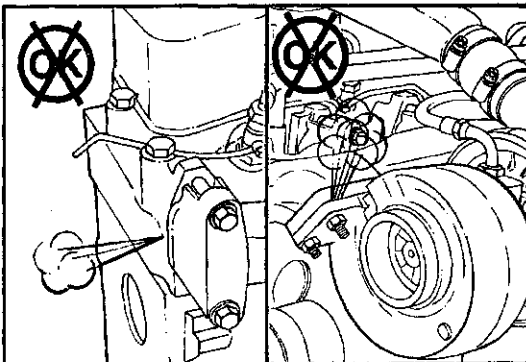


### Pressure Side Air Leaks

Excess smoke and low power from a turbocharged engine can be caused by pressurized air leaking from loose connections or cracks in the crossover tube or intake manifold.

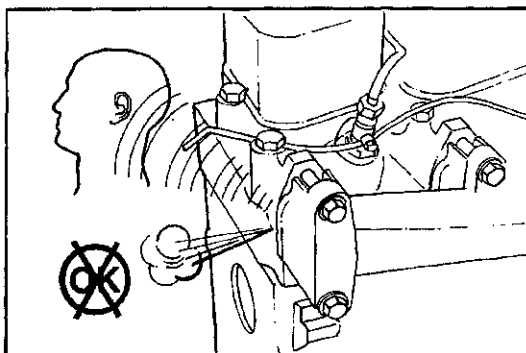


In addition to the visual inspection for cracks and loose fittings, liquid soap can be applied to the crossover tube, connections and the manifold cover sealing surfaces to find the leaks. The leaks will create bubbles that are easier to detect. Measurement of manifold pressure is described in this Section.



### Exhaust Leaks

Inspect for exhaust leaks at the exhaust manifold and turbocharger. Also check for exhaust pipe restrictions. Leaks or restrictions will cause the turbine and impeller to operate at a lower speed and reduce the amount of air being forced into the cylinders. Again, the symptom will be excess smoke, low manifold pressure and low power.

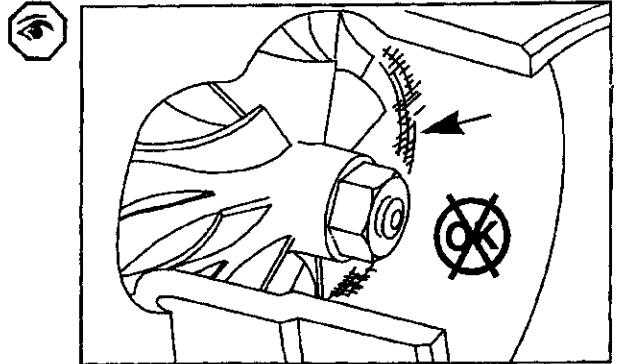


Exhaust leaks can often be detected audibly and usually visually by a discoloration caused by the escaping hot gases.

Don't overlook exhaust restrictions as a cause of low power. If the exhaust gasses cannot flow freely, the turbocharger will not operate efficiently.

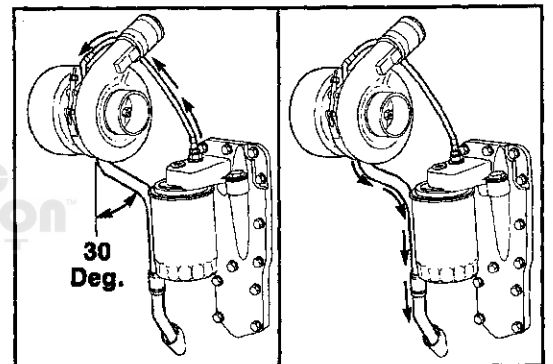
### Malfunctioning Turbocharger

Failure of the internal components of the turbocharger can reduce its effectiveness and also cause excess smoke and low power. A bearing failure can produce friction which will slow the speed of the rotor assembly. Failed bearings can also allow the blades of the rotor assembly to rub the housings, thus reducing the rotor assembly speed.

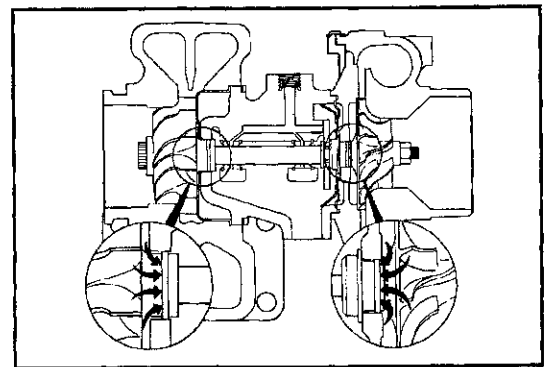


### Oil Consumption and Leaks

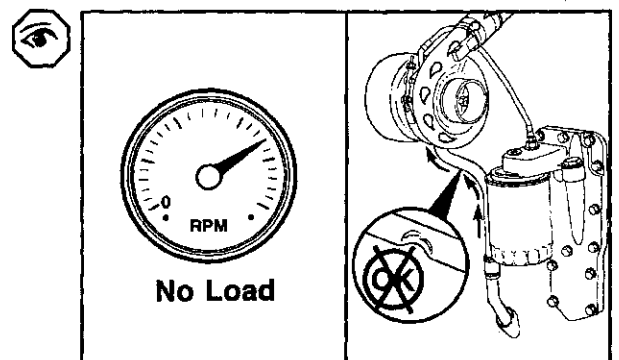
Engine lubricating oil is used to lubricate the bearings and provide some cooling for the turbocharger. The oil is supplied to the turbocharger through the supply line at engine operating pressure. A return line connected to the bottom of the turbocharger routes the oil back to the engine oil pan.

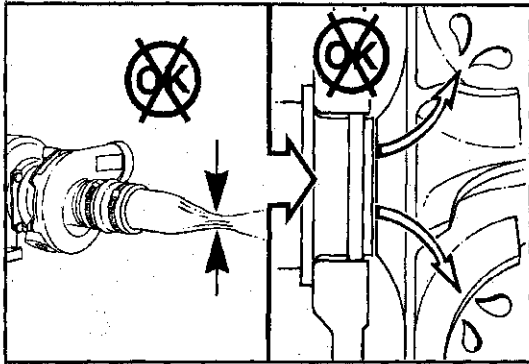


Seals are used on each end of the rotor assembly. The primary function of the seals is to prevent exhaust gases and compressed air from entering the turbocharger housing. Oil leakage from the seals is rare, but it can occur.

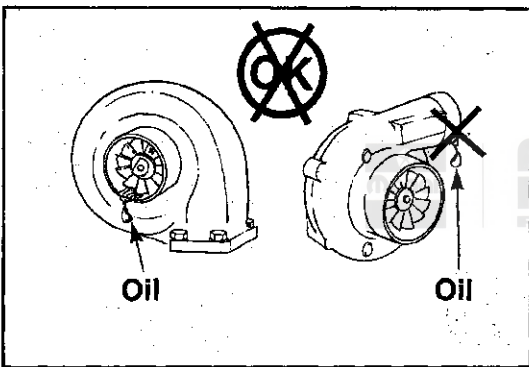


A restricted or damaged oil return line will cause the turbocharger housing to be pressurized causing oil to migrate by the seals.



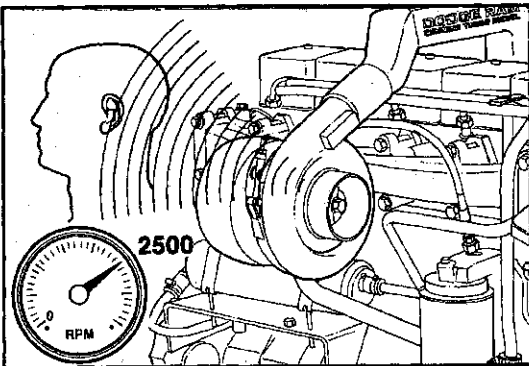


Additionally, high intake or exhaust restrictions can cause a vacuum between the compressor and the turbocharger housing resulting in oil leaking by the seals.



To verify oil leakage past the seals, remove the exhaust pipe and crossover tube and look for oil in the turbine casing and the crossover tube. Locate and correct the restriction as previously discussed.

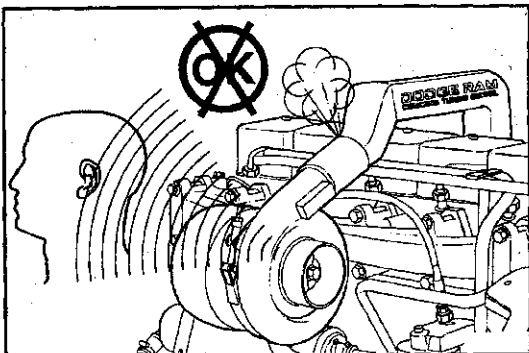
**Note:** Excess fuel in the exhaust side of the turbocharger will look like oil leakage. This may occur because of injector overfueling or excessive engine operation under "no load" conditions.



### Turbocharger Noise

It is normal for the turbocharger to emit a "whine" sound that varies in intensity depending on engine speed and load. The sound is caused by the very high rotational speed of the rotor assembly. Consequently, the sound will be more audible at full speed.

**Note:** If possible, operate the engine at full speed and load to verify the noise level.

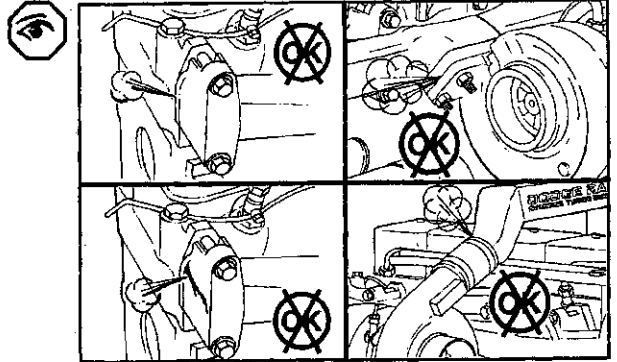


Leaks in the air system, both intake and exhaust components, can produce additional noises.

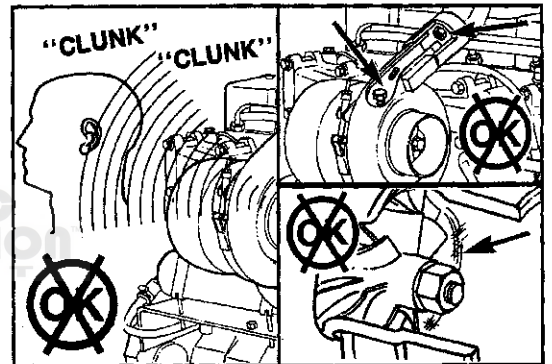
Check the air intake and crossover tube leaks.

**Note:** Before removing a turbocharger, make sure that the noise complaint is not caused by leaks in the air system components.

Look for loose turbocharger mounting, exhaust manifold gasket leaks, and cracks in the exhaust manifold.



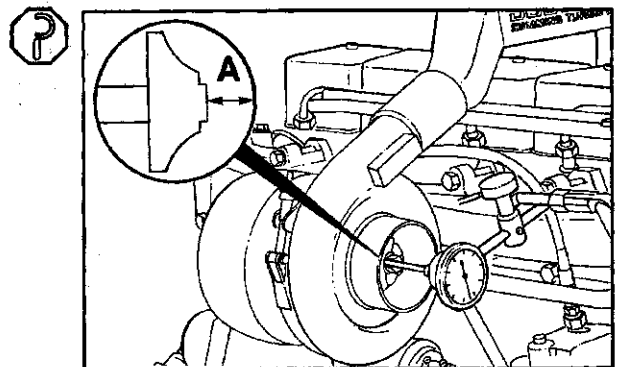
Lower pitch sounds or rattles at slower engine speeds can indicate debris in the system or the rotor assembly is touching the housings.



**Rotor Assembly Clearance – Measure**

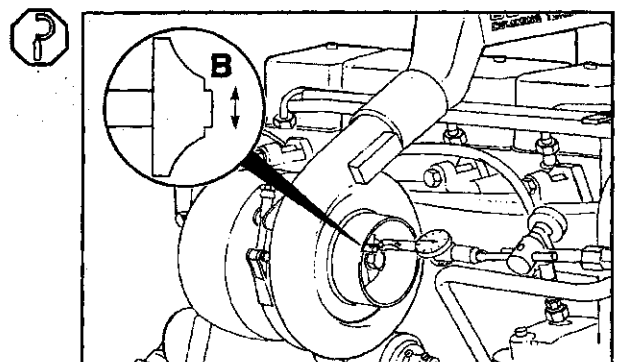
Measure the shaft end play.

End Play (A)		
mm		In
0.026	MIN	[0.001]
0.076	MAX	[0.003]



Measure radial clearance of the shaft.

Radial Clearance (B)		
mm		In
0.30	MIN	[0.012]
0.46	MAX	[0.018]



### White Smoke

White smoke indicates unburned fuel during cold engine operation.

The intake manifold heater system is not directly connected to the fuel system but it monitors the temperature of the air to the engine. The thermistor sends varying resistance values to the Electronic Control Module. The ECM in turn controls the "Wait to Start" light and the heater solenoids.

The intake manifold heater elements operate in both the preheat and postheat modes.

- In preheat, the ignition switch is on but the engine has not been started.
- In postheat, the engine is running.

The proper operation of the intake manifold heater system and starting procedures will preclude excessive engine starter motor use and minimize white exhaust smoke when the engine is first started.

### Normal Operation of the Intake Manifold Heater System

Engine Intake Manifold Temp.	Preheater Cycle Time Ign. Key "ON" Before Crank Cycle	Post Heater Cycle Occurs Ign. Key "ON" After Crank Cycle
Above 15°C [59°F]	0-Seconds	No
-9°C to 15°C [15°F to 59°F]	* 10-Seconds	Yes
-18°C to -9°C [0°F to 15°F]	15-Seconds	Yes
-26°C to 18°C [-15°F to 0°F]	17-Seconds	Yes
Below -26°C [15°F]	20-Seconds	Yes

**Note:** The KSB Valve activation voltage is independent of the Intake Manifold Heater Control System. The KSB Valve will be activated any time the intake manifold temperature is above 15°C [59°F], the ignition key is in the "ON" position and the ECM is monitoring the thermistor (reading resistance).

\* Heater Control Modules / Electronic Control Modules with serial numbers below 0080000A will not have a Preheat Cycle during this cycle.

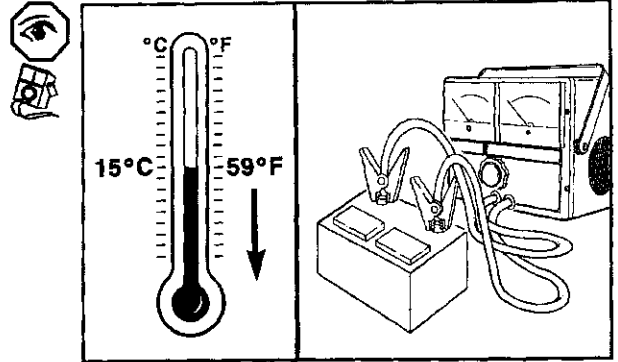
### Intake Manifold Heater – Check

#### Check Battery Voltage

The temperature in the Intake manifold must be below  $-9^{\circ}\text{C}$  [ $15^{\circ}\text{F}$ ] (early module before serial number 0080000A)  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ] (late module) for preheat to occur.

Check the voltage output of the battery.

Minimum: 6.5 volts



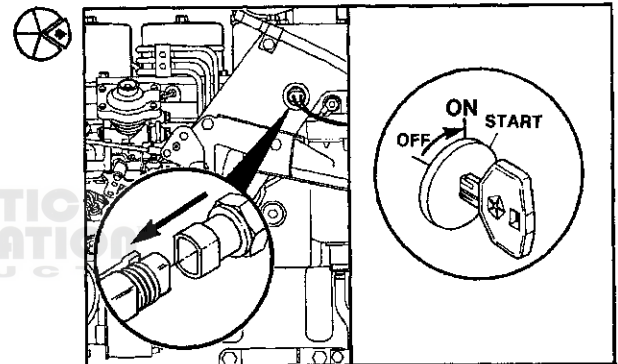
#### Check Thermistor

Disconnect the thermistor.

Turn the ignition switch to the "ON" position.

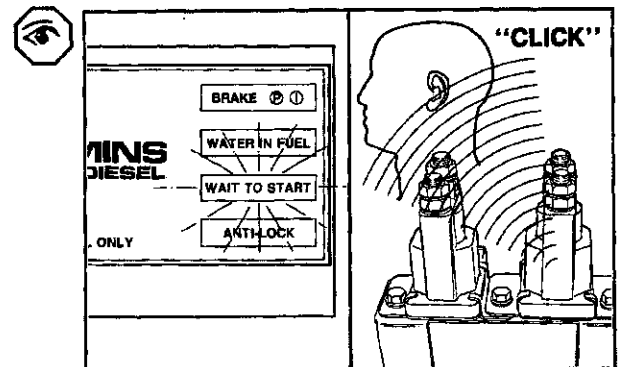


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**Note:** The "Wait to Start" light should come on.

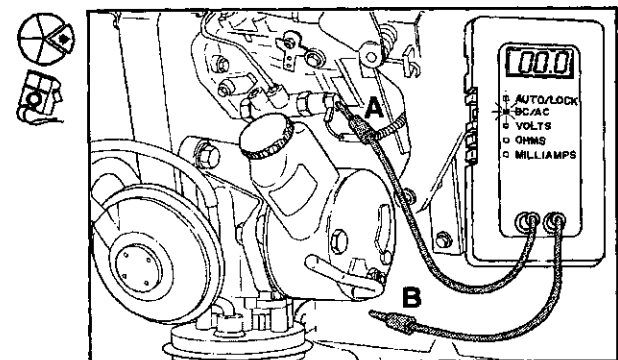
The solenoids should click on.

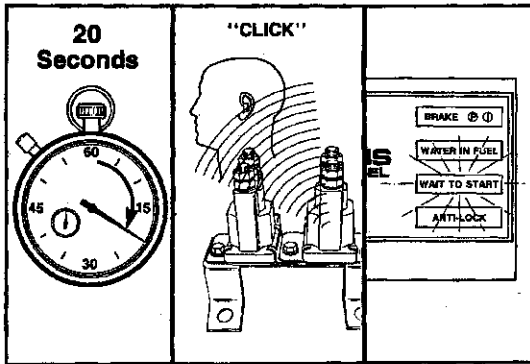


Set the multimeter scale to read DC voltages.

Connect one lead to the KSB Valve wire terminal (A) and the other to a convenient ground on the engine (B).

There should be no voltage.



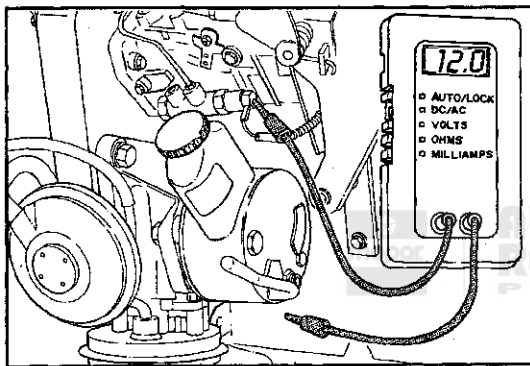


Wait 20 seconds.

The solenoids should click off.

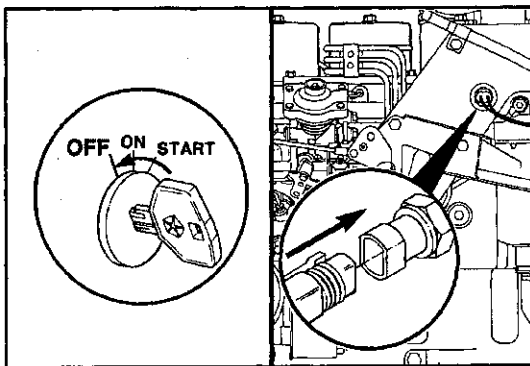
The "Wait to Start" light should begin flashing.

**Note:** The wait to start light will flash indicating an open circuit in the thermistor wiring. Disconnecting the thermistor simulates this condition.



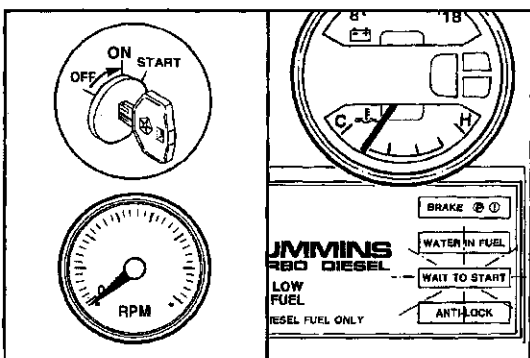
The multimeter should show voltage at the KSB Valve wire terminal. This voltage reading is an indication that the thermistor is sensing a temperature of 15°C [59°C] or above.

**Note:** No intake manifold postheat will occur while the thermistor is disconnected.



Turn the Ignition switch to the "OFF" position.

Connect the thermistor wire harness.



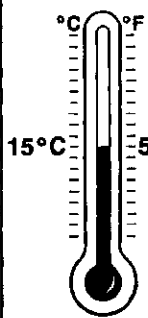
**Check Preheat Cycle**

Turn the ignition switch to the "ON" position.

**Do not start engine.**



**Note:** If the intake manifold air temperature is below  $-9^{\circ}\text{C}$  [ $15^{\circ}\text{F}$ ] (early module before serial number 0080000A)  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ] (late module), the heater will preheat before the engine starts. This will repeat until the intake manifold air temperature increases to  $-9^{\circ}\text{C}$  [ $15^{\circ}\text{F}$ ] (early module before serial number 0080000A)  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ] (late module) each time the Ignition key is turned from the OFF to the ON position.

Intake Manifold Heater Operation—Engine Intake Manifold Temperature	Preheat Cycle Time Ignition Key ON *Before crank cycle	Preheat Cycle Occurrence Ignition Key Off *After crank cycle
Above $15^{\circ}\text{C}$ [ $59^{\circ}\text{F}$ ]	0 Seconds	No
$-9^{\circ}\text{C}$ [ $15^{\circ}\text{F}$ ] to $15^{\circ}\text{C}$ [ $59^{\circ}\text{F}$ ]	10 Seconds	Yes
$-18^{\circ}\text{C}$ [ $0^{\circ}\text{F}$ ] to $-9^{\circ}\text{C}$ [ $15^{\circ}\text{F}$ ]	15 Seconds	Yes
$-26^{\circ}\text{C}$ [ $-15^{\circ}\text{F}$ ] to $-18^{\circ}\text{C}$ [ $0^{\circ}\text{F}$ ]	17.5 Seconds	Yes
Below $-26^{\circ}\text{C}$ [ $-15^{\circ}\text{F}$ ]	20 Seconds	Yes

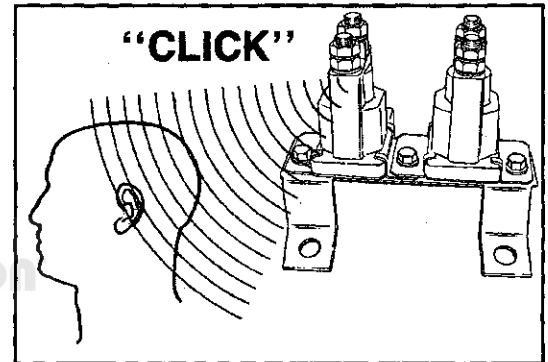
NOTE: The KSB valve activation voltage is independent of the intake manifold heater control system. The KSB valve will be activated any time the manifold temperature is above  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ] and the ignition key is in the ON position.

The solenoids (2) should click on.

**Note:** If the engine has been running, the temperature is probably above  $15^{\circ}\text{C}$  [ $59^{\circ}\text{F}$ ].



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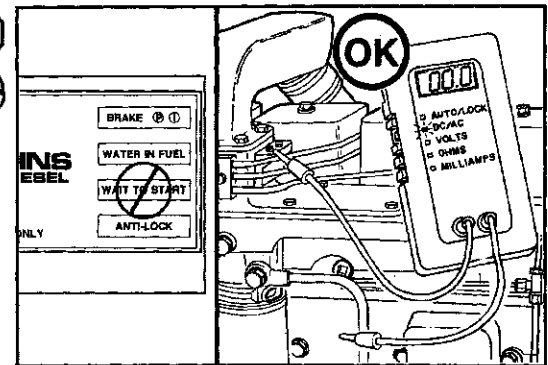


After the preheat period, the "Wait to Start" light will go off and not flash.



Set the multimeter scale to read DC-voltage.

Connect the multimeter lead to the intake manifold heater terminals. Check each terminal individually.

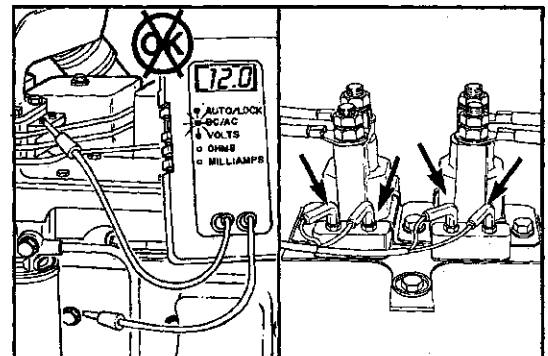


If voltage is present, check the pull-in coil of the solenoids.

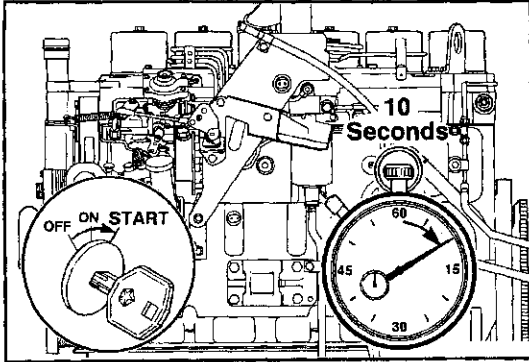


Check for voltage at the pulling coil of solenoid.

1. If voltage at pull-in coil replace electronic control module
2. If no voltage present at pull-in, replace solenoid



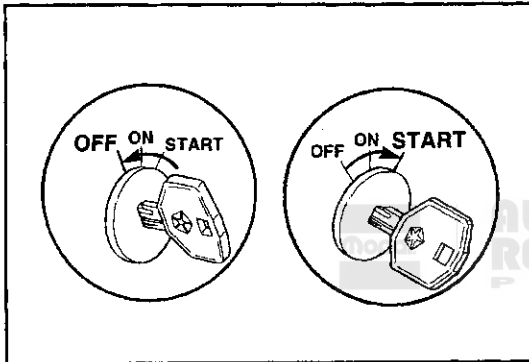




**Start the Engine**

Do not hold the ignition switch in the start position longer than 10 seconds.

If the engine does not start, turn the ignition switch to the "OFF" position.



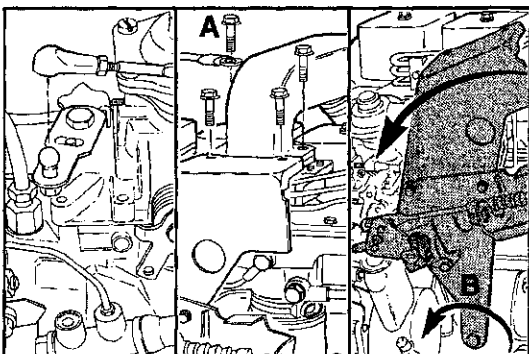
Return the ignition switch to the "ON" position then begin the normal starting cycle again.

Intake Manifold Heater Operation—Engine Intake Manifold Temperature	Preheat Cycle Time Ignition Key ON *Before crank cycle	Postheat Cycle Occurrence Ignition Key ON *After crank cycle
Above 15°C [59°F]	0 Seconds	No
-9°C [15°F] to 15°C [59°F]	10 Seconds	Yes
-18°C [0°F] to -9°C [15°F]	15 Seconds	Yes
-25°C [-15°F] to -18°C [0°F]	17.5 Seconds	Yes
Below -26°C [-15°F]	20 Seconds	Yes

NOTE: The HSB valve activation voltage is independent of the intake manifold heater control system. The HSB valve will be activated any time the manifold temperature is above 15°C [59°F] and the ignition key is in the ON position.



**Note:** If the intake manifold air temperature is below -9°C [15°F] (early module before serial number 0080000A) 15°C [59°F] (late module), the heater will again heat after the engine starts. This will repeat until the intake manifold air temperature increases to -9°C [15°F] (early module before serial number 0080000A) 15°C [59°F] (late module).



**Air System Replacement Procedures**



**Air Crossover – Replacement**

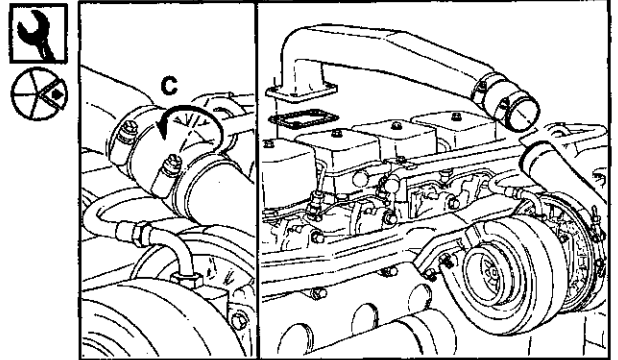
10mm, 13mm

Disconnect the throttle rod from the throttle lever. Remove the four mounting cap screws (A). Loosen the throttle control bracket lower mounting cap screw (B) and move the top end away from the engine.

**5/16 inch**

Loosen the hose clamp (C).

Remove the air crossover and gasket.

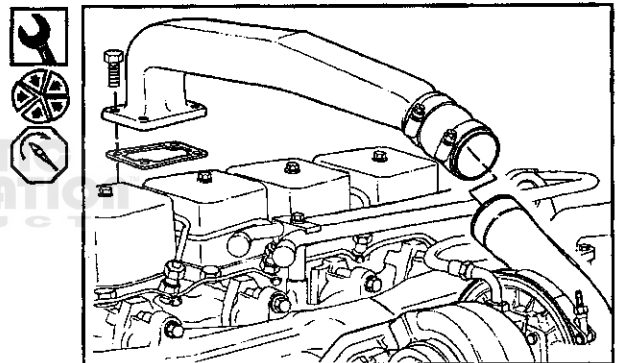


**10mm, 5/16 inch**

Use new gaskets on the heater and new hoses and clamps as required to install the air crossover tube.

**Torque Value:**

- Capscrews - 24 N·m [18 ft-lbs]
- Hose Clamps - 5 N·m [44 in-lbs]



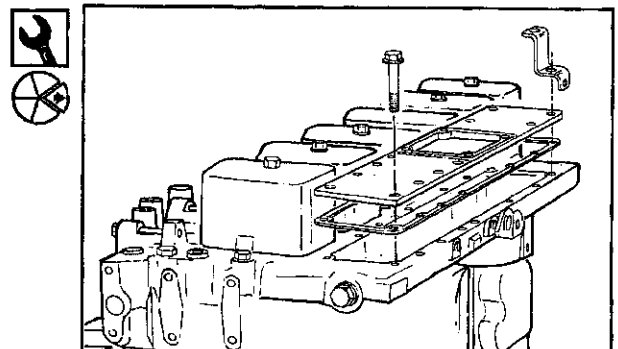
**Intake Manifold Cover and Gasket - Replacement**

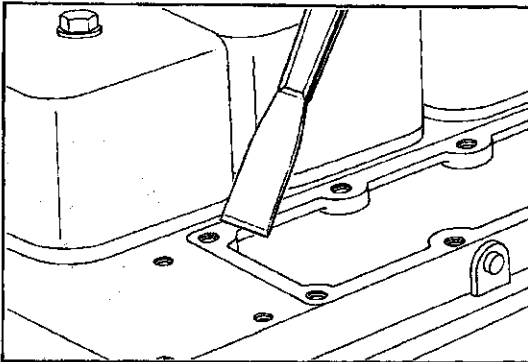
**Preparatory Steps:**

- Remove the throttle control bracket and linkage.
- Remove the high pressure fuel lines.
- Disconnect the intake manifold heater.
- Disconnect the fuel heater ground wire from intake manifold.
- Remove the air crossover tube and the intake manifold heater.

**13mm, 3/8 inch**

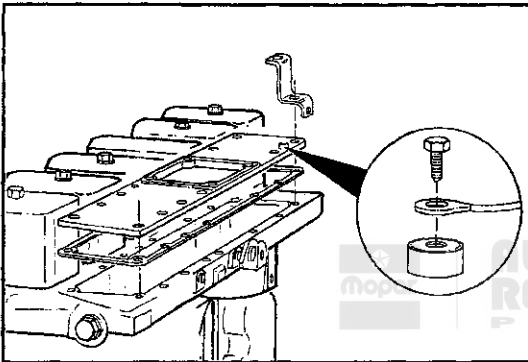
Remove the manifold cover and complete the following steps.





**Caution: Keep the gasket material and any other material out of the air intake.**

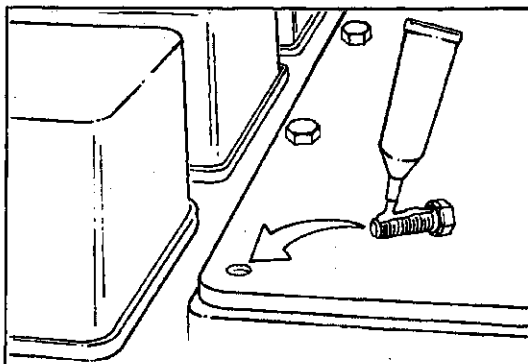
Clean the sealing surface.



Install the gasket and cover.

Install the fuel heater ground wire.

**Torque Value: 12 N·m [110 in-lbs]**



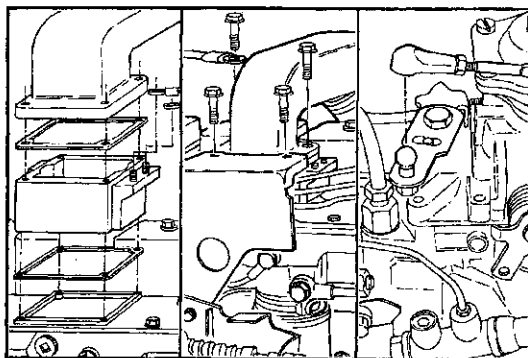
13mm



**Caution: Some of the capscrew holes are drilled through and must be sealed. Apply liquid teflon sealant to the capscrews.**

Install the capscrews.

**Torque Value: 24 N·m [18 ft-lbs]**



5/16 inch, 10mm, 3/8 inch



Install the intake manifold heater power supply connections. Assemble the intake piping and intake manifold heater.



Install the throttle control bracket and connect the intake manifold heater ground wire. Install the throttle rod to the throttle lever.

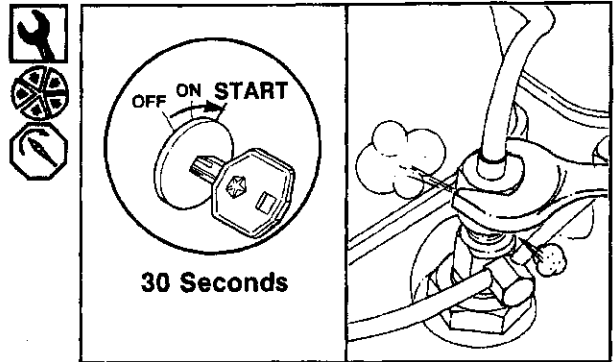
**Torque Value:**

- Intake manifold heater power supply - 14 N·m [10 ft-lbs]
- Intake crossover tube capscrews - 24 N·m [18 ft-lbs]
- Hose clamps - 5 N·m [44 in-lbs]

17mm

Install and bleed the high pressure fuel lines.

Torque Value: 24 N·m [18 ft-lbs]



### Turbocharger – Replacement

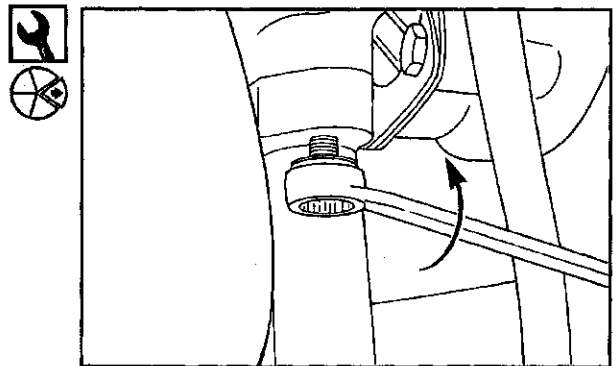
#### Preparatory Steps:

- Loosen the air crossover hose.
- Disconnect the intake and exhaust piping.



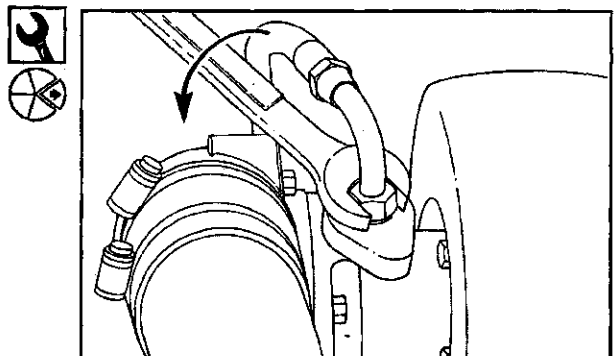
10mm

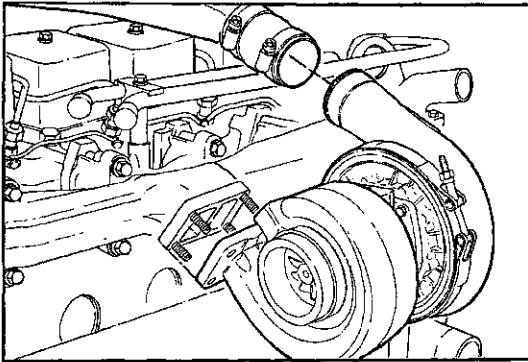
Remove the oil drain tube capscrews and complete the following steps.



5/8 Inch

Remove the oil supply line.

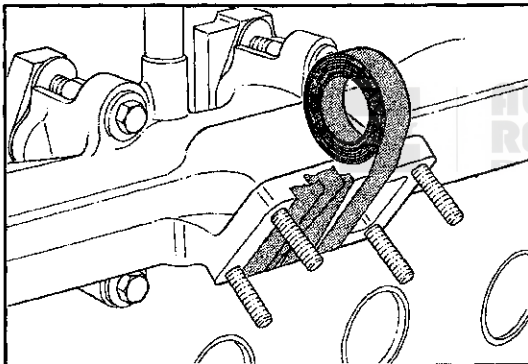




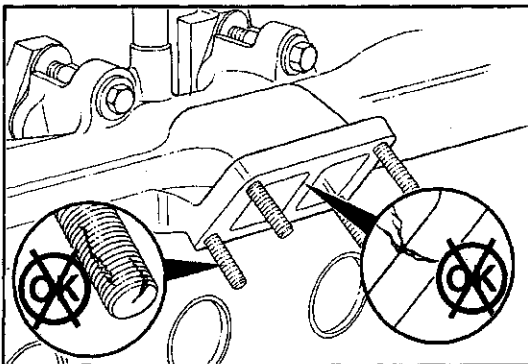
15mm



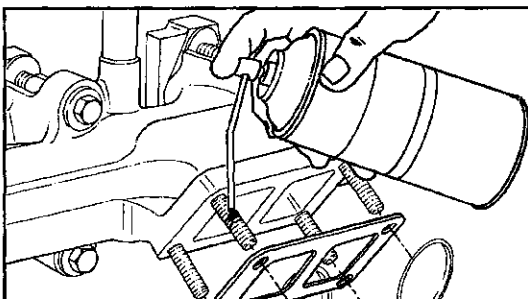
Remove the turbocharger mounting nuts and the turbocharger.



**Caution:** If the turbocharger is not to be installed immediately, cover the opening to prevent material from falling into the manifold.



Clean and inspect the sealing surface.



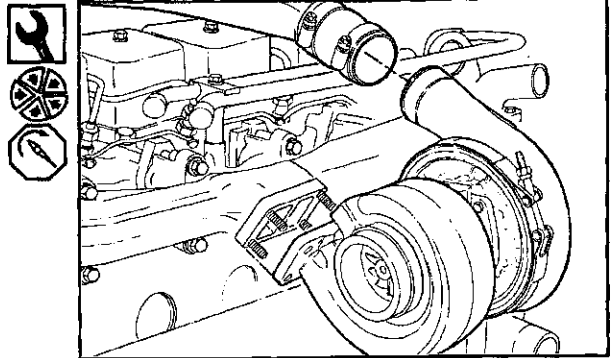
Install a new gasket and apply antiseize compound to the mounting studs.

5/16 inch, 15mm

Install the turbocharger and connect the air crossover tube.

**Torque Value:**

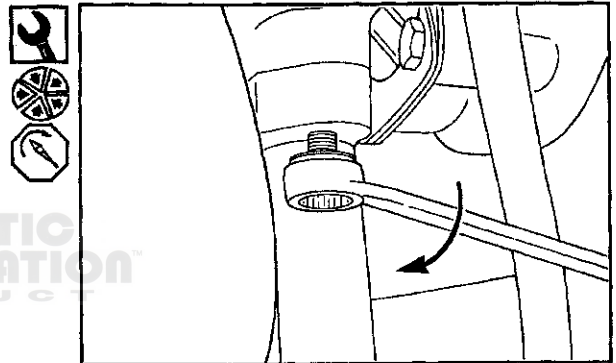
- Turbocharger mounting nuts - 32 N·m [24 ft-lbs]
- Turbocharger air crossover clamps - 5 N·m [44 in-lbs]



10mm

Use a new gasket and connect drain line.

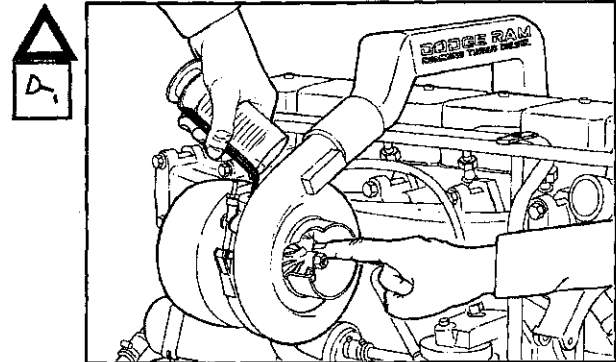
**Torque Value:** 24 N·m [18 ft-lbs]



**Caution:** New turbochargers must be prelubricated with clean engine lubricating oil before start up.

Pour 50 to 60cc [2 to 3 ounces] of oil into supply fitting.

**Note:** Rotate the turbine wheel to allow oil to enter the turbocharger.

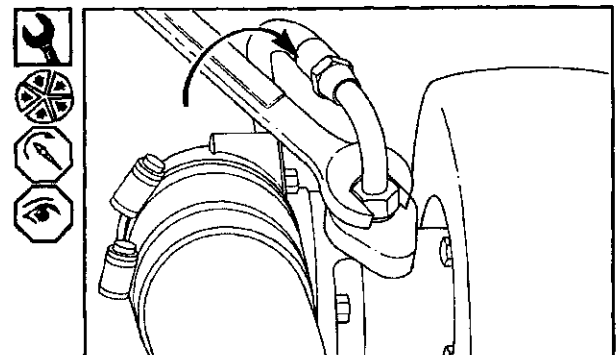


5/8 inch

Install the oil supply line.

**Torque Value:** 15 N·m [11 ft-lbs]

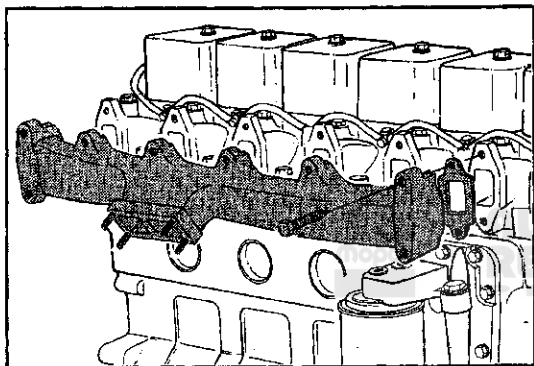
After installing the air intake and exhaust piping, operate the engine to check for leaks.



### Exhaust Manifold and/or Gasket – Replacement

#### Preparatory Steps:

- Loosen the air crossover hose clamp.
- Disconnect the air intake and exhaust piping.
- Remove the turbocharger and gasket.



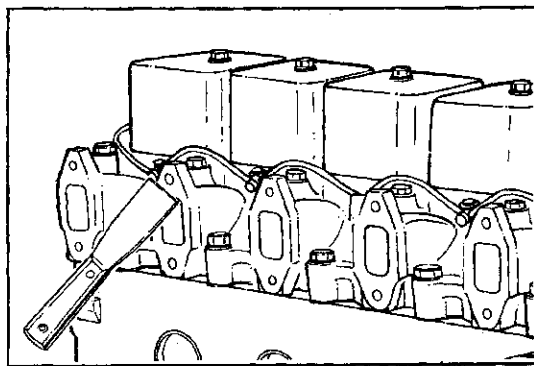
10mm, 13mm



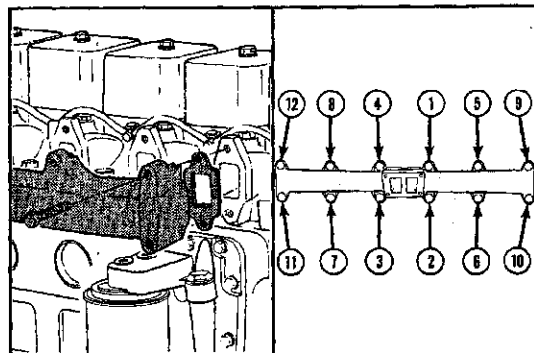
Remove the cab heater supply and return lines.

Remove the manifold and gaskets.

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Clean the sealing surfaces.



13mm



Install the manifold and gaskets.



Torque Value: 43 N·m [32 ft-lbs]

Follow the sequence shown in the illustration.

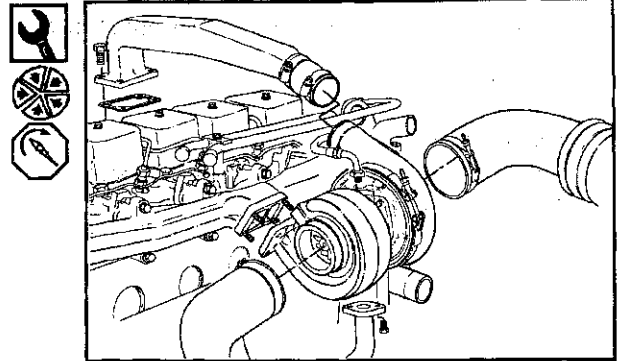


5/16 inch, 10mm, 15mm, 5/8 inch

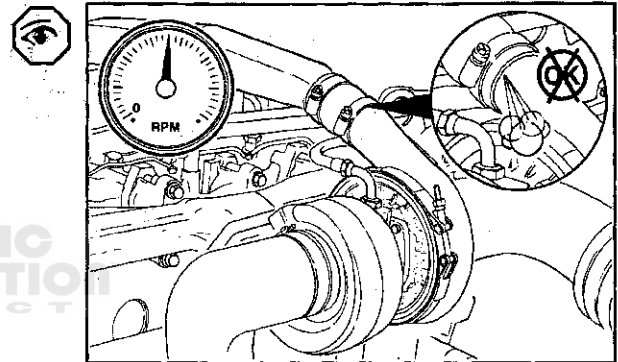
Install the turbocharger, air crossover, oil drain tube, oil supply line, and the exhaust and intake piping.

**Torque Values:**

- Turbocharger air crossover clamp - 5 N·m [44 in-lbs]
- Drain line capscrews - 24 N·m [18 ft-lbs]
- Turbocharger mounting nuts - 32 N·m [24 ft-lbs]
- Turbocharger oil supply line - 15 N·m [11 ft-lbs]
- Cab heater supply and return lines - 24 N·m [18 ft-lbs]



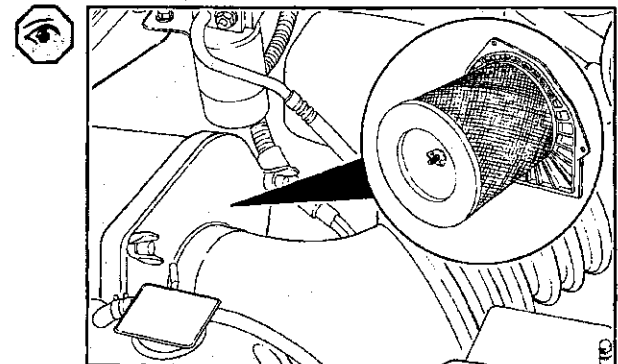
Operate the engine to check for leaks.



**Air Cleaner Element - Replacement**

Replace the air cleaner element when the restriction reaches the maximum limit at rated engine RPM.

635mm H<sub>2</sub>O [25 in. H<sub>2</sub>O]

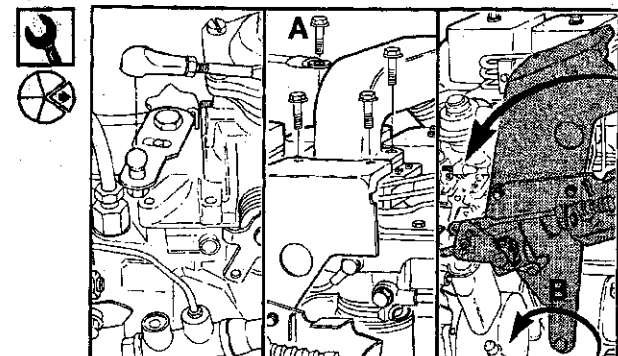


**Intake Manifold Heater - Replacement**

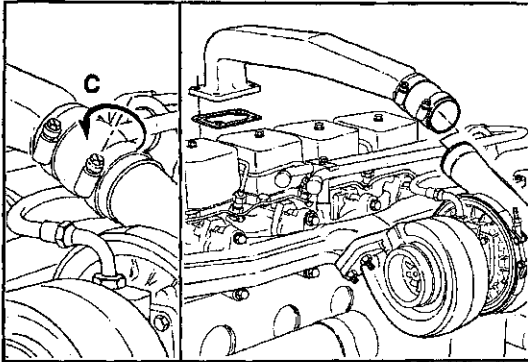
**Remove**

10mm, 13mm

Disconnect the throttle rod from the throttle lever. Remove the four mounting capscrews (A). Loosen the throttle control bracket lower mounting capscrew (B) and move the top end away from the engine.



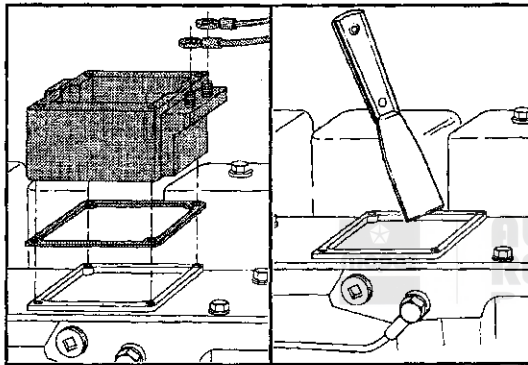




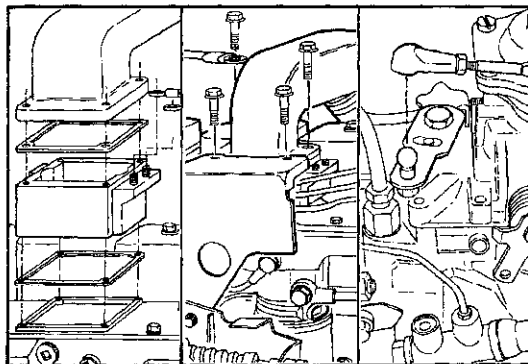
5/16 Inch

Loosen the hose clamp (C).

Remove the air crossover and gasket. Stuff a clean shop towel into the turbocharger opening.



Disconnect the intake manifold heater power supply connections and remove the intake manifold heater and gasket. Clean the mounting surface of the intake manifold.



**Install**

Install the new gasket and the intake manifold heater. Connect the electrical wiring.

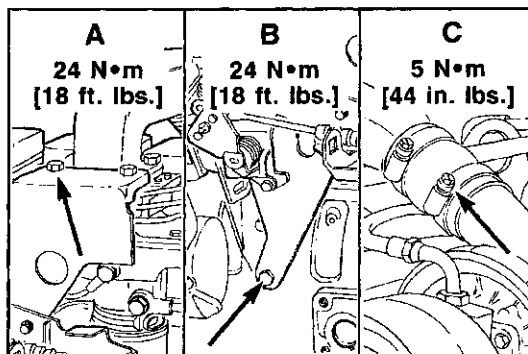
**Torque Value:** 14 N·m [10 ft-lbs]

Install the air crossover and gasket.

Install the throttle control bracket.

Install the intake manifold heater ground wire.

Attach the throttle rod to the throttle lever.



5/16 Inch, 10mm, 13mm

Tighten the four mounting capscrews (A).

**Torque Value:** 24 N·m [18 ft-lbs]

Tighten the throttle bracket lower mounting capscrew (B).

**Torque Value:** 24 N·m [18 ft-lbs]

Tighten the hose clamp (C).

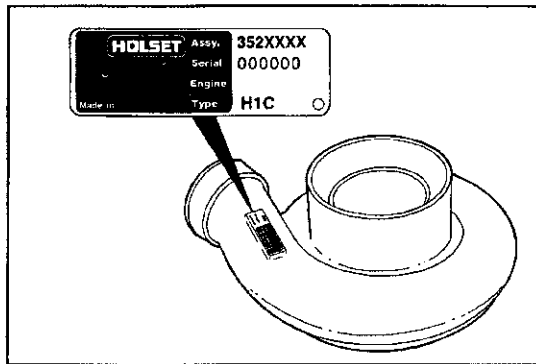
**Torque Value:** 5 N·m [44 in-lbs]

## Turbocharger – Rebuilding

### Description

A turbocharger is a mechanical device which uses the engine's exhaust gases to force more air into the engine cylinders. A turbocharger uses energy from the engine to help increase its overall efficiency. Hot exhaust gas energy is used to turn a "shaft and wheel". At the other end of the shaft and wheel is the "compressor impeller" (or compressor wheel), which draws in air and forces it into the engine cylinders.

Supplying increased air mass flow to the engine provides improved engine performance, lowers exhaust smoke density, improves operating economy, altitude compensation, and noise reduction. The turbocharger has proven to be one of the most beneficial devices for improving engine performance. It performs its job very well, as long as it is properly cared for.

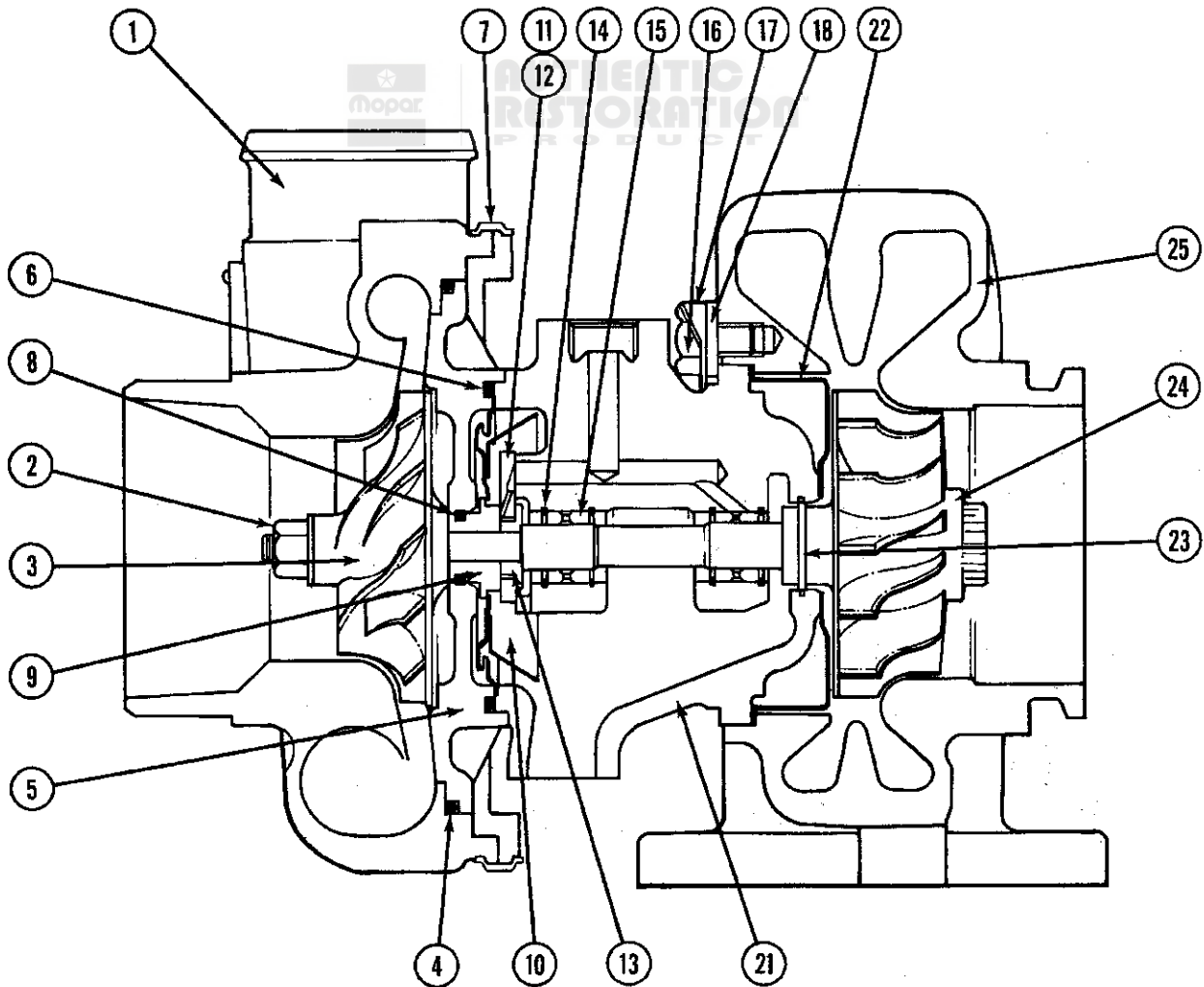


### Identification

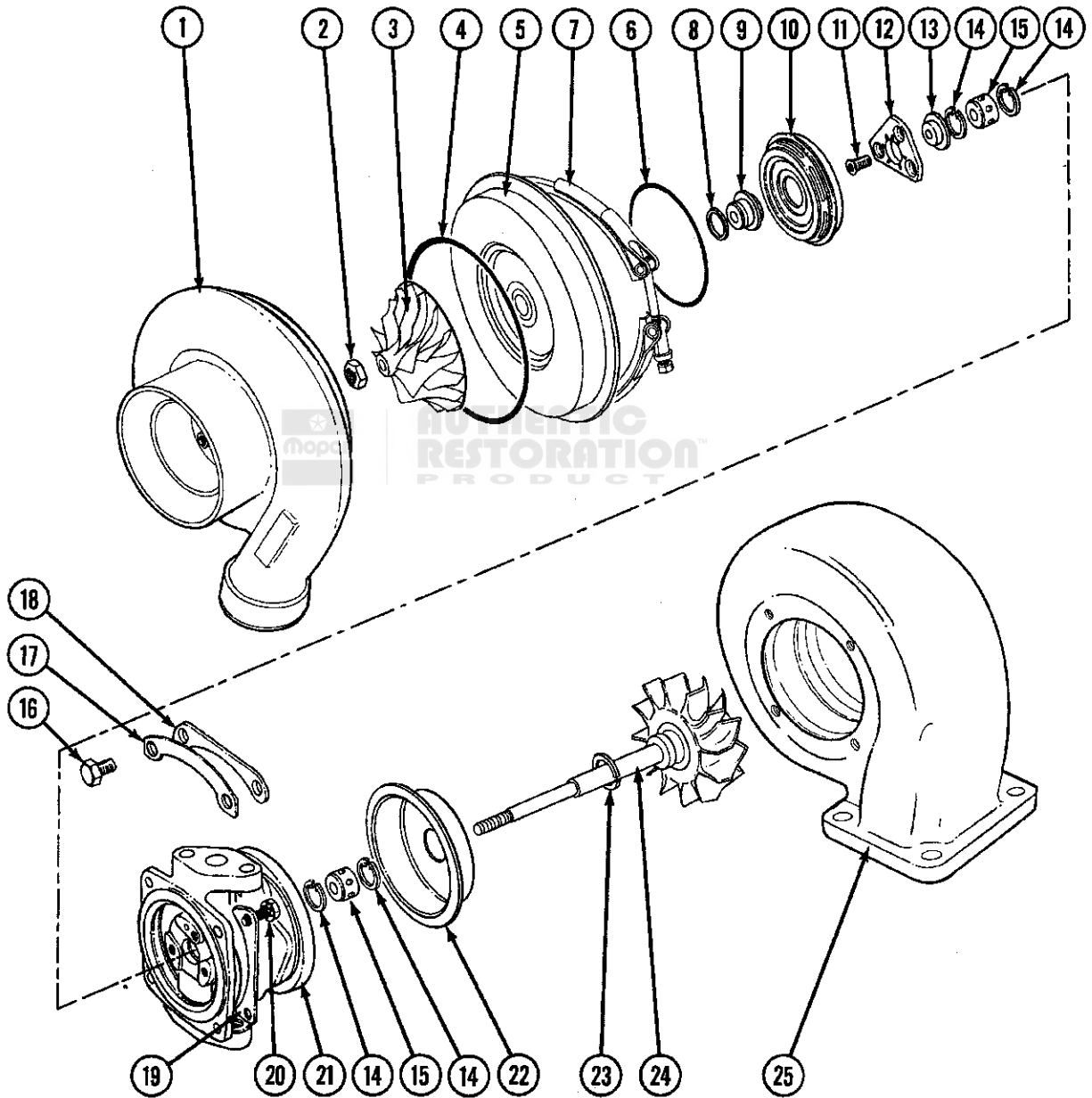
A Dataplate is located on the inlet side of the compressor housing. Always write the assembly number of the turbocharger, and turbocharger type on all orders for parts.

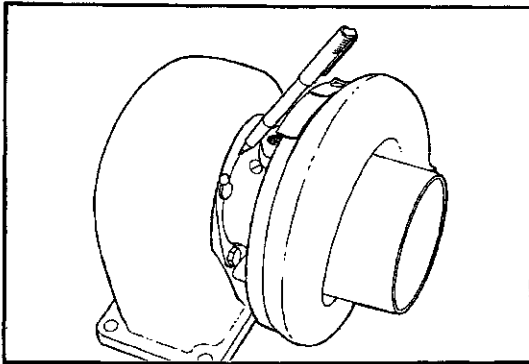
**Note:** The turbocharger Dataplate **must not** be changed unless approved by Cummins Engine Co., Inc.

REF. NO.	DESCRIPTION	QUANTITY	REF. NO.	DESCRIPTION	QUANTITY
1	Compressor Housing	1	14	Retainer Ring	4
2	Impeller Nut	1	15	Bearing	2
3	Compressor Impeller	1	16	Hex Head Capscrew	4
4	Rectangular Seal Ring	1	17	Lockplate	2
5	Turbocharger Diffuser	1	18	Clamping Plate	2
6	Rectangular Ring Seal	1	19	Lockplate	2
7	V-Band Clamp	1	20	Hex Head Capscrew	4
8	Split Ring Seal	1	21	Bearing Housing	1
9	Oil Slinger	1	22	Heat Shield	1
10	Oil Baffle	1	23	Split Ring Seal	1
11	Flat Head Capscrew	3	24	Shaft and Wheel	1
12	Thrust Bearing	1	25	Turbine Housing	1
13	Thrust Collar	1			



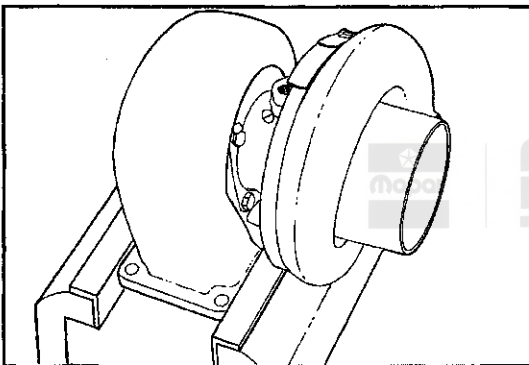
**Exploded View of the Turbocharger**



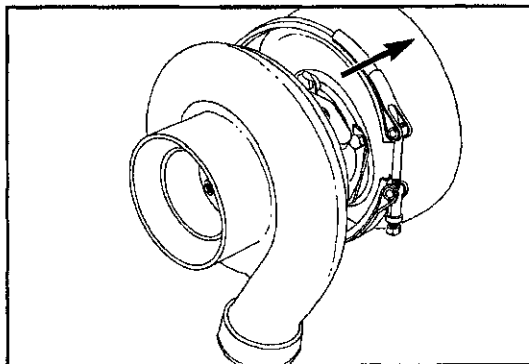


### Disassembly of the Turbocharger

Scribe the housings so they can be reassembled in the same position as before disassembly.



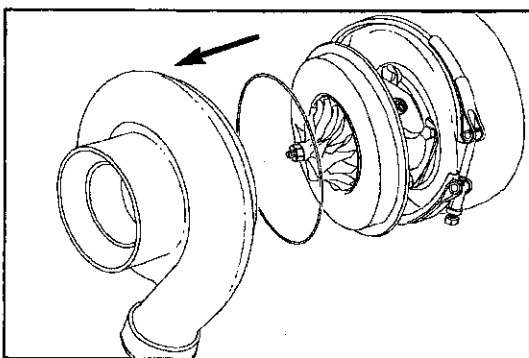
Clamp the turbocharger in a bench vise.



7/16 Inch



Remove the compressor housing v-band clamps.



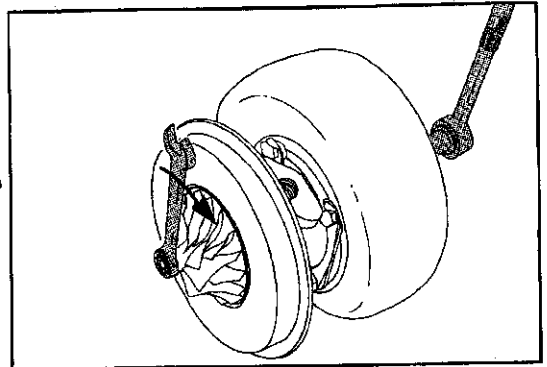
Remove the compressor housing and inspect for impeller contact.

Remove the square cut o-ring.

13mm, 16mm

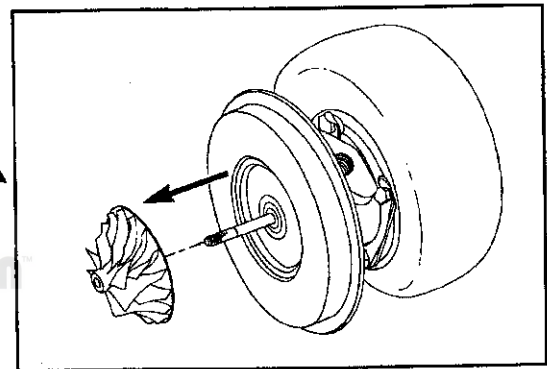
Remove the impeller nut.

**Caution:** Turn the nut to the right to loosen. The nut and shaft have left hand threads.



Remove the impeller and inspect the blades for damage.

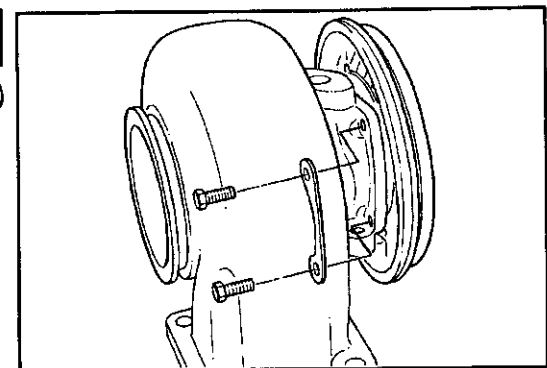
**Caution:** The wheel and shaft assembly is balanced as a unit. If the impeller is damaged the complete assembly must be replaced.



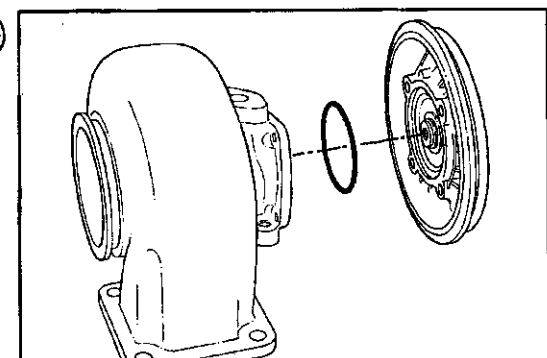
AUTHENTIC  
RESTORATION  
PRODUCT

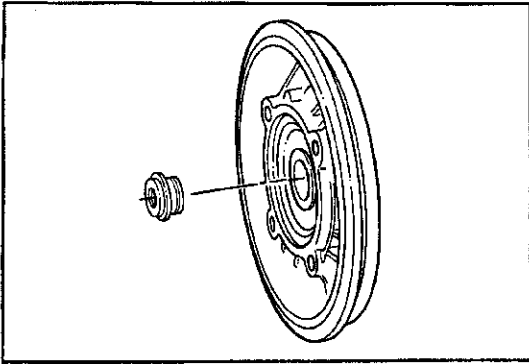
10mm



Remove the diffuser capscrews and lockplate.

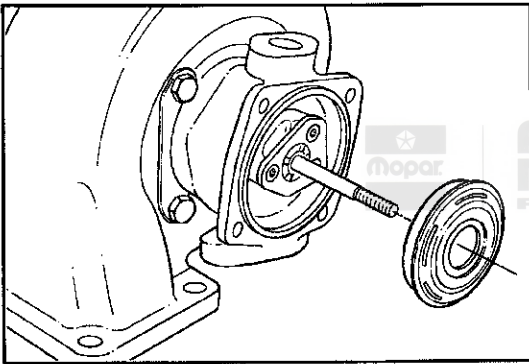


Remove the diffuser and discard the o-ring.

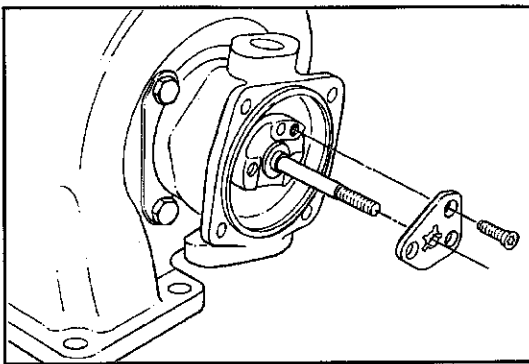







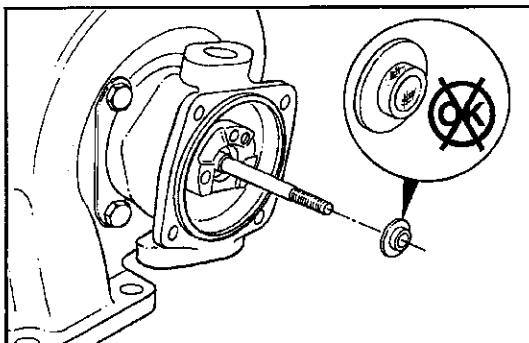
-  Remove the oil slinger and discard the piston ring.
-  Inspect for cracks and excessive wear.




-  Remove the oil baffle.



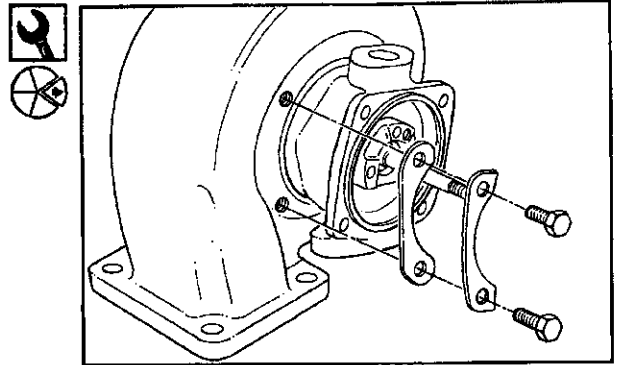
-  T20 Torx
-  Remove the thrust bearing and retainer screws.
-  **Caution: Do not reuse the thrust bearing.**



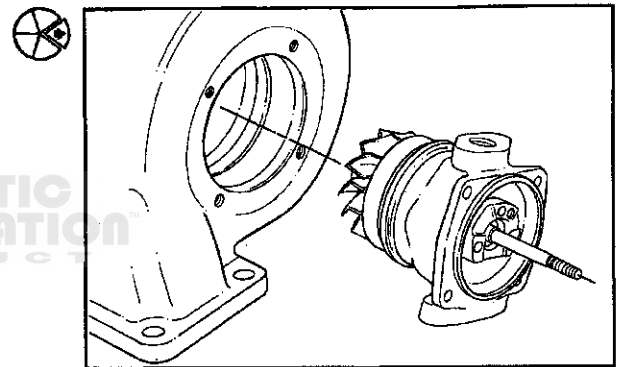
-  Remove the thrust collar.
- Inspect the collar for excessive wear.

1/2 Inch

Remove the turbine housing lockplates and clamp plates.

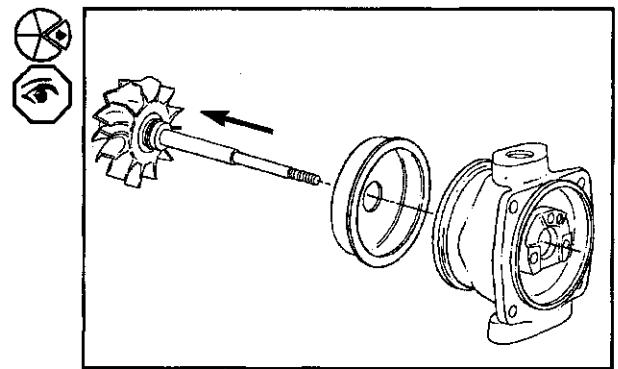


Remove the bearing housing.



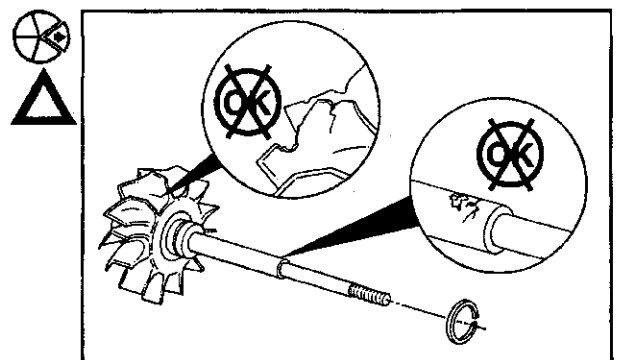
Remove the turbine shaft and heat shield.

Inspect the turbine blades and the shaft for excessive wear.

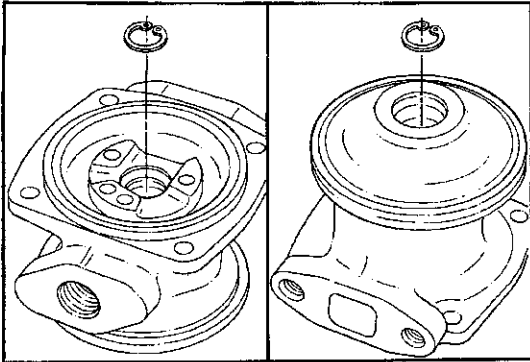


Remove and discard the piston ring type seal.

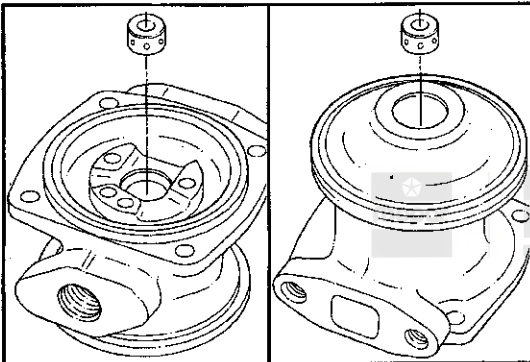
**Caution:** The wheel and shaft assembly is balanced as a unit. If the turbine blades or shaft are damaged, the complete assembly must be replaced.




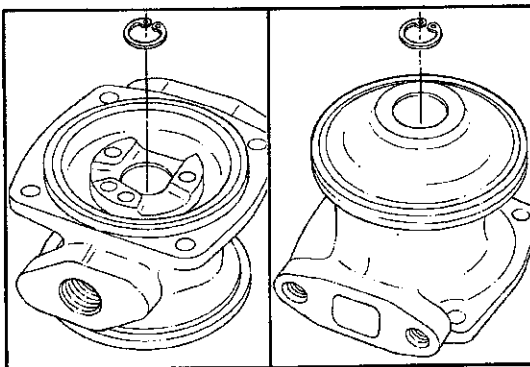




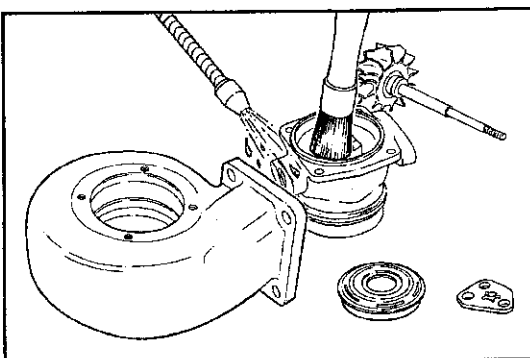
 Remove and discard the outer retainer rings.



 Remove and discard the turbocharger shaft bearings.



 Remove and discard the inner snap rings.



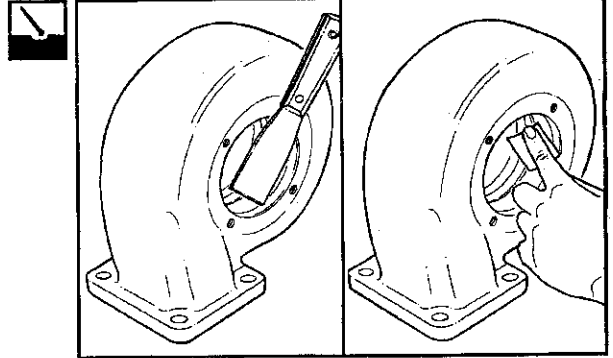
### Cleaning of the Turbocharger

Use a stiff bristle nylon brush and solvent to clean all parts.

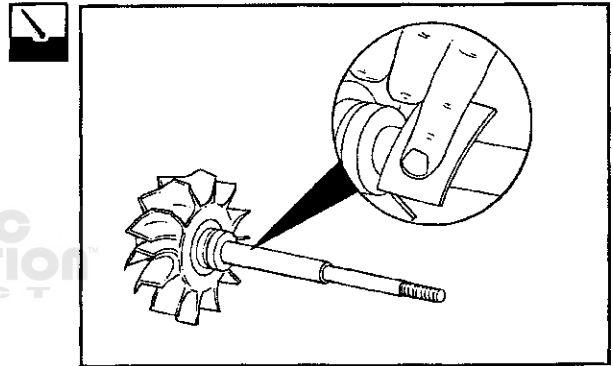


**Caution:** Do not use a wire brush on the compressor wheel. Do not bead blast the parts.

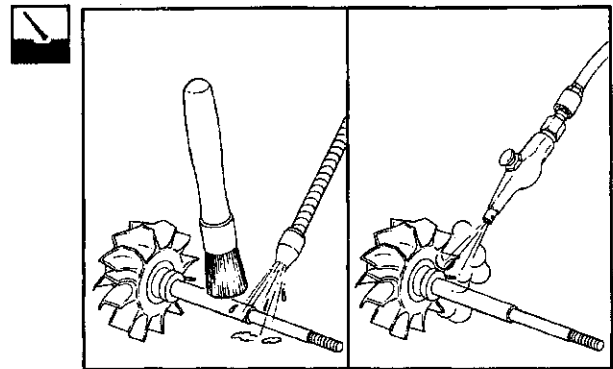
Remove the carbon build up from the housing with a scraper and 240 grit emery cloth.



Polish the bearing surfaces with crocus cloth and kerosene or diesel fuel.



After rinsing in clean solvent, use compressed air to dry the parts.



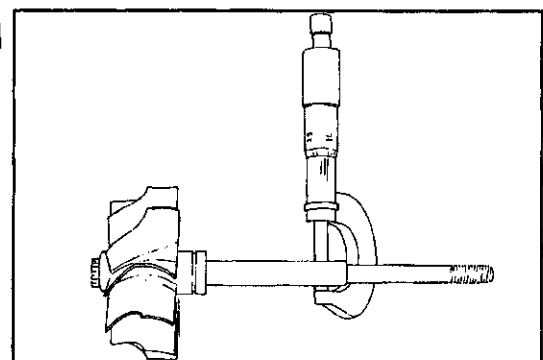
### Inspection of the Turbocharger

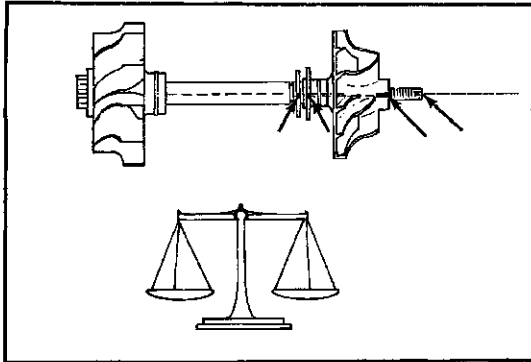
In addition to the inspection specified during disassembly, inspect all parts after cleaning.



Measure the shaft bearing diameter.

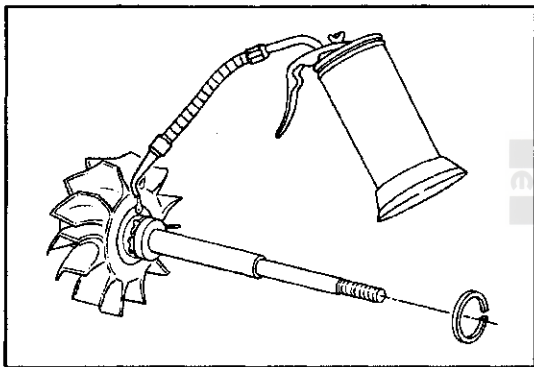
10.97mm                      Diameter  
MIN                              [0.432 inch]



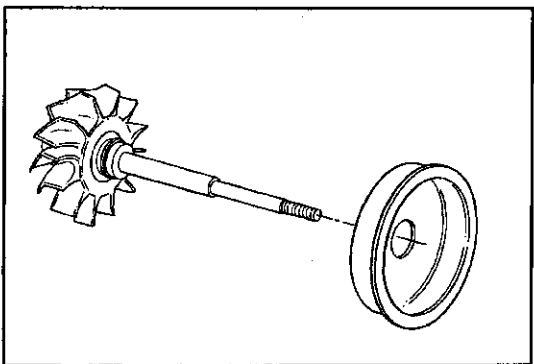


**△ Assembly of the Turbocharger**

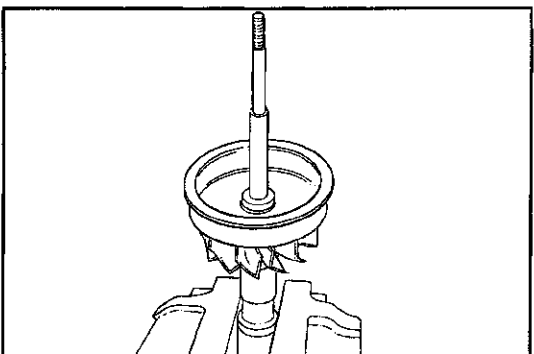
The balance marks must be aligned to make sure the wheel and shaft assembly is balanced.




 Install the piston ring and lubricate the groove with engine oil.



 Install the heat shield.

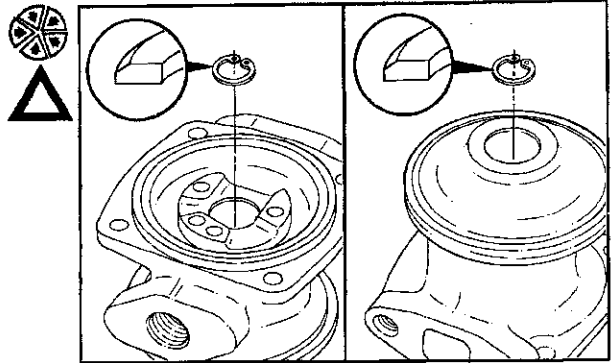


 16mm

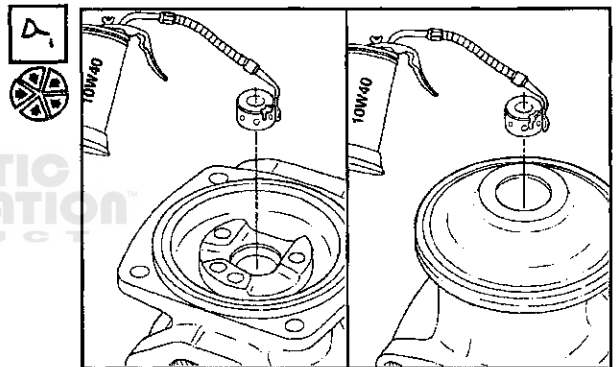
 Clamp a socket in a soft jawed vice and position the shaft in the socket.

Install the inner retainer rings.

**Caution: The beveled face must be towards the bearing.**

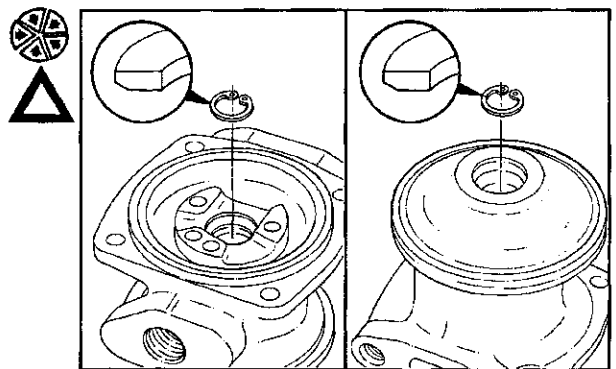


Lubricate the turbocharger bearings with engine oil and install the bearings in the housing.



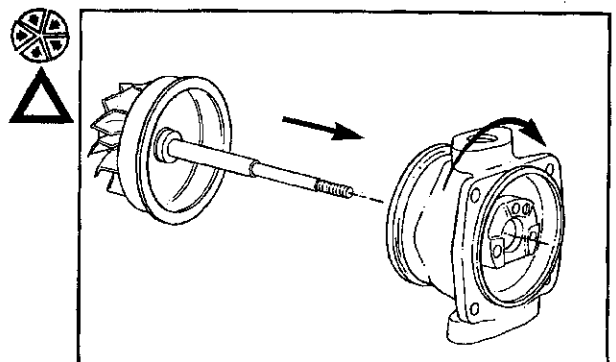
Install the outer retainer ring.

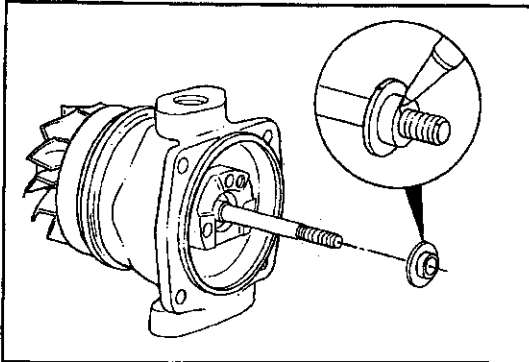
**Caution: The beveled face must be towards the bearings.**



Assemble the turbine shaft and heat shield to the bearing housing.

**Caution: Rotating the housing as you press downward will assist in properly seating the piston ring.**

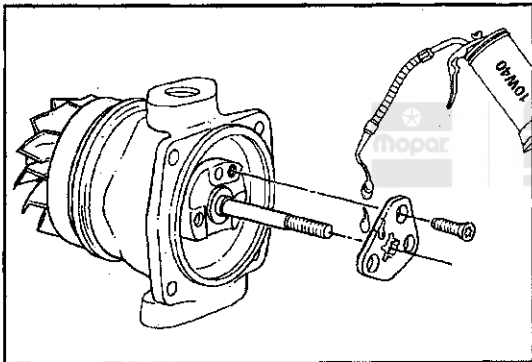




Install the thrust collar.



**Caution:** Align the balance mark with the balance mark on the shaft. Mark the top surface with a marker pen so alignment can be verified after installing the thrust bearing.



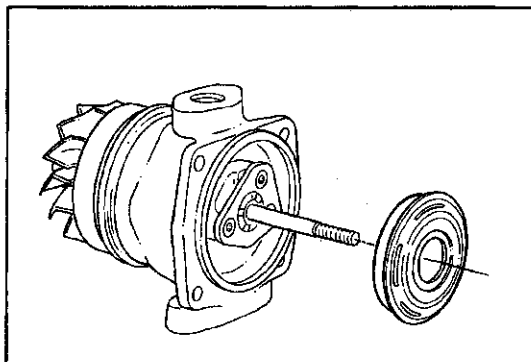
T20 Torx



Lubricate the thrust bearing with engine oil and install it on the housing.



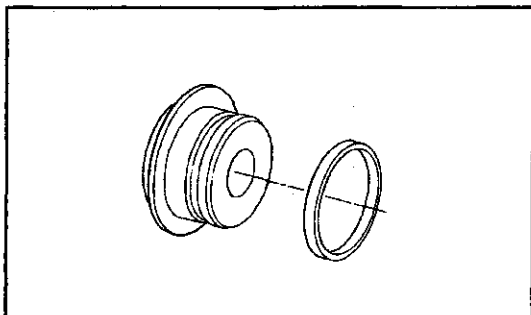
Torque Value: 4.5 N-m [40 in-lbs]



Install the oil baffle.

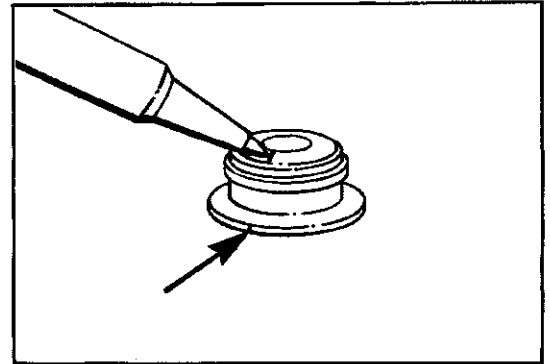


**Caution:** Check the balance mark alignment.

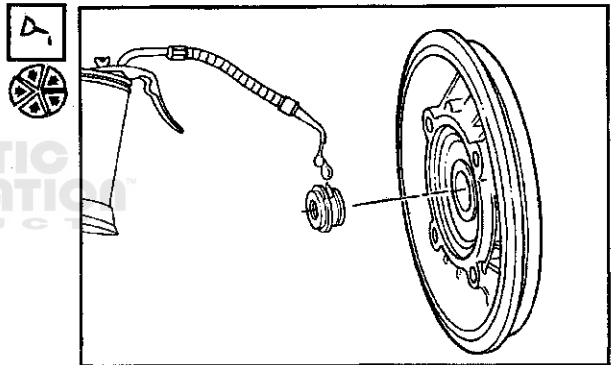


Install the piston ring type seal on the oil slinger.

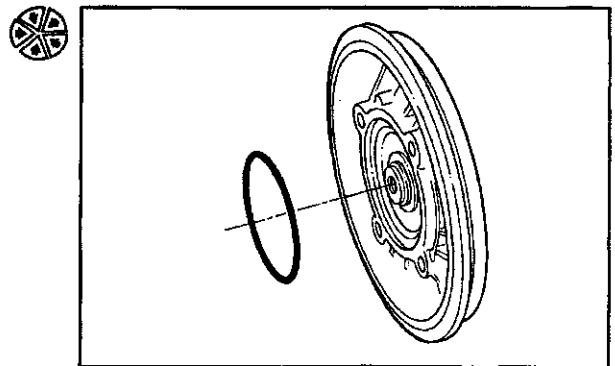
Mark the top surface of the oil slinger in line with the balance mark.



Lubricate the oil slinger with engine oil and install it into the diffuser.

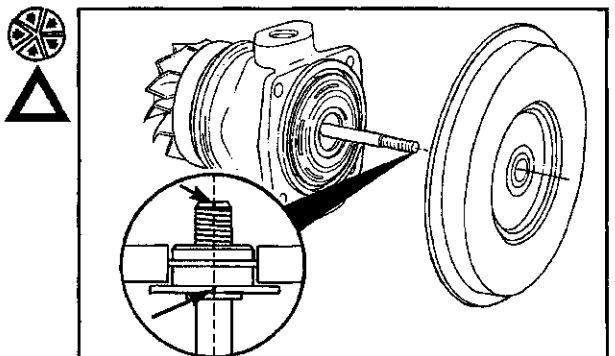


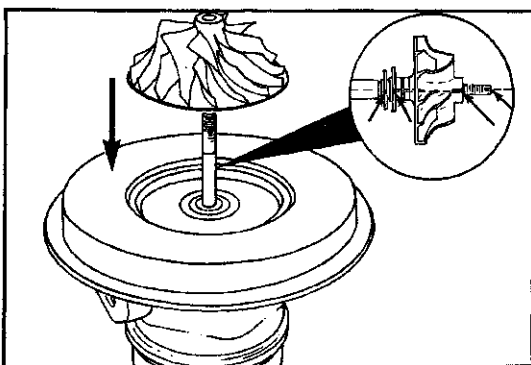
Install the o-ring into the diffuser.



Install the diffuser.

**Caution:** Align the balance marks on the shaft and the oil slinger.

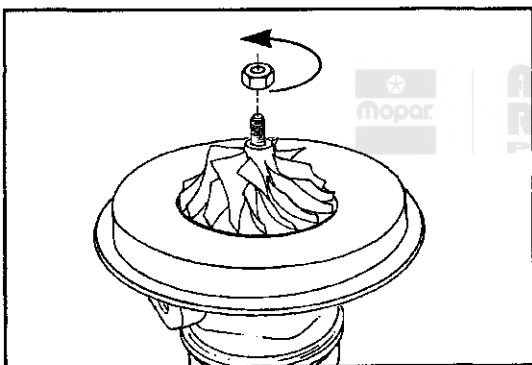




Align the balance mark and install the impeller.



Caution: Be careful not to move the bearing housing.



1/2 Inch



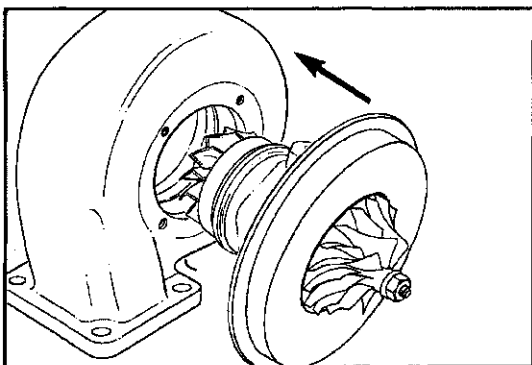
Caution: Impeller nut and shaft have left hand threads.



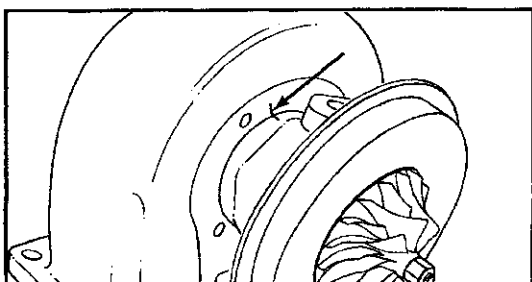
Do not allow the impeller to turn when installing the nut.



Torque Value: 14 N·m [129 in-lbs]

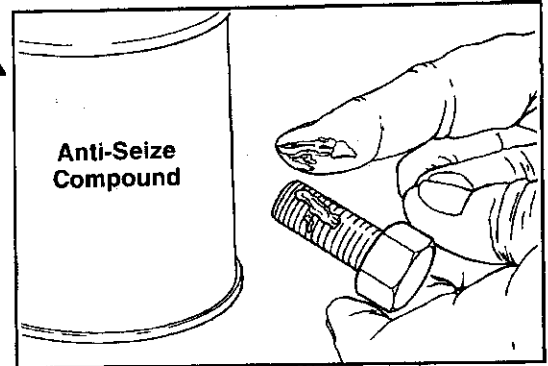


Install the bearing housing assembly into the turbine housing.



Align the scribe marks.

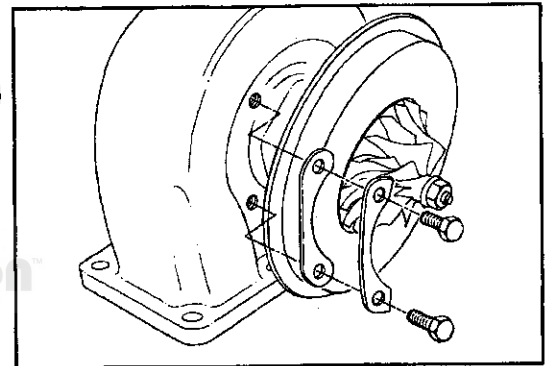
Apply anti-seize compound to the capscrew threads.



13mm

Install the clamp plates, lockplates and capscrews.

**Torque Value:** 11.3 N·m [100 in-lbs]



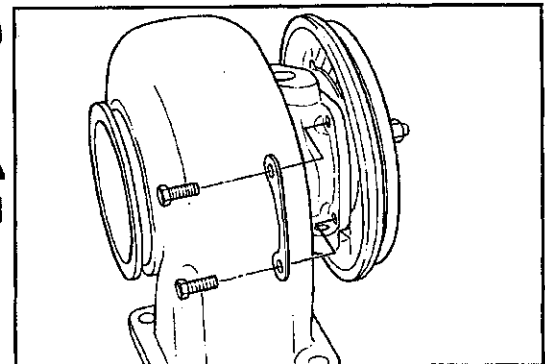
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PRODUCT

Install the lockplates and capscrews into the diffuser.

After tightening the capscrews, bend the lockplate tabs to lock the capscrews.

**Caution:** Be sure the scribe marks are aligned.

**Torque Value:** 5.7 N·m [50 in-lbs]

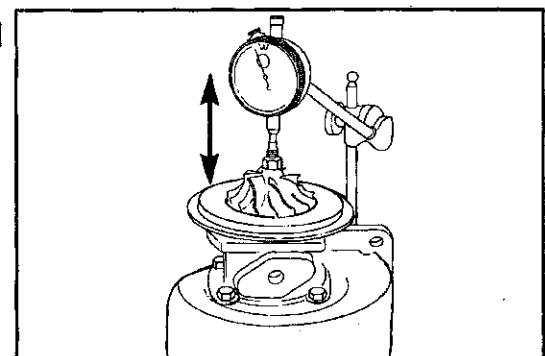


Measure the end play.

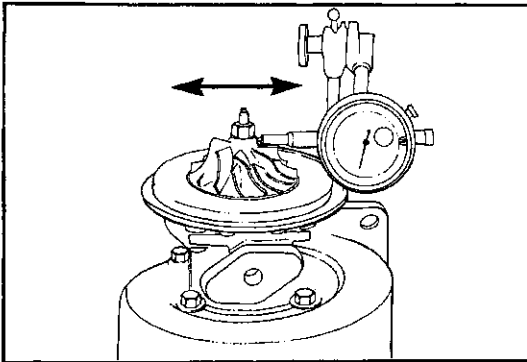


End Play		
mm		In
*0.03	MIN	[0.001]
0.08	MAX	[0.003]

\*For turbochargers with a serial number after and including 840638.

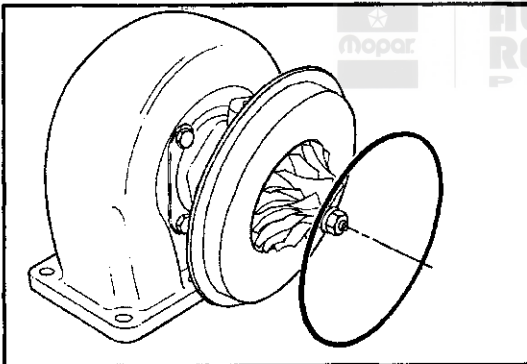




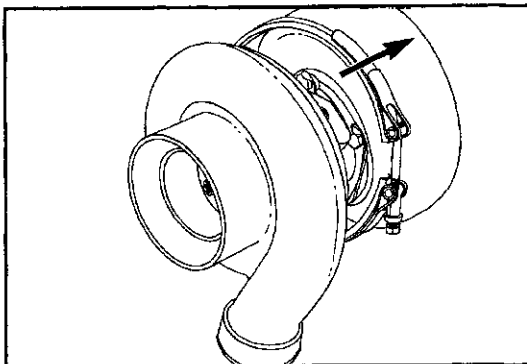


Measure radial clearance of the shaft.

Radial Clearance		
mm		in
0.30	MIN	[0.012]
0.46	MAX	[0.018]



Install the square cut o-ring.



7/16 inch



**Caution: Be sure the scribe marks are aligned.**



Install the compressor housing and v-band clamp.



**Torque Value: 8 N·m [72 in-lbs]**

**Note:** Apply anti-seize compound to the v-band bolt threads. Tighten the clamp to the specified torque. Tap against the clamp on 4 places around its circumference. Again tighten the clamp to the specified torque.

## Specifications

### Torque Values:

Air Crossover to Intake Manifold Capscrews .....	24 N•m	[18 ft-lbs]
Turbocharger Air Crossover Hose Clamps .....	5 N•m	[44 in-lbs]
Intake Manifold Cover Capscrews .....	24 N•m	[18 ft-lbs]
Fuel Heater Ground Capscrew .....	12 N•m	[110 in-lbs]
Injector Fuel Nut .....	24 N•m	[18 ft-lbs]
Turbocharger Exhaust Manifold Nuts .....	32 N•m	[24 ft-lbs]
Turbocharger Drain Line Connection Capscrews .....	24 N•m	[18 ft-lbs]
Turbocharger Oil Supply Line Fitting .....	15 N•m	[11 ft-lbs]
Exhaust Manifold Capscrews .....	43 N•m	[32 ft-lbs]
Throttle Control Bracket Mounting Capscrews .....	24 N•m	[18 ft-lbs]
Turbocharger Impeller Nut .....	14 N•m	[129 in-lbs]
Turbocharger Bearing Housing to Turbine Housing Capscrews .....	11.3 N•m	[100 in-lbs]
Turbocharger Bearing Housing to Diffuser Capscrews .....	5.7 N•m	[50 in-lbs]
Turbocharger V-Band Clamp .....	8 N•m	[72 in-lbs]

### Dimensions / Clearances:

Turbocharger Rotor Assembly End Play .....	0.026 - 0.076 mm [0.001 - 0.003 inch]
Turbocharger Radial Clearance .....	0.30 - 0.46 mm [0.012 - 0.018 inch]
Turbocharger Shaft Bearing Diameter .....	10.97 mm [0.432 inch]
Air Intake Restriction .....	635 mm H <sub>2</sub> O [25 inches H <sub>2</sub> O] maximum



# Fuel System

## Section 14

### Contents

Subject	Page
Fuel System Components And Flow .....	14-2
Fuel System Specification Dodge Ram 5.9 Liter Diesel .....	14-2
Fuel System Malfunction - Diagnosis .....	14-3
Lift Pump .....	14-3
Air In the Fuel System .....	14-4
Fuel Water Separator/Filter Unit .....	14-5
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## Fuel System Components And Flow

The following illustration identifies the components of the fuel system.

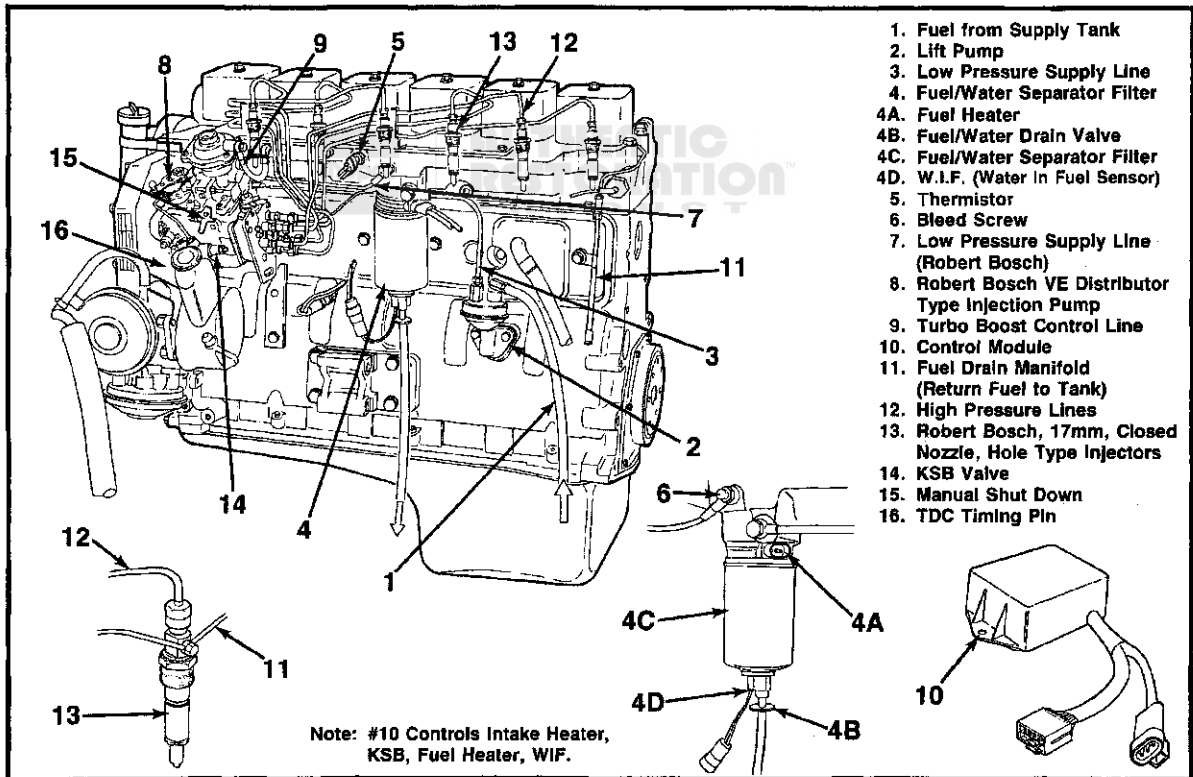
The engine is equipped with a cam-actuated lift pump. Fuel flow begins as the lift pump pulls fuel from the supply tank. The pump supplies low-pressure fuel (21-35 kPa, [3-5 psi]) to the fuel filter head, through the filter and then to the distributor injection pump.

The engines use distributor-type fuel pumps supplied by Robert Bosch.

The distributor pump builds the high injection pressures required for combustion, and routes the fuel through individual high-pressure fuel lines to each injector.

When the high-pressure fuel reaches the injector, the pressure lifts the needle valve against the spring tension to let the fuel enter the combustion chamber.

Any leakage past the needle valve enters the fuel drain manifold. The fuel drain manifold routes controlled venting from the distributor injection pump and leakage from the injectors back into the fuel tank.



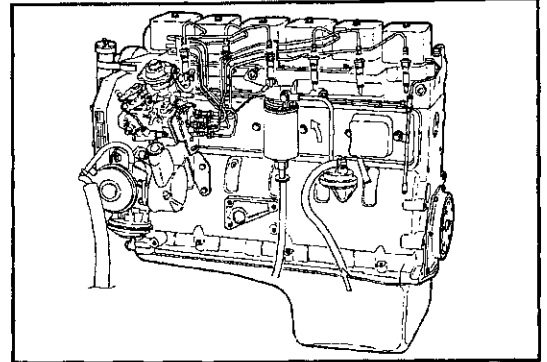
### Fuel System Specification Dodge Ram 5.9 Liter Diesel

Maximum Allowable Restriction to Lift Pump with Dirty Filter - mm Hg [in. Hg] .....	95 [3.75]
Maximum Allowable Return Line Restriction - mm Hg [in. Hg] .....	518 [20.4]
Maximum Allowable Pressure Drop Across Fuel Filter - kPa [psi] .....	21 [3]
Minimum Allowable Lift Pump Volume .....	0.75 liter [0.70 U.S. quart]

**Note:** Within 30 seconds at cranking speed.

## Fuel System Malfunction – Diagnosis

The function of the fuel system is to inject clean, atomized fuel into the engine cylinders at a precise time near the end of the compression stroke of each piston. The components of the system contribute to the delivery of fuel to the cylinders.



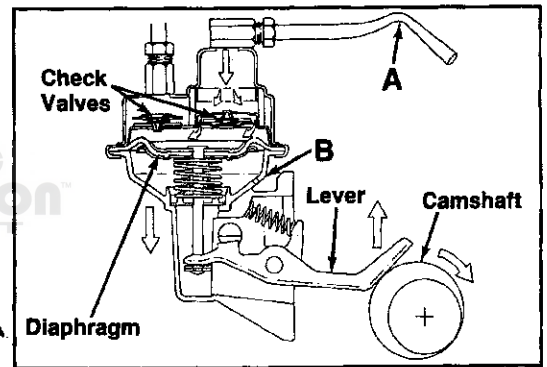
### Lift Pump

**Note:** A malfunctioning lift pump can cause low power.

The lift pump is mechanically driven by a lobe on the camshaft. Wear on the lever or a damaged lobe can reduce the pumping action.

Do not operate the fuel system with a suction restriction (A) of more than 95mm (3.75 inch) Hg.

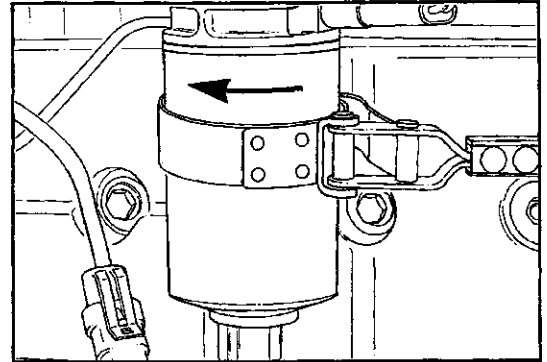
**Caution:** If the diaphragm ruptures, fuel will drain from the weep hole (B) in the housing.



Pressure drop across the filter is 21 kPa [3 psi], maximum.

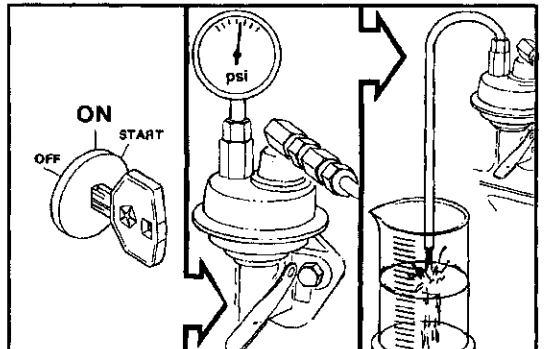
The pressure drop will increase as the filter removes contamination from the fuel. Therefore, a worn lift pump will have reduced capacity to force fuel through a dirty filter. This can cause low engine power.

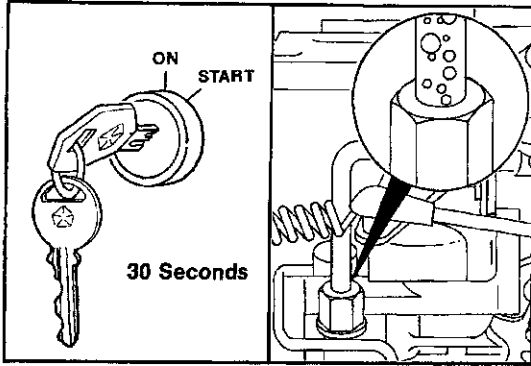
**Note:** Frequent filter replacement to get full power from the engine can indicate a worn lift pump.



The output of the pump can be measured at cranking speed:

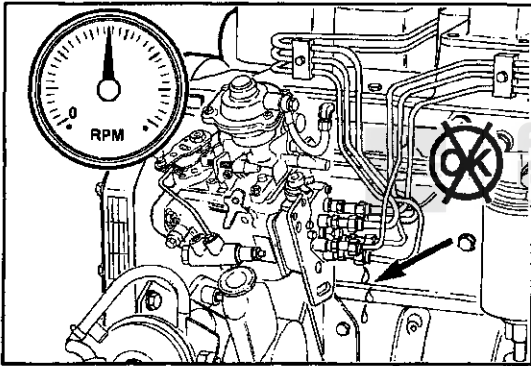
- Volume (within 30 seconds): 0.75 liters [0.70 U.S. quarts]
- Pressure: 21 to 35 kPa [3 to 5 psi]





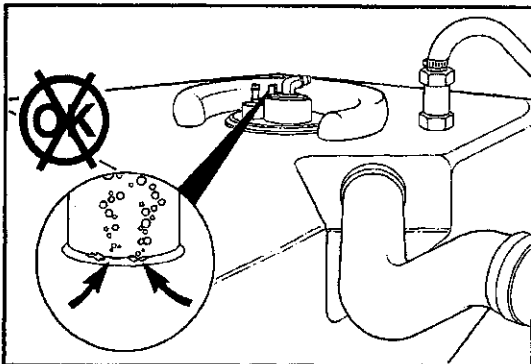
### Air In the Fuel System

A replacement of supply lines, fuel filters, injection pump, high pressure lines and injectors will let air enter the fuel system. Follow the specified procedure to bleed the air from the system.

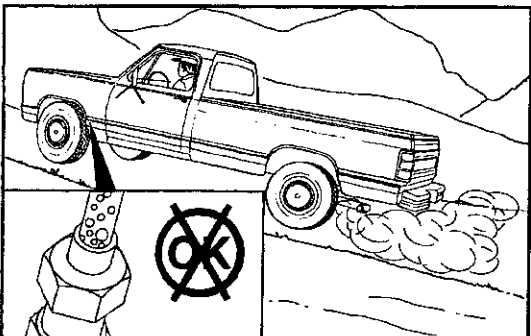


Since the lift pump and injection pump provide a positive pressure through the fuel filter and supply line to the injection pump, loose connections or defective seals will show as a fuel leak.

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The most usual place for air to enter the fuel system is between the inlet of the lift pump and the suction tube in the tank. The fuel tank has the outlet fitting at the top with a suction tube that extends down in the tank. Cracks or pin holes in the tube to the fitting can let air enter the fuel system.

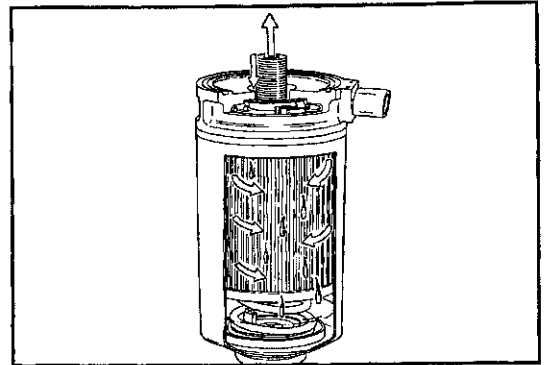


Air in the system will make the engine: hard to start, run rough, misfire, produce low power, and can cause excessive smoke and a fuel knock.

## Fuel Water Separator/Filter Unit

**Caution:** Be sure to use the correct filter element.

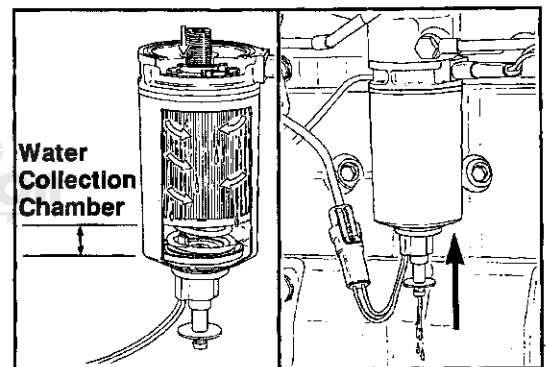
Filtration and separation of water from the fuel is important for trouble-free operation and long life of the fuel system. Some of the clearances between the pump parts are very close. For this reason the parts can easily be damaged by rust formation and contaminants.



The element has a valve which can be opened regularly to drain the collected water.



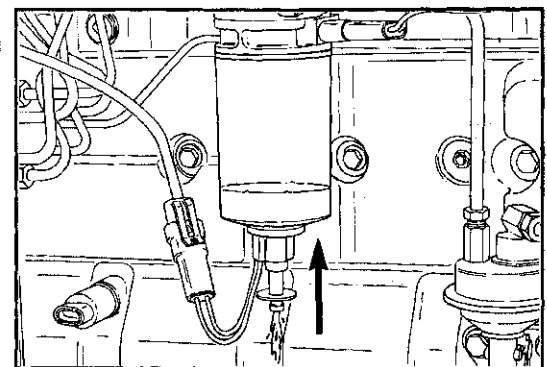
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Regular maintenance, including draining moisture from the fuel water separator/filter is essential to keep water out of the fuel pump.

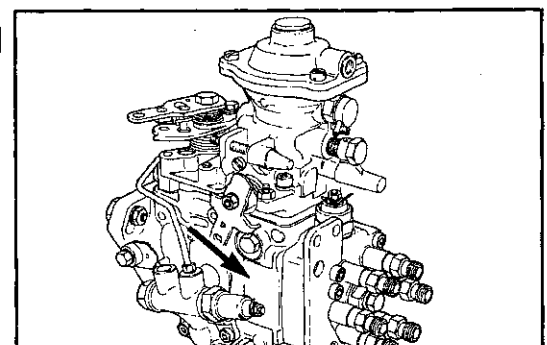


**Note:** If excess water re-appears in the fuel water separator filter in a short period of time, the fuel tank must be removed, drained and cleaned.

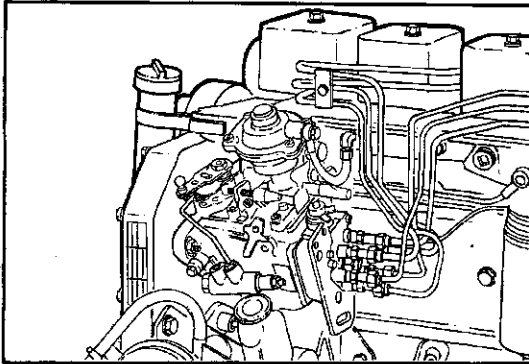


## Injection Pump Identification

Production pump data is imprinted on the housing as shown.



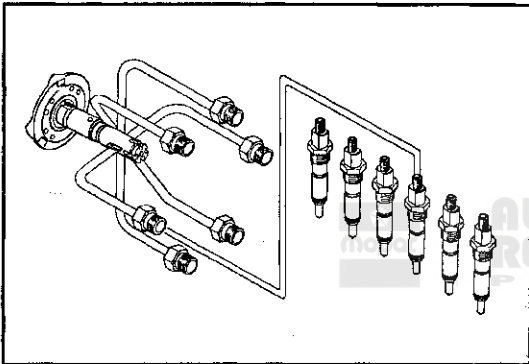




### Injection Pump

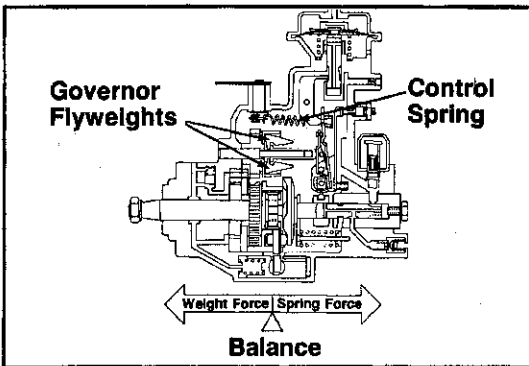
The **Robert Bosch VE** injection pump is a rotary distributor type pump. This pump performs four basic functions of:

1. Producing the high fuel pressure required for injection.
2. Metering the exact amount of fuel for each injection cycle.
3. Distributing the high pressure, metered fuel to each cylinder at the precise time.
4. Varying the timing relative to engine speed.



The pump uses a single plunger to develop and distribute the high pressure required for injection.

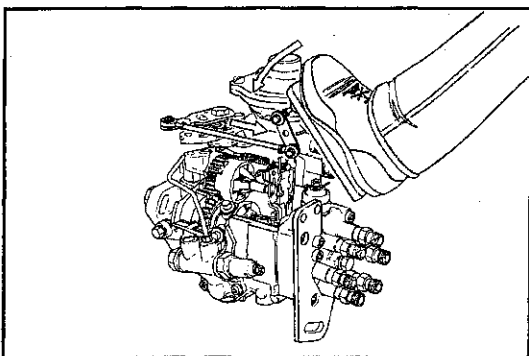
A worn or damaged plunger can affect the pressure and amount of fuel injected, thus reducing the power from the engine. Generally, if the pump is injecting fuel from one outlet, it will deliver from all outlets. The only exception to this would be a malfunctioning delivery valve.



### Governor Malfunctions

Balance between the flyweight governor and control lever position controls the metering of the amount of fuel to be injected.

The pump governor performance and setting can affect engine power. Special equipment and qualified personnel are required to verify governor performance. If the seals are broken on the external adjustment screw, the fuel rate may be out of adjustment. **The warranty of the pump and engine may be void if the seals have been tampered with or removed.**

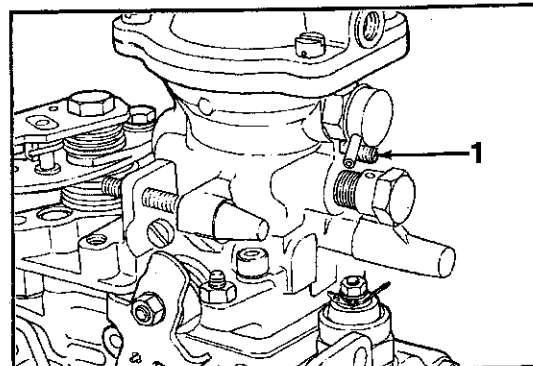


### Fuel Control Lever Travel and Adjustment

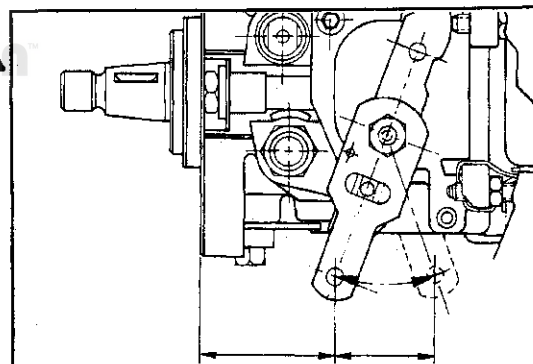
The amount of fuel injected and subsequently the speed and power from the engine is controlled by the fuel control lever. Restricted travel of the lever can cause low power. Always check for full travel of the lever when diagnosing a low power complaint.

The only adjustment that can be made on the fuel pump is the Low Idle Adjustment (Screw #1).

1. Idle Screw



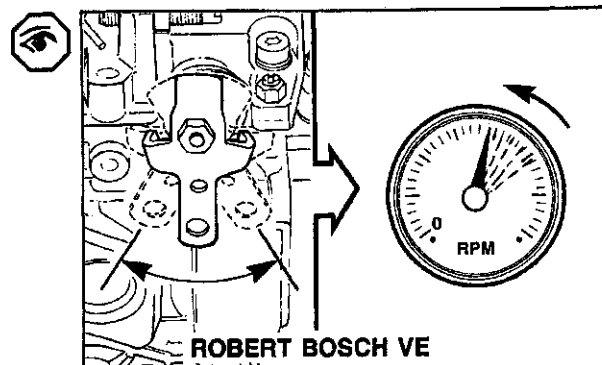
**Caution:** The fuel control lever is indexed to the shaft during pump calibration. Do not remove the throttle lever from the fuel pump.

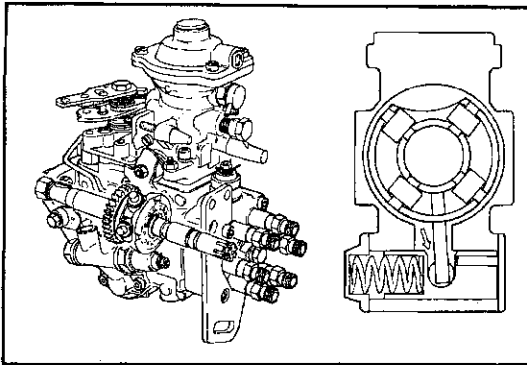


### Manual Shut Down Lever

The injection pump is equipped with a mechanical shut down lever. This lever is spring-loaded in the run position. There is no cable or rod connected to the lever.

**Note:** Partial actuation of the mechanical shutdown lever will affect fuel flow and engine power.



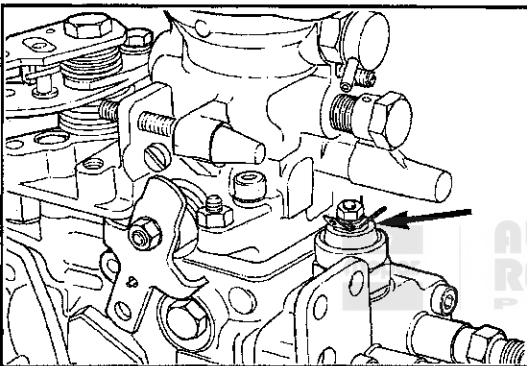


**Advance Timing Mechanism**

Regulated pressure produced by the vane supply pump in the injection pump is used to advance the timing. Timing advances as the engine speed increases. A return spring is used to retard the timing as the engine speed is reduced. If a spring should break, the timing will go to the advance position resulting in torque loss, a fuel knock and possible engine overheating,

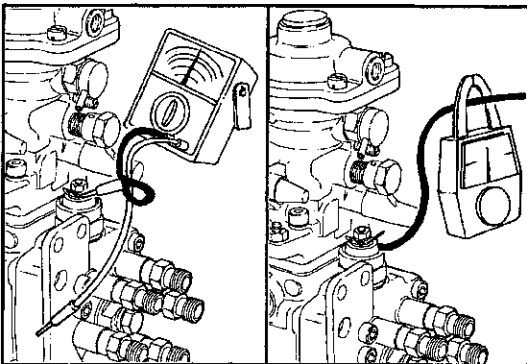
Retarded (late) timing will result in torque loss, high fuel consumption and white to black smoke.

Replacement of the spring and repair of the advance timing mechanism **must** be performed by an authorized injection pump service center.



**Electrical Shut Off Valve**

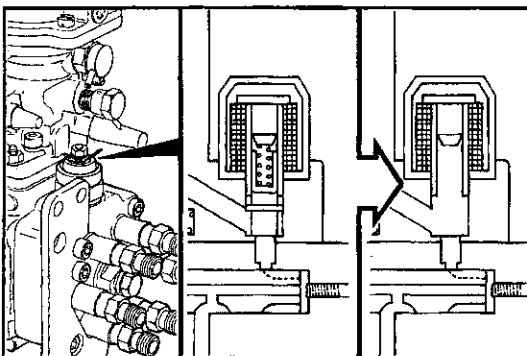
The injection pump is equipped with electrical shut off valve. This solenoid-operated valve blocks the supply of fuel to the high pressure pumping and distribution components.



The valve does not make a very audible sound when actuated, but it can be checked with a volt or ohm meter for the following values:

**Shut Down Values**

Operating Voltage	Minimum Voltage to Open	Resistance Ohms	Peak Amperes
12 Volt DC	10 Volt DC	7.4 + 0.5	2



**Caution:** Do not connect the electrical wire to the solenoid when the plunger has been removed. Without the plunger the valve can be damaged.

Malfunctioning valves can be diagnosed by removing the plunger and spring, then reinstall the solenoid.

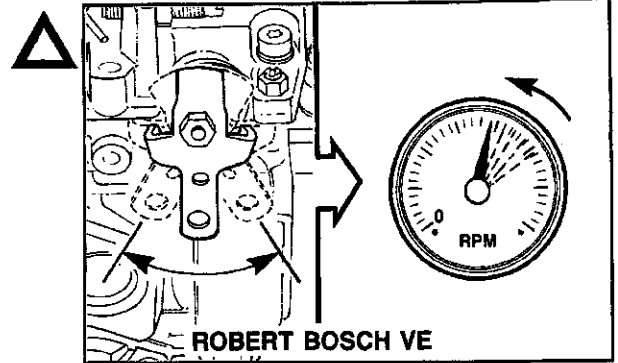


**Warning:** If the plunger and spring is removed from the solenoid, the engine will start when cranked. Make sure the transmission is in Park or Neutral with the Parking Brake Set.

**Caution:** Use the mechanical shut down lever to stop the engine.

If the engine will start without the valve, the valve is malfunctioning.

This method of removing the plunger to start the engine can be used if necessary to move the equipment to a service location.



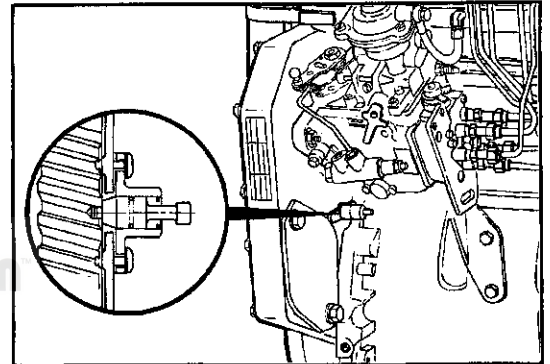
### Injection Pump Timing

Pump-to-engine timing is extremely critical. Pump timing that is off by only a few crankshaft degrees will cause:

1. Poor performance - starting and power
2. Excessive smoke and emissions
3. Poor fuel economy

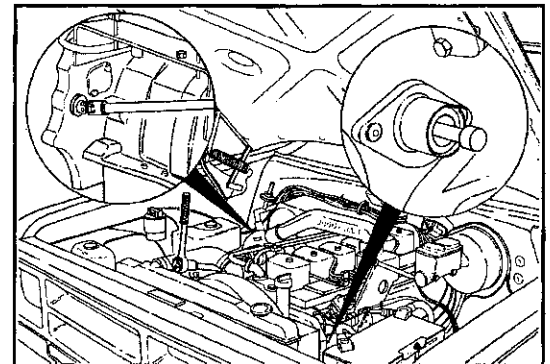


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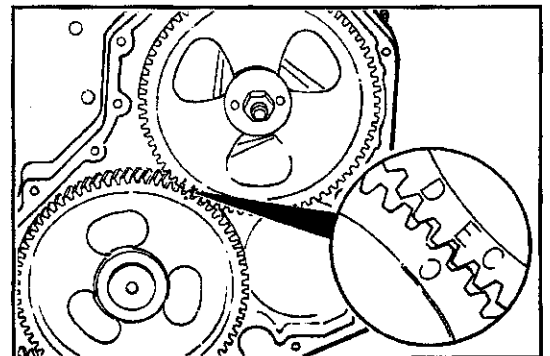
Engine pump timing begins with the timing of the injection pump drive gear to the camshaft gear.

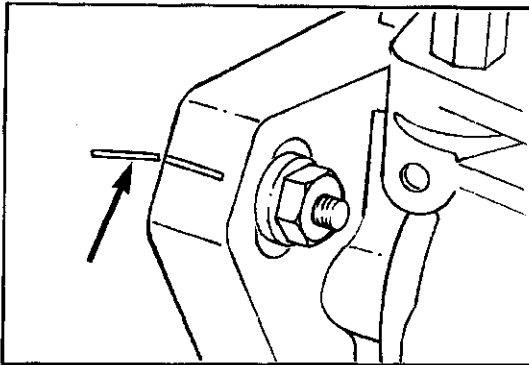
The first step is the location of TDC for Cylinder Number 1.



Then, depending on the engine configuration, a letter on the fuel pump gear is aligned with the mark on the camshaft gear. The Dodge 5.9 Liter Diesel Engine uses timing letter "E".

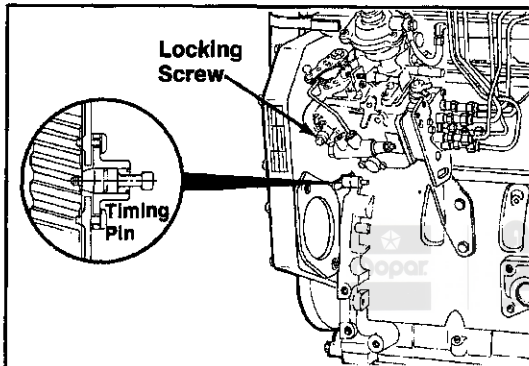
Letter	Engine
E	6BT5.9 (Robert Bosch VE, CARB)





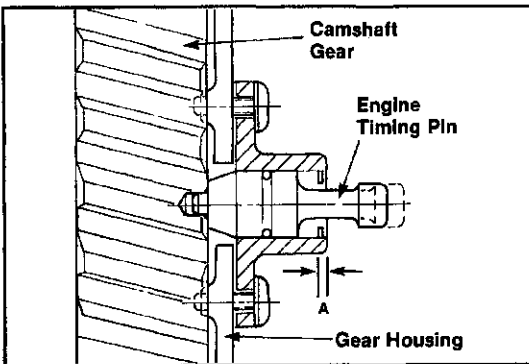
To verify that the injection pump is timed correctly, first check the alignment marks on the pump flange and gear housing.

**Note:** The alignment mark is unique to each engine.

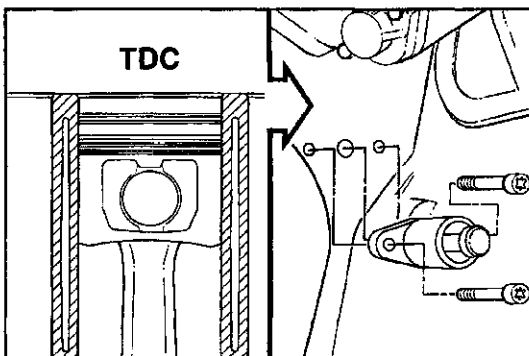


The pump has a provision for locking the pump shaft at a position corresponding to top-dead-center for Cylinder Number 1.

New and reconditioned pumps should be received with the shafts locked in this position.



The engine is equipped with an engine timing pin to locate TDC for Cylinder Number 1.



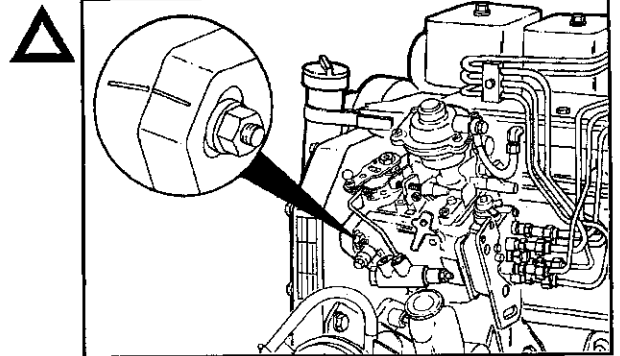
**Caution:** If the timing pin is incorrectly located on the gear housing, the timing procedure will not ensure that the pump is timed correctly.

After precisely locating TDC for Cylinder Number 1, the factory positions the timing pin assembly to the gear housing using the timing pin and the hole in the camshaft gear. If the gear housing or timing pin assembly are removed, the same precision is required to relocate it.

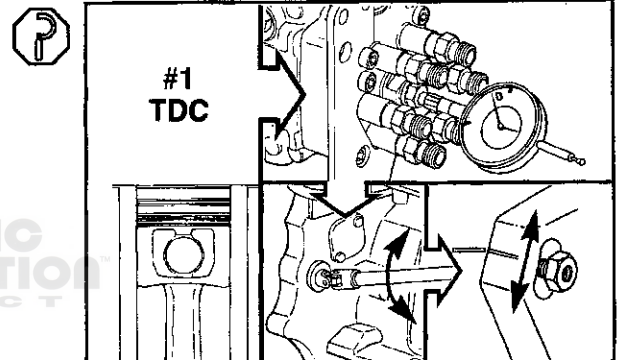
**Caution:** The flange of a replacement pump will not have an alignment mark. After the replacement pump is installed, mark the flange to correspond with the mark on the gear housing.

During production, after the locked pump is fitted to the engine with Cylinder Number 1 at TDC, a mark is stamped on the gear housing and the pump flange. Thereafter, when these marks are aligned, the pump is correctly timed to the engine.

**Note:** The marks on the gear housing and the pump flange are unique to each engine.



A special indicator can be used to measure the position of the pump plunger to check pump timing.

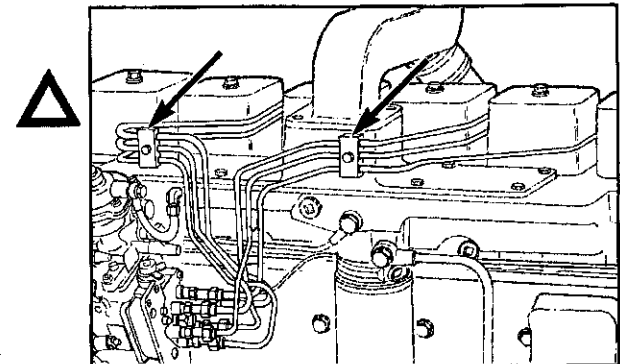


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## High Pressure Fuel Lines

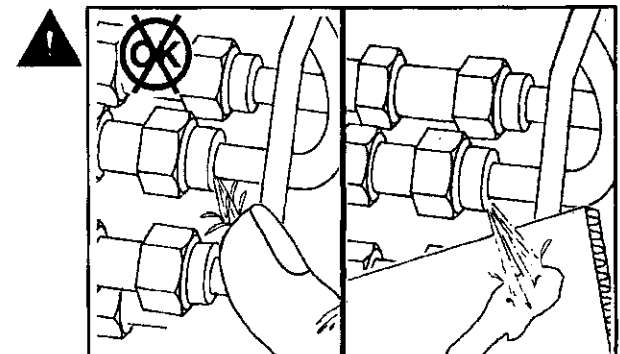
**Caution:** The high pressure lines must be clamped securely and routed so they do not contact each other or any other component. Do not weld or substitute lines. Use only the specified part number for the engine. An attached metal tag is used to identify each line with a part number.

High pressure fuel lines are designed and manufactured to deliver fuel at injection pressure to the injectors. The high pressure pulses will cause the lines to expand and contract during the injection cycle. The length, internal size and rigidity of the lines is critical to smooth engine operation.

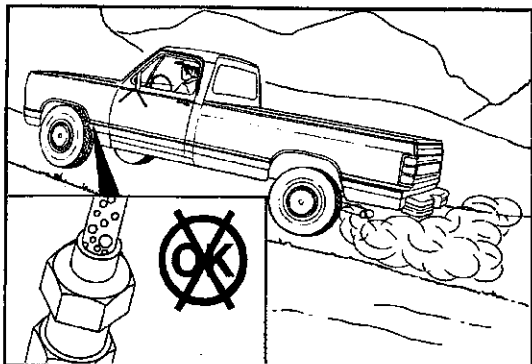


**Warning:** A fuel leak from high pressure fuel line has sufficient pressure to penetrate the skin and cause serious bodily harm.

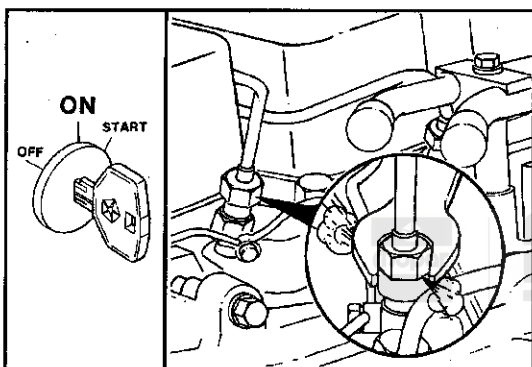
Use a piece of cardboard to check for fuel leaks. With the engine running, move the cardboard over the fuel lines and look for fuel spray on the cardboard. Fuel leaks can cause poor engine performance.





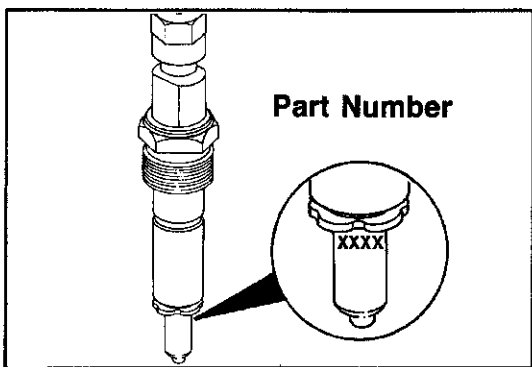


It is normal to have entrapped air in the fuel lines after replacing the pump or the lines. Air in the lines will cause the engine to run rough or produce a fuel knock.



Bleed the air from the high pressure line at the fitting that connects the injector. With the engine running or cranking, bleed one line at a time until the engine runs smooth.

If the air cannot be removed, check the pump and supply line for suction leaks.



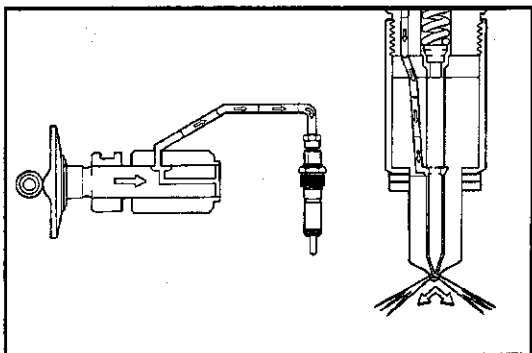
### Injectors



**Caution:** Use only the specified injector for the engine.

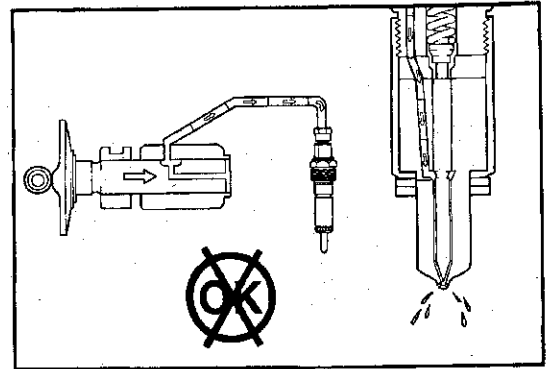
All engines use Robert Bosch, 17mm closed nozzles, hole-type injectors. The injectors however, can have different part numbers for different engine ratings. The last four digits of the Cummins part number are used to identify the injectors.

**Note:** The XXXX shows location only. This number can change. Contact your local Dodge Dealer to verify correct numbers.



During the injection cycle, the injection pressure increases to the "pop" pressure level. The "pop" pressure is the pressure required to lift the injector needle valve off its seat. With the injector needle valve off its seat, fuel is injected into the cylinder. A spring is used to force the needle valve closed as the injection pressure drops below the "pop" pressure. The injector nozzle is sealed after injection.

Failure of the needle valve to lift and close correctly can cause the engine to misfire and produce low power. Fuel leaking from the open nozzle can cause a fuel knock, poor performance, smoke, poor fuel economy, and rough running.



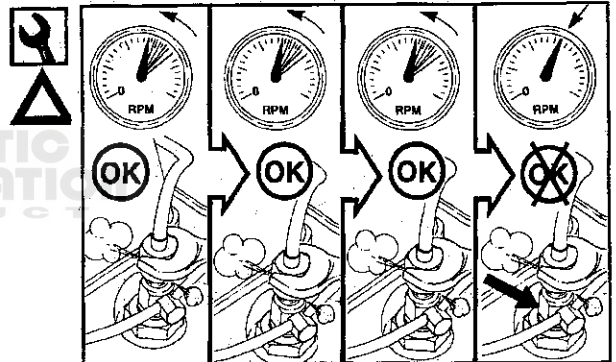
17mm

**Caution:** When bleeding a line, be sure to tighten the fuel line nut before proceeding to the next injector.

To find which cylinder is misfiring, operate the engine and loosen the fuel line nut at one injector and listen for a change in engine speed.

**Note:** A drop in engine speed indicates the injector was delivering fuel to the cylinder.

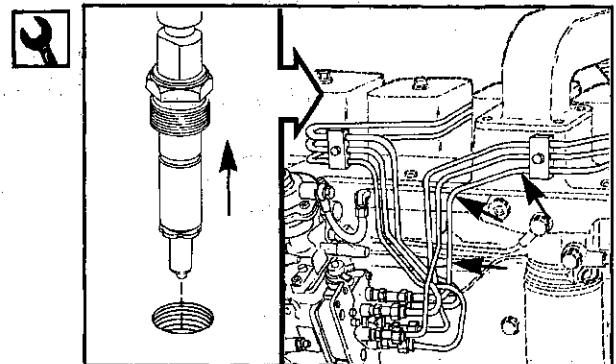
Check each cylinder until the malfunctioning injector is found.



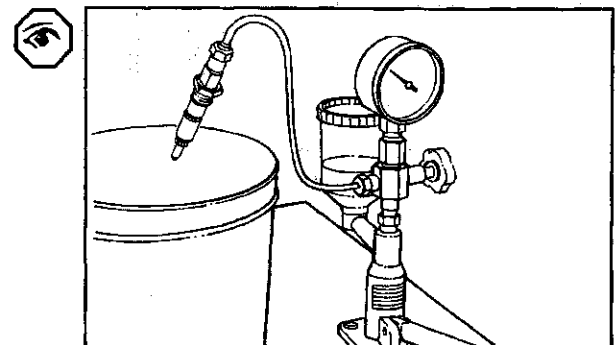
24mm

Remove the malfunctioning injector to test or replace it.

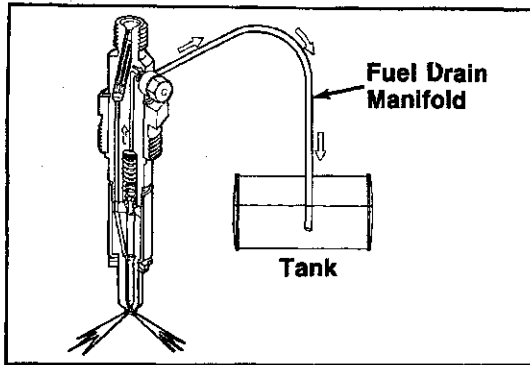
If the engine continues to misfire after replacing the injector, check for leaks in the high pressure line. Also check for a defective delivery valve that lets the fuel drain back into the injection pump.



Carbon build up in the orifices in the nozzle will also cause low power from the engine. Remove and check the spray pattern or replace the injectors.

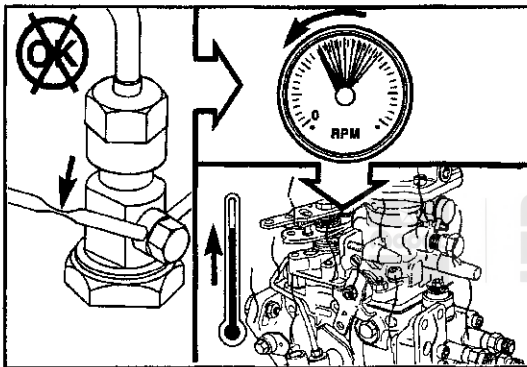






### Fuel Drain Manifold

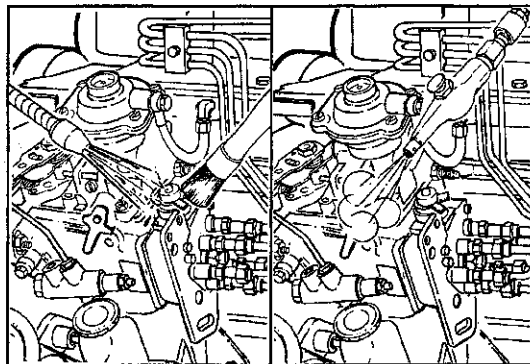
The fuel system is designed to use fuel to cool and lubricate the injection pump and injectors. Fuel is continually vented from the injection pump and a small amount of fuel leaks by the injector needle valve during injection. This fuel is returned to the supply tank by the fuel drain manifold.



Restricting the fuel drain manifold raises the case pressure of the injection pump which can prevent injection.

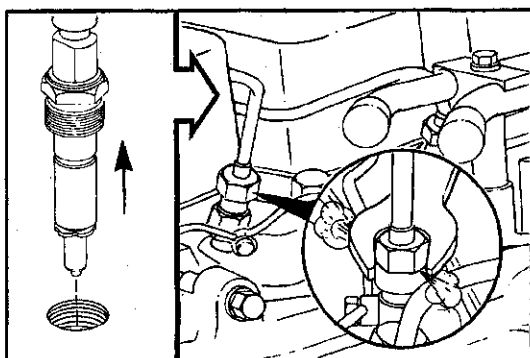
If the engine will restart after a waiting period following an unexplained shut down, look for a restriction of the manifold drain line.

**Note:** Restriction can cause the fuel temperature to rise reducing power from the engine.



### Cleanliness is Important

During any fuel system repair, cleanliness is of utmost importance. Thoroughly clean all affected parts with solvent and then blow dry with compressed air.

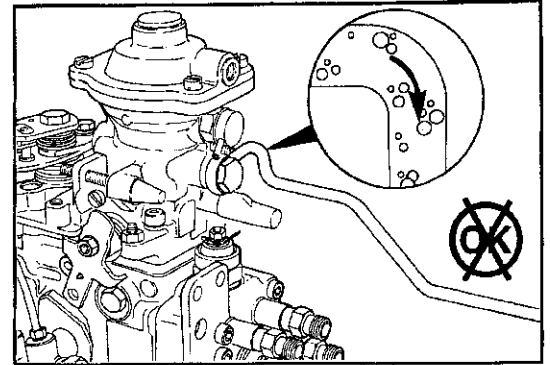


### Fuel System Replacement Procedures

A certain amount of air will be entrapped in the system during replacement of any of the system components. After replacement of a component, bleed the system according to the following procedure.

## Fuel System – Bleeding

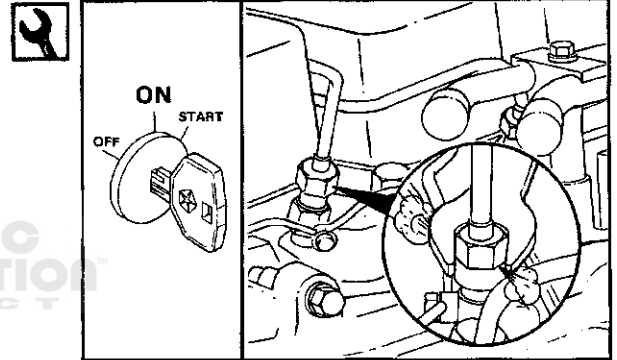
Controlled venting is provided at the injection pump through the fuel drain manifold. Small amounts of air introduced by changing the filters or injection pump supply line will be vented automatically, if the fuel filter is changed in accordance with the instructions.



17mm

However, manual bleeding will be required if:

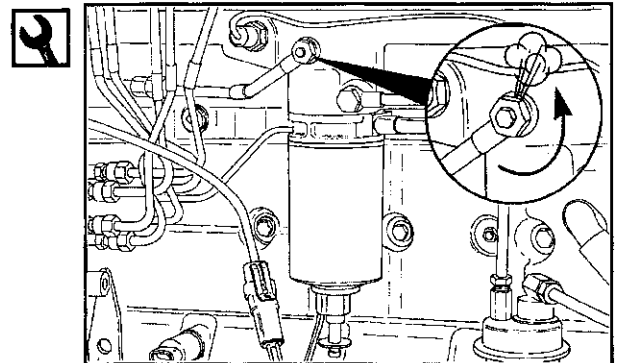
- The fuel filter is not filled prior to installation.
- Injection pump is replaced.
- High pressure fuel line connections are loosened or lines replaced.
- Initial engine start up or start up after an extended period of no engine operation.



10mm

### Low Pressure Lines and Fuel Filter – Venting

Open the bleed screw.



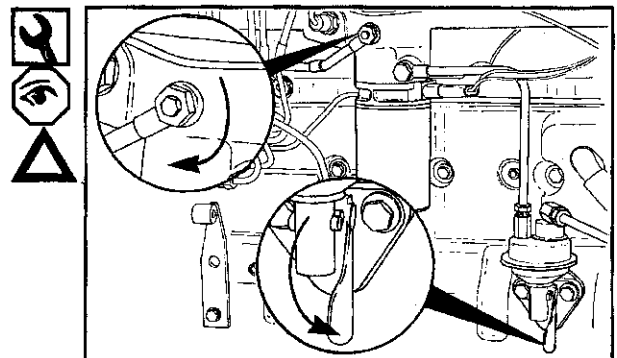
10mm

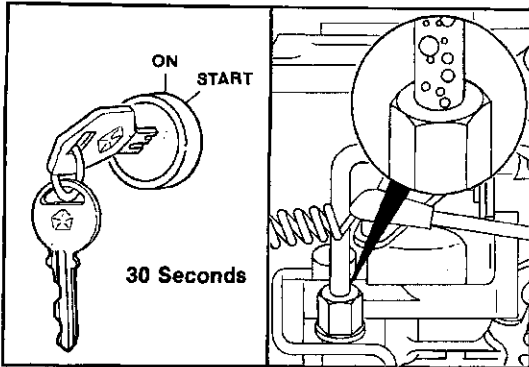
Operate the hand lever until the fuel flowing from the bleed screw fitting is free of air. Tighten the bleed screw.

**Torque Value:** 8 N·m [6 ft-lbs]

**Note:** If the lever feels as though it is not pumping, rotate engine approximately 90 degrees and proceed.

**Caution:** The hand priming lever must be returned to the lock position after priming. The lever will be in the up position when locked.



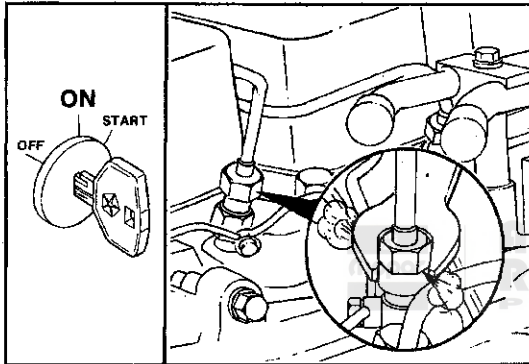


### Injection Pumps - Venting

**Warning:** It is necessary to put the engine in the "run" position: Because the engine may start, be sure to follow all safety precautions. Use the normal engine starting procedure.

**Caution:** When using the starting motor to vent the system, do not engage it for more than 30 seconds at a time: Wait two (2) minutes between engagements.

Air can also be vented through the fuel drain manifold line by operating the starting motor.

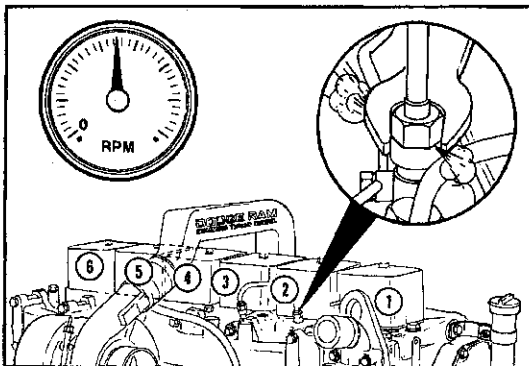


**17mm**

### High Pressure Lines - Venting

**Warning:** A fuel leak from high pressure fuel line has sufficient pressure to penetrate the skin and cause serious bodily harm.

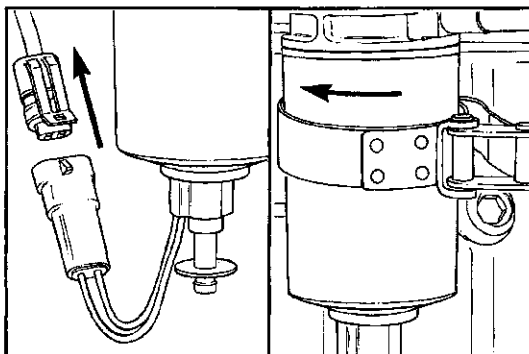
Loosen the fittings at the injector, and crank the engine to allow entrapped air to bleed from the line. Tighten the fittings.



**17mm**

**Warning:** Do not bleed a hot engine as this could cause fuel to spill onto a hot exhaust manifold creating a danger of fire.

Start the engine and vent one line at a time until the engine runs smoothly.



### Fuel Filter - Replacement

**Standard Filter Wrench**

Disconnect the (WIF) electrical connection.

Remove the fuel filter assembly with a standard filter wrench.

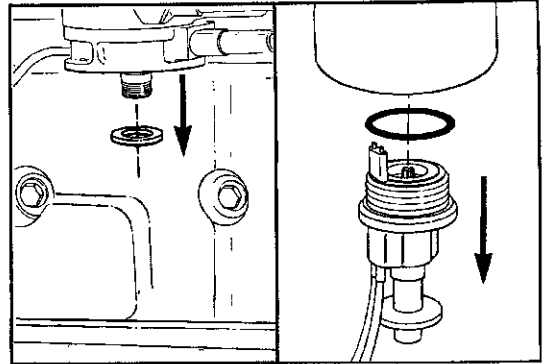
**Note:** The fuel heater assembly should not move during the filter removal.

Remove the square cut o-ring from the filter mounting bushing.



Drain fuel/water separator filter and remove WIF and fuel/water drain valve. Remove the o-ring from the sensor.

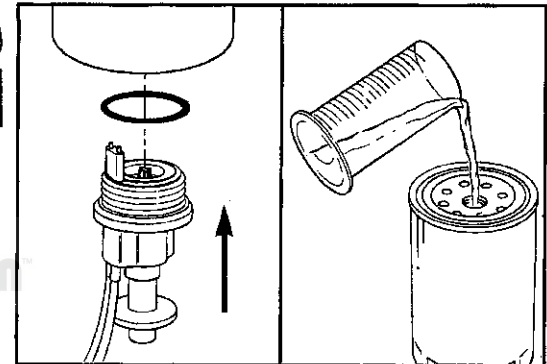
**Note:** This assembly is threaded into the filter element and it is sealed with an o-ring.



Install a new o-ring on the WIF sensor.

Reinstall the WIF sensor into a new fuel filter element.

Fill the new fuel water separator/filter with clean fuel.



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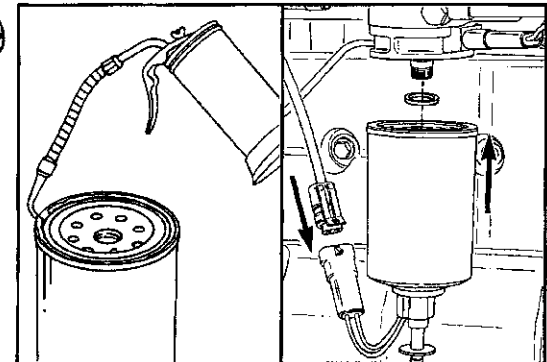
Apply a light film of lubricating oil to the sealing surface before installing the filter.



Install a new square cut o-ring on filter mounting bushing.

Install the fuel water separator/filter and tighten it 1/2 turn after its seal contacts the filter head.

Reconnect WIF electrical connection.



## Low Pressure Fuel Line - Replacement

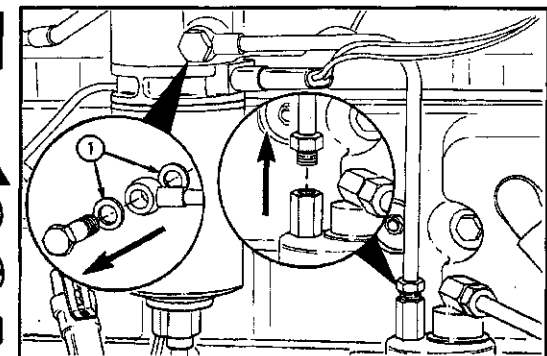
14mm and 17mm

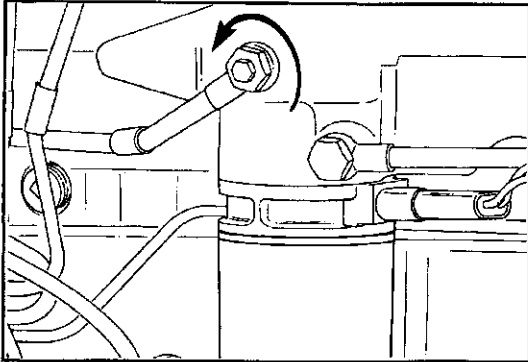
Remove the line from the lift pump and filter head.

**Caution:** When replacing fuel lines, replace banjo fitting sealing washers (1) each time they are removed.

Install the line and tighten the fittings securely.

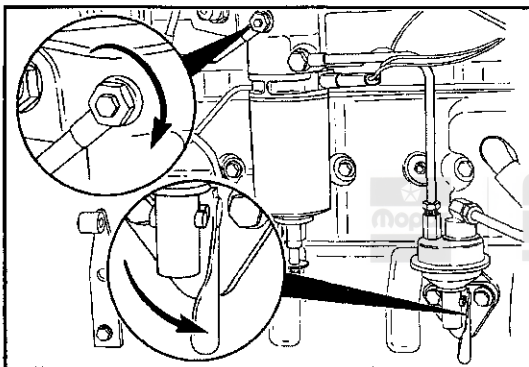
**Banjo fitting Torque Value:** 24 N·m [18 ft·lbs]





10mm

Bleed the line by opening the banjo bleed screw.



10mm

Bleed the air from the system.

Operate the hand lever until the fuel flowing from the fitting is free of air. Tighten the bleed screw.

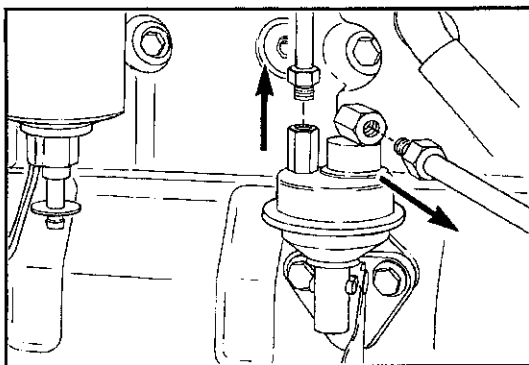


Torque Value: 8 N·m [6 ft-lbs].



Note: If the lever feels as though it is not pumping, rotate the engine approximately 90 degrees and proceed.

Caution: The hand priming lever must be returned to the lock position after priming. The lever will be in the up position when locked.

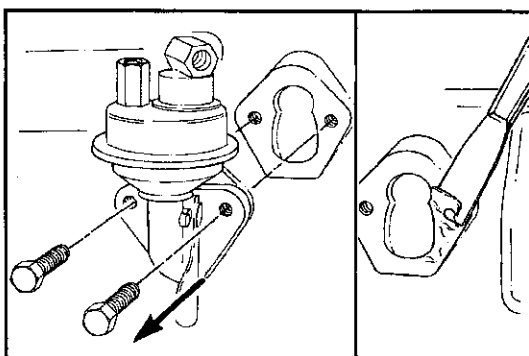


14mm and 17mm

Lift Pump - Replacement



Disconnect the low pressure fuel lines.



10mm

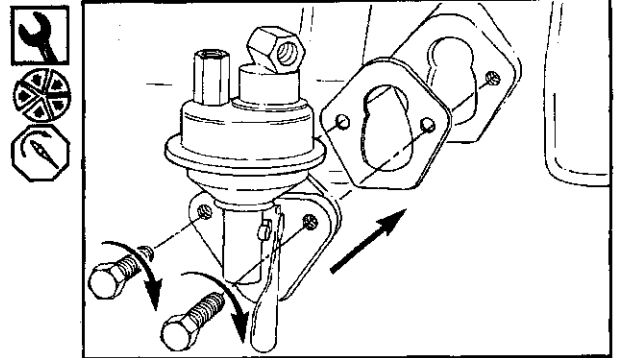


Remove the two capscrews and lift pump from the cylinder block. Clean the mounting surface to remove any gasket.

10mm

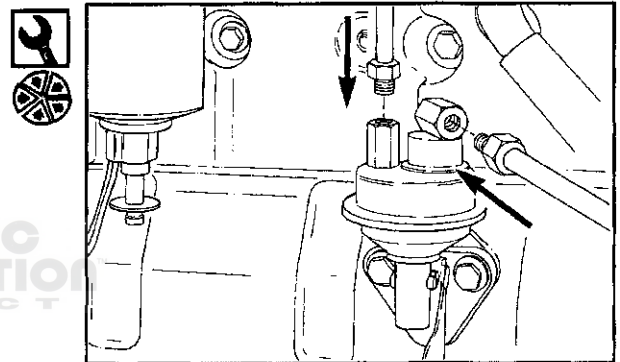
Install the lift pump with a new gasket and tighten the capscrews.

Torque Value: 24 N·m [18 ft-lbs].



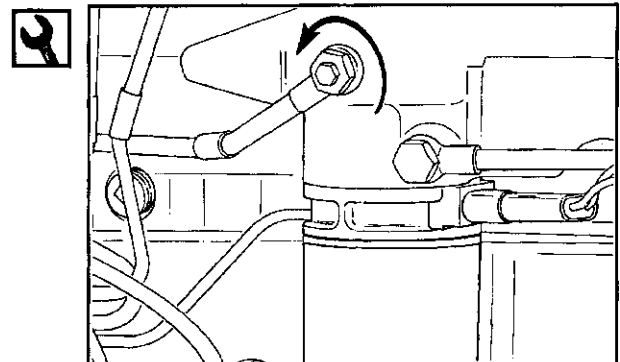
14mm and 17mm

Install the low pressure fuel lines.



10mm

Open the banjo fitting bleed screw.



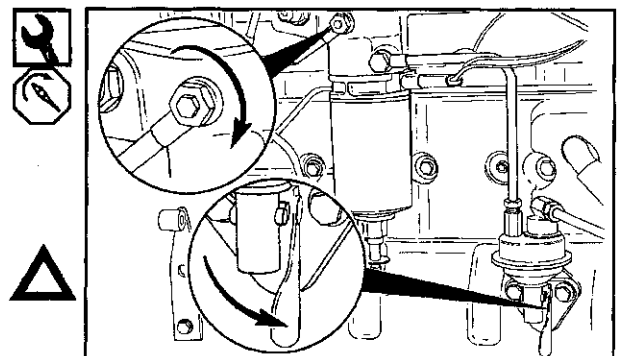
10mm

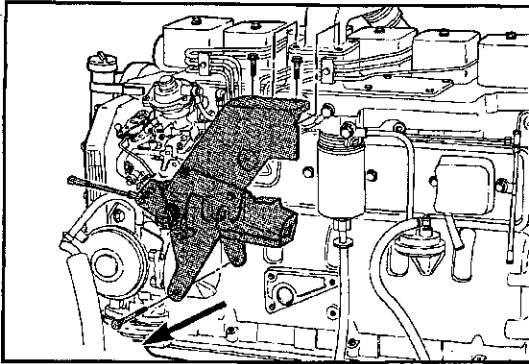
Operate the hand lever until the fuel flowing from the fitting is free of air. Tighten the bleed screw.

Torque Value to 8 N·m [6 ft-lbs].

Note: If the lever feels as though it is not pumping, rotate the engine approximately 90 degrees and proceed.

Caution: The hand priming lever must be returned to the lock position after priming. The lever will be in the up position when locked.

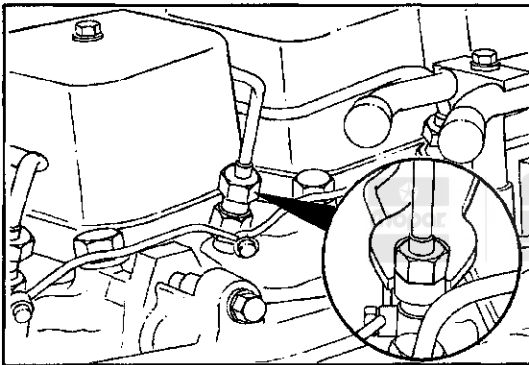




### High Pressure Lines - Replacement

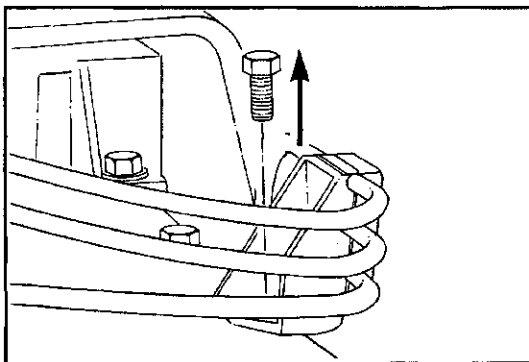
10mm

Remove the throttle linkage and bracket from the engine.



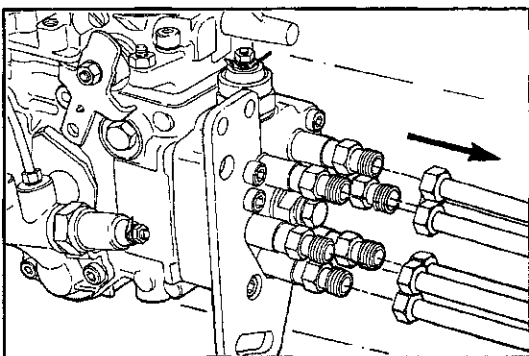
17mm

Disconnect the high pressure lines from the injectors.



13mm

Remove the line clamp capscrows from the intake cover.



14mm, 17mm

Remove the lines from the injection pump.

**Note:** Use two wrenches to prevent the delivery valve holder from turning.

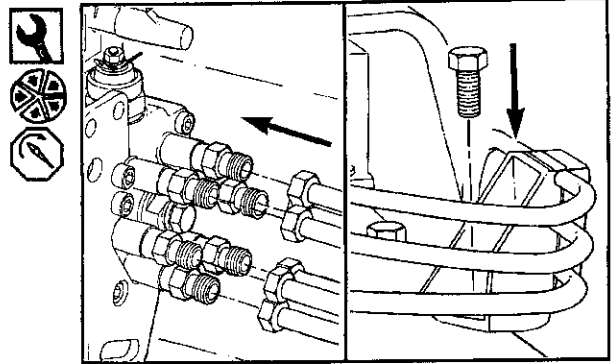


13mm, 14mm, 17mm

Assemble the lines in the reverse order of removal.

Tighten the high pressure lines. Tighten the high pressure line clamp capscrews.

Torque Value: 24 N·m [18 ft-lbs]

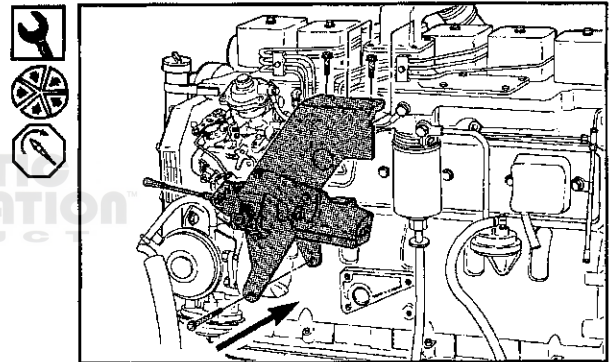


10mm

Re-assemble the throttle bracket and linkage.

Tighten the bracket capscrews.

Torque Value: 24 N·m [18 ft-lbs]

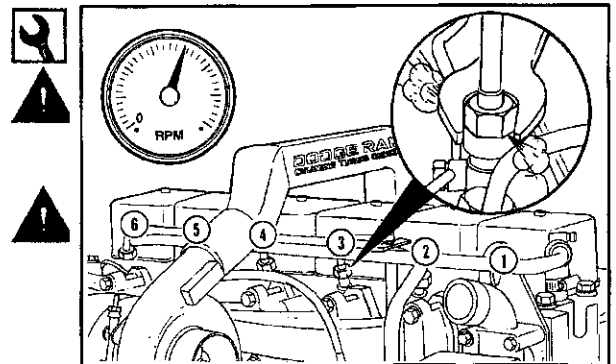


17mm

**Warning:** A fuel leak from high pressure fuel line has sufficient pressure to penetrate the skin and cause serious bodily harm.

**Warning:** Do not bleed a hot engine as this could cause fuel to spill onto a hot exhaust manifold creating a danger of fire.

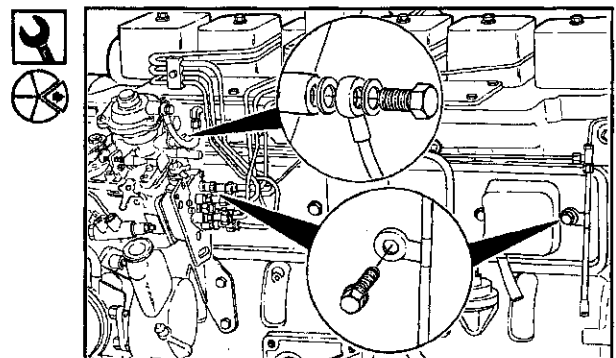
Start the engine and vent one line at a time until the engine runs smoothly.



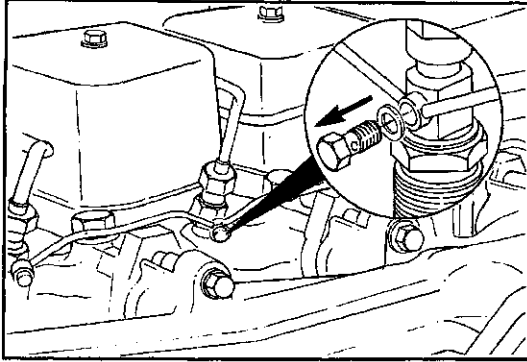
### Fuel Drain Manifold - Replacement

10mm, 17mm

Remove the capscrews from the hold-down clamps. Remove the fuel pump vent capscrew.



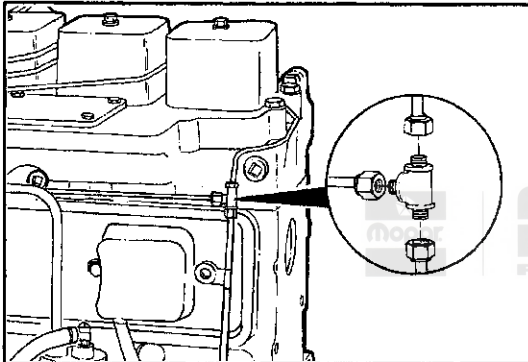




10mm



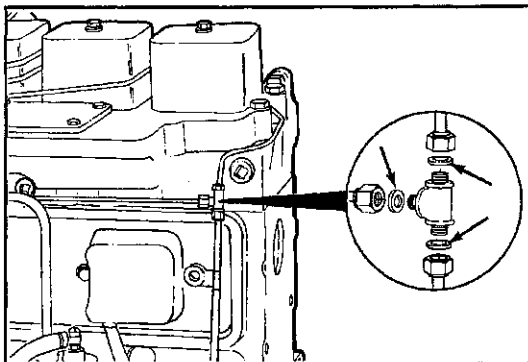
Remove the banjo fitting screws and washers.



13mm

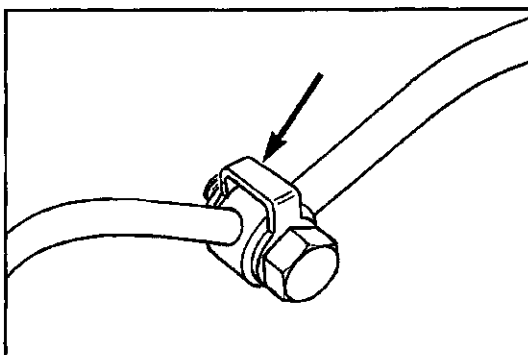


Disconnect the drain line fittings.



Assemble the drain line and fuel drain manifold in the reverse order of disassembly.

**Note:** Use new seals on all fittings.



10mm



Tighten the banjo fitting screw.

**Torque Value:** 8 N-m [6 ft-lbs]

**Note:** Use new sealing washers for the fuel drain manifold.

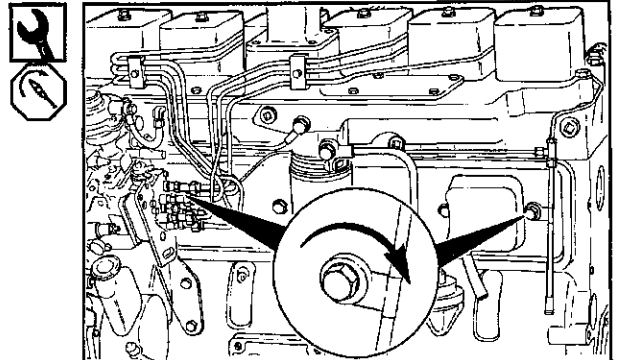
13mm, 17mm

Tighten the clamp capscrews.

**Torque Value:** 24 N·m [18 ft-lbs]

Tighten the fuel pump vent capscrew.

**Torque Value:** 32 N·m [24 ft-lbs]



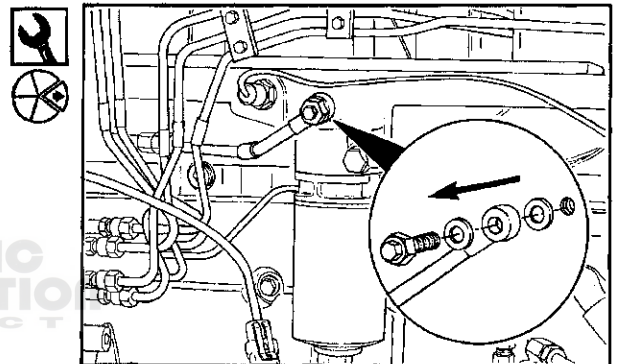
### Injection Pump Supply Line - Replacement

17mm

Remove the bleed screw banjo fitting and complete the following steps.



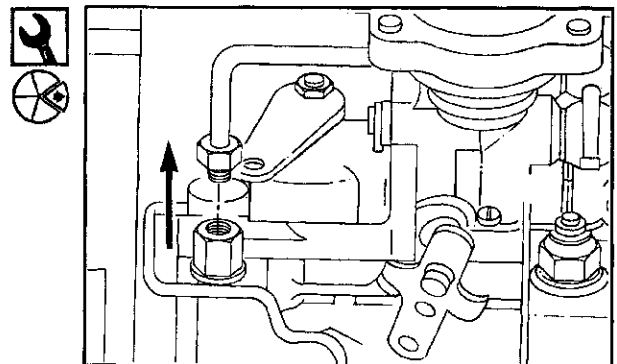
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14mm, 17mm

Remove the line from the Bosch pump fitting.

**Note:** To prevent loosening the pump inlet fitting, use two wrenches when removing the supply line.



14mm, 17mm

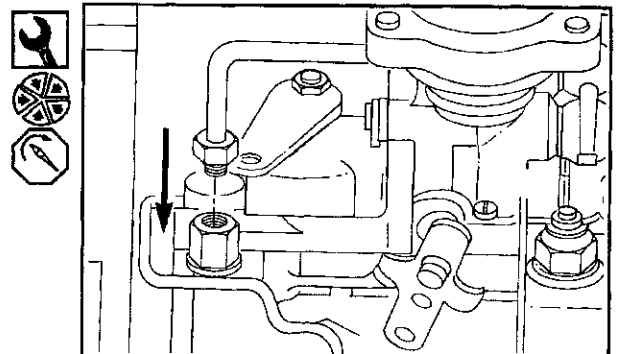
Install the supply line in the reverse order of removal. Tighten line securely to pump fittings.

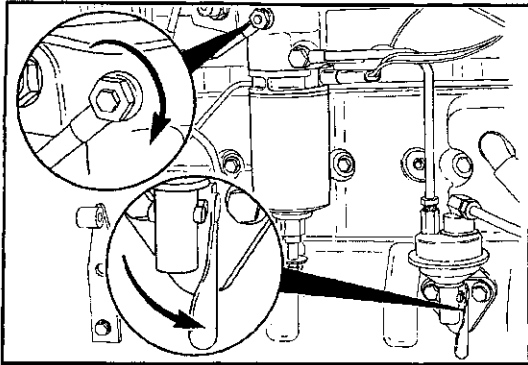
**Note:** Use the new sealing washers when installing banjo fitting.

**Torque Value:** 24 N·m [18 ft-lbs]

Tighten the banjo fitting screw.

**Torque Value:** 24 N·m [18 ft-lbs]





10mm

Bleed the line. Open the banjo fitting bleed screw and operate the hand lever until the fuel flowing from the fitting is free of air.

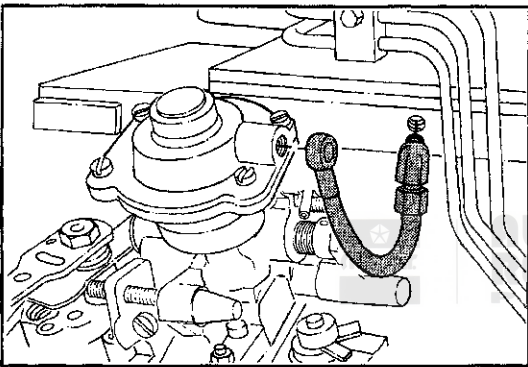
Tighten the bleed screw.

**Torque Value:** 8 N·m [6 ft-lbs]

**Note:** If the lever feels as though it is not pumping, rotate engine approximately 90 degrees and proceed.



**Caution:** The hand priming lever must be returned to the lock position after priming. The lever will be in the up position when locked.



### Air Fuel Control Tube - Replacement

12mm, 1/2 inch

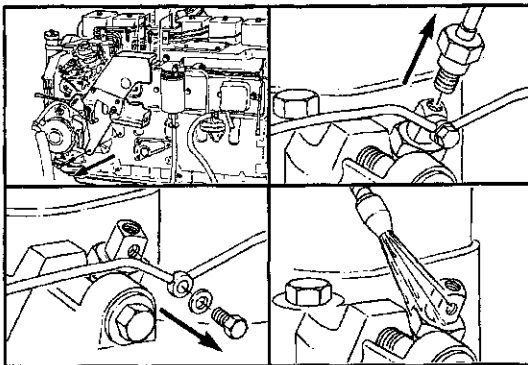
Remove the tube from the manifold fitting and from the pump.

**Note:** Use new sealing washers when installing the tube.

**Torque Values:**

Air Fuel Control Banjo Screw: 12 N·m [9 ft-lbs]

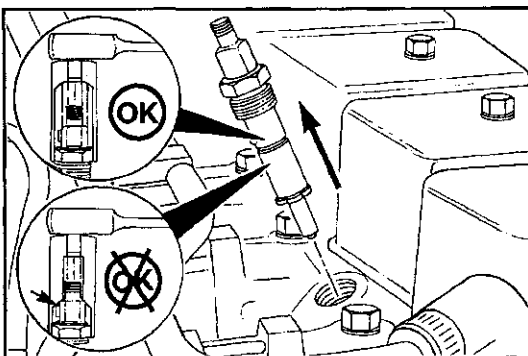
Air Fuel Control Fitting: 8 N·m [6 ft-lbs]



### Injector - Replacement

Preparatory Steps:

- Remove the throttle linkage and bracket.
- Disconnect the high pressure fuel supply lines
- Disconnect the fuel drain manifold
- Clean around the injectors

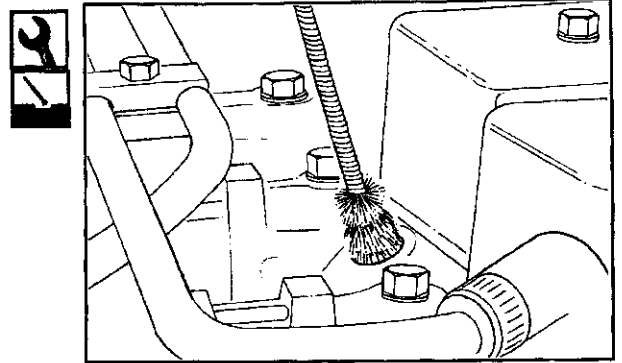


24mm Deep Well Socket

Remove the injector from the cylinder head.

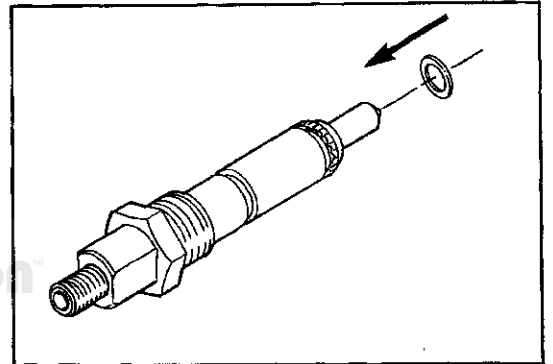
### Injector Bore Brush

Clean the injector nozzle bore with a bore brush.

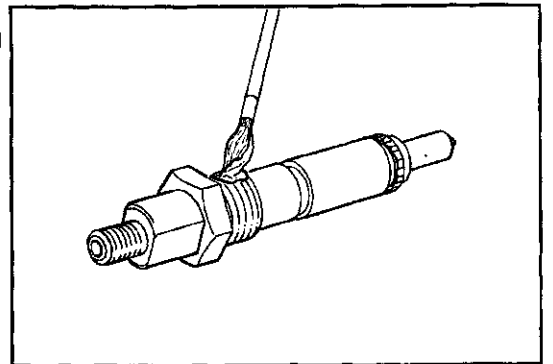


Assemble the injector and new copper sealing washer.

**Note:** Use Only One Copper Washer.



Apply a coat of anti-seize compound to the threads of the injector hold-down nut and between the top of the nut and injector body.



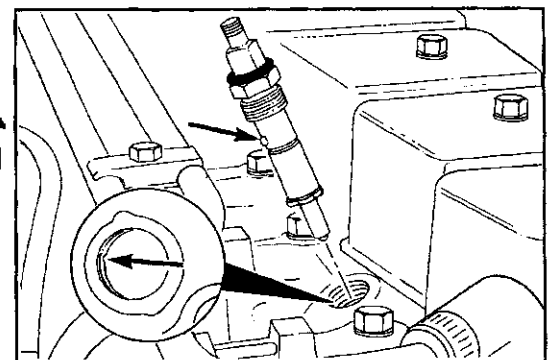
### 24mm Deep Well Socket

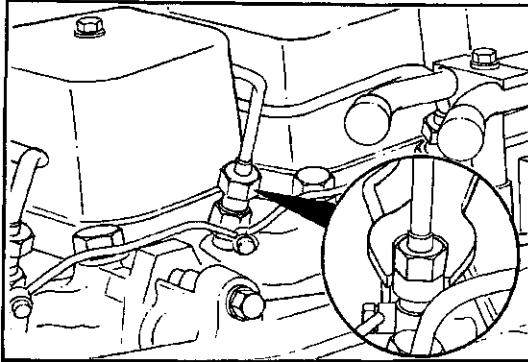
**Caution:** Align the injector's protrusion with the notch in the bore.

Tighten the injector retainer nut.

**Torque Value:** 60 N·m [44 ft-lbs]

**Note:** After tightening the injector be sure to push the o-ring into the groove.





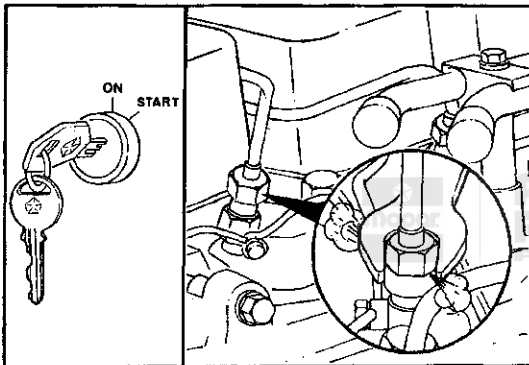
10mm

Assemble the fuel drain manifold and high pressure lines. Leave the high pressure fittings loose at the injectors.

**Note:** Use new sealing washers when installing fuel drain manifold.

Tighten the banjo fitting screw:

**Torque Value:** 8 N·m [6 ft-lbs]



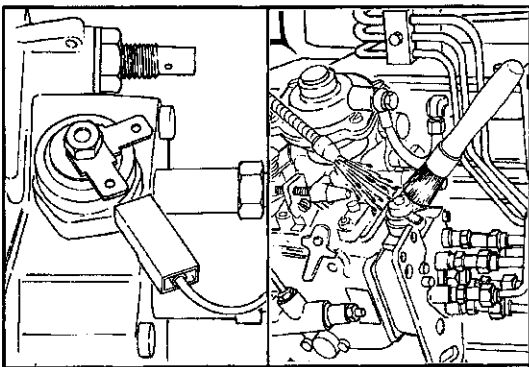
17mm

**Warning:** It is necessary to put the ignition switch in the "start" position to bleed the lines. Because the engine may start, be sure to follow all the safety precautions. Use the normal engine starting procedure.

Crank the engine to allow entrapped air to bleed from the lines. Tighten the fittings.

Tighten the high pressure fuel lines.

**Torque Value:** 24 N·m [18 ft-lbs]

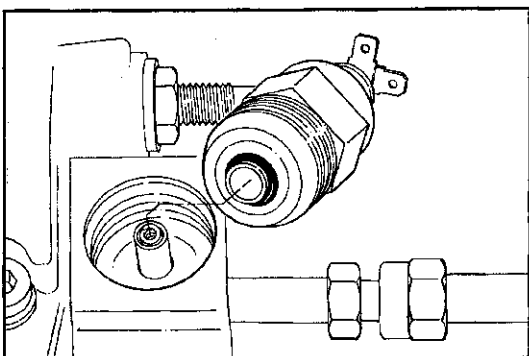


**Electric Fuel Shut Off Valve – Replacement**

8mm

Remove the electrical wire.

Clean the area around the valve.



24mm

Remove the valve.

**Caution:** When removing the valve, be careful not to drop the plunger and spring from inside the valve body.

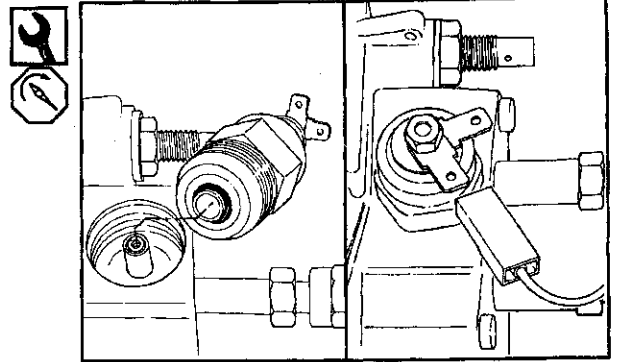
24mm

Replace the solenoid, o-ring, spring and plunger.

Tighten the solenoid.

**Torque Value:** 43 N·m [32 ft-lbs]

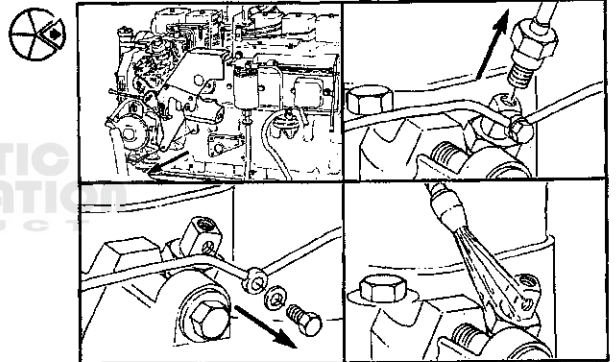
Connect the electric wire.



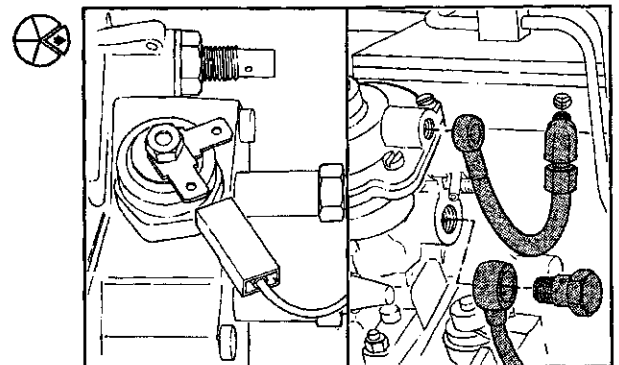
### Injection Pump - Replacement

Preparatory Steps:

- Remove the throttle linkage and bracket.
- Disconnect the fuel drain manifold.
- Remove the injection pump supply line.
- Remove the high pressure lines.

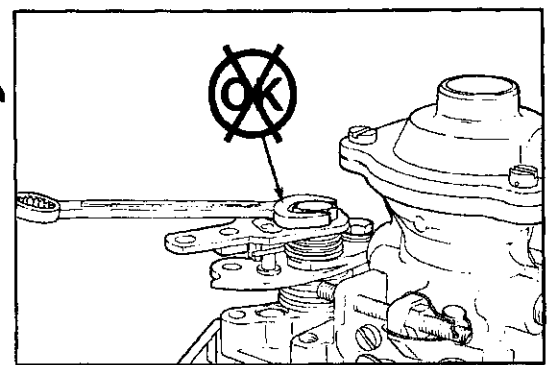


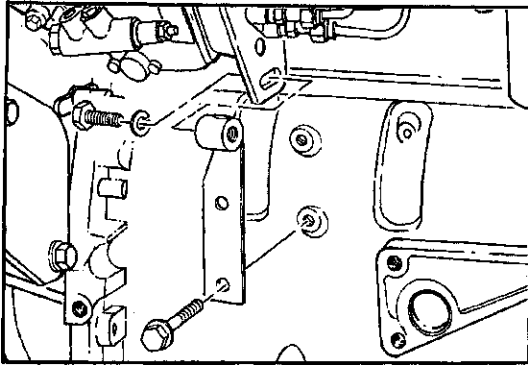
- Disconnect the electrical wire to the fuel shut off valve.
- Remove the fuel air control tube.
- Remove the fuel pump vent line and capscrew.



### Removing the Pump

**Caution:** Do not remove the control lever. The Bosch VE lever is indexed to the shaft during pump calibration.

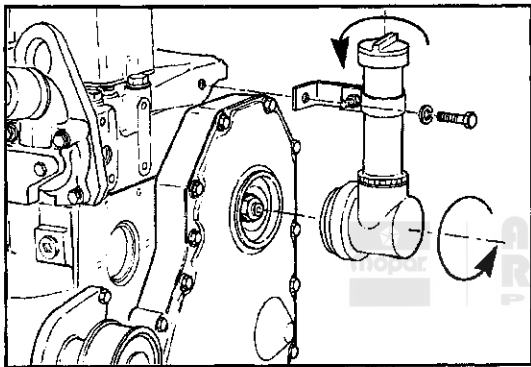




10mm, 13mm



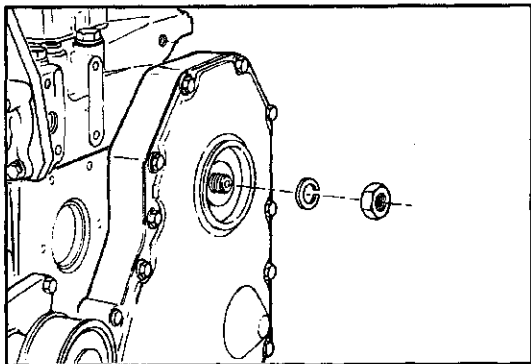
Remove the pump support bracket.



17mm



Remove the oil fill tube bracket capscrew. Remove the fill tube and adapter from the front gear cover.



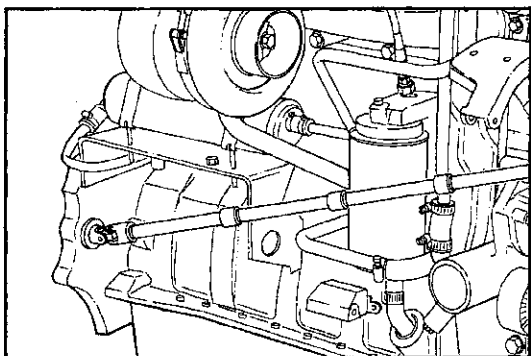
22mm



**Caution: Be careful when removing the gear retainer nut and washer. If the nut or washer drop into the front gear housing, the front gear cover must be removed to retrieve them.**



Place a shop towel in the gear cover opening between the gear and cover. This will prevent the nut or washer from falling into the gear housing. Remove the gear retaining nut and washer.



**Barring the engine**

**Barring Tool**

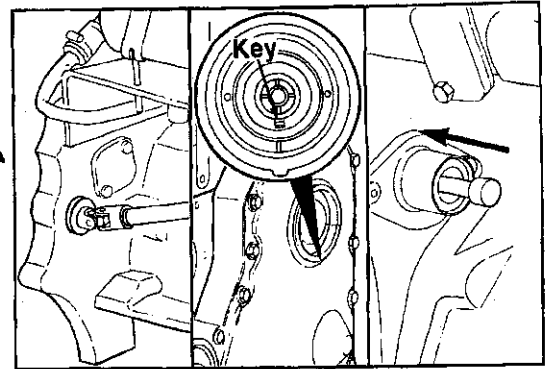
The barring tool is inserted into the flywheel housing opening on the exhaust side of the engine. Place a 1/2 drive universal joint in the barring tool. Put enough 1/2 inch drive extensions together to equal at least 36 inches. Place the extension under the turbocharger to the barring tool as shown. Use a ratchet to turn the barring tool.



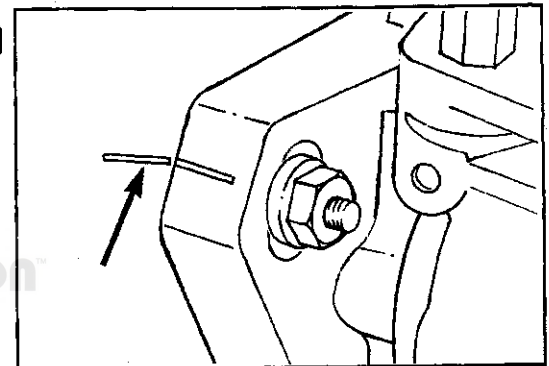
Bar the engine until the key way on the fuel pump shaft is in the approximate position shown.

**Caution:** Be sure to disengage the pin after locating TDC.

Locate TDC for Cylinder Number 1 by barring engine slowly while pushing in on TDC pin. Stop barring the engine as soon as pin engages with the gear timing hole.



**Note:** Check the timing marks on the flange of the injection pump. Each pump and engine have unique marks. It is not possible to exchange pumps and use the same marks for alignment.



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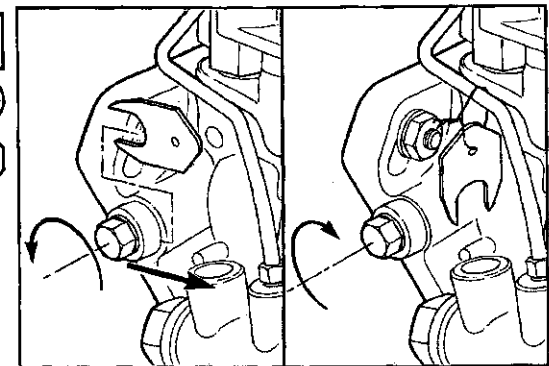
### 10mm Hex

Loosen the lock screw and remove the special washer from injection pump. Tighten the lock screw against the drive shaft.

Tighten the lock screw.

**Torque Value:** 30 N·m [22 ft-lbs]

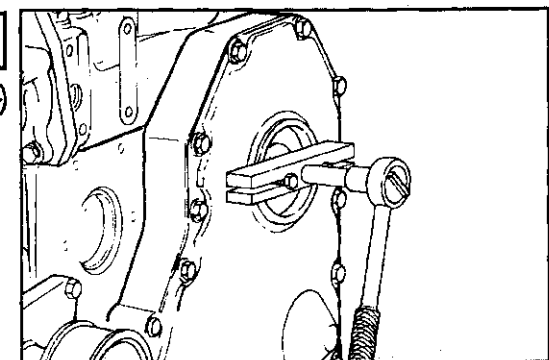
**Note:** Wire the special washer to the pump so it can be re-installed later.



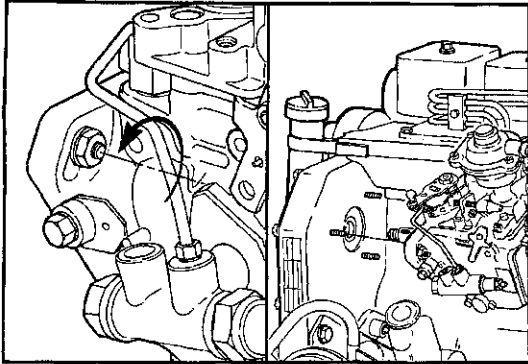
### 75mm T-Bar

Pull the pump drive gear from the drive shaft.


**Note:** Puller cap screw size is M8-1.25.




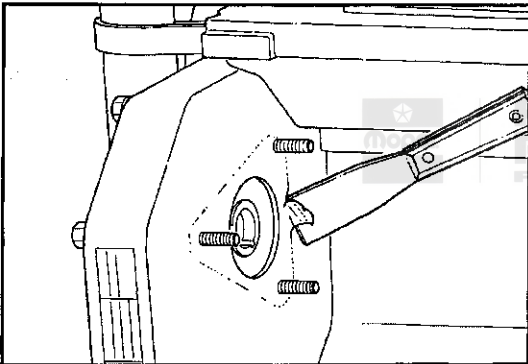




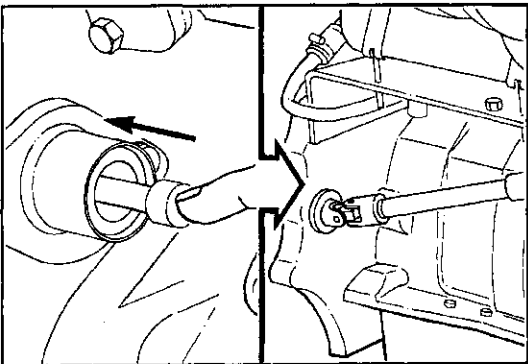
 13mm

 **Caution: Do not drop the drive gear key into the front cover when removing the pump.**

 Remove the 3 mounting nuts and the injection pump.

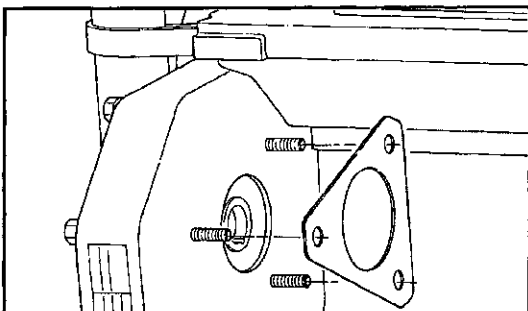



 Remove the gasket and clean the pump mounting surface.



**Installing the Pump**

Verify Cylinder Number 1 Is at TDC by barring engine slowly while pushing in on TDC pin.

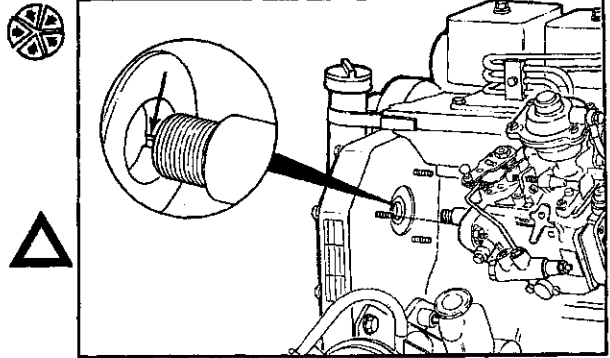


 Install a new gasket.

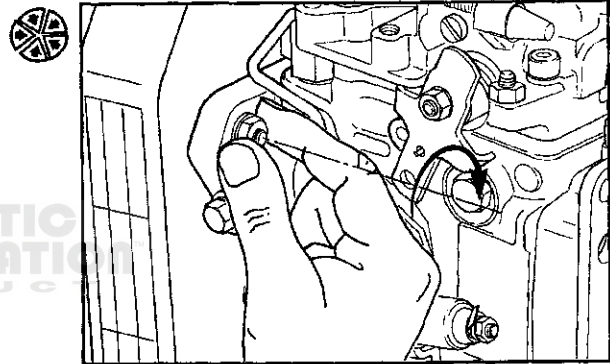
**Note:** The shaft of a new or reconditioned pump is locked so the key aligns with the drive gear keyway when Cylinder Number 1 is at TDC on the compression stroke.

Install the pump. Make sure the key does not fall into the gear housing.

**Caution:** If the alignment key drops into the gear train it must be removed.



Finger tighten the three mounting nuts. The pump must be free to move in the slots.



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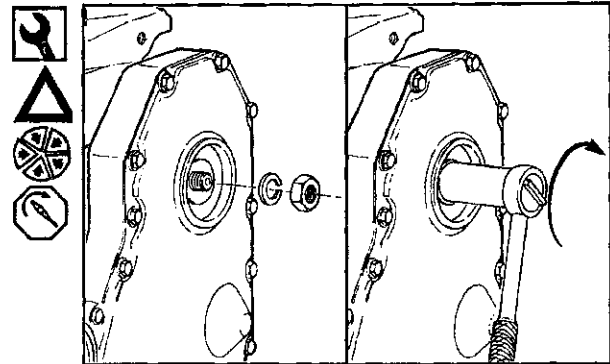
22mm

**Caution:** Do not overtighten. This is not the final torque.

Install the pump drive shaft nut and spring washer. The pump will rotate slightly because of gear helix and clearance. This is acceptable providing the pump is free to move on the flange slots and the crankshaft does not move.

Tighten the drive shaft nut.

**Torque Value:** 15 to 20 N-m [11 to 15 ft-lbs]

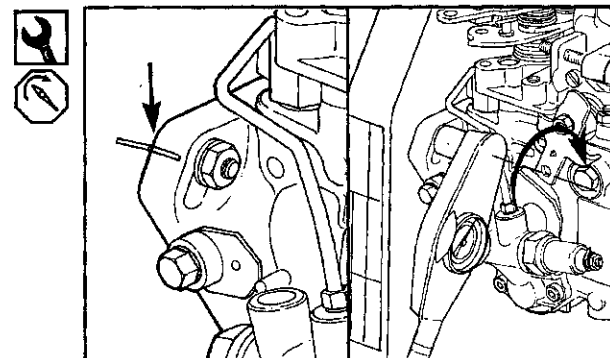


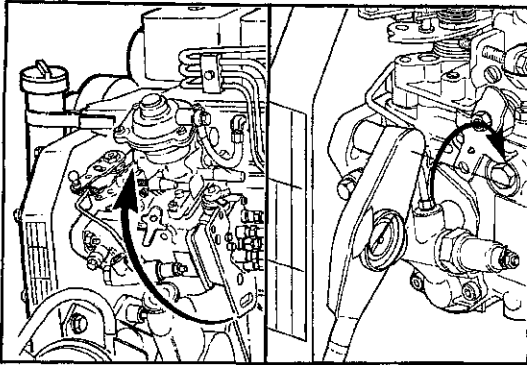
13mm

If installing the original pump, rotate the pump to align the timing marks.

Tighten the flange mounting nuts.

**Torque Value:** 24 N-m [18 ft-lbs]

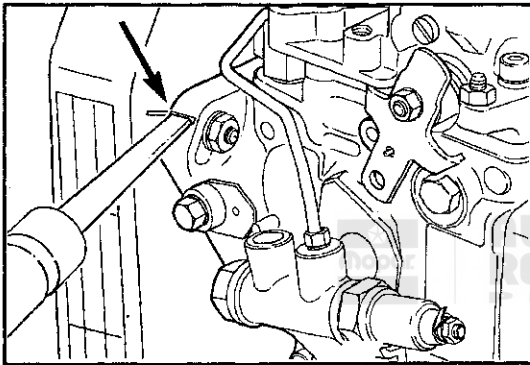




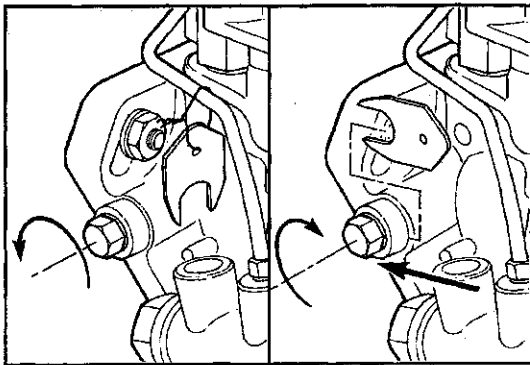
If installing a new or rebuilt pump without a timing mark, take up gear lash by rotating the pump counter clockwise (toward cylinder head).

Tighten the flange mounting nuts.

**Torque Value: 24 N·m [18 ft-lbs]**



Permanently mark the new injection pump flange to match the mark on the gear housing.

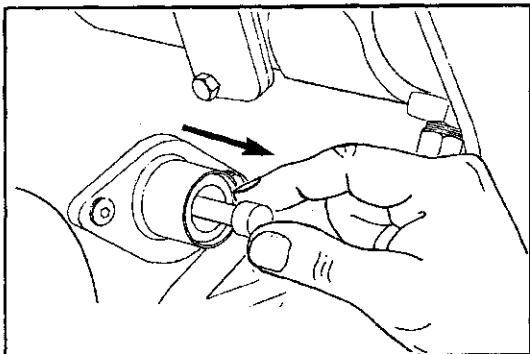


**10mm Hex**

Loosen the lock screw and install the special washer (the washer will be wired to the pump) under the lock screw.

Tighten the lock screw.

**Torque Value: 13 N·m [10 ft-lbs]**



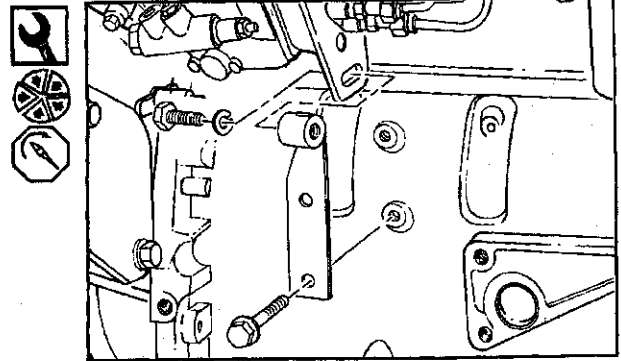
**Caution: Disengage the timing pin, before rotating the crankshaft.**

10mm, 13mm

Install the injection pump support bracket. Finger tighten the capscrews only. Use the following sequence to torque the capscrews.

1. Tighten the bracket to block mounting capscrews.
2. Tightening the bracket to injection pump capscrews.
3. Tighten the throttle support bracket capscrews.

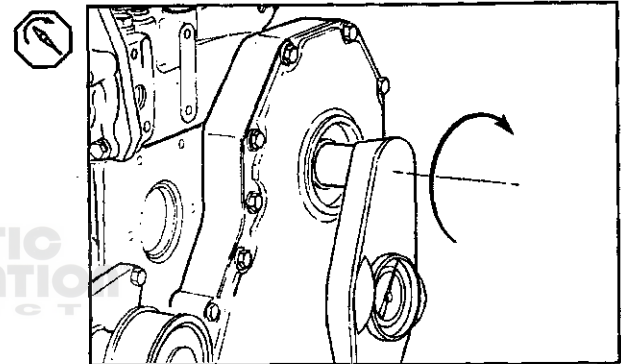
**Torque Value:** 24 N·m [18 ft-lbs]



22mm

Tighten the pump retaining nut.

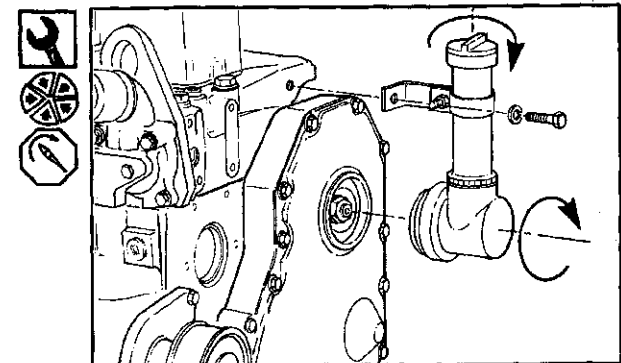
**Torque Value:** 65 N·m [48 ft-lbs].



17mm

Install the oil filler tube assembly and clamp.

**Torque Value:** 43 N·m [32 ft-lbs]

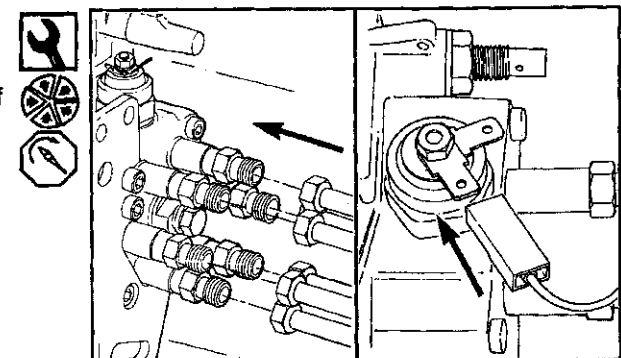


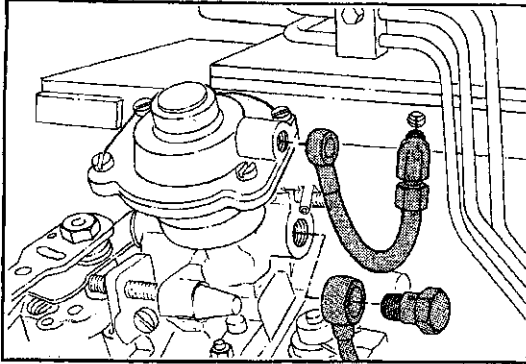
14mm, 17mm

Install all fuel lines and the electrical wire to the fuel shut off valve.

Tighten the high pressure fuel lines.

**Torque Value:** 24 N·m [18 ft-lbs]





12mm, 1/2 inch, 17mm

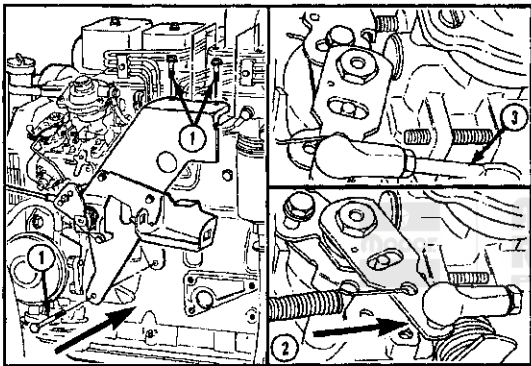
Install the fuel pump vent line and capscrew.

**Torque Value** 32 N·m [24 ft-lbs]

Install the air fuel control tube.

Tighten the banjo fitting.

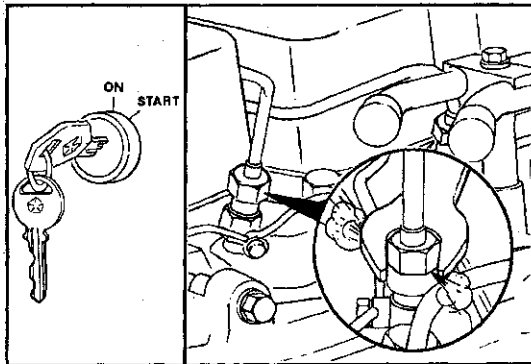
**Torque Value** 12 N·m [9 ft-lbs]



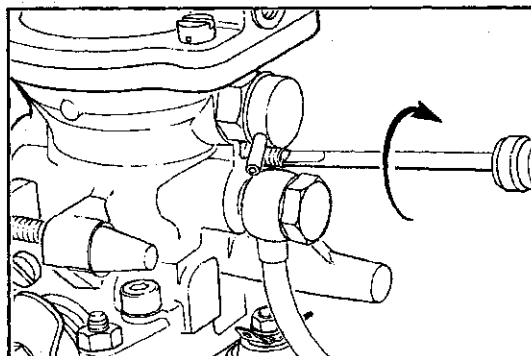
10mm

Install the throttle bracket and linkage. When connecting the cable to the control lever, adjust the length so the lever has stop-to-stop movement.

1. **Torque Value:** 24 N·m [18 ft-lbs]
2. **Torque Value:** 10 N·m [7.5 ft-lbs]
3. Stop to Stop Adjustment



Bleed all air from the fuel system.



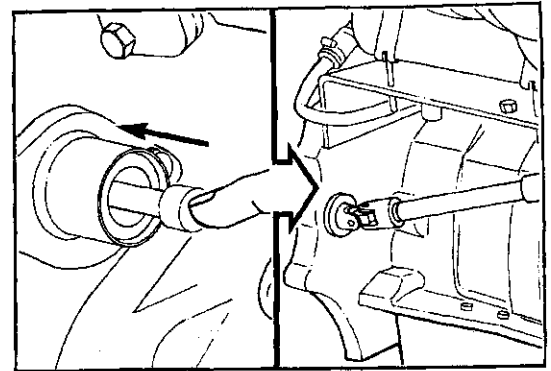
**Screw Driver, 10mm Wrench**

If necessary, adjust the idle speed.

## Bosch VE Pump Timing Check

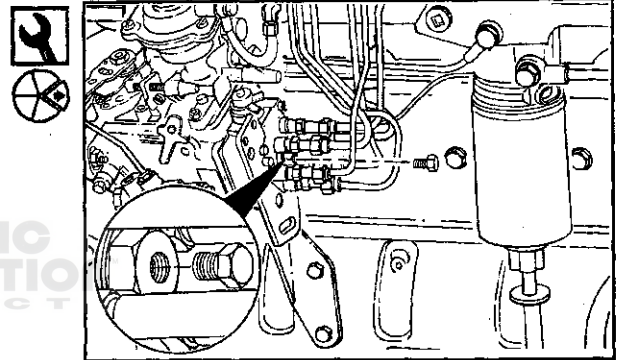
Rotate the engine to TDC.

**Note:** Locate TDC with the timing pin. After TDC is located pull the timing pin out of engagement to the normal Run position.



12mm

Remove the plug from the end of the pump.



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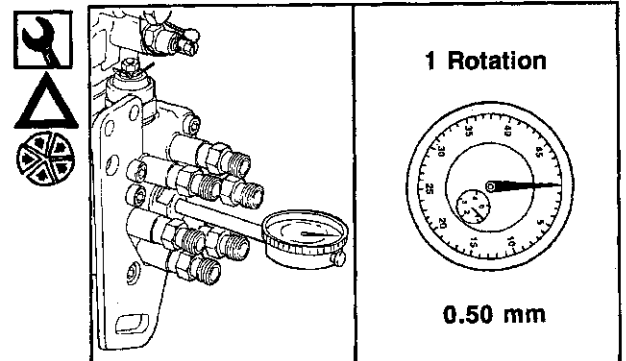
### Timing Indicator

**Caution:** Do not bend the fuel lines.

Install the timing indicator. Be sure to allow adequate travel for the indicator.

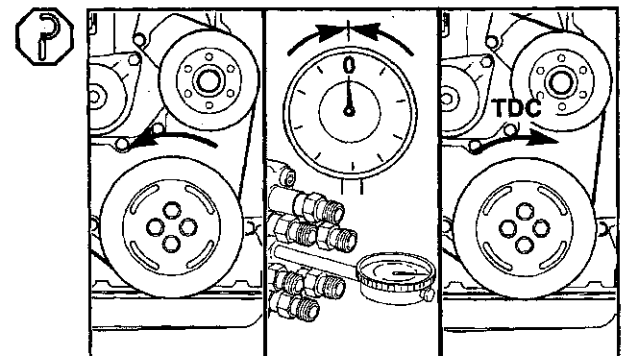
In order to install the timing indicator, it may be necessary to disconnect one or more of the fuel lines from the fuel pump.

**Note:** This indicator is marked in increments of 0.01 mm. One revolution of the indicator needle is equal to 0.50 mm.

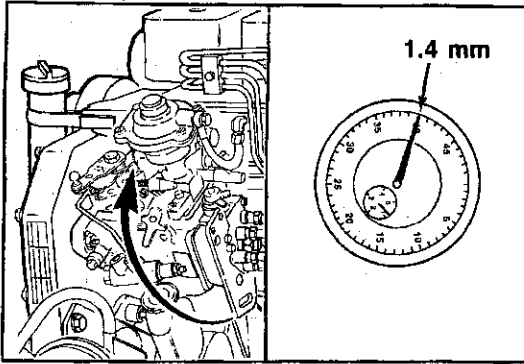


Bar the engine in the direction opposite engine rotation until the indicator needle stops moving. Adjust the indicator face to read zero. Rotate the engine back to TDC.

Rotate the engine back to TDC and count the number of revolutions of the indicator needle. The reading shown when the engine timing pin engages is the amount of plunger lift the pump has at that point.







13mm



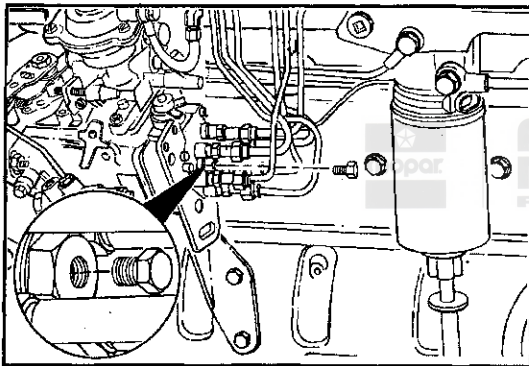
Rotate the pump on the mounting studs until the indicator reads the correct value for plunger lift.



Tighten the flange mounting nuts.



Torque Value: 24 N-m [18 ft-lbs]



12mm



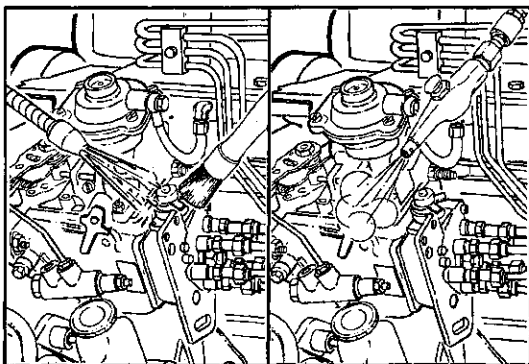
Remove the timing indicator. Install the plug and all other parts removed.



Tighten the plug.

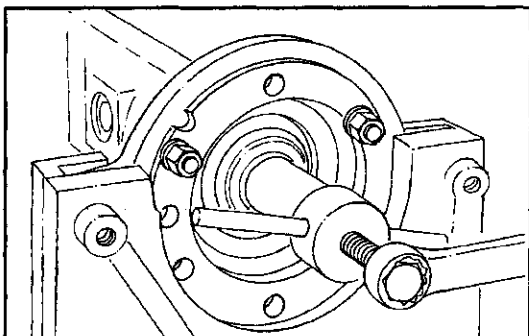


Torque Value: 10 N-m [7.5 ft-lbs]



**Cleanliness Is Important**

During any fuel system repair, cleanliness is of utmost importance. Thoroughly clean all affected parts with solvent and then blow dry with compressed air.



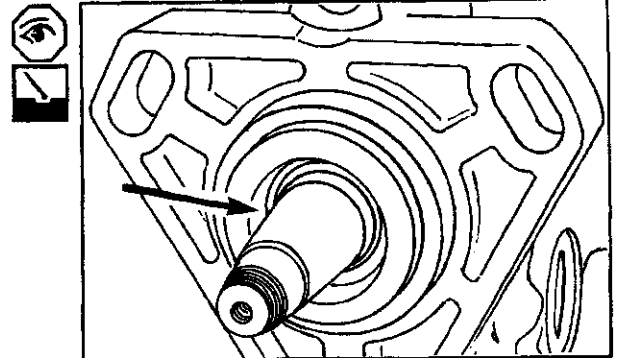
**Shaft Seal - Replacement**



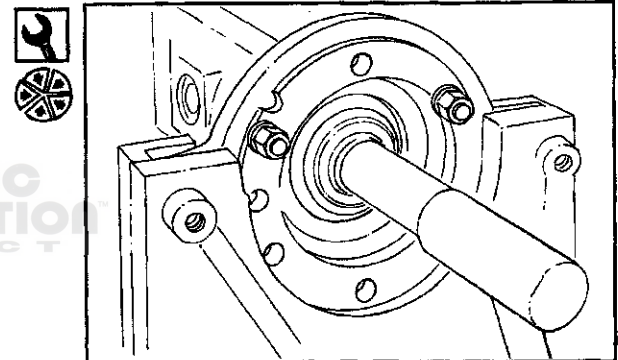
Remove the shaft seal.

Inspect the seal seating area for nicks and burns.

Minor clean-up is allowed providing the area is thoroughly flushed with solvent and dried with compressed air.



Install the new seal. Drive the seal in the housing until it bottoms.



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## Accelerator Pedal and Throttle Controls

### General Information

All models have a torsion return spring on the distributor fuel pump and an accelerator pedal return spring (extension spring) which gives positive throttle return and lower throttle pedal efforts while meeting safety requirements.

### Service Procedures

#### Remove

From inside the vehicle, hold up the pedal and remove the cable retainer and throttle cable from the upper end of the pedal shaft.

Working from the engine compartment, remove nuts from pedal shaft and bracket assembly studs.

Remove assembly from vehicle.

#### Install

Position assembly on dash panel and install retaining nuts, tighten to specifications. From inside the vehicle, hold up the pedal and install the throttle cable and cable retainer in the upper end of the pedal shaft.



## Throttle Controls

### Remove

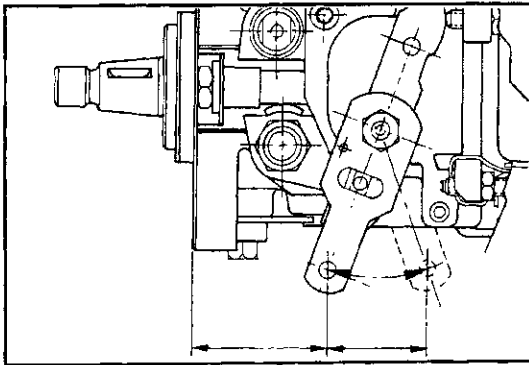
From inside the vehicle, remove the cable housing retainer clip and core wire cable retainer. Next, remove the core wire from the pedal shaft. From the engine compartment, pull the housing end-fitting out of the dash panel grommet. The grommet should remain in the dash panel hole. Remove the spring loaded socket from the throttle cam. Now, the cable mounting bracket will separate by using wide jaw pliers to compress the end-fitting tabs.

### Install

Install the cable housing into the cable mounting bracket on the engine and attach the cable spring loaded socket with the retaining ball onto the throttle cam. Install the remaining cable housing end-fitting into the dash panel grommet and attach the housing retainer clip from inside the vehicle. Install the ball end of the cable through the hole in the pedal shaft and install the plastic cable retainer.

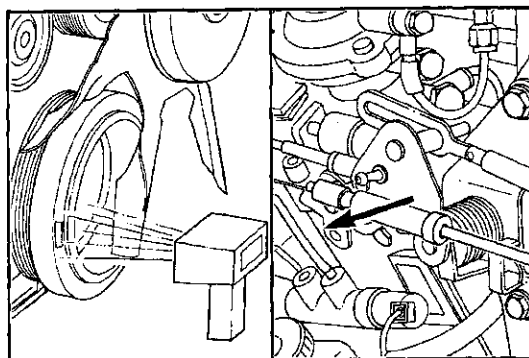


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## Throttle Linkage Adjustments

The throttle linkage between the throttle cam and the fuel pump throttle lever must be adjusted to insure full travel of the throttle lever.



**Note:** Before adjusting the fuel pump throttle linkage, verify that the engine is set at the Low Idle Setting Speed. Use an optical tachometer to obtain engine speed.

Low idle stop speed (Minimum).

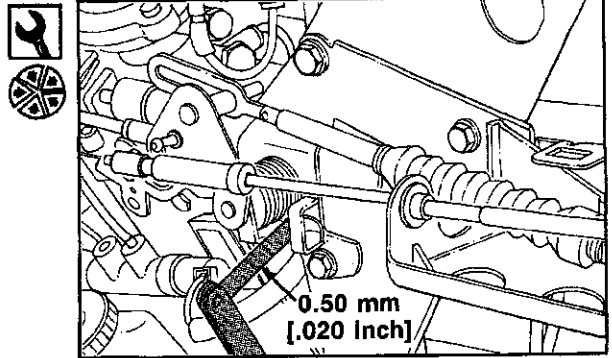
Automatic .... 700 RPM \*  
Manual ..... 750 RPM \*

\* Air conditioning ON.

1. Remove the throttle pedal cable from the throttle cam ball.

### Feeler Gauge

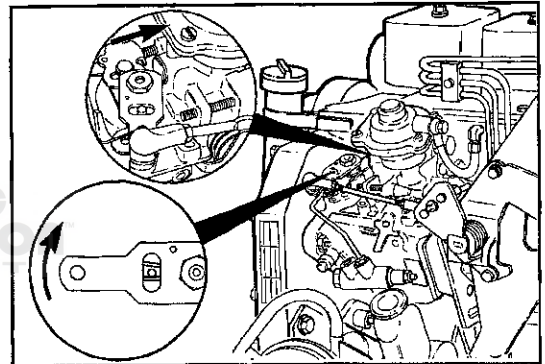
2. Insert a 0.50 mm [.020 inch] feeler gauge between the throttle cam and the cam stop.



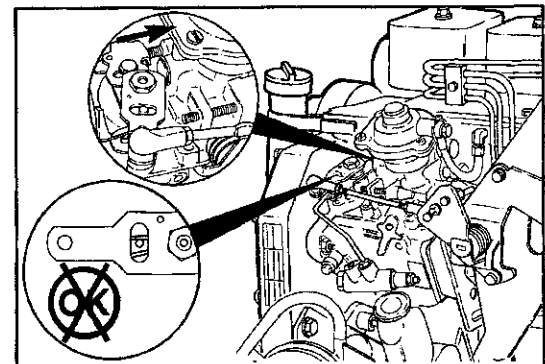
3. Observe that the throttle lever of the distributor pump is making contact with the low idle stop screw. Also that the spring load breakover lever has moved off the stop and is against the breakover spring.



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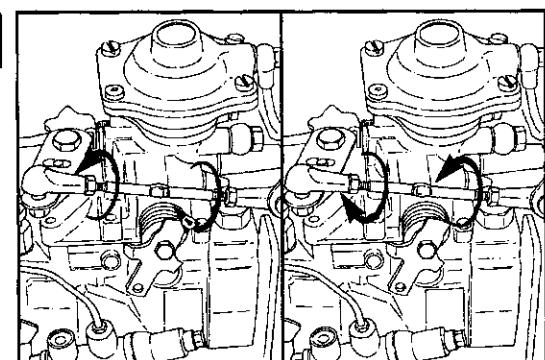
4. If the low idle stop screw and the breakover spring is not contacted, then the throttle actuation rod must be adjusted.

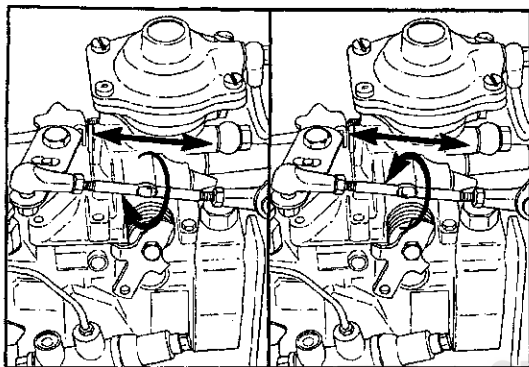


### 10mm

5. Hold the actuation rod flat and loosen the locking nuts.

**Note:** One nut is a left hand thread. "L" marked on the flat will indicate the side of the rod with this nut.

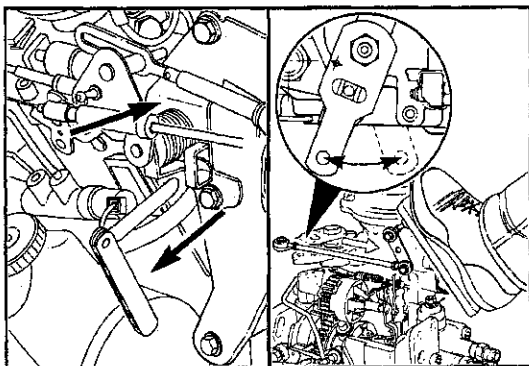




10mm

6. The throttle actuation rod can be rotated to increase or decrease adjustments.
7. Tighten the locking nuts.

**Torque Value: 9 N·m [7 ft-lbs]**



8. Remove the feeler gauge.



9. Connect throttle cable to throttle cam ball.



10. Operate foot throttle and inspect for throttle lever breakover in both idle and full positions.
11. Check engine RPM from low to full throttle.

**Low Idle Stop Speed**

	(Min.)
Automatic	700 RPM
Manual	750 RPM

**Full Throttle Stop**

(Min.)	(Max)
2825 RPM	2925 RPM

**Note:** If the engine will not meet the full throttle limit and the low pressure fuel system and injectors are functioning correctly, remove the fuel pump for service.

## Specifications

### Torque Values

Air Fuel Control Tube - Banjo Fitting .....	12 N·m	[9 ft-lbs]
Banjo Fitting on Filter Head .....	24 N·m	[18 ft-lbs]
Bleed Screw on Filter Head .....	8 N·m	[6 ft-lbs]
Fuel Line Clamp to Intake Manifold Capscrews .....	24 N·m	[18 ft-lbs]
Fuel Line Fittings at Injector - High Pressure .....	24 N·m	[18 ft-lbs]
Fuel Line Fittings at Pump - High Pressure .....	24 N·m	[18 ft-lbs]
Fuel Pump Flange Mounting Nut .....	24 N·m	[18 ft-lbs]
Fuel Pump Lock Screw (Locked Position) .....	30 N·m	[22 ft-lbs]
Fuel Pump Lock Screw (Unlocked Position) .....	13 N·m	[10 ft-lbs]
Fuel Pump Shaft Retainer Nut .....	65 N·m	[48 ft-lbs]
Fuel Pump Solenoid .....	43 N·m	[32 ft-lbs]
Fuel Pump Support Bracket .....	24 N·m	[18 ft-lbs]
Fuel Pump Timing Plug .....	10 N·m	[7.5 ft-lbs]
Fuel Pump Vent Capscrew .....	32 N·m	[24 ft-lbs]
Injector Drain Banjo Screw .....	8 N·m	[6 ft-lbs]
Injector Retainer Nut .....	60 N·m	[44 ft-lbs]
Lift Pump Mtg. Capscrews .....	24 N·m	[18 ft-lbs]
Throttle Actuation Rod Lock Nuts .....	9 N·m	[7 ft-lbs]
Throttle Control Bracket Capscrews .....	24 N·m	[18 ft-lbs]
Throttle Rod Mounting to Throttle Lever (and Nut) .....	10 N·m	[7.5 ft-lbs]

### Electrical Values – Shut Off Valve:

Current Draw .....	2 Amps
Minimum Voltage .....	10 Volts D.C.
Operating Voltage .....	12 Volts D.C.
Resistance .....	7.4 Ohms

### Engine Speed:

Full Throttle Stop Speed (NO Load) .....	2,925 RPM Max.
Full Throttle Stop Speed (NO Load) .....	2,825 RPM Min.
Low Idle Stop Speed (Air Conditioning ON) (Automatic) .....	700 RPM
Low Idle Stop Speed (Air Conditioning ON) (Manual) .....	750 RPM

### Pressure / Restrictions / Flows

Fuel Pressure Drop Across Filter .....	21 kPa [3 psi] Max.
Fuel Return Line Restriction .....	518 MM Hg [20.4 in Hg] Max.
Injector Operating Pressure (Pop Pressure) .....	245 bar [3550 psi]
Lift Pump Inlet Restriction .....	95 MM Hg [3.75 in Hg] Max.
Lift Pump Output - Flow .....	0.75 liter [0.70 U.S. quart] / 30 Sec. Max.
Lift Pump Output - Pressure .....	21 to 35 kPa [3 to 5 psi]



## Steering



### Section 19

#### **Notice to Consult Other Sources:**

The power steering pump on the DODGE Turbo Diesel is bolted onto the rear of the vacuum pump and is driven by the accessory drive through a common shaft. For information on troubleshooting and servicing the power steering pump and all other components of the vehicle steering, consult the 1990 Service Manual for Rear Wheel Drive Trucks (D&W 150-350 Ramcharger).

For information concerning the vacuum pump, Refer to the Service Brakes Section of this manual.



# Transmission

## Section 21

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Chrysler A727 three speed (Modified for Dodge Ram/Cummins Turbo 5.9 Liter Engine) .....	21-3
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Throttle Linkage .....	21-3
Road Test .....	21-3
Throttle Cable Adjustment .....	21-4
Adjustment Procedure .....	21-4



## Manual Transmission Getrag - G360 five speed

The Getrag - G360 is a fully-synchronized manual transmission with 0.77:1 overdrive in fifth gear.

### Transmission Ratios

1st .....	5.531	4th .....	1.00
2nd .....	3.017	5th .....	0.770
3rd .....	1.600	Reverse .....	5.029

### Rear Axle Ratio

3.54:1 (Dana - 70)

### Front Axle Ratio

3.54 (Dana - 60)

The Getrag Transmission will be serviced as a module.

The only repairs that will be performed at a Dodge Service Location are as follows:

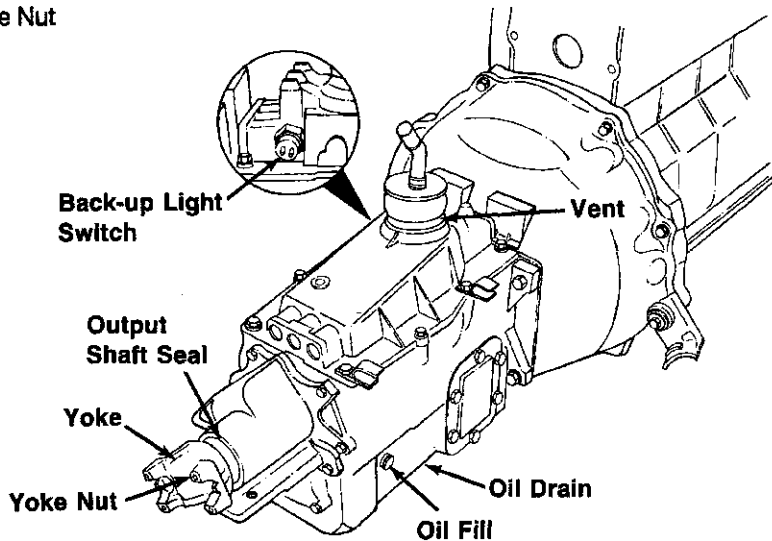
### Removal/Replacement

D250/D350

Case Vent  
Backup Light Switch  
Oil Fill Plug  
Oil Drain Plug  
Out-Put Shaft Seal  
Yoke  
Yoke Nut

W250/W350

Case Vent  
Backup Light Switch  
Oil Fill Plug  
Oil Drain Plug



### Specifications

#### Tightening Reference

	N·m	[ft·lb]
Backup Safety Switch .....	20	[15]
Oil Drain/Fill Plugs .....	90	[66]
Yoke Nut .....	380	[280]
Transmission Mounting Bolts .....	47	[35]

## Automatic Transmission

### Chrysler A727 three speed (Modified for Dodge Ram/Cummins Turbo 5.9 Liter Engine)

The Loadlite A727 (Diesel Option) is designed with a new case, larger capacity front pump and Borg Warner [12.2 inch] torque converter. The transmission is designed to be input torque-limited at [400 ft-lb] with a converter stall speed of 1775 RPM.

The Borg Warner Torque Converter is a nonlockup converter.

#### Transmission Ratios

1st .....	2:45
2nd .....	1:45
3rd .....	1:00

**Rear Axle Ratio**  
3.07:1 (Dana - 71)

**Front Axle Ratio**  
3.07:1 (Dana - 61)

#### Throttle Linkage

The throttle cable adjustment is very important to proper transmission operation. This adjustment positions a valve which controls shift speed, shift quality and part throttle downshift sensitivity. If the setting is too short, early shifts and slippage between shifts may occur. If the setting is too long, shifts may be delayed and part throttle downshifts may be very sensitive. Refer to "Throttle Cable Adjustment".

#### Road Test

Prior to performing a road test, be certain that the fluid level and condition, and control linkage adjustments have been checked and approved.

During the road test the transmission should be operated in each position to check for slipping and any variation in shifting. Note whether the shifts are harsh or spongy and check the speeds where the upshifts and downshifts occur.

Observe closely for slipping or engine speed flare-up. Slipping or flare-up in any gear usually indicates clutch, band, or overrunning clutch problems. If the condition is far advanced, and overhaul will probably be necessary to restore normal operation.

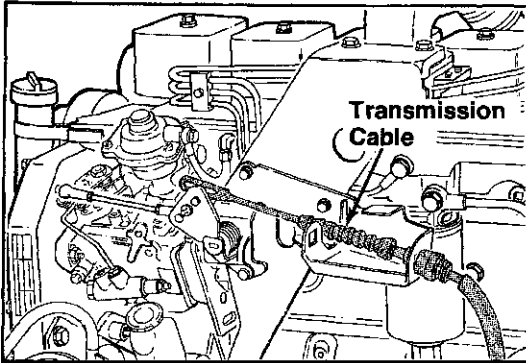
In most cases, the clutch or band that is slipping can be determined by noting the transmission operation in all selector positions and by comparing which internal units are applied in those positions.

By observing that the rear clutch is applied in both the "D" first gear and "1" first, if the transmission slips in "D" range first gear but does not slip in "1" first gear, the overrunning clutch must be the unit that is slipping. Similarly, if the transmission slips in any two forward gears, the rear clutch is the slipping unit.

Using the same procedure, the rear clutch and front clutch are applied in "D" third gear. If the transmission slips in third gear, either the front clutch or the rear clutch is slipping. By selecting another gear which does not use one of those units, the unit which is slipping can be determined. If the transmission also slips in reverse, the front clutch is slipping. If the transmission does not slip in reverse, the rear clutch is slipping.

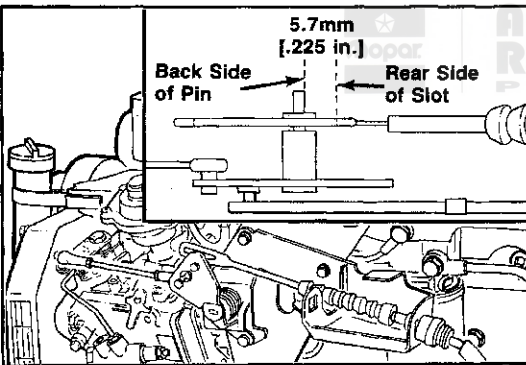
This process of elimination can be used to detect any unit which slips and to confirm proper operation of good units. However, although road test analysis can usually diagnose slipping units, the actual cause of the malfunction usually cannot be decided. Practically any condition can be caused by leaking hydraulic circuits or sticking valves.

**Therefore, unless the condition is obvious, like no drive in "D" range first gear only, the transmission should never be disassembled until hydraulic pressure tests have been performed.**



### Throttle Cable Adjustment

With the engine at operating temperature, adjust the idle speed of the engine using an optical tachometer. Refer to "Fuel System" Group 14 for idle speed specifications and fuel pump throttle adjustments.

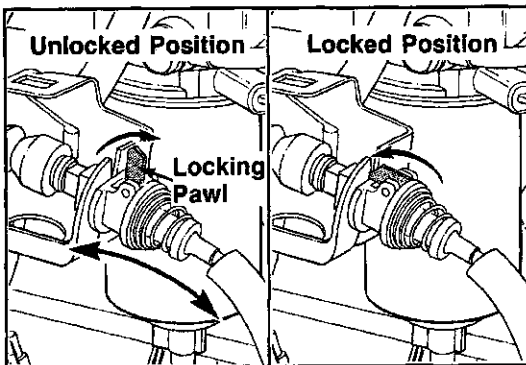


### Adjustment Procedure

Perform the transmission throttle cable adjustment while the engine is at normal operating temperature.

Observe the position of the transmission throttle slotted cable end and actuation pin on the throttle cam.

With the throttle lever seated against the low idle stop screw (normal foot off throttle position), the actuation pin and the slotted cable end of the throttle cable should have a clearance of 5.7mm [.225 inch].



If the throttle cable is not positioned correctly, then adjustments can be made by lifting the locking pawl and sliding the cable to the proper position.

The lock pawl should need only finger pressure to return to locked position.

**Note:** Refer to the "Transmission" section of the 1989 Service Manual for the rear wheel drive trucks (D and W 150-350 Ramchargers).

## Heating and Air Conditioning

### Section 24

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Refrigerant Compressor - Install .....	24-3



## Introduction

This section describes only those procedures associated with removing and installing the refrigerant compressor on the Dodge 5.9 liter Turbo Diesel. For complete information on troubleshooting, servicing, and testing the vehicle heating and air conditioning components, consult the 1990 Service Manual for Rear Wheel Drive Trucks (D&W 150-350 Ramcharger).

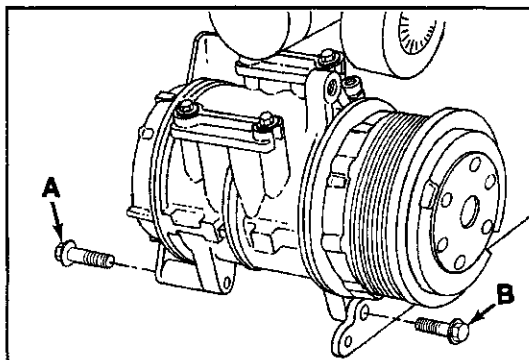
## Refrigerant Compressor - Remove

### Preparatory Steps

1. Remove the drive belt.
2. Discharge the system.
3. Disconnect the suction and discharge lines from their respective ports. Immediately cap the lines and the ports to prevent moisture and dirt from entering the system.
4. Disconnect the clutch electrical wire.



**Warning:** To prevent suffocation and frostbite, wear protective clothing and **ONLY** disconnect liquid refrigerant (freon) lines in a well ventilated area.

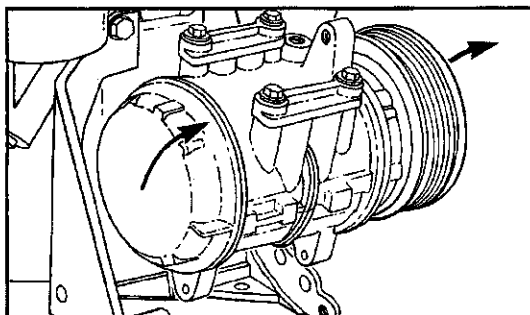


 9/16 inch



Remove the two cap screws (B) that fasten the compressor front bosses to the water inlet bracket.

Remove the two cap screws (A) that fasten the compressor to the rear bracket.



Remove the compressor.

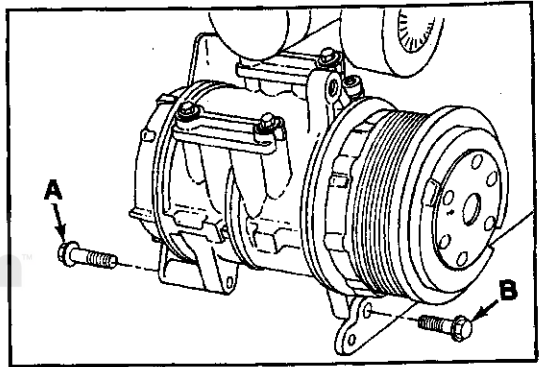
### Refrigerant Compressor - Install

9/16 inch

Position the compressor so the four capscrew bosses are aligned with the holes in the brackets.

Insert the capscrews (A) and (B) and tighten evenly.

**Torque Value:** 47 N·m [35 ft-lb]

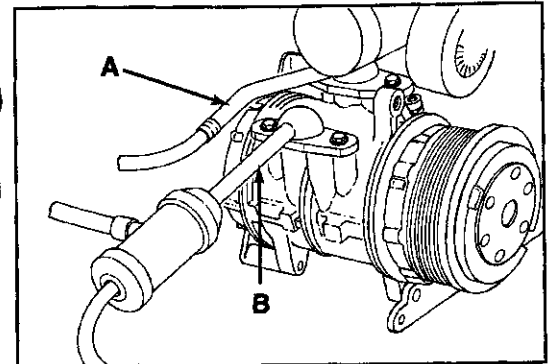


10mm

Remove the protective caps from suction (A) and discharge (B) line and ports and install onto the compressor using new gaskets. Tighten the capscrews.

**Torque Value:** 20 N·m [15 ft-lb]

Reconnect the clutch electrical wire.





# Emission Control System

## Section 25

### General Information

All Federal models regardless of gross vehicle weight rating (GVWR) must meet light duty cycle emission standards.



Vehicles built for sale in California and Canada having GVWR of 3855 kg [8,500 lb] or less must meet light duty cycle emission standards.

Vehicles built for sale in California and Canada having a GVWR of 3860 kg [8,501 lb] or more must conform to heavy duty cycle emission standards.

All new DODGE Ram/Cummins Turbo Diesels conform to heavy duty cycle emission standards.

### Emission Related Parts

#### Part

		   	Service Information Source
Fuel Injection system components .....			Fuel system - Section 14
Exhaust manifold .....			Exhaust system and Intake manifold - Section 11
Intake Manifold .....			Exhaust system and Intake manifold - Section 11
Turbocharger .....			Exhaust system and Intake manifold - Section 11
Air filter .....			Requires scheduled cleaning and replacement. See Maintenance Guidelines - Section 0C, Scheduled Maintenance for Vehicle Emissions - Section 0F, and Exhaust System and Intake Manifold - Section 11.







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AUTHENTIC  
RESTORATION

