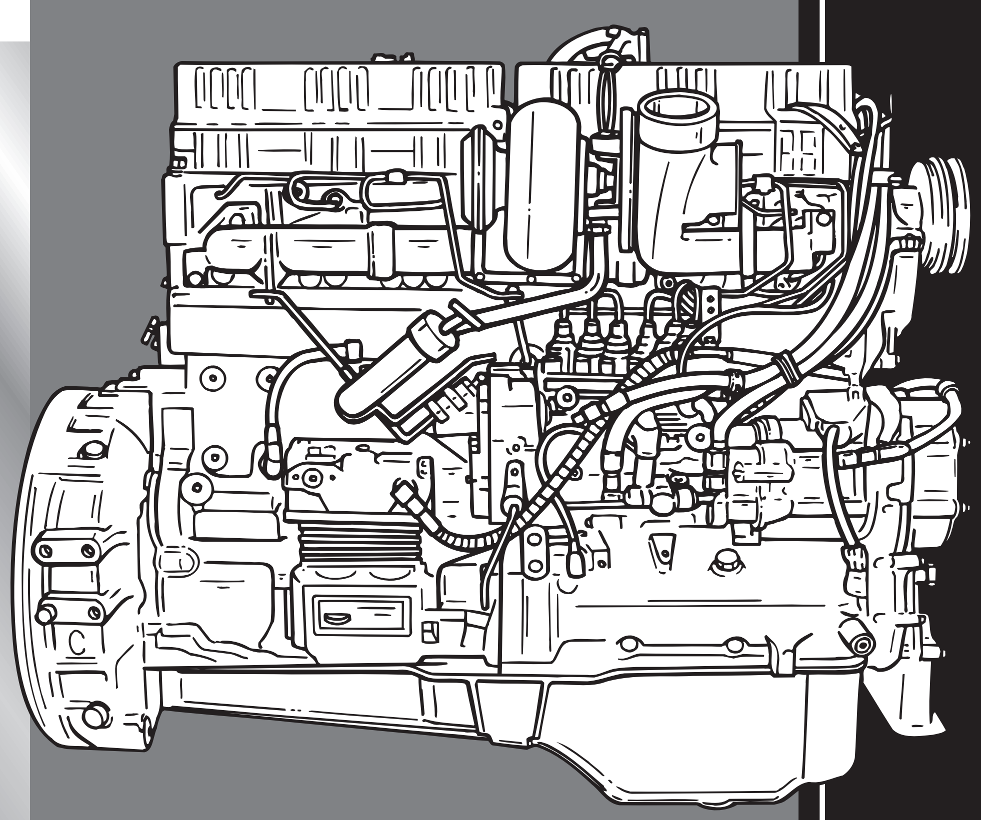

E7 ENGINE

OVERHAUL

AUGUST 1997
ENGINE 5-101

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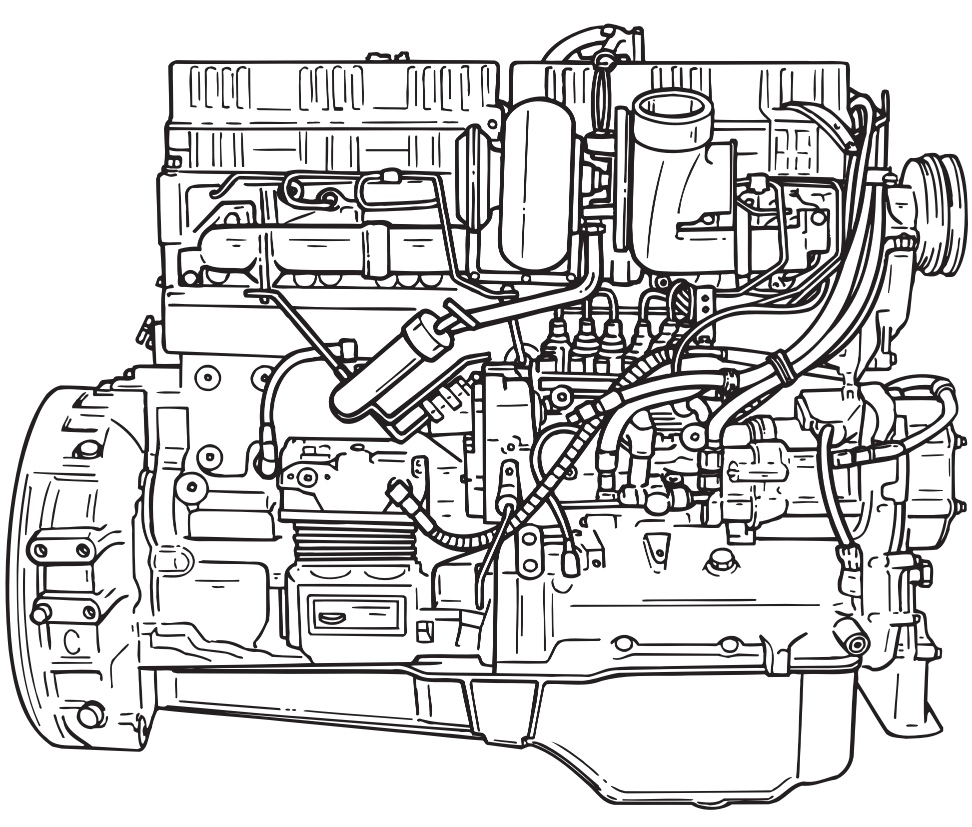

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ENGINE 5-101

ATTENTION

The information in this manual is not all inclusive and cannot take into account all unique situations. Note that some illustrations are typical and may not reflect the exact arrangement of every component installed on a specific chassis.

The information, specifications, and illustrations in this publication are based on information that was current at the time of publication.

SAFETY INFORMATION

SAFETY INFORMATION

Advisory Labels

Cautionary *signal words* (Danger-Warning-Caution) may appear in various locations throughout this manual. Information accented by one of these signal words must be observed to minimize the risk of personal injury to service personnel, or the possibility of improper service methods which may damage the vehicle or render it unsafe. Additional Notes and Service Hints are utilized to emphasize areas of procedural importance and provide suggestions for ease of repair. The following definitions indicate the use of these advisory labels as they appear throughout the manual:

CAUTION

Directs attention to unsafe practices which could result in damage to equipment and possible subsequent personal injury or death if proper precautions are not taken.

WARNING

Directs attention to unsafe practices which could result in personal injury or death if proper precautions are not taken.

DANGER

Directs attention to unsafe practices and/or existing hazards which will result in personal injury or death if proper precautions are not taken.

NOTE

An operating procedure, practice, condition, etc., which is essential to emphasize.

SERVICE HINT

A helpful suggestion which will make it quicker and/or easier to perform a certain procedure, while possibly reducing overhaul cost.

000001a

SAFETY INFORMATION

Service Procedures and Tool Usage

Anyone using a service procedure or tool not recommended in this manual must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects. Individuals deviating in any manner from the instructions provided assume all risks of consequential personal injury or damage to equipment involved.

Also note that particular service procedures may require the use of a special tool(s) designed for a specific purpose. These special tools must be used in the manner described, whenever specified in the instructions.

WARNING

1. **Before starting a vehicle, always be seated in the driver's seat, place the transmission in neutral, be sure that parking brakes are set, and disengage the clutch.**
2. **Before working on a vehicle, place the transmission in neutral, set the parking brakes, and block the wheels.**
3. **Before towing the vehicle, place the transmission in neutral and lift the rear wheels off the ground, or disconnect the driveline to avoid damage to the transmission during towing.**

REMEMBER,
SAFETY . . . IS NO ACCIDENT!

SAFETY INFORMATION

Mack Trucks, Inc. cannot anticipate every possible occurrence that may involve a potential hazard. Accidents can be avoided by recognizing potentially hazardous situations and taking necessary precautions. Performing service procedures correctly is critical to technician safety and safe, reliable vehicle operation.

The following list of general shop safety practices can help technicians avoid potentially hazardous situations and reduce the risk of personal injury. DO NOT perform any services, maintenance procedures or lubrications until this manual has been read and understood.

- Perform all service work on a flat, level surface. Block wheels to prevent vehicle from rolling.
- DO NOT wear loose fitting or torn clothing. Remove any jewelry before servicing vehicle.
- ALWAYS wear safety glasses and protective shoes. Avoid injury by being aware of sharp corners and jagged edges.
- Use hoists or jacks to lift or move heavy objects.
- NEVER run engine indoors unless exhaust fumes are adequately vented to the outside.
- Be aware of hot surfaces. Allow engine to cool sufficiently before performing any service or tests in the vicinity of the engine.
- Keep work area clean and orderly. Clean up any spilled oil, grease, fuel, hydraulic fluid, etc.
- Only use tools that are in good condition, and always use accurately calibrated torque wrenches to tighten all fasteners to their specified torques. In instances where procedures require the use of special tools which are designed for a specific purpose, use only in the manner described in the instructions.

EXPLANATION OF NUMERICAL CODE

EXPLANATION OF 3-DIGIT NUMERICAL CODE

The organization of MACK service manuals has been upgraded to standardize manual content according to a reference system based on component identification. The new reference system will help link the information contained in this publication with related information included in other MACK service/warranty publications, such as associated service bulletins, warranty manuals, and the TS477 Service Labor Time Standards Manual.

The system is based on a numerical code, the first **digit** of which identifies the general component grouping as listed here:

GROUP **0**00 — INSPECTIONS

GROUP **1**00 — CHASSIS

GROUP **2**00 — ENGINE

GROUP **3**00 — CLUTCH, TRANSMISSION, TRANSFER CASE AND PTO

GROUP **4**00 — STEERING, AXLES, WHEELS AND TIRES, DRIVELINE

GROUP **5**00 — BRAKES, AUXILIARY SYSTEMS

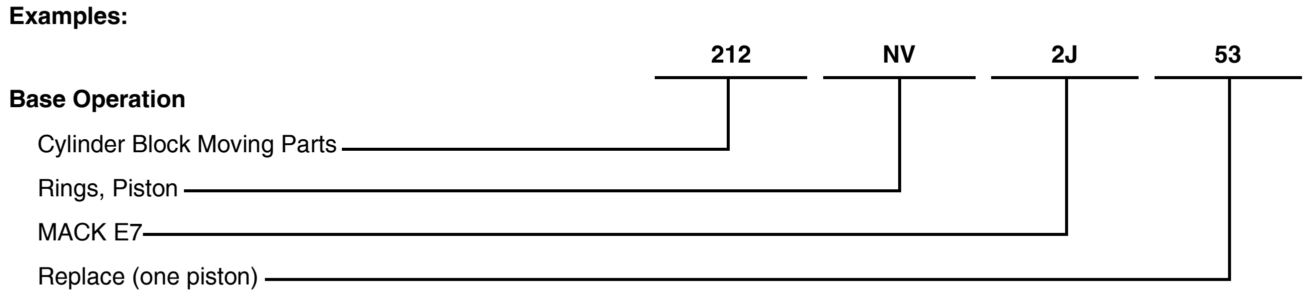
GROUP **6**00 — CAB, TRUCK BODY

GROUP **7**00 — ELECTRICAL

The second two digits of the 3-digit code are used to identify the **system, assembly** or **subassembly**, as appropriate, within each of the groupings. The codes applicable to this publication are shown at the TOP OF EACH PAGE and at SECTION HEADINGS, as necessary, and may also appear in the TABLE OF CONTENTS, to guide you to specific component information.

Additionally, a two-character alpha code (i.e. [NV] RINGS, PISTON) is shown with each operation. This alpha code, in combination with the three-digit Group number, identifies the specific assembly, subassembly or part, and directly relates to the first five positions of the operation code listed in the Service Labor Time Standards Manual, TS477.

Examples:



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ABOUT THIS MANUAL

CHANGES FROM THE EXISTING E7 MANUAL

Mack Trucks, Inc. has made many major improvements to this E7 Service Manual, with changes to both content and organization. The specifications have been revised to reflect changes and improvements in E7 engines.

All specifications and torque values are given in English and metric measurements. Torque values are also included in the text, eliminating the need to refer to the Fits and Limits chart each time a specified torque value is required. The Special Tools list has been revised to include new special tools. Warnings, cautions, notes and service hints help the technician service the engine safely and efficiently.

The ENGINE DISASSEMBLY section shows how to remove components in an order that requires the least amount of handling. It includes brief component descriptions and information needed to properly service that component.

The BENCH PROCEDURES section guides the technician in disassembly, cleaning, inspection and assembly of each component. It also helps in determining if the part is serviceable or should be replaced. This section alerts the user to component upgrades and helps the technician to decide whether to use the latest available parts or reinstall existing parts. Precise descriptions aid in component identification.

The ENGINE ASSEMBLY section includes step-by-step procedures for reassembling the engine. This helps to ensure proper installation and longer service life.

The SETUP AND ADJUSTMENTS section has the latest setup information, complete with charts showing necessary data for adjusting all E7 engine models. Engines perform best and conserve fuel most efficiently when adjusted properly.

Two additional sections are included as guides for removing and reinstalling the engine. Both sections are generic in nature. E7 engine installation procedures vary from one vehicle style to another. These procedures are intended as a checklist to remind the technician of all necessary tasks.

While troubleshooting procedures are similar for most diesel engines, this manual includes only those that pertain to the E7 engine. The TROUBLESHOOTING section contains questions to help the technician consider all possible problem sources.

This service manual has been revised to include all applicable active service bulletins and service letters since publication of the earlier E7 Service Manual (October 1992).

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NOTES

GENERAL INFORMATION

INTRODUCTION

This manual is intended to assist the technician in properly overhauling MACK E7 engines. The manual is divided into nine major sections. Working on the E7 engine is not difficult, but like most present-day precision equipment, it requires proper tools and knowledge.

The overhaul procedures are separated into three sections: engine disassembly, bench procedures and engine assembly. Each section contains detailed procedures that must be followed in the order specified. If a step calls for a procedure that has already been described earlier in the manual, you will be referred to the section where the original procedure appeared. This manual covers the overhaul of an engine once it is removed from the vehicle, but also gives instructions for removing the engine from a nonspecified chassis.

The new E7 is the most fuel-efficient diesel engine MACK has ever produced. This engine provides higher horsepower ratings, better fuel economy, increased durability and improved serviceability. In addition, the E7 still easily meets all applicable emissions standards. All this, coupled with the latest manufacturing techniques and equipment, makes the new E7 the highest-quality MACK engine ever made.

Externally, all E7 engine models look the same. However, Mack Trucks, Inc. has made many major internal design changes to comply with current and future EPA emission standards. To properly identify the E7 engine model year, refer to the engine information plate and the following pages of this section for additional engine plate information.

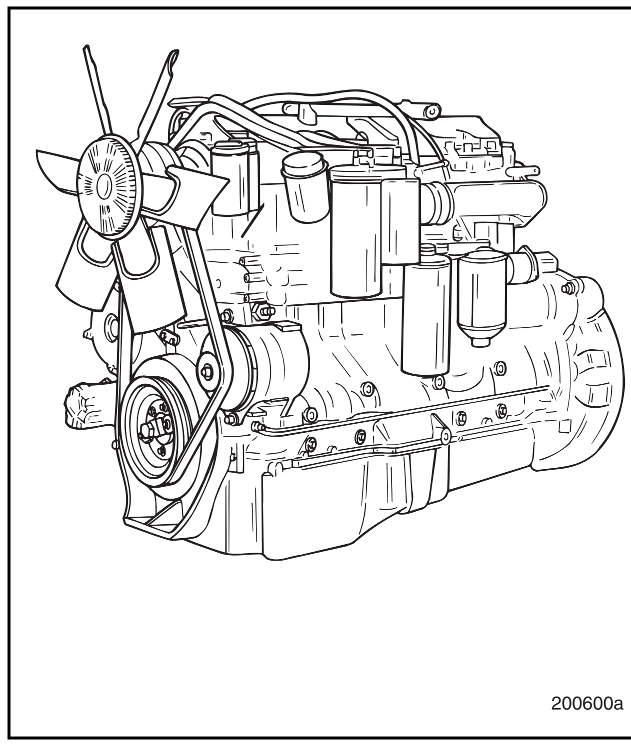


Figure 1 — 3/4 View E7, Front, Left

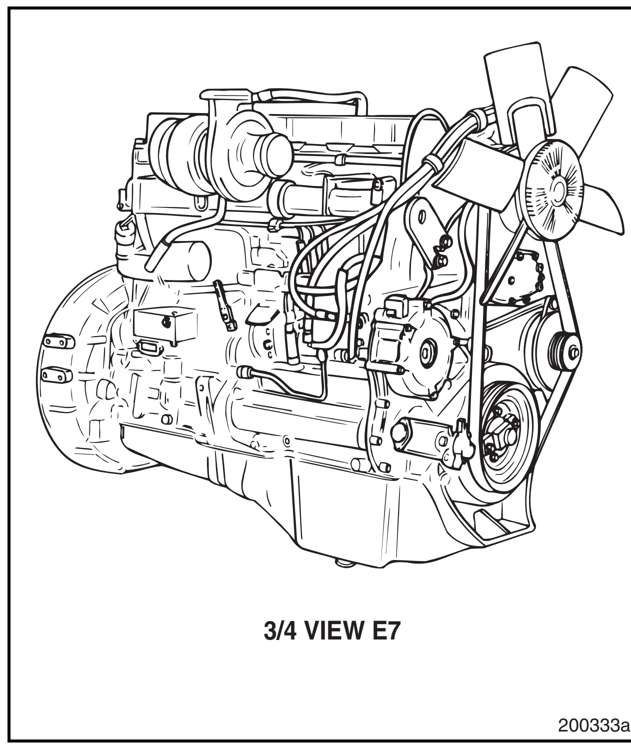


Figure 2 — 3/4 View E7, Front, Right

ENGINE MODEL IDENTIFICATION

Engine Information Plate

All engines are identified by an engine information plate located on the front valve cover of the engine. This plate indicates the engine's 11GBA number, emission standards, serial number and various engine adjustments. The engine is also identified by the serial number stamped into the cylinder block above the timing cover on early engines, or on the pad just to the rear of the air compressor on later engines.

For some current MACK engines, the engine information plate also includes pertinent emissions characteristics of NO_x and particulates unique to that engine.

A given MACK engine may meet federal emission regulations in 49 states (excluding California) or an engine may meet emission regulations of all 50 states (including California). To determine which regulations a given engine meets, refer to the engine information plate. If the engine plate has a series of dashes in the long upper-left block, and two dashes in the CALIF. FAMILY block, the engine does not meet California regulations.

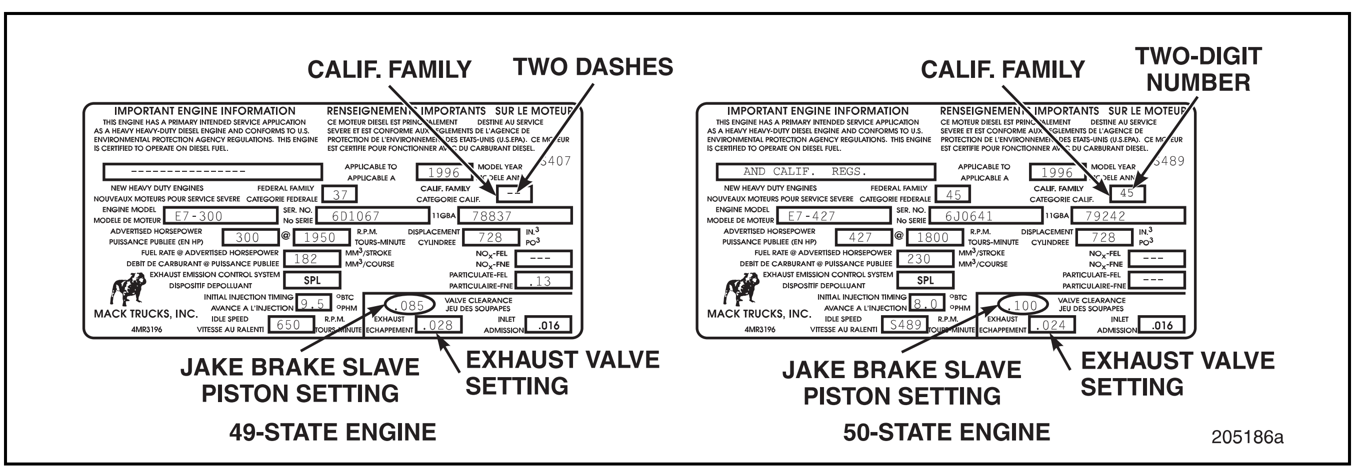


Figure 3 — Engine Information Plates

New Engine Information Plate

The following explanations are provided to aid in interpreting some of the key information found on the new engine information plate (effective late 1996). Refer to Figure 1-4.

Block 1 — U.S. EPA Regulations

- An "X" in block one means the engine meets United States EPA regulations for the year stamped in block No. four.
- Two dashes in block one indicates the engine does not meet United States EPA regulations for the year stamped in block No. four. This is only permissible with certain export engines. All domestic engines will have an "X" in block one.

Block 2 — California Regulations

- An "X" in block two indicates the engine meets California emissions regulations for the year stamped in block No. four. This engine is referred to as a "50-state" engine and can be sold in any state throughout the U.S.
- Two dashes stamped in block two means the engine does not meet California emissions regulations. If an engine has an "X" in block one and two dashes in block two, it is referred to as a "49-state" engine, meaning it is not certified for sale in California.

Block 3 — ADR Regulations

- An “X” in block three means the engine has been certified to meet Australian emissions regulations.
- Two dashes in block three means the engine does not meet Australian emissions regulations.

Block 4 — Model Year

- The four-digit numeral stamped in block four represents the year in which the engine was certified.

Block 5 — Federal Family

- A two-digit numeral stamped in block five denotes the Federal Family to which the engine belongs, for emissions certification purposes.
- All domestic engines will have a two-digit Federal Family number in block five.

Block 6 — California Family

- If the engine meets California emissions regulations, the same two-digit numeral stamped in the Federal Family block is stamped in the California block.
- If the engine does not meet California emissions regulations, there will be two dashes in block six.

Block 7 — Initial Injection Timing

- Block seven indicates the initial setting for E7 injection timing.
- E7 EUP (E-Tech™) engines do not have an initial injection timing, as this is controlled electronically. E-Tech™ engines have “NA” stamped in block seven.

Block 8 — Engine Brake

- This block is only used when the engine is equipped with a Jake Brake. The stamping in this block indicates the Jake Brake slave-piston lash setting.

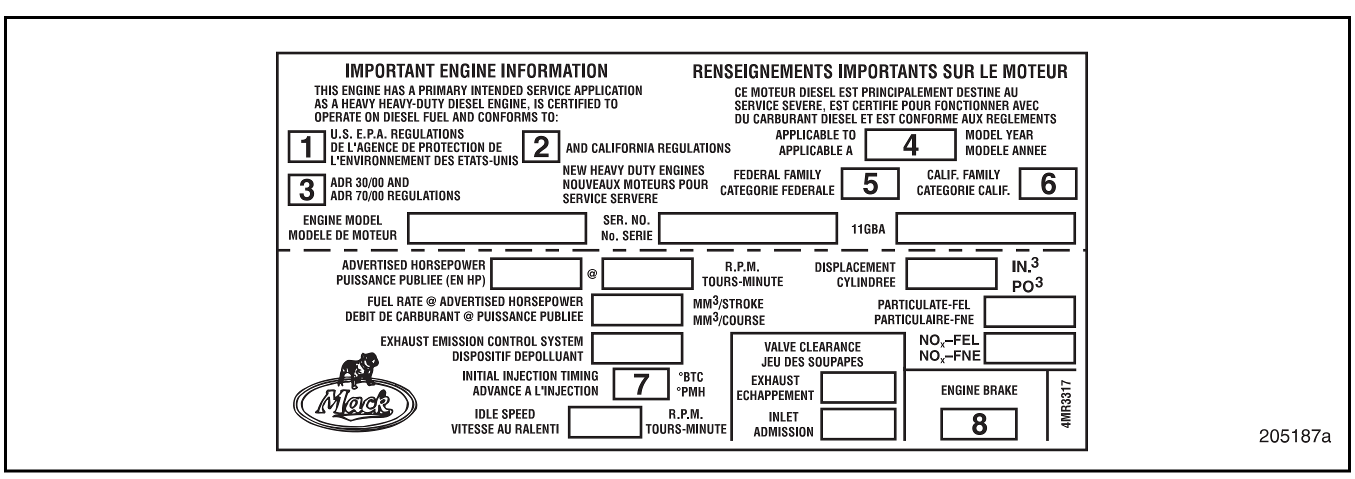


Figure 4 — Engine Information Plate

LUBRICANTS AND SEALANTS

Use only the following recommended sealing compounds and lubricants.

NOTE

All genuine MACK cylinder head gaskets are precoated and do not require any type of sealing compound. Before installing new gaskets, degrease both gasket sealing surfaces to avoid leaks.

Location	Sealant or Lubricant
Cup plugs/threaded plugs	Loctite® 277 or equivalent/Teflon thread sealer
Injection nozzle holder inserts (upper and lower end)	Loctite® 620
Camshaft gear assembly	Loctite® 609
Timing gear cover	MACK Silastic (RTV Silicone Adhesive Sealant) part No. 342SX32
Timing event marker with jam nut	
Oil filter sealing gasket	Clean engine oil
Holding metal parts in place	MACK MG-C grease or petroleum jelly (Vaseline®)
Valve stems	
Engine parts, fasteners (sides and threads), and washers	Clean engine oil
Cylinder sleeve upper crevice seal (on sleeve)	Ethylene glycol or propylene glycol
Cylinder sleeve seat	MACK Silastic (RTV Silicone Adhesive Sealant) part No. 342SX32
Oil cooler assembly	Permatex® gasket sealer
Oil cooler assembly O-ring	Drydene® No. 4000
O-rings (except as noted)	MACK O-ring lubricant part No. 243SX41
Chassis-mounted charge air cooling system (core sealing)	Dow Corning® No. 1200 primer, Dow Corning RTV 734 adhesive (clear), and naphtha solvent or equivalent
Engine oil pressure sensor	Sealing compound on threads
Intake manifold temperature sensor	
Coolant temperature sensor	
Coolant level sensor	
Fuel injection pump actuator connector	O-ring lube Lubrizol® No. OS-50044 or equivalent
Fuel injection pump driven gear access cover	
Econovance® drive coupling bolt threads	Loctite® 242
Crankshaft flange and wear ring	Loctite® 609
Turbocharger mounting nuts	Fel Pro C5A

OVERHAUL PART REPLACEMENT

Use genuine MACK parts at all times. Parts that are typically replaced during an engine overhaul are listed below:

- Gaskets and seals
- Bearings and bushings
- Pistons (aluminum) and piston rings
- Cylinder sleeves
- Cylinder block cup plugs and cylinder head cup plugs
- Connecting rod capscrews

NOTE

Steel top pistons should not be replaced without first inspecting them for excessive wear or other damage. Clean, inspect and measure pistons to determine need for replacement.

SPECIFICATIONS

SPECIFICATIONS

Improved Design

Compared to earlier designs, the E7 engines include improvements required to accommodate higher horsepower ratings and future emission standards. These changes require increased displacement, higher peak cylinder pressures and a superior engine cooling system. This was all accomplished without a substantial change in engine weight.

Engine General Specifications

Characteristic	Description
Weight (wet*)	2300 lbs. (1043.3 kg)
Weight (dry)	2210 lbs. (1002.5 kg)
Displacement	728 cu. in. (12L)
Bore and stroke	4-7/8 x 6-1/2 in. (123.83 x 165.10 mm)
Engine oil capacity	33.5 qts. (32L)
Coolant capacity	13 qts. (12.3L)
Compression ratio	16.5:1 (up to 375 hp); 15.3:1 (375 hp and above)
Fasteners and threads	Metric and English

*Wet includes oil and coolant

Engine Features

Component	Description
Cylinder block	Alloyed gray cast iron
Main bearing caps	Ductile iron, intermediate supported with buttress screws to prevent bulkhead movement
Flywheel housing	Standard — Aluminum, standard SAE No. 1, precision doweled Optional — Ductile iron
Cylinder sleeves	Wet/dry, replaceable, centrifugally cast, alloyed cast iron
Cylinder sleeve seal	Teflon-coated AFLAS/EPDM, intolerant of oil (use glycol for installation lubricant)
Cylinder heads	Alloy gray cast iron; four valves per cylinder, two cylinder heads per engine
Cylinder head gaskets	
— Body	Nonasbestos material with a steel core (two per engine)
— Fire ring	Steel, six per engine
Piston assembly	Refer to Tune-Up Specifications manual.
Pistons (1989–1990)	Aluminum alloy, Ni-resist insert top two grooves, steel insert third groove, oval and roll burnished pin bores, continuous oil cooling
Pistons (1991 and later)	Two-piece, top crown material steel, aluminum alloy skirt, three-ring piston
Piston rings (1989–1990)	
— Compression	Chrome, three per cylinder
— Oil control	Chrome, one per cylinder
Piston rings (1991 and later)	
— Compression	Plasma, top ring; chrome, second ring
— Oil control	Chrome, one per cylinder
Piston pins	Full-floating, 2.25 inch (5.72 cm) diameter, full-pressure lubrication through rifle-drilled holes in connecting rods

Engine Features (Cont.)

Component	Description
Connecting rods	Forged steel, I-beam with tapered pin end, 35-degree cap angle, 10.4 inches (26.42 cm) center-to-center length
Crankshaft	Drop-forged, medium carbon steel, elotherm hardened journals and fillets, eight integral counterweights, 3.25 inch (8.26 cm) piston journal diameter, 4.5 inch (11.43 cm) main journal diameter
Bearings	
— Main	Steel-backed, lead-tin overlay
— Rod	Steel-backed, lead-tin overlay deltawall
Vibration damper	Viscous fluid filled
Camshaft	Carbon steel, carburized journals and lobes, gear driven
Valves	
— Inlet	30-degree face angle (before November 1996), 20-degree face angle (November 1996 and later), poppet with positive rotator, two per cylinder
— Exhaust	30-degree face angle, poppet with positive rotator, two per cylinder
Valve lifters	Mushroom type, durafaced (tungsten carbide)
Oil filters	Spin-on, disposable (two); Centri-Max® centrifugal filter (one)
Oil pan (isolating)	
— 240GB5240M	Used as either front or rear sump by reversing pan.
— 240GC5240M2	Same as 240GB5240M except for the addition of three bosses located in the front of oil pan, one each for oil temperature sensor, turbocharger unloader and tandem air compressor
— 240GB5240M3	Same as 240GB5240M2 except it is for a rear sump
— 240GB5420M4	Used as either front or rear sump, includes five bosses to accept all variations
Air compressor	Flange mounted, gear driven, engine oil lubricated, water cooled (integral to engine coolant system) (Bendix or Holset)
Turbocharger	Exhaust gas driven, radial flow, engine oil lubricated (Schwitzer or Garrett)
Lubrication system	Full pressure, wet sump, 33.5 quart (32 L) capacity, 25,000 mile (40,225 km) highway/300 hour stop-and-go change interval, MACK approved EO-L oil.
Valve seat inserts	Pressed-in cylinder heads (30° inlet seat before November 1996, 20° inlet seat after November 1996, 30° exhaust seat)
Manifolds	
— Air inlet	Two-piece, six-port
— Exhaust	Three-piece, six-port
— Coolant	Two-piece, four-port
Injection pump	Robert Bosch, P7100 fixed timing, Bosch LDA. V-MAC engines use P8500, multiple plunger, flange mounted, gear driven, with variable timing by Econovance
Injection nozzles	Refer to Tune-Up Specifications manual.
Fuel filters	Spin-on, disposable
Water pump	Centrifugal-rotor, belt driven
Coolant conditioner	Spin-on, disposable
Thermostat	180°F (82°C), with rubber seated flange seal and caged check ball

NOTE

For additional information on tune-up specifications for 1992 and 1993 E7 V-MAC engines, refer to 1992 MACK Engine Tune-Up Specifications No. 5-304ID92 and V-MAC Service Manual No. 8-201. For information on 1993 V-MAC E7 engine, refer to 1993 MACK Engine Tune-Up Specifications No. 5-305ID93.

NOTE

All 1992 engine models use 1991 injection nozzles except 1992 EM7-300 V-MAC with 20-degree Econovance, No. 710GB51AM. 1992 EM7-300 models with 20-degree Econovance use nozzle holder assembly No. 736GB343P4 and nozzle tip No. 114GC325P3. 1992 EM7-300 V-MAC models with 10-degree Econovance, No. 710GB416CM, use 1991 EM7-300 V-MAC injection nozzles.

Good Shop Practice — Fasteners

Make sure that all components are clean and free from foreign material or corrosion. Use suitable tools and assembly procedures to prevent permanent damage to the engine components.

Metric fasteners are used on the E7 engine with a few exceptions. The exceptions are fasteners with English threads, as noted in the charts that follow.

Patchlock/Hyloc fasteners follow the same guidelines as standard fasteners.

A calibrated manual torque wrench is required to tighten the fasteners listed in the charts. Threads, washers and underhead of screws or washer face of nuts should be lubricated with engine oil, unless otherwise specified.

NOTE

Some designs require individual consideration and may deviate from torque guidelines in this manual.

Performance Specifications (Oil Pressure and Intake Manifold Temperature)

Description	650 rpm (idle)	1200 rpm	1750 rpm	Full Load (Peak Torque rpm)
Oil pressure				
— Cool engine	20 psi (138 kPa)	45 psi (310 kPa)	65 psi (448 kPa)	—
— Warm engine	15 psi (103 kPa)	30 psi (207 kPa)	45 psi (310 kPa)	—
Intake manifold temperature	Outside air temperature	—	—	100–140°F* (38–60°C)

*Dependent on outside air temperature and vehicle speed.

FASTENER TORQUE

Fastener Selection and Installation

Selection and correct installation of threaded fasteners are essential parts of any assembly or rebuild procedure. Fasteners hold much of a vehicle together. If a fastener fails to do its job properly, it can cause a minor problem such as a loose mirror, or a large problem, such as loss of steering control.

Because there are so many styles of fasteners, in various sizes and quality grades, a mechanic must have a working familiarity with the fasteners commonly used in vehicles. Only in this way can the correct selection and installation of the proper fastener be ensured. Each fastener is intended to do a particular job, and is selected by the vehicle manufacturer for its suitability for that job.

Proper installation is as important as the selection of the correct fastener. Improperly installing a correct fastener is just as bad as using an incorrect one. Undertightening and overtightening both result in an improperly installed fastener. When threaded fasteners are tightened, a slight stretching of the fastener occurs, and it is this stretching that binds the assembly together. If too little tightening occurs, the slight stretching does not happen, and the joint is not clamped securely. If too much tightening occurs, the fastener will be excessively stretched, causing narrowing of the fastener and possibly breaking. Correct and consistent use of a torque wrench ensures the fasteners are properly tightened, and clamping the pieces of the assembly together.

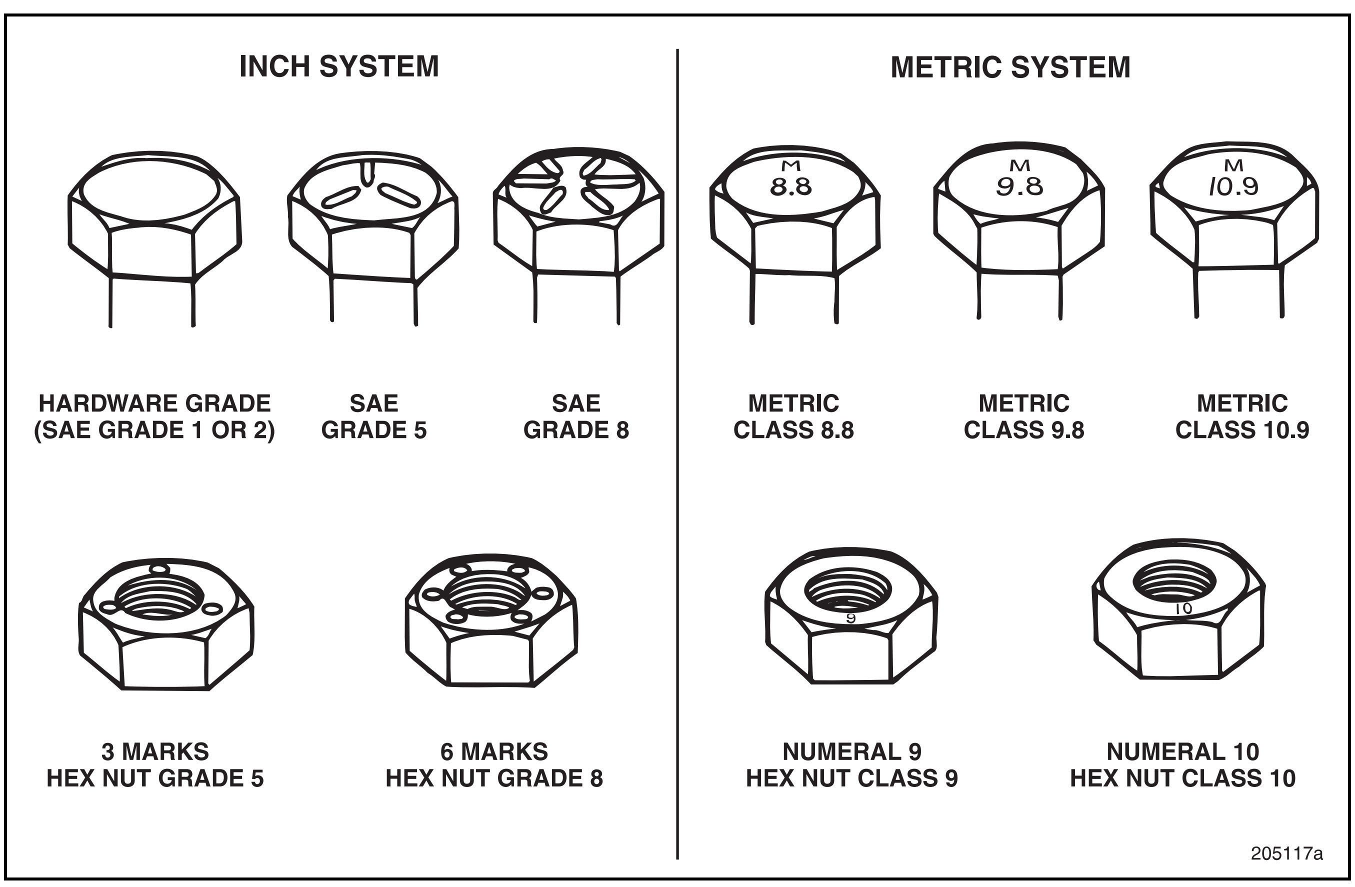


Figure 2-1 — Fastener Grading System

Fastener Sizes and Types

The first and most important fact that the mechanic must know about a fastener is whether it is a U.S. (Inch System) or a metric thread. Next, the size of the fastener, which is usually determined by the diameter of the shank, the length of the fastener, which is usually measured from the bottom of the head to the end of the thread, and the pitch of the threads.

The pitch of U.S. (Inch System) fasteners is measured by determining the number of threads per inch. The two pitches commonly used in vehicles are coarse thread, officially called Unified National Coarse (UNC), and fine thread, officially called Unified National Fine (UNF).

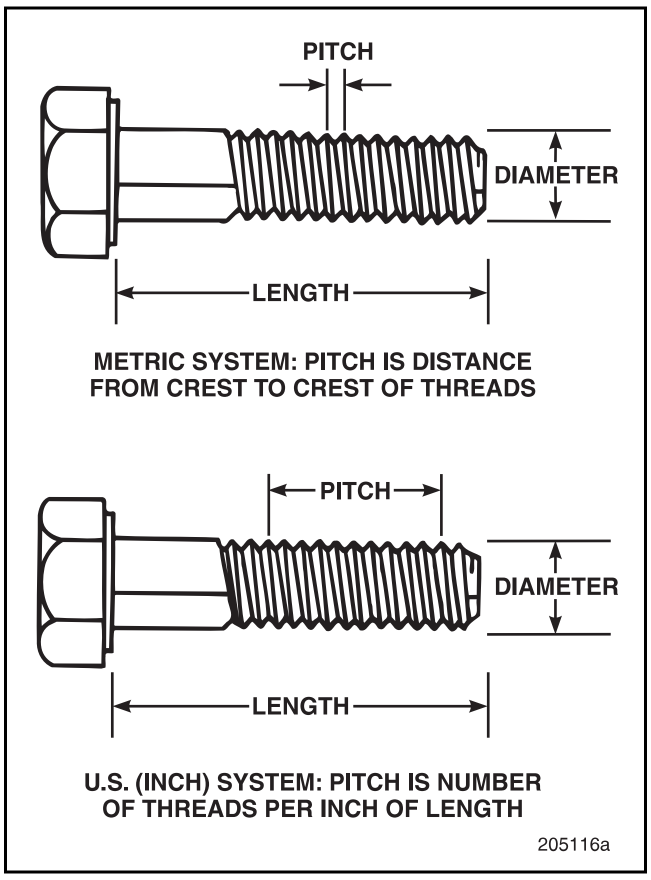


Figure 2-2 — Fastener Dimensions

The pitch of metric fasteners is measured by determining the millimeters per thread. For example, a bolt with 0.8 pitch would have 125 complete threads in a 100-millimeter section (100 mm divided by 125 threads equals 0.8), and a bolt with 1.0 pitch would have 100 threads in a 100-millimeter section. Pitch may be measured directly, using a ruler and counting the threads. Also, thread pitch gauges are available for both U.S. and metric threads, which make it easy to check the pitch of a fastener.

In the U.S. system, a typical designation would be: 7/16-20 x 1. This describes a bolt that is 7/16 inch in diameter, has 20 threads per inch, and is one inch long. The metric system is similar. A typical metric designation would be: 10 x 0.8 x 25 mm. This describes a bolt that is 10 mm in diameter, has a thread pitch of 0.8 (0.8 mm per thread), and is 25 mm long.

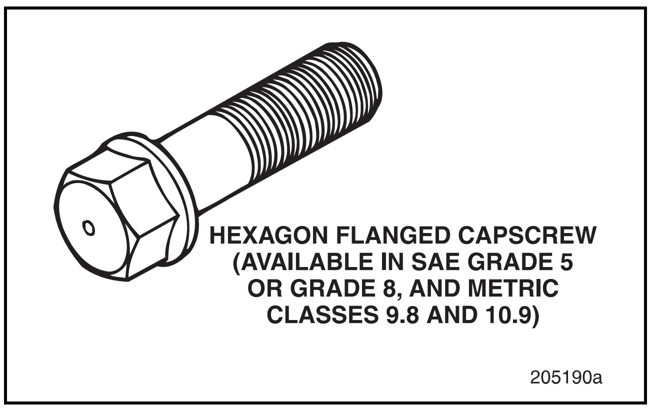


Figure 2-3 — Flanged Capscrew

TORQUE SPECIFICATIONS

This section includes specifications for torquing all critical and standard non-critical fasteners.

Torque Specifications for Critical Fasteners

Description	Torque	
	Lb-Ft	N•m
Air compressor-to-cylinder block screw	70	95
Auxiliary driveshaft gear nut (front)	300 dry	407
Auxiliary driveshaft hole cover stud nut	40	54
Auxiliary driveshaft thrust washer-to-block screw	15	20
Brake harness adapter (at cylinder head)	8①	11
Brake (Dynatard®)		
Brake hydraulic lash adjuster retainer nut	27①	37
Brake solenoid to adapter	8①	11
Brake solenoid adapter to rocker arm shaft	24①	33
Brake (Jacobs)		
Cylinder head cover/spacer capscrews	20	27
Electrical connector	5	7
Engine brake hold-down capscrew	45	61
Oil supply screw	5	7
Rocker arm adjusting screw jam nut	40	54
Rocker arm bracket hold-down capscrew	40	54
Slave piston adjusting screw nut	17	23
Throttle switch actuating arm	55 (lb-in)	6
Yoke leveling screw jam nut	33	45
Buttress screw	90	122
Camshaft thrust washer-to-block screw	15	20
Centrifugal oil filter drain fitting stud nut	40	54
Clutch cover-to-flywheel screw	40	54
Connecting rod screw	150	203
Coolant conditioner-to-water fitting screw	15	20
Crankcase drain plug	55	75
Cylinder head breather-pipe-to-cylinder-head cover screw	15	20
Cylinder head capscrew	205	278
Cylinder head cover screw	16	22
Econovance assembly-to-cylinder block screw	40②	54②
Econovance control valve and cover plate-to-Econovance screw	180 lb-in②	20②
Econovance diagnostic port cap	125 lb-in②	14②
Econovance thrust washer retaining screw	150②	203②

① English threads.
② V-MAC applications.

Torque Specifications for Critical Fasteners (Cont.)

Description	Torque	
	Lb-Ft	N•m
Engine turnover bracket screw	40	54
Exhaust manifold-to-cylinder-head stud nut		
10 mm	55 dry	75
12 mm	65 dry	88
Fan drive pulley to hub	40	54
Flywheel housing-to-cylinder block screw	170	231
Flywheel-to-crankshaft screw	185	251
Fuel filter bracket-to-inlet manifold screw	35	48
Hydraulic steering pump-to-timing gear cover stud nut	40	54
Injection line clamp bracket stud nut	40	54
Injection nozzle holder clamping screw (1991 and later)	45	61
Injection nozzle holder clamping screw (1989/1990)	45	61
Injection pump driven gear hub-to-injection pump shaft nut	200 dry	271
Injection pump driven gear-to-hub screw	40	54
Injection pump housing-to-Econovance assembly-to-cylinder block screw	40②	54②
Injection pump housing-to-Econovance assembly screw	40②	54②
Injection pump driven gear-to-Econovance outer shaft	40②	54②
Injection pump mounting stud nut (mechanical pumps)	40	54
Inlet manifold-to-cylinder head screw	40	54
Injection pump access cover capscrews	30	41
Injection pump rear support		
Lower bracket-to-cylinder block screw	40②	54②
Upper bracket-to-injection pump screw	15②	20②
Link(s)-to-lower bracket screw	40②	54②
Link(s)-to-upper bracket screw	40②	54②
Injection pump-to-adapter housing screw	40②	54②
Main bearing capscrew	210	285
Nozzle fuel inlet tube clamp screw (at cylinder head)	35	47
Nozzle fuel inlet tube nut (at cylinder head)	25	34
Nozzle fuel inlet tube nut (at pump)	25	34
Oil cooler fitting-to-water pump	60	81
Oil cooler oil inlet tube screw	40	54
Oil cooler water inlet fitting screw	20	27
OC/OFT fitting-to-oil filter bracket screw	40	54

① English threads.
② V-MAC applications.

Torque Specifications for Critical Fasteners (Cont.)

Description	Torque	
	Lb-Ft	N•m
Oil fill hole cover screw	15	20
Oil filler/tube drain-to-block screw	15	20
Oil filter bracket-to-cylinder block screw	60	81
Oil filter valve plunger spring cap	100	136
Oil pan-to-cylinder block screw	30	41
Oil pump driven gear retaining nut	60	81
Oil pump-to-cylinder block mounting screw	40	54
Oil pump housing cover screw	15	20
Oil pump inlet fitting-to-pump assembly screw	35	47
Oil pump pressure relief valve cap	80	109
Piston cooling nozzle screw	15	20
Rocker arm adjusting screw nut	40	54
Rocker arm bracket-to-cylinder head screw	40	54
Rocker arm shaft locating screw	23 ①	31
Timing gear cover and front support bracket-to-cylinder block screw	70	95
Timing gear cover-to-cylinder block screw	40	54
Timing hole cover screw	40	54
Timing indicator screw	15	20
Torque drive hub retaining capscrew	15	20
Transmission-to-flywheel housing screw	40	54
Turbo oil inlet screw	15	20
Turbo oil drain screw	15	20
Turbo-to-exhaust manifold stud nut	40	54
Valve yoke screw locknut	33	45
Vibration damper hub-to-crank screw	360	488
Vibration damper-to-hub screw	45	61
V-MAC components:		
Control valve mounting capscrews	15	20
Drive hub retaining capscrew	150	203
Econovance mounting capscrews	40	54
Econovance drive coupling bolt	150	203
Injection pump mounting capscrews	40	54
Injection pump access cover capscrews	30	41
Injection pump driven gear capscrews	40	54
Link-to-support bracket capscrews	40	54

① English threads.
② V-MAC applications.

Torque Specifications for Critical Fasteners (Cont.)

Description	Torque	
	Lb-Ft	N•m
V-MAC components (cont.)		
Lower support bracket-to-cylinder block capscrews	40	54
Upper support bracket-to-injection pump capscrews	15	20
Timing event marker (TEM)	22	30
V-MAC 7-pin pump connector	15	20
Bracket-to-block capscrews	40	54
Hose clamp screw	15	20
RPM/TDC (engine position) sensor (jam nut)	15	20
MPH (road speed) sensor (jam nut)	15	20
Engine oil pressure sensor	6	8
Intake manifold temperature sensor	23	31
Coolant temperature sensor	23	31
Coolant level sensor	23	31
Bulkhead connector (jackscrew)	5	7
V-MAC module connector (jackscrew)	2	3
V-MAC ELAB valve terminal nut	3	4
Fuel injection pump actuator connector	15	20
Electrical equipment panel mounting leg hardware	6	8
Electrical equipment panel accessory studs	2	3
Timing solenoid to Econovance (four bolts)	15	20
Water manifold screw	25	34
Water pump cover-to-water pump housing screw	15	20
Water pump shaft locknut	90	122
Water pump-to-cylinder block screw	60	81

① English threads.
② V-MAC applications.

Torque Specifications for Hose Clamps

Hose Clamps	Torque	
	Lb-In	N•m
SAE J536 Type F		
Air inlet systems	38	4
Water or coolant systems	28	3
Oil drain systems	28	3
Hi-torque heavy-duty worm clamp	80	9
T-bolt type hose clamp	50	6

NOTE: The band of any hose clamp in all installations should be a minimum of 0.090 inch (2.290 mm) from the end of the hose and must be clear of tube bead.

Torque Specifications for Pipe Plugs

Pipe Plugs	Torque	
	Lb-Ft	N•m
1/8 NPT	6	8
1/4 NPT	18	24.4
3/8 NPT	23	31
1/2 NPT	23	31
3/4 NPT	28	38
1 NPT	43	58
1-1/2 NPT	75	102

NOTE: All pipe plugs which are not new plugs with preapplied thread sealer must be sealed using Loctite® PST pipe thread sealant with Teflon or equivalent.

Torque Specifications for Non-Critical Fasteners

PROPERTY CLASS 8.8

Size (mm)	Pitch	Tightening Torques	
		Lb-Ft	N•m
6	0.75	6	8
6	1.00	6	8
8	1.00	15	20
8	1.25	14	19
10	1.25	30	41
10	1.50	28	38
12	1.25	55	75
12	1.75	50	68
14	1.50	86	117
14	2.00	80	109
16	1.50	133	180
16	2.00	124	168
18	1.50	193	262
18	2.50	172	233
20	1.50	270	366
20	2.50	244	331
22	1.50	365	495
22	2.50	332	450
24	2.00	459	622
24	3.00	421	571
27	2.00	666	903
27	3.00	618	838
30	2.00	928	1258

Torque Specifications for Non-Critical Fasteners (Cont.)

PROPERTY CLASS 8.8 (Cont.)

Size (mm)	Pitch	Tightening Torques	
		Lb-Ft	N•m
30	3.50	838	1136
33	2.00	1250	1695
33	3.50	1140	1546
36	3.00	1551	2103
36	4.00	1465	1986

PROPERTY CLASS 9.8

Size (mm)	Pitch	Tightening Torques	
		Lb-Ft	N•m
6	0.75	7	10
6	1.00	6	8
8	1.00	16	22
8	1.25	15	20
10	1.25	33	45
10	1.50	31	42
12	1.25	59	80
12	1.75	54	73
14	1.50	94	127
14	2.00	87	118
16	1.50	144	195
16	2.00	135	183
18	1.50	210	285
18	2.50	187	254
20	1.50	293	397
20	2.50	264	358
22	1.50	395	536
22	2.50	360	488
24	2.00	498	675
24	3.00	456	618
27	2.00	722	979
27	3.00	669	907
30	2.00	1005	1363
30	3.50	908	1231
33	2.00	1355	1837
33	3.50	1235	1674
36	3.00	1681	2279
36	4.00	1587	2152

Torque Specifications for Non-Critical Fasteners (Cont.)

PROPERTY CLASS 10.9

Size (mm)	Pitch	Tightening Torques	
		Lb-Ft	N•m
6	0.75	9	12
6	1.00	8	11
8	1.00	21	29
8	1.25	20	27
10	1.25	42	57
10	1.50	40	54
12	1.25	76	103
12	1.75	69	94
14	1.50	120	163
14	2.00	111	151
16	1.50	184	250
16	2.00	172	233
18	1.50	268	363
18	2.50	239	324
20	1.50	374	507
20	2.50	337	457
22	1.50	505	685
22	2.50	460	624
24	2.00	636	862
24	3.00	583	790
27	2.00	922	1250
27	3.00	855	1159
30	2.00	1284	1741
30	3.50	1159	1571
33	2.00	1730	2346
33	3.50	1578	2140
36	3.00	2146	2910
36	4.00	2027	2748

FITS AND LIMITS

The specifications listed are for new parts. Good judgement, experience and sound shop practice must be used when determining whether to reuse or replace service parts.

Fits and Limits

Component	Standard Size or Fit	
	English	Metric
AUXILIARY DRIVESHAFT (CAPTURED THRUST WASHER)		
Shaft bushing — presized ID (front and rear)	2.064–2.068 in.	52.426–52.527 mm
— presized OD (front and rear)	2.3140–2.3155 in.	58.7756–58.8137 mm
— bore in block (front and rear)	2.311–2.312 in.	58.699–58.725 mm
— press fit in bore (front and rear)	0.002–0.0045 in.	0.0518–0.1143 mm
Shaft end play	0.003–0.012 in.	0.076–0.305 mm
Shaft journal to bushing (front and rear)	0.0020–0.0072 in.	0.0508–0.1829 mm
Shaft journal diameter OD (front and rear)	2.061–2.062 in.	52.349–52.375 mm
Oil pump driving gear ID (press fit)	1.6255–1.6250 in.	41.2877–41.2750 mm
Auxiliary shaft oil pump drive journal	1.6278–1.6272 in.	41.3461–41.3309 mm
Air compressor drive sprocket (press fit)	1.1250–1.242 in.	28.575–31.547 mm
Auxiliary shaft air compressor sprocket journal	1.1272–1.1268 in.	28.6309–28.6207 mm
CAMSHAFT		
Bushing — presized ID (No. 1 through No. 7)	2.693–2.692 in.	68.402–68.377 mm
— free OD (No. 1 through No. 7)	2.8785–2.8765 in.	73.1139–73.0631 mm
— bore in block (No. 1 through No. 7)	2.874–2.873 in.	73.000–72.974 mm
— press fit in bore (No. 1 through No. 7)	0.0025–0.0055 in.	0.0635–0.1397 mm
End play	0.003–0.012 in.	0.076–0.305 mm
Journal diameter (No. 1 through No. 7)	2.6895–2.6885 in.	68.3133–68.2879 mm
Journal-to-bushing clearance (No. 1 through No. 7)	0.002–0.004 in.	0.051–0.102 mm
Camshaft gear bore ID	1.8758–1.8750 in.	47.6453–47.6250 mm
Camshaft gear journal (press fit)	1.8784–1.8779 in.	47.7114–47.6987 mm
Camshaft gear driving injection pump drive (press fit)	1.8135–1.8125 in.	46.0629–46.0375 mm
Camshaft gear driving journal	1.8159–1.8153 in.	46.1239–46.1086 mm
CONNECTING ROD		
Length between centers	10.4375 in.	26.5113 cm
Cap angle	35 degrees	
Bore for bushing	2.4355–2.4345 in.	61.8617–61.8363 mm
Burnish bushing to	2.2305–2.2275 in.	56.6547–56.5785 mm
Finish bore to	2.2504–2.2500 in.	57.1602–57.1500 mm
Crankpin bore diameter — as bored	3.4305–3.4297 in.	87.1347–87.1144 mm
— reassembled	3.4309–3.4294 in.	87.1449–87.1068 mm
Bearing ID in place	2.9993–3.0013 in.	76.1822–76.2330 mm
Journal clearance	0.0012–0.0054 in.	0.0305–0.1372 mm

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
CONNECTING ROD (CONT.)		
Side clearance	0.007–0.014 in.	0.1778–0.3556 mm
Twist within 12 inches (30.48 cm)	0.010 in.	0.254 mm
Bend within 12 inches (30.48 cm)	0.004 in.	0.1016 mm
CRANKSHAFT		
Crankpin journal OD	3.248–3.247 in.	82.4992–82.4738 mm
End play at No. 4 main	0.004–0.013 in.	0.1016–0.3302 mm
Main journal OD	4.4974–4.4964 in.	114.2340–114.2086 mm
Journal out-of-round or taper (maximum diameter)	0.00035 in.	0.00889 mm
Max. Runout at No. 4 journal (shaft supported on No. 1 and No. 7)	0.007 in.	0.178 mm
CYLINDER BLOCK		
Deck flatness	0.002 in.	0.0508 mm
Dowel pin holes (flywheel housing to block mounting)	0.6237–0.6247 in.	15.8420–15.8674 mm
Cylinder bore in block — upper	5.501–5.500 in.	139.725–139.970 mm
— lower	5.1266–5.1250 in.	130.2156–130.1750 mm
Cylinder bore out-of-round or taper on diameter For service block only — maximum on reboring block: 0.001 inch (0.0254 mm).	0.004 in. max.	0.1016 mm
Sleeve, flange channel depth above block deck (do not measure from top of bead)	0.022–0.027 in	0.5588–0.6858 mm
Sleeve OD at upper pilot diameter	5.5040–5.5030 in.	139.8016–139.7762 mm
Sleeve bead for fire ring — protrusion above sleeve channel	0.0067–0.010 in.	0.1702–0.2540 mm
Sleeve in bore — upper press fit	0.004–0.002 in.	0.1016–0.0508 mm
— lower loose fit	0.0029–0.0003 in.	0.0737–0.0076 mm
Sleeve ID installed STD — minimum	4.8755 in.	123.8377 mm
— maximum	4.877 in.	123.8758 mm
Main bearing bore in block	4.818–4.817 in.	122.3772–122.3518 mm
Main bearing-to-crankshaft journal clearance	0.0022–0.0056 in.	0.0559–0.1422 mm
Main bearing ID in place	4.502–4.4996 in.	104.3508–114.2898 mm
Valve lifter bore	0.6865–0.6875 in.	17.4371–17.4625 mm
Valve lifter shank diameter	0.6855–0.6860 in.	17.4117–17.4244 mm
Valve lifter OD	1.380–1.385 in.	35.052–35.179 mm
Valve lifter to bore clearance	0.0005–0.0020 in.	0.0127–0.0508 mm
NOTE: Extension of the cylinder sleeve above the cylinder block deck can vary under the same head, as long as all are within the 0.022–0.027 inch specification.		
CYLINDER HEAD		
Alignment across exhaust ports	0.005 in.	0.127 mm
Deck flatness over 18 in. (45.72 cm)	0.0015 in.	0.0381 mm
Overall height	6.391–6.397 in.	162.331–162.484 mm

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
CYLINDER HEAD (CONT.)		
Injection nozzle holder insert to bore fit — upper and intermediate	0.001–0.003 in. tight	0.0254–0.0762 mm
— lower	0.0015–.004 in. tight	0.0381–0.1016 mm
Injection nozzle holder insert bore — upper and intermediate bore	0.9360–0.9375 in.	23.7744–23.8125 mm
— bottom bore	0.904–0.906 in.	22.962–23.012 mm
Injection nozzle holder insert OD — upper and intermediate	0.9390–0.9385 in.	23.8506–23.8379 mm
— lower 1/2 inch (12.7 mm)	0.9080–0.9075 in.	23.0632–23.0505 mm
Fire ring groove — width	0.030–0.036 in.	0.762–0.914 mm
— depth	0.005–0.013 in.	0.127–0.330 mm
— ID	5.137–5.139 in.	130.479–130.531 mm
Valve guide OD	0.6886–0.6881 in.	17.4904–17.4777 mm
Valve guide ream ID (after installation) inlet and exhaust (used with 3/8 valve stem)	0.3745–0.3755 in.	9.5123–9.5377 mm
Top end of valve guide to valve spring seat	0.959 ± 0.040 in.	24.359 ± 1.016 mm
Valve guide bore in head	0.686–0.687 in.	17.424–17.450 mm
Valve guide to bore (press fit)	0.0011–0.0026 in.	0.0279–0.0660 mm
Valve guide extension (fire deck to top of guide)	5.24 ± 0.03 in.	113.096 ± 0.762 mm
Yoke guide pin OD	0.4389–0.4392 in.	11.1481–11.1557 mm
Yoke guide pin installed height	1.848–1.918 in.	46.939–48.717 mm
Valve seat width — exhaust	0.051–0.081 or 1/16 ± 1/64 in.	1.295–2.057 mm or 1.588 ± 0.397 mm
— inlet	0.051–0.081 or 1/16 ± 1/64 in.	1.295–2.057 mm or 1.588 ± 0.397 mm
Valve seat insert face angle		
Before November 1996 — inlet and exhaust	30° – 0'/+30'	
November 1996 and later — inlet	20° 30' ± 15'	
— exhaust	30° – 0'/+30'	
Valve seat width runout	0.001 in. F.I.M.	0.0254 mm
Valve seat insert counterbore diameter — exhaust	1.6875–1.6885 in.	42.8625–42.8879 mm
— inlet	1.8285–1.8295 in.	46.4439–46.4693 mm
Valve seat OD — exhaust	1.692–1.693 in.	42.977–43.002 mm
— inlet	1.831–1.832 in.	46.507–46.533 mm
Valve seat insert press fit in head — exhaust	0.0035–0.0055 in.	0.0889–0.1397 mm
— inlet	0.0015–0.0035 in.	0.0381–0.0889 mm
Valve seat counterbore depth — exhaust	0.372–0.376 in.	9.449–9.550 mm
— inlet	0.360–0.364 in.	9.144–9.246 mm

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
FLYWHEEL AND HOUSING		
Dowel pins		
Hole in flywheel housing — LH for round pin	0.6259–0.6263 in.	15.8979–15.9080 mm
— RH for diamond pin	0.6831–0.6835 in.	17.3507–17.3609 mm
— RH for blade pin		
Pin OD — LH round pin	0.6251–0.6253 in.	15.8775–15.8826 mm
— RH diamond pin		
— RH blade pin		
Cylinder block end	0.6251–0.6253 in.	15.8775–15.8826 mm
Flywheel housing end	0.6820–0.6825 in.	17.3228–17.3355 mm
Crankshaft seal mounting bore	6.748–6.752 in.	171.3992–171.5008 mm
Flywheel housing transmission mounting face runout	0.008 in. T.I.R.*	0.2032 mm*
Flywheel housing transmission pilot bore runout	0.010 in. T.I.R.*	0.254 mm*
Flywheel housing rear seal bore runout	0.009 in. T.I.R.*	0.2286 mm*
Starter motor mounting bore	3.625–3.629 in.	92.075–92.117 mm
* Must be held relative to main bearing bores. Check runout with an alignment bar installed through the cylinder block main bearing bores.		
OIL PUMP		
Gear-to-cover end clearance	0.0035–0.0060 in.	0.0889–0.1524 mm
Gear-to-cavity side clearance	0.0030–0.0045 in.	0.0762–0.1143 mm
Gear backlash in pump	0.0235–0.0295 in.	0.5969–0.7493 mm
Oil pump drive gear-to-oil pump driven gear backlash	0.0072–0.0138 in.	0.1829–0.3505 mm
Relief valve spring, free length	6.38 in.	162.052 mm
Spring pressure when compressed to 5.56 inches (14.12 cm)	63 lbs.	28.6 kg
Relief valve opening pressure	90–115 psi	621–793 kPa
OIL PRESSURE RELIEF VALVE		
Oil filter bypass relief valve spring, free length	4.648 in.	118.06 mm
Spring pressure when compressed to 3.625 inches (9.27 cm)	12.27 ± .61 lbs.	5.57 ± .28 kg
PISTON		
Top, extension above cylinder block deck at TDC	(–)0.002 – (+)0.020 in.	0.0508–0.508 mm
Wrist pin — pin bore hole ID (vertical direction only)	2.2491–2.2497 in.	57.1271–57.1424 mm
— length	3.820–3.825 in.	97.028–97.155 mm
— pin to bushing clearance	0.0002–0.0009 in.	0.0051–0.0229 mm
— OD	2.24875–2.24895 in.	57.11825–57.12333 mm
— fit	0.00035–0.00075 in.	0.00889–0.01905 mm
Piston-to-liner clearance 90 degrees from pin axis (Zollner piston No. 240GC590A)	0.004–0.006 in.	0.1016–0.1524 mm

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
PISTON (CONT.)		
Ring groove service limit over 0.120 inch pins (3.048 mm)		
Top groove	4.912 in.	124.765 mm
PISTON RINGS		
Piston ring end gap — when checked in 4.875 gauge diameter		
Compression rings — No. 349GC3101	0.016–0.028 in.	0.406–0.711 mm
Compression rings — No. 349GC3102	0.013–0.025 in.	0.330–0.635 mm
Oil control ring — No. 350GC340	0.013–0.028 in.	0.330–0.711 mm
Piston ring side clearance (new)	0.0016–0.0030 in.	0.0406–0.0762 mm
Piston ring side clearance (used)	Maximum 0.0045 in.	Maximum 0.1143 mm
NOTE: Refer to MACK branch or distributor for specifications for piston ring part numbers not listed above. NOTE: For every 0.001 in. (0.0254 mm) increase in gauge diameter, ring gap will increase by 0.003 in. (0.076 mm).		
ROCKER ARM		
Ratio	1.5:1	
Hole ID	1.1306–1.1326 in.	28.7172–28.7680 mm
Hole-to-shaft clearance	0.004–0.0015 in.	0.1016–0.0381 mm
Shaft OD	1.1286–1.1291 in.	28.6664–28.6791 mm
Push rod overall length — intake and non-brake exhaust (flat to cup top)	15.751–15.813 in.	400.075–401.650 mm
Push rod overall length — exhaust w/Dynatard (flat to flat)	16.353–16.388 in.	415.366–416.255 mm
TIMING GEAR COVER		
Dowel Pins		
Holes in cylinder block (both)	0.4987–0.4997 in.	12.6670–12.6924 mm
Hole in timing gear cover — RH for round pin	0.5005–0.5012 in.	12.7127–12.7305 mm
— LH for diamond pin	0.5577–0.5584 in.	14.1656–14.1834 mm
Pin OD — RH for round pin	0.5001–0.5003 in.	12.7025–12.7076 mm
— LH for diamond pin, cylinder block end	0.5001–0.5003 in.	12.7025–12.7076 mm
— LH for diamond pin, timing cover end	0.5570–0.5575 in.	14.1478–14.1605 mm
Crankshaft seal mounting bore	3.9995–4.0025 in.	101.5873–101.6635 mm
Seal square to hub	0.010 in.	0.254 mm
Seal mounting bore-to-crank runout	0.015 in. T.I.R.*	0.381 mm*
Hydraulic steering pump mounting bore	3.2525–3.2545 in.	82.6135–82.6643 mm
* Must be held relative to main bearing bores. Check runout with an alignment bar installed through the cylinder block main bearing bores.		
TIMING GEAR		
Backlash — injection pump drive gear to injection pump driven gear	0.0025–0.0095 in.	0.0635–0.2413 mm
— all other gears	0.0013–0.0108 in.	0.0330–0.2743 mm

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
TURBOCHARGER		
Model S3B (S4D)		
Shaft end play	0.003–0.006 in.	0.0762–0.1524 mm
Bearing radial check (measured at bearings)	0.018–0.030 in.	0.4572–0.7620 mm
	(0.018–0.025) in	(0.4572–0.6350 mm)
Model S300, S400		
Shaft end play	0.003–0.006 in.	0.0762–0.1524 mm
Bearing radial check (measured at bearings)	0.018–0.029 in.	0.4572–0.7366 mm
VALVE		
Deck to valve face — inlet	+ 0.0425 ± 0.007 in.	+1.0795 ± 0.1778 mm
— exhaust (pre-1994)	– 0.0414 ± 0.007 in.	–1.0516 ± 0.1778 mm
— exhaust (Pyromet, 1994 and later)	– 0.021 ± 0.007 in.	–1.5334 ± 0.1778 mm
Stem to guide — inlet	0.0015–0.0035 in.	0.0381–0.0889 mm
— exhaust	0.0025–0.0045 in.	0.0635–0.1143 mm
Stem to rocker arm lash (cold static) — inlet	0.016 in.	0.4064 mm
— exhaust (prior to May 1996)	0.024 in.	0.6096 mm
— exhaust (May 1996 and later)*	0.028 in.	0.7112 mm
*Cam part No. 454GC5205		
Face runout, inlet and exhaust	0.0015 in.	0.0381 mm
Seat angle before November 1996 — inlet and exhaust	30° + 0'/–30'	
November 1996 and later — inlet	20° 30' ± 15'	
— exhaust	30° + 0'/–30'	
Stem OD — inlet (3/8 in.)	0.373–0.372 in.	9.474–9.449 mm
— exhaust (7/16 in.)	0.3720–0.3710 in	9.4488–9.4234 mm
VALVE SPRINGS		
Free length	2.640 in.	67.056 mm
Spring pressure — when compressed to 1.435 in. (36.45 mm)	142.5–157.5 lbs.	64.6–71.4 kg
VALVE SPRINGS (with Jacob combination compression and exhaust brake)		
Free length	2.830 in.	71.882 mm
Spring pressure — when compressed to 1.5 in. (38.1 mm)	190–210 lbs.	86.184–95.256 kg

METRIC MISMATCH

WARNING

Certain metric/English fastener thread combinations are incompatible and may result in mismatch conditions. These conditions can cause thread stripping and/or assembly weaknesses which may lead to service failure, rendering a vehicle inoperative or unsafe for operation.

Inch Thread vs. Metric Thread Fastener Combinations Contributing to Thread Stripping

The following inch/metric screw and nut (or tapped hole) combinations can be finger started (at least two full turns), but will strip if fully assembled.

Inch Screws	Metric Nuts
4-40	M3 x 0.5
5/16-18	M8 x 1.25
*5/16-24	M8 x 1.25
3/8-16	*M10 x 1.25
*3/8-24	*M10 x 1.25
	M10 x 1.5
	*M10 x 1.0
7/16-14	*M12 x 1.25
*7/16-20	M12 x 1.75
	*M10 x 1.25
*1/2-20	M14 x 2
*5/8-18	*M16 x 1.5
*7/8-14	M24 x 3
*1-12	M27 x 3

*Fine thread

Inch Nuts	Metric Screws
5-40	M3 x 0.5
1/4-20	M6 x 1.0
*1/4-28	M6 x 1.0
*5/16-24	*M8 x 1.0
7/16-14	M10 x 1.5
7/16-14	*M10 x 1.25
7/16-14	*M10 x 1.0
1/2-13	M12 x 1.75
*1/2-20	M12 x 1.75
1/2-13	*M12 x 1.5
*1/2-20	*M12 x 1.5
1/2-13	*M12 x 1.25
9/16-12	M14 x 2
*9/16-18	*M14 x 1.5
*5/18-18	*M16 x 1.5
1-8	*M24 x 2

*Fine thread

Inch Thread vs. Metric Thread Fastener Combinations Contributing to Assembly Weakness

The following inch/metric screw and nut (or tapped hole) combinations can be fully tightened, but the resulting assembly will be 25% to 60% weaker than required. Service failure of the assembly is probable.

Inch Screws	Metric Nuts
*4-48	M3 x 0.5
5-40	M3.5 x 0.6
6-40	M3.5 x 0.6
*8-36	M4 x 0.7
*10-32	M5 x 0.8
12-24	M6 x 1.0
*1/4-28	M7 x 1.0
3/8-16	M10 x 1.5
7/16-14	M12 x 1.75
1/2-13	M14 x 2
3/4-10	M20 x 2.5
*3/4-16	*M20 x 1.5
7/8-9	M24 x 3

*Fine thread

Inch Nuts	Metric Screws
*5-44	M3 x 0.5
*6-40	M3.5 x 0.6
8-32	M4 x 0.7
*8-36	M4 x 0.7
*10-32	M5 x 0.8
12-24	M5 x 0.8
*12-28	M5 x 0.8
*1/2-20	*M12 x 1.25
3/4-10	M18 x 2.5
*3/4-16	*M18 x 1.5
1-8	M24 x 3
*1-12	M24 x 2

*Fine thread

Incompatible Metric vs. Metric Fastener Systems

Thread mismatch can also result when combining fasteners from incompatible metric fastener systems. The resulting faulty thread engagement typically causes thread stripping and/or assembly weakness which may lead to service failure.

CONVERSION FACTORS

1 inch	= 25.4 millimeters
1 mile	= 1.61 kilometers
1 pint (U.S. liquid)	= .473 liter
1 quart (U.S. liquid)	= .946 liter
1 cubic inch	= .01639 liter
1 pound-foot	= 1.3558 Newton-meters
1 horsepower	= .746 kilowatt
1 pound/square inch	= 6.895 kilopascals
1 pound/square inch	= 27.6 inches of water/2.04 inches of mercury
degrees Fahrenheit	= (1.8 x degrees Celsius) + 32
1 gallon (U.S. liquid)	= .83267 imperial gallon
1 millimeter	= .03937 inch
1 kilometer	= .6214 mile
1 liter	= 2.1134 pints (U.S. liquid)
1 liter	= 1.0567 quarts (U.S. liquid)
1 liter	= 61.024 cubic inches
1 Newton-meter	= .7376 pound-foot
1 kilowatt	= 1.34 horsepower
1 kilopascal	= .145 pound/square inch
degrees Celsius	= .556 x (degrees Fahrenheit – 32)
1 imperial gallon	= 1.2009 gallons (U.S. liquid)

000068a

SPECIAL TOOLS

Special Tool List

Tool No.	Description
814	Midget Seal Tool
022001	Jacobs Thickness Gauge, 0.060 inch (1.52 mm)
018781	Jacobs Thickness Gauge, 0.080 inch (2.03 mm)
014177	Jacobs Thickness Gauge, 0.085 inch (2.16 mm)
021327	Jacobs Thickness Gauge, 0.100 inch (2.54 mm)
945-6041	Connecting Rod Fixture (Sweeney)
HT77136	Valve Seat Insert Counterbore
J 21588	Injector Gasket Retriever
J 22738-02	Universal Spring Tester, Model MST 50
J 23442	Piston Ring Compressor
J 2619-01	Slide Hammer
J 26589	Nozzle Insert Carbon Reamer
J 26637-A	Thermostat Seal Installer
J 26948	Depth Gauge
J 28452	Injection Pump Drive Coupling Holder R.B.
J 28452-A	Injection Pump Drive Coupling Holder
J 29109	Engine Stand
J 29294-B	Valve Spring Keeper Remover
J 29296	Valve Yoke Guide Pin Installer
J 29297	Nozzle Sleeve Installer
J 29510	Keystone Piston Ring Groove Gauge
J 29539-15	Top Dead Center Indicator Metric Adapter
J 29539-A	Top Dead Center (TDC) Indicator
J 29600-C	Fire Ring Groove Cutter
J 29880	Nozzle Sleeve Extractor
J 34046-A	Compression Gauge Adapter Set
J 34046-5	Compression Tester Metric Adapter (Used with J 34046-A)
J 34684	Cylinder Head Core Plug Installer (13/16 inch)
J 34687	Cylinder Head Core Plug Installer (1-1/16 inch)
J 35529	Wear Ring and Seal Installer
J 37077	Position Sensor
J 37078	P7100 Series Injection Pump Holding/Alignment Fixture
J 37085	Pump Drive Gear Aligner
J 37092	Dynatard Valve Lash Adjusting Wrench
J 37093	Injection Nozzle Puller
J 37481	Valve Guide Reamer (3/8-inch diameter)
J 37482	Valve Guide Remover (3/8 inch)

Special Tool List (Cont.)

Tool No.	Description
J 37710-A	Timing Gear Cover Diamond Dowel Aligner
J 37711	Flywheel Housing Diamond Dowel Aligner
J 37712	Flywheel Housing/Timing Cover Locating Pin Driver
J 37713	Camshaft Bushing Installation Removal Kit (Use with J 21428-01 Kit)
J 37715-A	Crankshaft Front Seal Installer
J 37716-B	Crankshaft Rear Seal Installer
J 37717	Connecting Rod Bushing Remover/Installer
J 37718	Piston Pin Burnishing Broach
J 37719	Fire Ring Groove Cutter
J 37720-C	Tappet Holders
J 37721-A	Piston Cooling Nozzle Spray Position Set (for 1989/1990 production)
J 37809	Valve Guide Installer (3/8 inch)
J 38048	Engine Stand Adapter Plate
J 38373	Injection Pump Drive Hub Retaining Nut Socket
J 38586	Valve Seat Installation Set
J 38587-A	Engine Barring Socket
J 38880	Wear Ring Installer
J 39045	Two-Piece Piston Cooling Nozzle Aimer (for 1991 and later production)
J 41071	Air Compressor Coupling Holding Wrench
J 41461	Camshaft Removal/Installation Tool
J 41473	Charge Air Cooler Tester
J 42185	Belt Tension Gauge
J 42453	Valve Seal Installer
J 5347-B	Dial Bore Gauge
J 5902-01	Cylinder Hone and Glaze Breaker
J 6692-B	Cylinder Compression Gauge
J 7872	Magnetic Base Indicator Tool
J 8092	Universal Driver Handle (threaded 3/4-10)
PT2210	Counterbore Tool
PT2210-14	Hex Key Wrench
PT2210-3A	Counterbore Cutter Plate
PT5025	Universal Dial Depth Gauge
PT5025-11	3-inch Stylus Extension
PT5035	Flywheel Housing Dial Indicator Set
PT5035-1	Flywheel Housing Indicator Extension
PT6390	Valve Seat Extractor Tool
PT6390-4	Collet
PT6391	Valve Seat Extractor Kit

Special Tool List (Cont.)

Tool No.	Description
PT6435	Cylinder Liner/Sleeve Puller (lubricate with extreme pressure lubricant J 23444-A)
PT6570-11	Dowelout, Extractor (7/16 inch)
PT6575	Basic Heavy-Duty Dowelout Kit
PT6587	Piston Ring Expander
PT7070-A	Piston Ring Compressor

V-MAC Tools

Tool No.	Description
J 37490	Diesel Electronic Connector Replacement Kit
J 37809	Valve Guide Installer (3/8 inch)
J 38351-B	Serial Link Adapter Assembly
J 38480	Portable Printer (use with J 38500-1)
J 38500-1	Pro-Link Diagnostic Scan Tool
J 38500-60A	Pro-Link Cable (to vehicle), 6-Pin Deutsch
J 38500-61	PC Interface Cable
J 38500-603A	Pro-Link V-MAC I Diagnostic Cartridge
J 38500-620A	Pro-Link V-MAC II Diagnostic Cartridge
J 38581	Connector, Test Adapter Kit
J 38582	Terminal Crimping and Removal Tool Kit
J 38675-C	Pro-Link 9000 V-MAC Diagnostic Kit
J 38675-D	V-MAC I/ITC
J 38740	V-MAC Hub Barring Tool
J 38748	V-MAC Test Lead, Seven-Pin Connector
J 39200	Fluke Model 87 Digital Multi-Meter
J 41443	Pro-Link 9000 V-MAC II Diagnostic Kit

ENGINE REMOVAL

GENERAL

Details of the engine removal procedure vary from one vehicle to another. This section provides general guidelines for removing the engine from the vehicle.

NOTE

Before beginning engine removal, make sure all equipment is available for use and has been inspected for safety.

Vehicle Preparation

NOTE

It is good practice to steam-clean the engine to remove road grime, grease and oil before starting work. Steam cleaning the engine and engine area allows more detailed inspection and improved workmanship.

Care must be used to keep moisture from entering the air intake system. If moisture does enter the system, make sure it is removed (dried out) before the engine is reinstalled.

1. Position vehicle on a flat and level surface in an area with ample work space in and around the vehicle. Ensure that a suitable lifting device is available.
2. Apply the parking brake and block the vehicle wheels to prevent vehicle from moving. Observe all safety precautions.
3. Disconnect the battery negative (ground) cable.
4. Drain the air tanks.

Engine Removal

1. Remove the hood and position it away from the work area to prevent accidents or hood damage. Refer to Hood Removal procedures in the appropriate vehicle manual.
2. Place a suitable container beneath the engine and drain engine oil and coolant. Open the coolant drain valves in the block, if applicable.
3. Using an appropriate filter wrench, remove the oil filters, fuel filters and coolant conditioner.
4. Loosen clamps that secure the air intake tube to the turbocharger and air filter. Remove the intake tube.
5. If vehicle is equipped with air conditioning:
   a. Using A/C refrigerant recovery and recycling equipment, recover the A/C system refrigerant.
   b. Disconnect the A/C compressor discharge hose at connection near the radiator support.
   c. Disconnect the A/C line at the receiver/dryer.
   d. Locate and disengage the electrical connector from binary pressure switch on the receiver/dryer.
   e. Locate and disengage the electrical connector from the low-pressure cutout switch in the A/C refrigerant line.
6. Disconnect the upper radiator hose from the engine coolant outlet fitting.
7. Disconnect the lower radiator hose from the coolant inlet of the oil cooler assembly.
8. Remove the clamps that retain the coolant overflow tank. Remove tank.
9. Disconnect the chassis-mounted charge air cooler inlet hose at the cooler.
10. Disconnect the chassis-mounted charge air cooler outlet hose at the cooler.
11. Locate the engine coolant temperature sensor and disengage the electrical connector, if applicable. Remove sensor harness from the radiator support.
12. Remove fastener from the bracket that secures the radiator fan air clutch solenoid valve to the radiator support. Set the solenoid valve aside.
13. Remove the retaining bolts from the radiator support rods at the radiator support.
14. Obtain a lifting device (chain fall or engine hoist) and support the radiator.
15. Remove the retaining bolts from the radiator support mounts.
16. Remove the radiator from the vehicle using a lifting device and an assistant, if required.

17. Disconnect the heater hoses and A/C refrigerant lines, if applicable, from connections at the lower dash panel behind the engine.
18. Disconnect the tube connecting the turbocharger to the air cleaner assembly.
19. Remove all coolant tubes, ground straps, air lines, fuel lines, hydraulic hoses or tubes, throttle linkage and electrical wiring harnesses that are attached to the engine and would prevent its removal.
20. Remove the air cleaner assembly, if required.
21. Remove the exhaust bracket from the clutch, or the torque converter, flywheel housing and exhaust clamp at the turbocharger.
22. Remove power steering hoses and the reservoir, if applicable.
23. Disconnect any electrical cables or wires still connected to the starter. Remove three mounting capscrews from the mounting flange and remove the starter.
24. Support the transmission with an appropriate transmission jack.
25. Remove the retaining bolts that secure the transmission bell housing to the flywheel housing.
26. Remove the hood rest crossmember(s), if applicable.
27. Obtain the appropriate lifting equipment (bar or chain) and attach to the proper lift points on the engine.
28. Position and attach the engine hoist to the lift bar or chain and place tension on the bar or chain by operating hoist.
29. Remove the clutch linkage and bracket retaining bolts (manual transmission).
30. Remove torque converter access panel and remove capscrews that secure the torque converter to the flywheel (automatic transmission).
31. Remove the retaining bolts that secure the engine mounts to the engine.
32. Obtain assistance for removal of the engine. Remove engine while watching for obstructions that interfere with its removal such as engine or chassis components, brackets, clamps or other parts still attached to the engine.
33. Refer to the ENGINE DISASSEMBLY section of this manual for procedures for mounting the engine on an engine stand.

NOTES

ENGINE DISASSEMBLY

GENERAL

This section includes step-by-step procedures for complete disassembly of the MACK E7 engine upon removal from the vehicle. Major components are removed as assemblies and overhauled in the BENCH PROCEDURES section of this manual.

⚠ CAUTION

Failure to follow the sequence of operations listed below may result in damage to components or personal injury.

[219 EV] CENTRI-MAX™ AND SPIN-ON FILTER ELEMENTS

Refer to Figure 4-1.

1. Place a suitable container below the filter element area to catch any spilled fluids.

⚠ CAUTION

Do not apply the filter wrench to any area other than that labeled WRENCH HERE on the Centri-Max™ filter housing, or damage to the Centri-Max™ housing will result.

2. Using a suitable filter wrench, remove the fuel and oil filter elements. Do not reuse filter elements. Discard used elements in a responsible, environmentally safe manner.
3. Loosen drain hose assembly (4) from Centri-Max™ filter housing assembly by loosening hose clamp (3) at the Centri-Max™ housing.
4. Remove two nuts (6) and two washers (5) securing hose adapter (7) to studs (1) at the cylinder block. Discard O-ring (8).
5. Remove drain hose assembly (4).
6. Remove Centri-Max™ housing (9) and element (10). Discard seal ring (2).

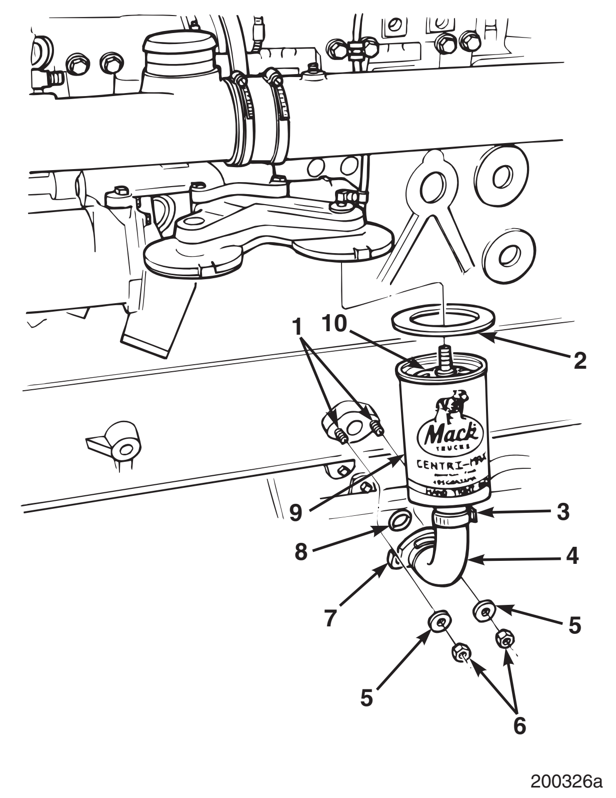


Figure 4-1 — Centri-Max™ Housing Removal Studs

1. Studs	6. Nuts
2. Seal ring	7. Adapter
3. Clamp	8. O-ring
4. Drain hose assembly	9. Centri-Max™ housing
5. Washers	10. Centri-Max™ element

MOUNTING ENGINE IN STAND

WARNING

The engine is heavy (approximately 2,300 lbs. [1043 kg] wet). Stay out from under the engine when it is being lifted. Failure of the lifting device could result in serious injury or death. Make sure to use lifting equipment that is rated at a capacity greater than the weight of the engine.

NOTE

The fuel and oil filter elements, as well as the Centri-Max™ assembly, must be removed before mounting the adapter plate to the engine.

CAUTION

Engine stand, Kent-Moore tool number J 29109, and adapter plate J 38048, are recommended to safely support the engine during disassembly and assembly procedures.

CAUTION

When servicing an E7 engine with an isolating oil pan arrangement, avoid using an engine stand that supports the engine on the oil pan rail while the oil pan is still installed. Damage to the oil pan, pan gasket or the isolators may result. If this type of stand must be used and the oil pan is to remain installed, support the engine on the pads provided at each corner of the cylinder block as shown in Figure 6-56.

Special Tools Required

- Engine Stand J 29109
- Adapter Plate J 38048

Refer to Figure 4-2.

1. Using three mounting capscrews (2), secure adapter plate J 38048 (1) to the left side of the engine.
2. Secure adapter plate (1) to engine stand J 29109 (3) with six mounting capscrews (4).
3. Remove lifting device from the engine.

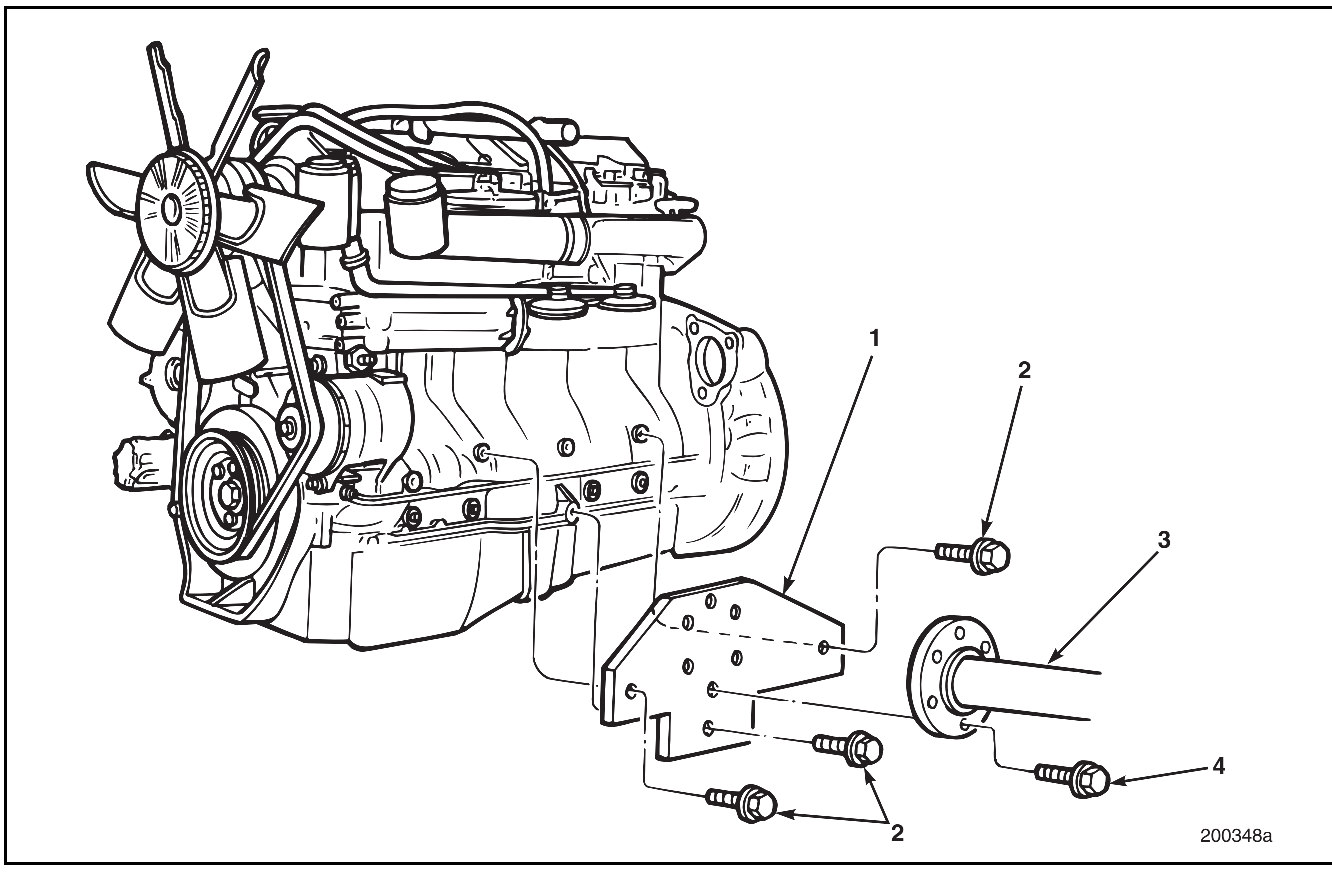


Figure 4-2 — Mount Engine in Stand

1. Adapter plate J 38048 2. Capscrews	3. Engine stand J 29109 4. Capscrew

[271 CB] ALTERNATOR

Refer to Figure 4-3.

1. Loosen adjusting capscrew (2) and mounting nuts (6).
2. Remove drive belts (1) and tag belts for reassembly.
3. Disconnect and tag electrical wires by removing mounting hardware.
4. Remove mounting nuts (6) and washers. Pull out capscrews (3) and remove alternator (7).
5. Remove alternator plate (5) by removing mounting hardware (4).

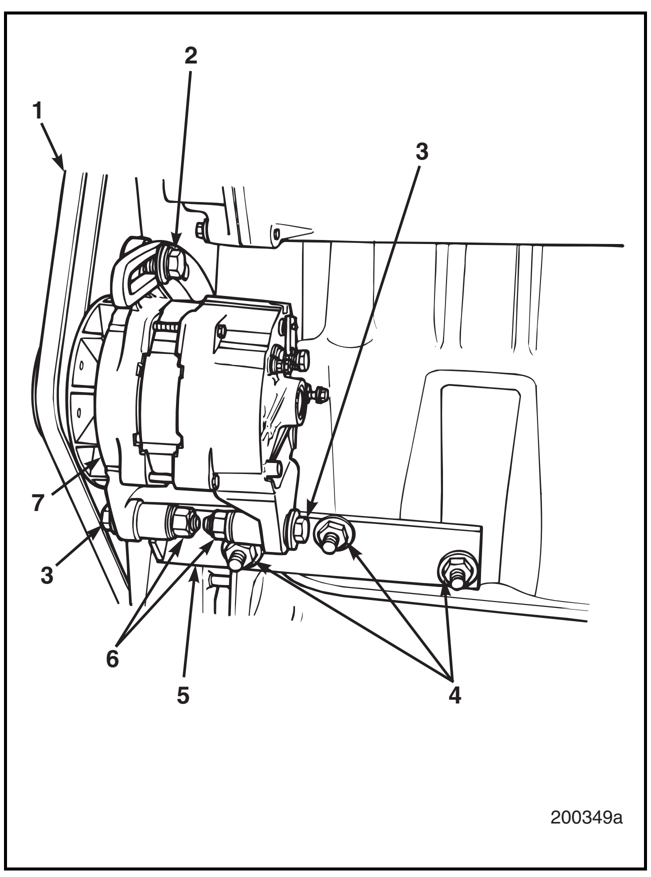


Figure 4-3 — Alternator Removal

1. Drive belt 2. Adjusting capscrew 3. Capscrew 4. Mounting hardware	5. Alternator plate 6. Mounting nuts 7. Alternator

[215 HB] FAN ASSEMBLY

Refer to Figure 4-4.

1. Loosen eight fan assembly mounting nuts (2) and capscrews (1).
2. While supporting fan assembly (3), remove nuts (2) from capscrews (1) and remove fan assembly.

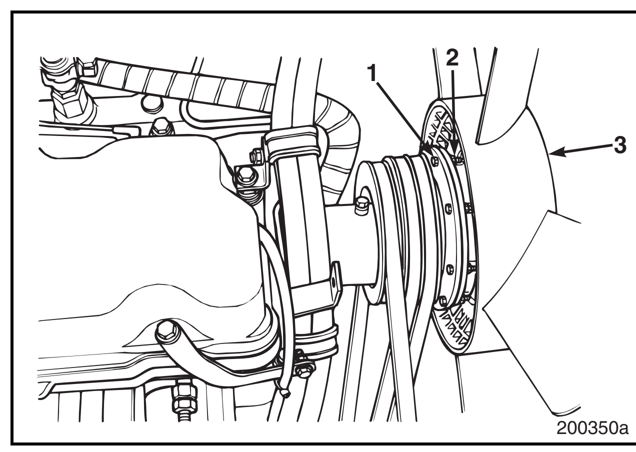


Figure 4-4 — Fan Assembly Removal

1. Capscrew 2. Nut	3. Fan assembly

Refer to Figure 4-5.

3. If the fan assembly is equipped with a viscous drive, be sure to store the assembly either horizontally, with the fan face down (hub flange up), or vertically, as shown in Figure 4-5. This will prevent fluid leaking from the assembly.

NOTE

Do not store the assembly horizontally with the fan face up (hub flange down). Fluid in the viscous drive reservoir can leak out.

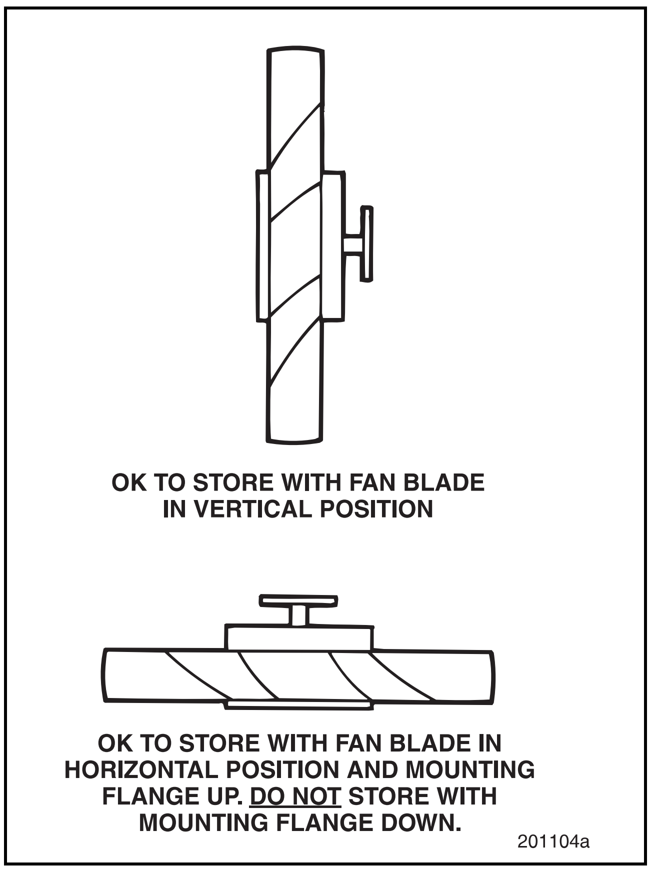


Figure 4-5 — Viscous Fan Drive Assembly Storage

[231 PB] FUEL FILTER ADAPTER ASSEMBLY

Refer to Figure 4-6

1. Disconnect three fuel lines from fittings (2, 3 and 5) on fuel filter adapter assembly (1). Tag and cap all lines.
2. Remove three capscrews (4) from the top of the fuel filter adapter assembly.
3. Remove fuel filter adapter assembly from the air inlet manifold (7).

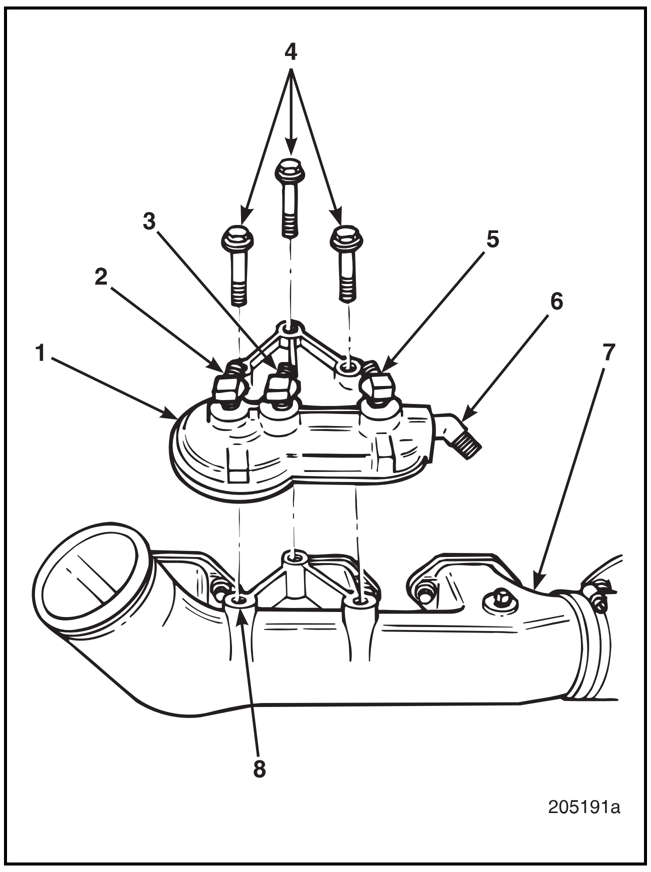


Figure 4-6 — Fuel Filter Adapter Assembly Removal

1. Fuel filter adapter assembly 2. Secondary filter fitting (out) 3. Secondary filter fitting (in)	4. Capscrews 5. Primary filter fitting (out) 6. Primary filter fitting (in) 7. Air inlet manifold 8. Mounting flange

[215 LD] COOLANT CONDITIONER ELEMENT

Refer to Figure 4-7.

1. Cut the plastic tie wrap (1) securing coolant conditioner supply tube (2) to cylinder head manifold overflow line.
2. Disconnect fittings (3) from both ends of the coolant conditioner supply tube. Remove tube (2).

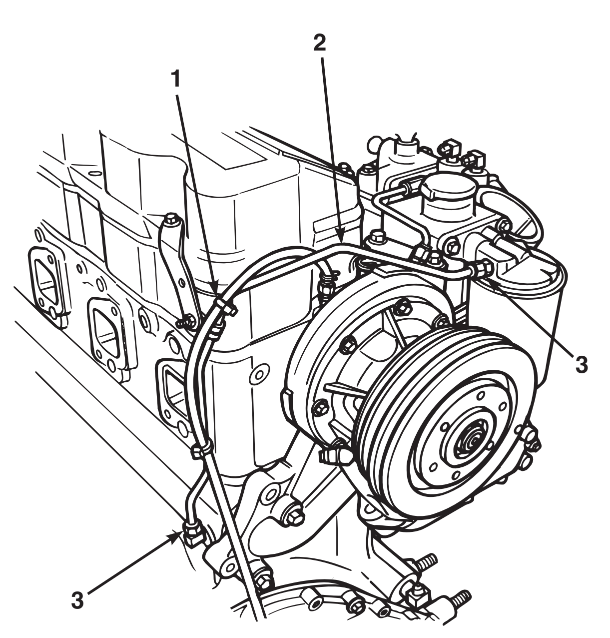


Figure 4-7 — Coolant Conditioner Supply Tube Removal

1. Plastic tie wrap 2. Coolant conditioner supply tube	3. Fittings

Refer to Figure 4-8.

3. Place a suitable container below the coolant filter area to catch any spilled coolant.
4. Using a suitable filter wrench (J 29927 or equivalent), remove the coolant conditioner filter element (13). Discard element.
5. Remove coolant conditioner head assembly (2) from thermostat housing (5) and coolant manifold (9) by removing mounting capscrews (1).
6. Remove and discard O-ring (4).
7. Carefully remove and examine the check valve assembly (3). Examine check valve assembly by depressing the check ball. If it resists movement and does not return to its seat freely, the check valve assembly must be replaced.

[215 NU] THERMOSTAT

Refer to Figure 4-8.

1. With the coolant conditioner element removed, remove two capscrews (13) that secure the thermostat housing (5) to coolant manifold (9).
2. Loosen two hose clamps (10) on the coupling (12) that connects the oil cooler supply tube (11) to the thermostat housing.
3. Taking care to prevent the thermostat (7) from falling, remove the thermostat housing (5) and thermostat. Discard gasket (8).

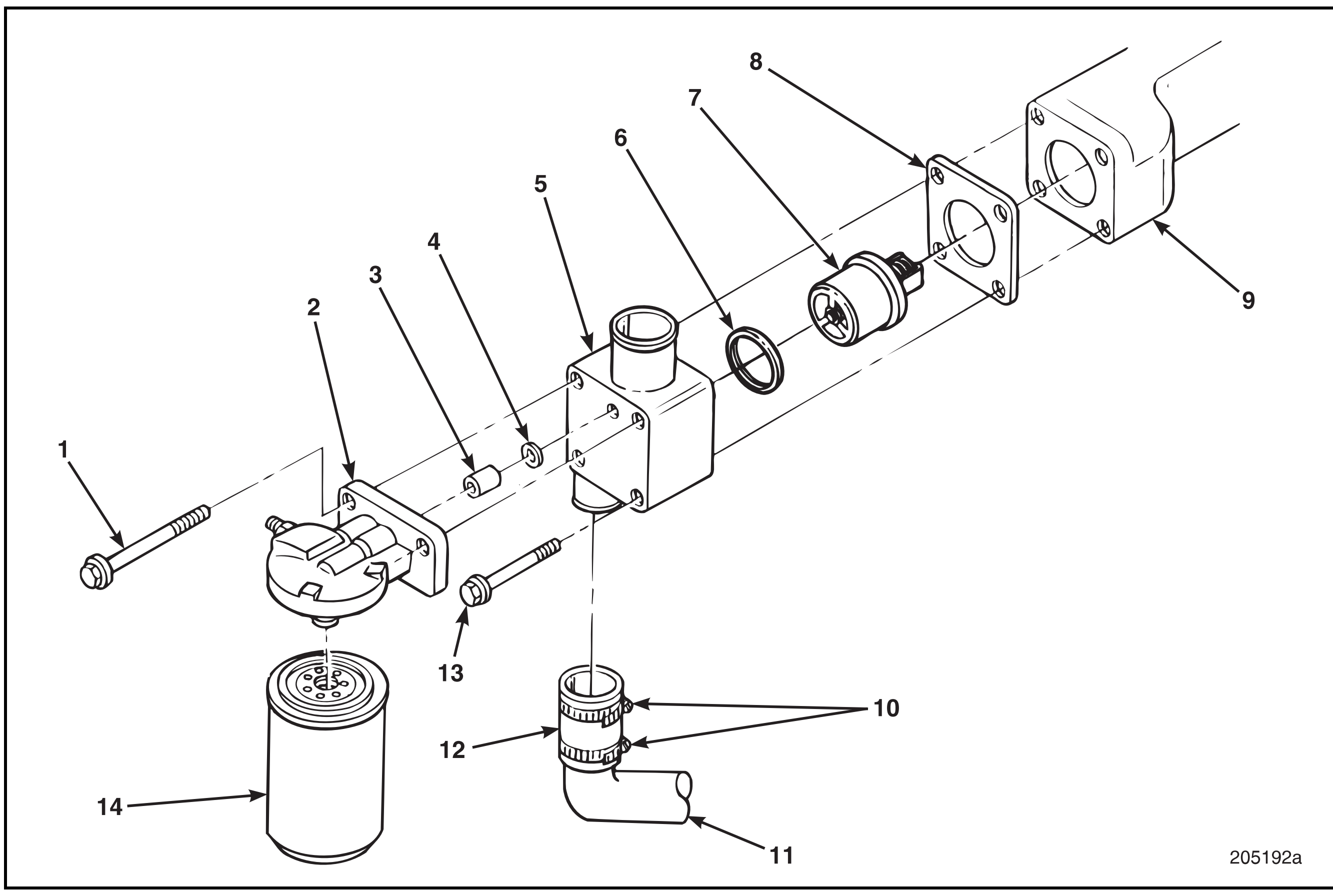


Figure 4-8 — Coolant Conditioner Removal

1. Capscrew	8. Gasket
2. Coolant conditioner head assembly	9. Coolant manifold
3. Check valve assembly	10. Clamps
4. O-ring	11. Oil cooler supply tube
5. Thermostat housing	12. Coupling
6. Thermostat seal	13. Capscrew
7. Thermostat	14. Coolant conditioner filter element

[214 HD] AIR INLET MANIFOLD

Refer to Figure 4-9.

1. Support the air inlet manifold sections and remove 12 capscrews (9) that secure the manifold sections (6 and 8) to the cylinder heads.
2. Remove air inlet manifold. It may be necessary to gently pry or tap the manifold lightly with a soft mallet to break the seal.
3. If the air inlet manifold is to be replaced, remove sensor (7) located on the inlet manifold (6), if installed.

[215 NK] COOLANT MANIFOLD

Refer to Figure 4-9.

1. Support the coolant manifold sections and remove 12 capscrews (5) retaining the manifold sections (1 and 4) to the cylinder heads.
2. Remove manifold assembly. It may be necessary to pry or tap lightly with a soft mallet on the housing sections to break the seal.
3. If necessary, separate the two coolant manifold sections (1 and 4) by loosening two clamps (3) and removing the coupling (2).

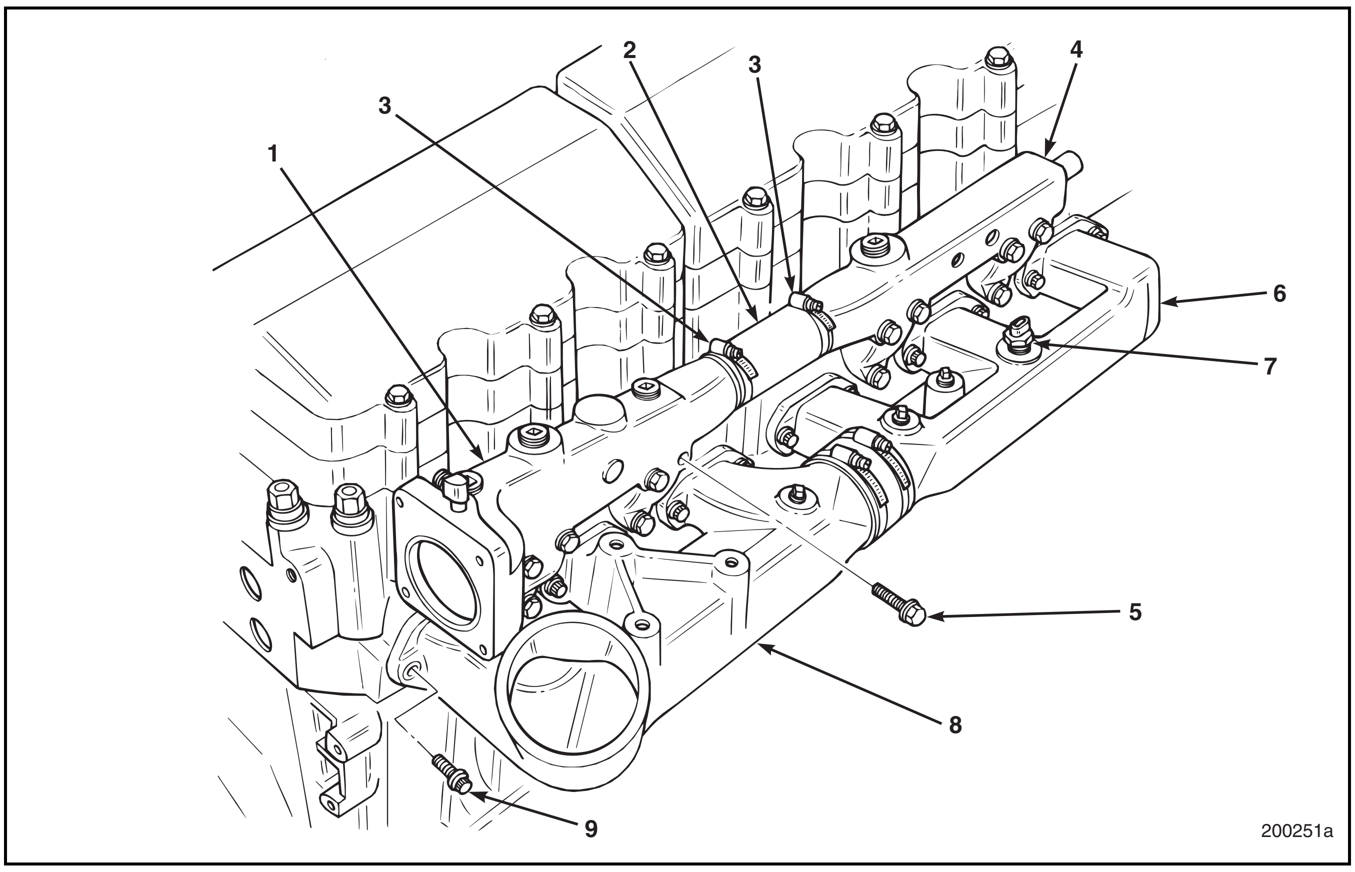


Figure 4-9 — Air Inlet Manifold Removal

1. Coolant manifold, front section 2. Coupling 3. Clamp 4. Coolant manifold, rear section 5. Capscrew	6. Air inlet manifold, rear section 7. Sensor 8. Air inlet manifold, front section 9. Capscrew, 12-point

[215 DW & 219 EP] OIL COOLER AND OIL FILTER HOUSING ASSEMBLY

Refer to Figure 4-10.

1. Disconnect turbocharger lubrication supply hose (6) from the oil filter/cooler assembly (5).
2. Disconnect feed line (2) from the centrifugal filter housing fitting. Tag and cap line and fitting.
3. Disconnect Centri-Max™ filter breather hose (1) by sliding hose from fitting. (For MR chassis Jake Brake applications, remove the Centri-Max™ breather filter. Clean with suitable solvent to make sure breather is clear.)
4. Remove four capscrews (3) securing oil filter feed assembly (4) to engine block.

NOTE

Unless it is necessary to repair any portion of the oil cooler or oil filter housing, remove the units as an assembly. The assembly can be disassembled later if necessary. Refer to Oil Cooler Disassembly in the BENCH PROCEDURES section.

NOTE

Effective with the introduction of the S300 and S400 model turbochargers (May 1996), a new style oil inlet line is used. The line is a stainless steel braided line which replaces the conventional hose type line and steel oil inlet tube. The new oil line is connected directly to the threaded oil inlet port at the turbocharger.

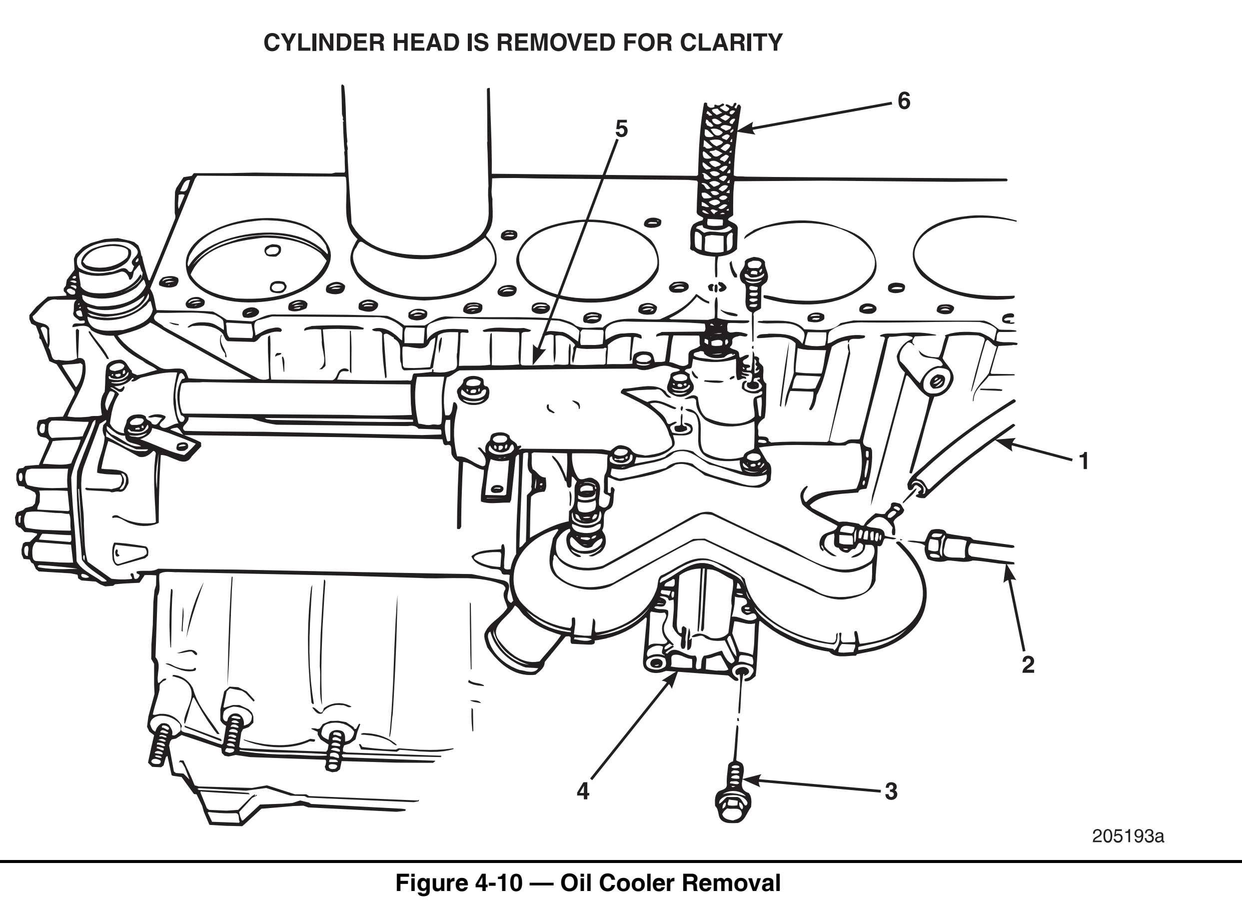


Figure 4-10 — Oil Cooler Removal

1. Centri-Max™ filter breather hose (MR chassis with Jake Brake uses breather assembly) 2. Feed line 3. Capscrew	4. Oil filter feed assembly 5. Oil filter/cooler assembly 6. Turbocharger lubrication feed hose

[215 SW] WATER PUMP

Refer to Figure 4-11.

1. Disconnect coolant return hose to air compressor (1) at fitting.
2. Remove three mounting capscrews (3) and remove water pump (2).

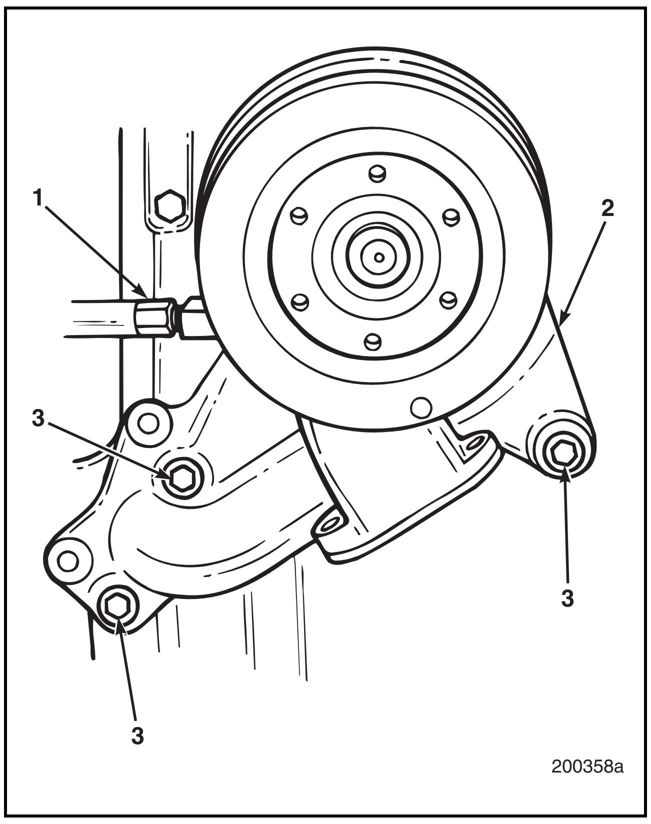


Figure 4-11 — Water Pump Removal

1. Air compressor coolant return line 2. Water pump	3. Capscrew

[214 SD] TURBOCHARGER

Refer to Figure 4-12.

1. Remove two capscrews (3) securing turbocharger lubrication drain tube (4) to turbocharger (1).
2. Loosen hose clamp (5) securing drain tube to oil fill tube. Remove drain tube (4).
3. Remove turbocharger lubrication feed hose (2).

NOTE

Beginning with May 1996 production, Schwitzer turbocharger models S300 and S400 replace models S3B and S4B. Service old with old and new with new. Also note that with the S300 and S400 models, a stainless-steel braided oil feed line is used.

4. Loosen four turbocharger mounting nuts (6) and remove turbocharger (1).

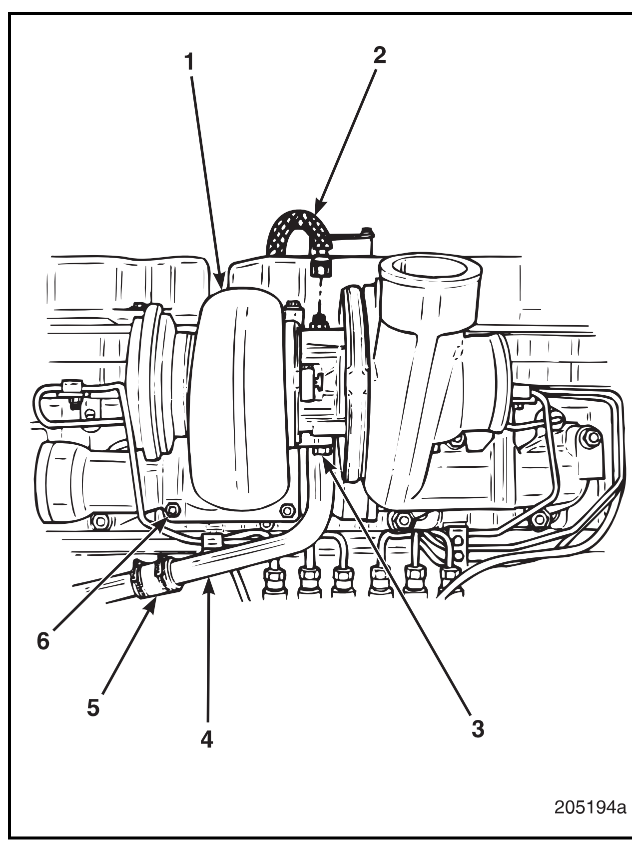


Figure 4-12 — Turbocharger Removal

1. Turbocharger 2. Lubrication feed hose 3. Capscrew	4. Lubrication drain tube 5. Clamp 6. Mounting nut

[222 KD] FUEL NOZZLE INLET TUBE ASSEMBLY

Refer to Figure 4-13.

1. Loosen six tube sleeve nuts (6) at the injection pump. Be careful to avoid twisting lines while loosening nuts.
2. Loosen brackets (3 and 5) by removing retaining hardware.
3. Loosen tube sleeve nuts (1) and tube clamping screws at the cylinder heads and remove front (4) and rear (2) tube assemblies. Cap all lines and fittings to prevent contaminants from entering the system.

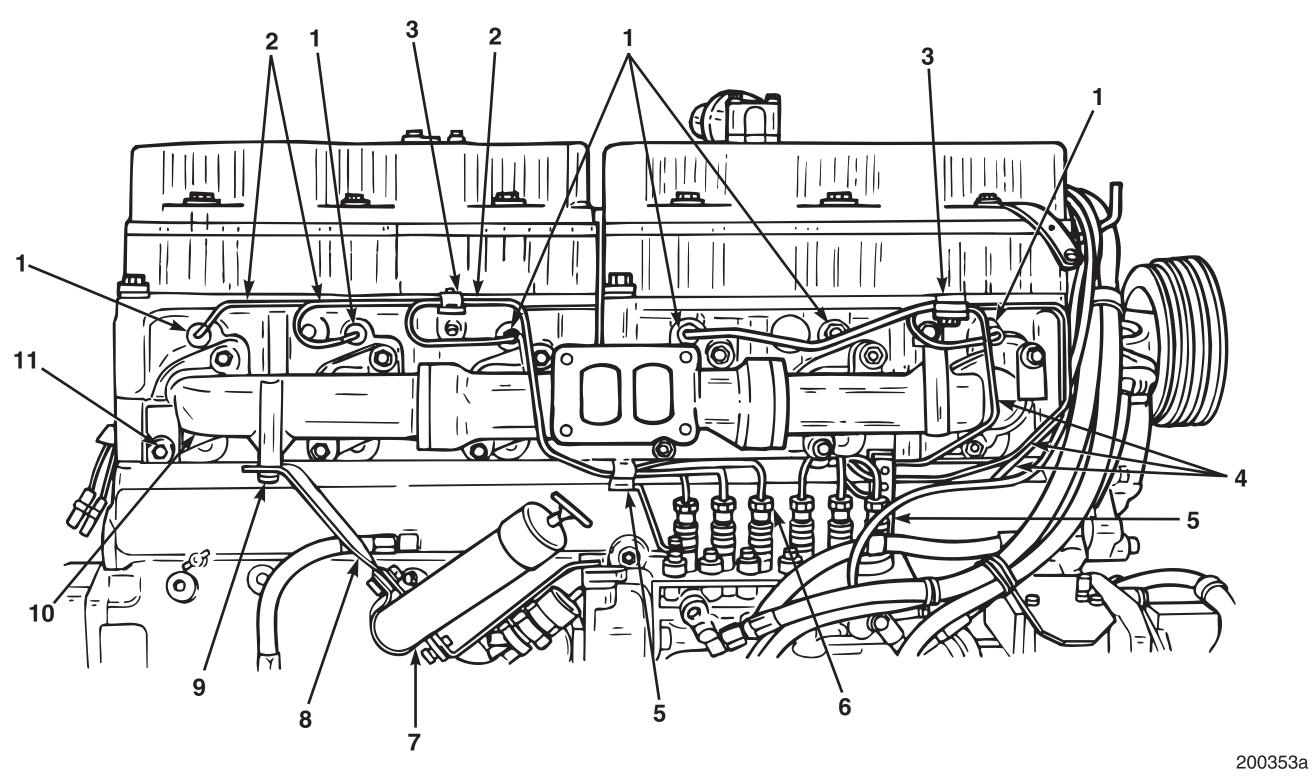


Figure 4-13 — Fuel Inlet Tube Assembly Removal

1. Nozzle fuel inlet tube and sleeve nut	7. Oil filler feed tube
2. Rear fuel inlet tube assembly	8. Oil filler feed tube bracket
3. Bracket/insulator (tube clamp)	9. Capscrew
4. Front fuel inlet tube assembly	10. Exhaust manifold
5. Bracket/insulator (tube clamp)	11. Capscrew
6. Sleeve nut	

Refer to Figure 4-14.

4. If necessary, separate fuel inlet tubes (4) from bracket assembly. Remove nuts (6) from capscrews (1) and remove clamp plate (2), insulators (3) and bracket (5).

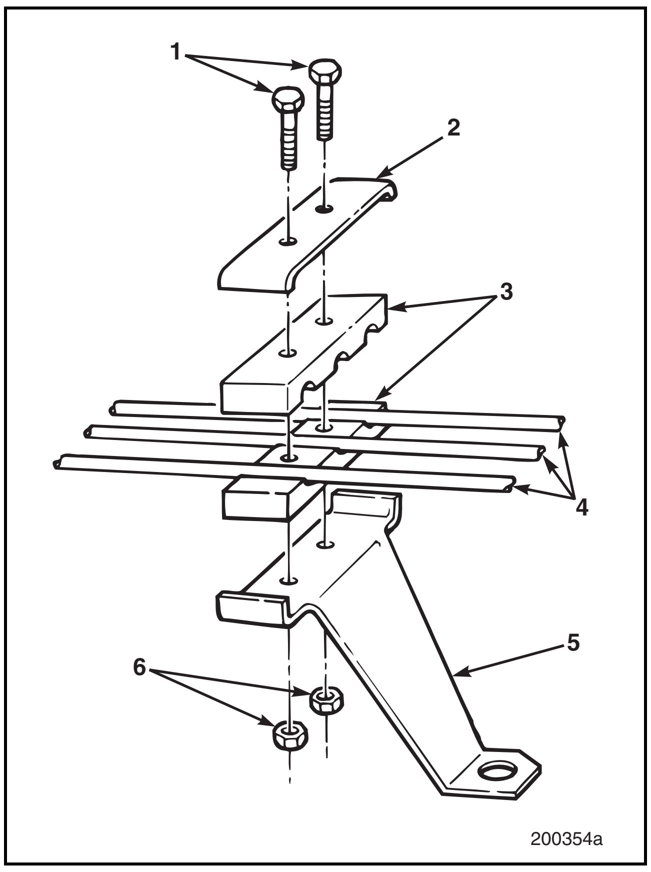


Figure 4-14 — Inlet Tube Clamp Disassembly

1. Capscrews 2. Clamp plate 3. Insulator	4. Fuel inlet tubes 5. Bracket 6. Nuts

[214 EG] EXHAUST MANIFOLD

Refer back to Figure 4-13.

1. Remove capscrew (9) securing oil filler tube bracket (8) to exhaust manifold (10).
2. If necessary, remove the retaining clamp for the injection pump wiring and connector from the holder.
3. Remove capscrews securing oil filler feed tube (7) to cylinder block. Remove tube.
4. Support the exhaust manifold and remove 12 mounting capscrews (11) securing the manifold (10) to cylinder heads.
5. Remove exhaust manifold.
6. Discard gaskets.

[213 JB] VALVE COVER AND RISER

NOTE

If engine is equipped with a Jake Brake®, a riser is installed under the valve cover. Longer capscrews are used to secure the valve cover and riser to the cylinder head.

.

Refer to Figure 4-16.

1. Remove valve covers (3) by removing six retaining capscrews (4 and 5) from each cover.
2. Discard seals.

Refer to Figure 4-15.

3. If a Jake Brake is installed, perform the following:
   a. Remove control wire (3) from left side of each riser housing (4).

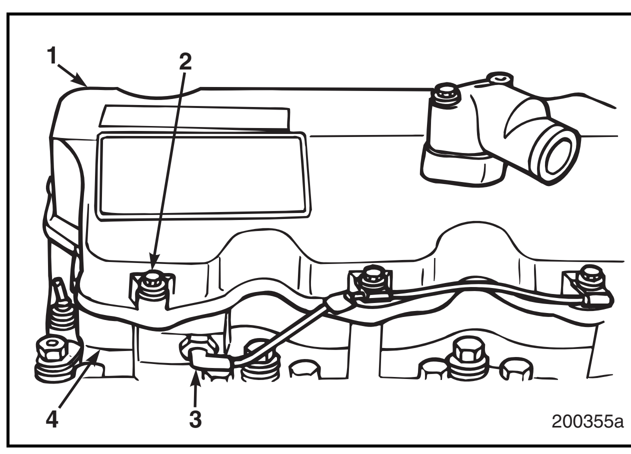


Figure 4-15 — Control Wire Removal

1. Valve cover 2. Capscrew	3. Control wire 4. Riser housing

Refer to Figure 4-16.

   b. Disconnect wires (1) at the actuator solenoid connector (14).
   c. Remove risers (2). Discard seals.

[213 LP, NV & LH] ROCKER ARM, VALVE YOKE AND PUSH ROD

Refer to Figure 4-16.

If equipped with a Jake Brake, perform the following:

1. Remove three capscrews (6) from each actuator assembly (15).
2. Remove actuator assemblies from cylinder heads (one actuator assembly per head).

NOTE

If a Jake Brake was not installed, there will be six capscrews per rocker arm assembly. If a Jake Brake was installed, there will be only three capscrews per rocker arm assembly remaining.

3. Remove remaining capscrews (13) and washers (12) from rocker arm shaft brackets (7). Remove rocker arm assembly (11) from each head.
4. Remove valve yokes (8) from each pair of valves by lifting straight up on each yoke. Tag yokes for reassembly.
5. Remove valve push rods (10) and tag rods for reassembly.

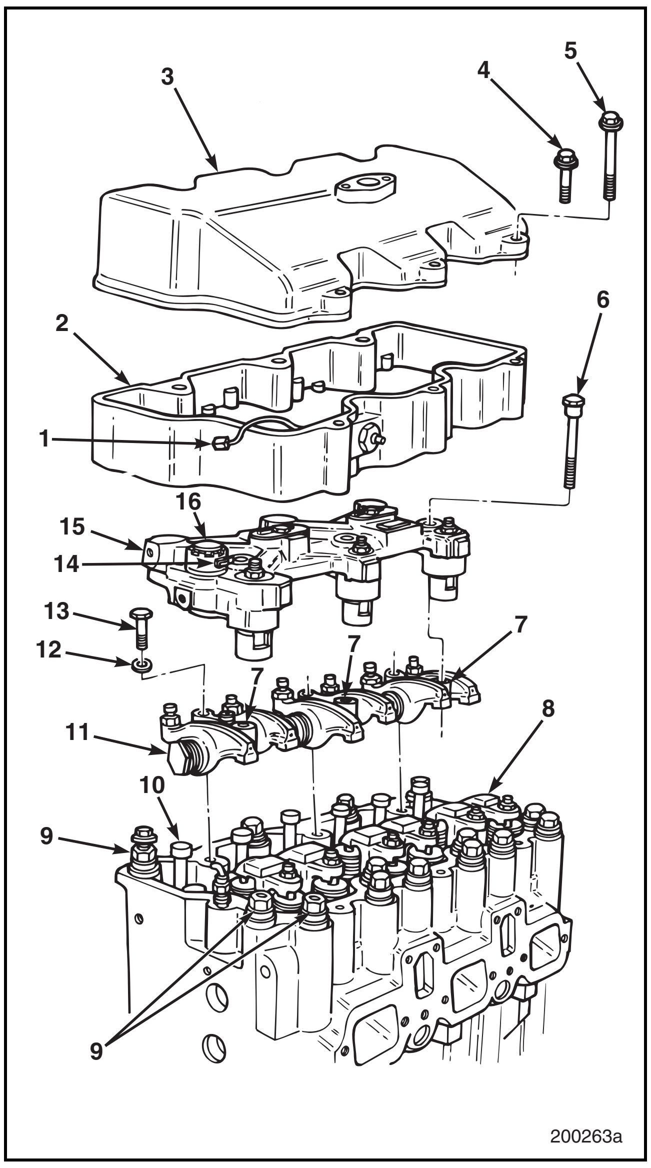


Figure 4-16 — Valve Cover and Rocker Arm Removal

1. Wire connector	9. Head bolt with threaded hole
2. Riser	10. Push rod
3. Valve cover	11. Rocker arm assembly
4. Short capscrew	12. Washer
5. Long capscrew	13. Capscrew
6. Actuator capscrew	14. Connector
7. Rocker arm shaft bracket	15. Actuator assembly
8. Valve yoke	16. Actuator solenoid

[222 KG] NOZZLE HOLDER

Special Tool Required

- Injection Nozzle Puller J 37093

SERVICE HINT

After removing the nozzles, it is a good practice to label or tag them for reinstallation into the same cylinders. After removal, place nozzles on a clean surface.

Refer to Figure 4-17.

1. Remove nozzle holder retainer (2).
2. Assemble injection nozzle puller J 37093 as follows:
   a. Attach nut (12), bearing (11), spacer (10) and rubber washer (9) to tool handle (1).
   b. Screw handle (1) in threaded hole of nozzle holder (5) until rubber washer (9) is slightly compressed.
3. With tool in position, turn nut (12) clockwise to draw nozzle holder from cylinder head nozzle mounting hole (8).
4. Continue turning nut until nozzle holder is free of insert. Remove nozzle holder and puller tool as an assembly.
5. Remove nozzle holder gasket (7). The gasket is manufactured from a special iron material 0.060 inch (1.524 mm) thick.
6. Remove remaining nozzle holders in the same manner.

NOTE

Current production nozzle holders do not have the lower O-ring groove.

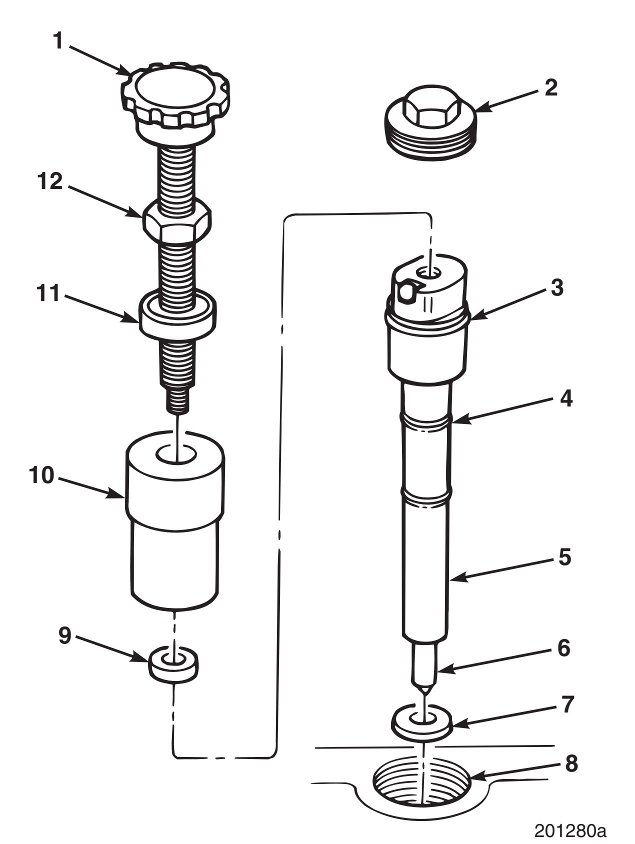


Figure 4-17 — Nozzle Holder Removal

1. Handle	7. Gasket
2. Nozzle holder retainer	8. Nozzle mounting hole
3. O-ring	9. Rubber washer
4. O-ring	10. Spacer
5. Nozzle holder	11. Bearing
6. Nozzle	12. Nut

[213 EV] CYLINDER HEAD ASSEMBLY REMOVAL

Refer to Figure 4-18.

1. Remove fuel return tube (3) from between the cylinder head assemblies (4) by loosening the tube sleeve nuts from each end.
2. Remove fuel return line (1) at the front of the forward cylinder head.
3. Remove cylinder head bolts (2 and 5). Refer to cylinder head bolt torque sequence chart in Cylinder Head Installation for location of bolts, if necessary.

WARNING

Cylinder head assemblies are heavy. Lifting a cylinder head requires the help of an assistant or suitable lifting device. Attempting to lift a cylinder head without assistance may result in severe personal injury.

4. Using a suitable lifting device, remove heads from the engine block.
5. Remove gaskets and six fire rings. Discard gaskets and fire rings.

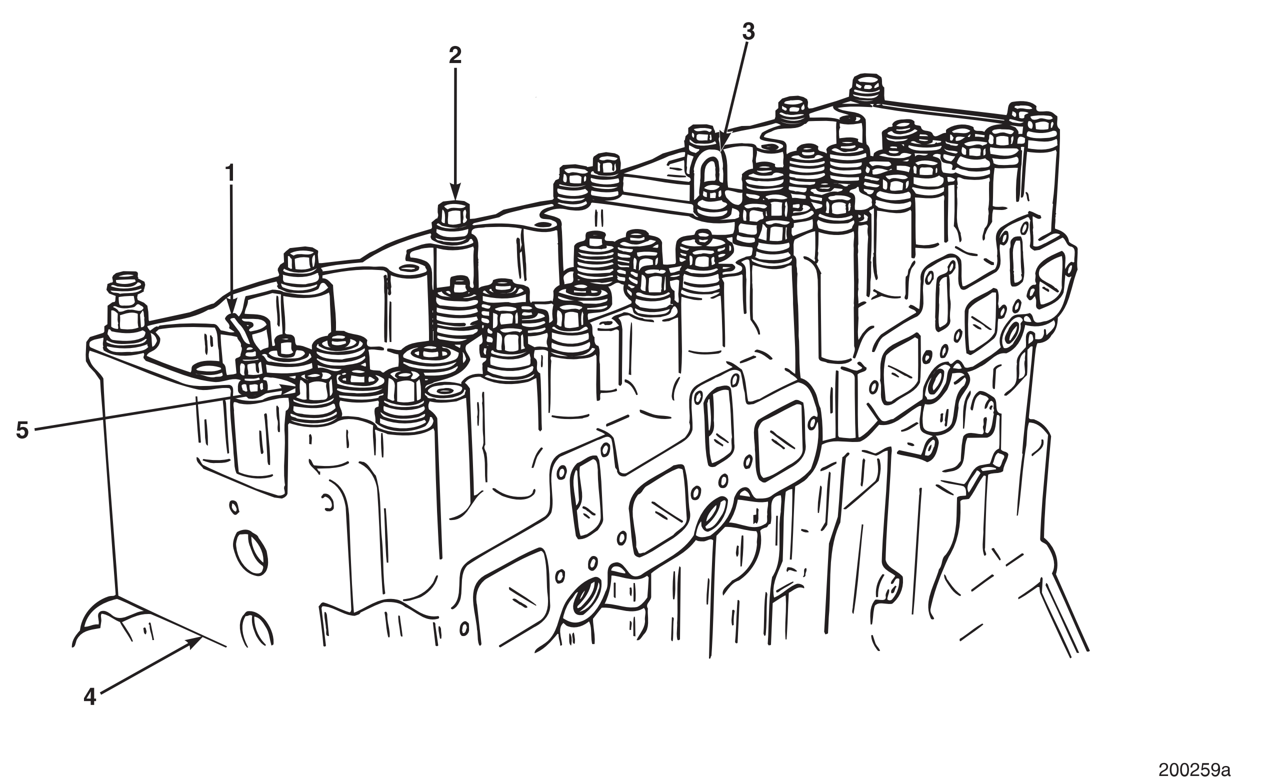


Figure 4-18 — Cylinder Heads

1. Fuel return line 2. Bolt 3. Fuel return tube	4. Cylinder head 5. Bolt with hole in head

[212 RB & RH] VIBRATION DAMPER AND CRANKSHAFT HUB

Refer to Figure 4-19.

1. Remove six mounting capscrews (4) and turnover bracket, if equipped.
2. Remove vibration damper (3) and fan belt drive pulley (1) together.
3. Using a 1-7/16 inch wrench, remove crankshaft hub capscrew (2).
4. Using a suitable puller such as J 24420-C, remove the crankshaft hub.

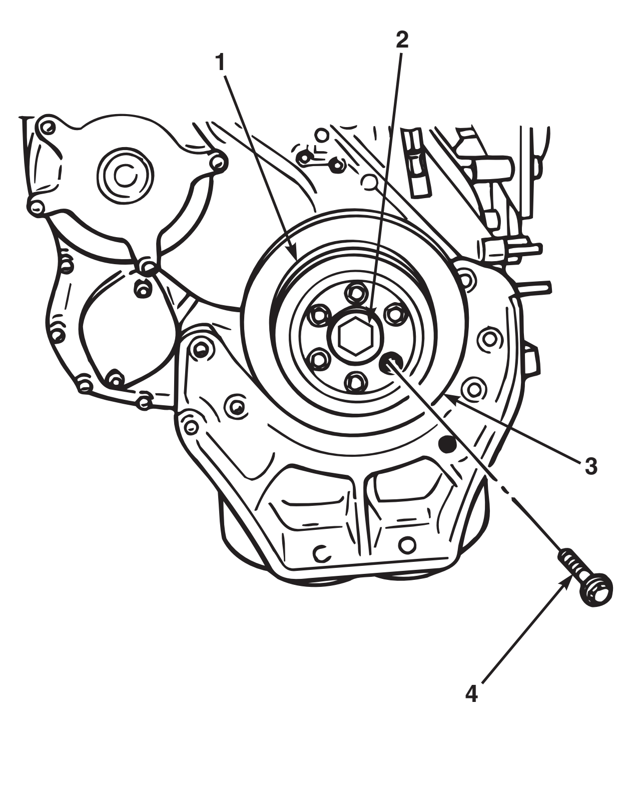


Figure 4-19 — Vibration Damper Removal

1. Pulley 2. Capscrew	3. Vibration damper 4. Capscrew

[261 CK] AIR COMPRESSOR

Refer to Figure 4-20.

Disconnect two coolant lines (1 and 4) from the air compressor head (2) at the fittings. Tag and cap lines.

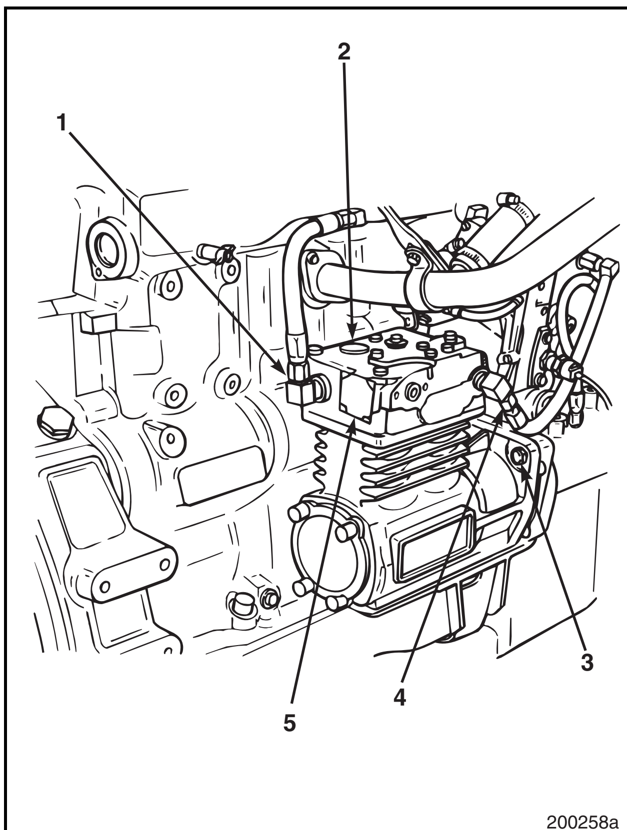


Figure 4-20 — Air Compressor Connections

1. Coolant supply line 2. Air compressor head 3. Capscrew	4. Coolant return line 5. Air governor mounting flange

WARNING

The air compressor is heavy. Lifting the air compressor may require the help of an assistant or suitable lifting device. Attempting to lift the compressor without such assistance may result in severe personal injury.

Refer to Figure 4-21.

1. Remove three mounting capscrews (5) securing air compressor (1) to auxiliary driveshaft housing (3).
2. Taking care not to damage or lose the lubrication oil supply tube (2), remove the air compressor by pulling it rearward out of the mounting flange. Discard gasket.

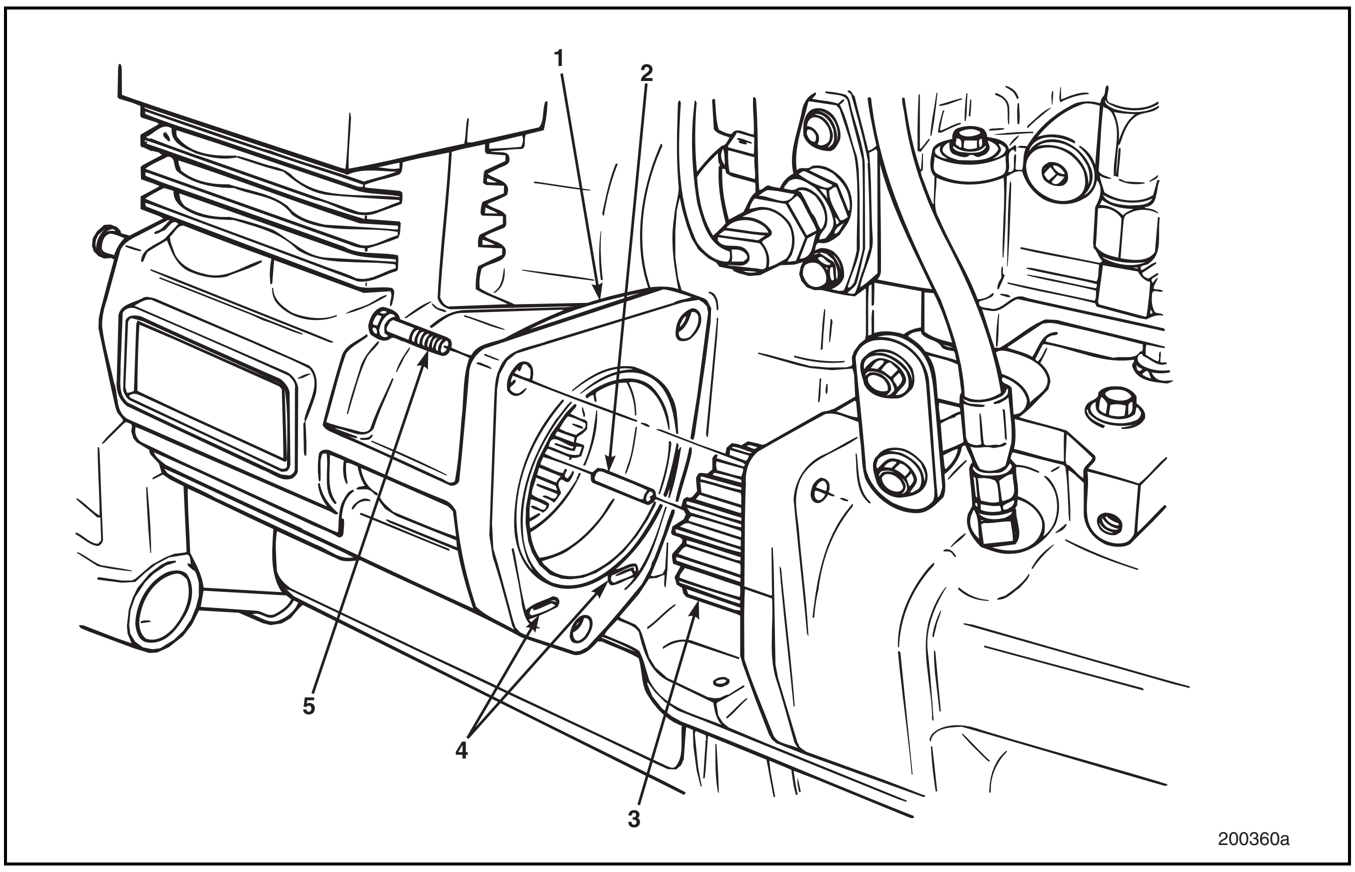


Figure 4-21 — Air Compressor Removal

1. Air compressor 2. Oil supply tube 3. Auxiliary driveshaft	4. Oil drain openings 5. Capscrew

[221 GP] INJECTION PUMP

Refer to Figure 4-22.

1. Disconnect lubrication supply line (6) at both fittings. Tag and cap fittings.
2. Disconnect fuel lines (1, 3, 4, and 5) at the fittings. Tag and cap all lines. Remove lines from the engine by removing clamp retaining capscrew. Set fuel lines on a clean surface.

SERVICE HINT

If the fuel injection pump does not require servicing, set pump-to-engine timing before removal. This will allow ease of installation. Refer to the SETUP AND ADJUSTMENTS section for Fuel Injection Pump Fixed Timing Procedure.

3. Remove rear support link assembly by removing mounting hardware (7 and 8), V-MAC engines only.
4. Mechanically governed engines — Working from the front of the engine, remove four capscrews securing the injection pump drive gear and remove gear. For V-MAC engines, omit this step and go on to step 5.
5. Remove mounting capscrews securing pump to adapter.
6. Remove injection pump by moving it away from mounting flange.

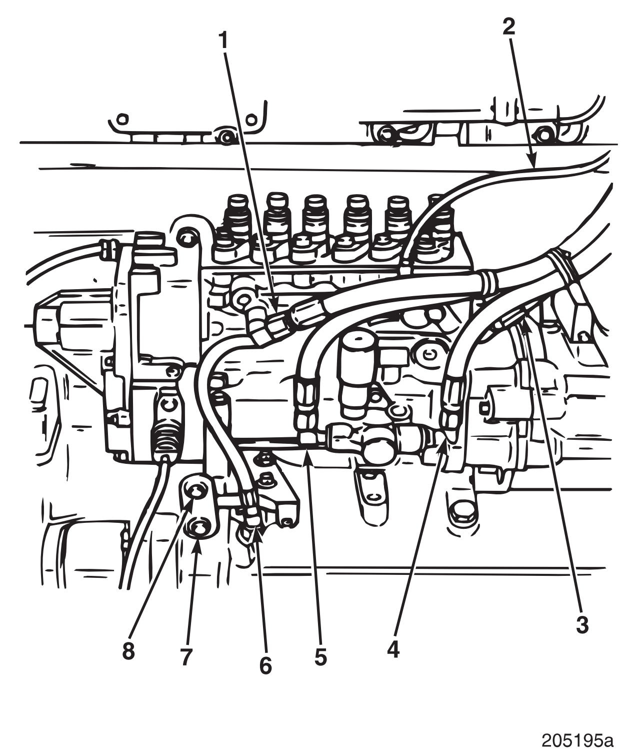


Figure 4-22 — Fuel Line Removal

1. Return from secondary filter 2. Cylinder head overflow line 3. Return to tank line 4. Return to secondary filter	5. Return from primary filter 6. Lubrication supply line 7. Capscrew 8. Capscrew

[221 CD] ECONOVANCE

V-MAC Equipped Engines

Refer to Figure 4-23.

1. Working from front of engine, remove four capscrews securing the injection pump drive gear. Remove gear.

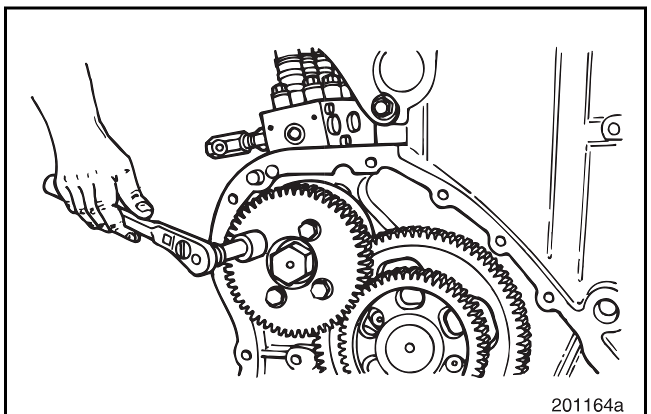


Figure 4-23 — Fuel Injection Pump Drive Gear Removal

Refer to Figure 4-24.

2. Remove mounting capscrews (1) securing injection pump adapter (2) to Econovance housing. Remove adapter.
3. Remove the drive coupling (3) by slipping it off of the splines (6).

NOTE

A metal two-piece style drive coupling was introduced into production on certified E7 V-MAC engines built after July 1, 1992 — beginning with serial No. 2P and above. When the Celeron drive coupling requires replacement, replace the drive coupling with the updated two-piece style. Older style shown.

4. Remove the Econovance (5) by removing four mounting capscrews (4). Rotate shaft to clear the camshaft gear.

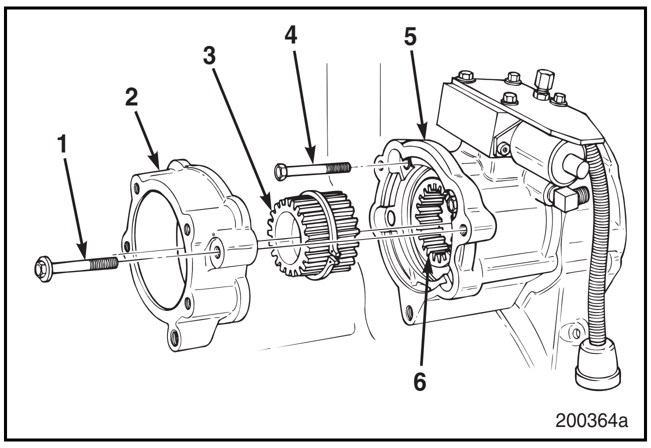


Figure 4-24 — Econovance Housing Removal (Pre-1992 Style Shown)

1. Mounting capscrew 2. Injection pump adapter 3. Drive coupling	4. Capscrew 5. Econovance 6. Splines

[211 NB] OIL PAN

Refer to Figure 4-25.

1. Remove the nuts from the two studs securing the oil pan to the timing gear cover.
2. Remove the two nuts from the two studs securing the oil pan to the flywheel housing.
3. Remove the remaining shouldered bolts securing the oil pan to the pan rails and remove the oil pan.

NOTE

Oil pans with isolating gaskets are secured with nuts and shouldered studs at the timing gear cover and flywheel housing. Refer to Figure 4-25.

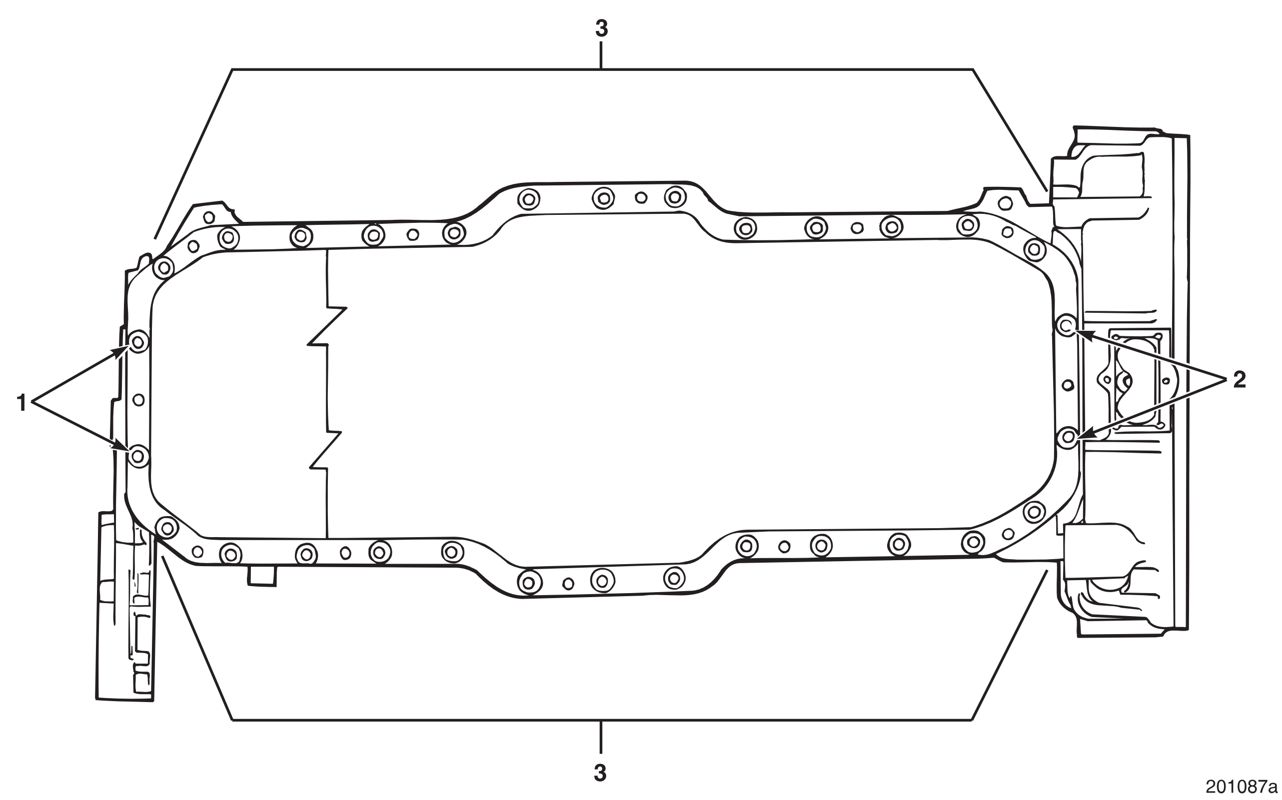


Figure 4-25 — Oil Pan Bolt Locations

1. Studs and nuts at timing gear cover 2. Studs and nuts at flywheel housing	3. Shouldered bolts along pan rails

[219 MU] OIL PUMP

Refer to Figure 4-26.

SERVICE HINT

If the oil pump must be disassembled for any reason, it will be easier to loosen the housing cover retaining capscrews (2), the screen capscrews (5), the sump capscrews (3), the cover plate capscrews (9), and the relief valve cap (8) while the pump is still secured in position. Do so before loosening the three retaining capscrews (1).

Remove the oil pump as a unit by removing three retaining capscrews (1).

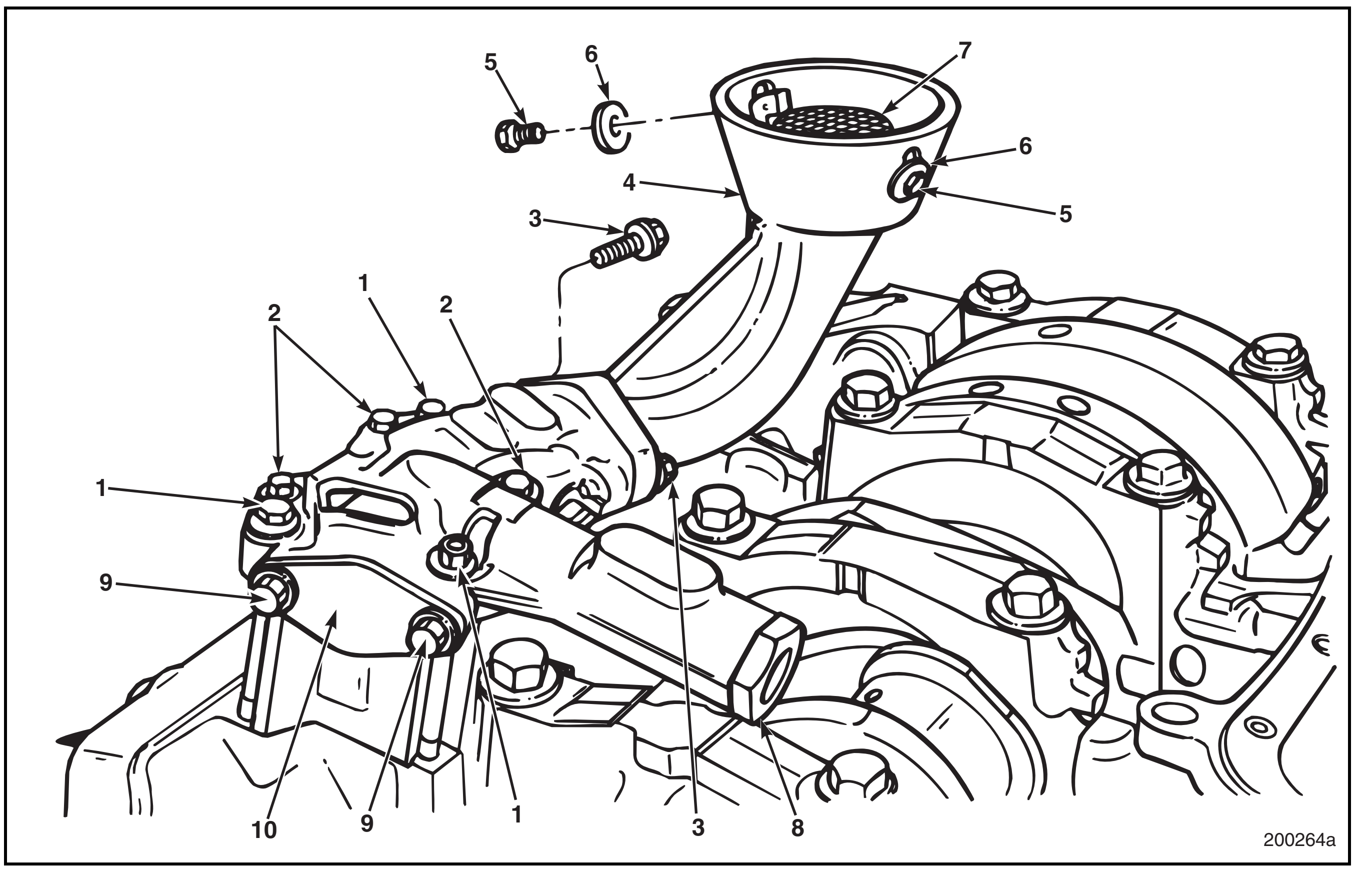


Figure 4-26 — Lubrication Oil Pump

1. Capscrews	6. Washer
2. Capscrews	7. Screen
3. Capscrews, 12-point	8. Relief valve cap
4. Sump	9. Capscrews
5. Capscrews	10. Plate

[211 RP] TIMING GEAR COVER

CAUTION

Do not attempt to remove timing gear cover without removing oil pan. Doing so may result in damage to the isolating oil pan gasket.

Refer to Figure 4-27.

1. Remove front engine mount pedestal (4) by removing six retaining capscrews (7 and 9).
2. Remove auxiliary pump and connecting hardware, if equipped. Discard O-ring seal.
3. If not equipped with an auxiliary pump, remove cover (12) and gasket (8) by removing mounting nuts (10) and washers (11).
4. Remove the injection pump timing cover (14) by removing the mounting capscrews (1 and 13). Discard O-ring (2).
5. Remove remaining mounting capscrews (13) from timing gear cover (3).

CAUTION

Do not damage the timing indicator (5), if equipped, when removing timing gear cover.

6. Remove timing gear cover. It will be necessary to pry the cover from the engine block. Be careful not to damage cover or block while using sharp tools around machined surfaces.

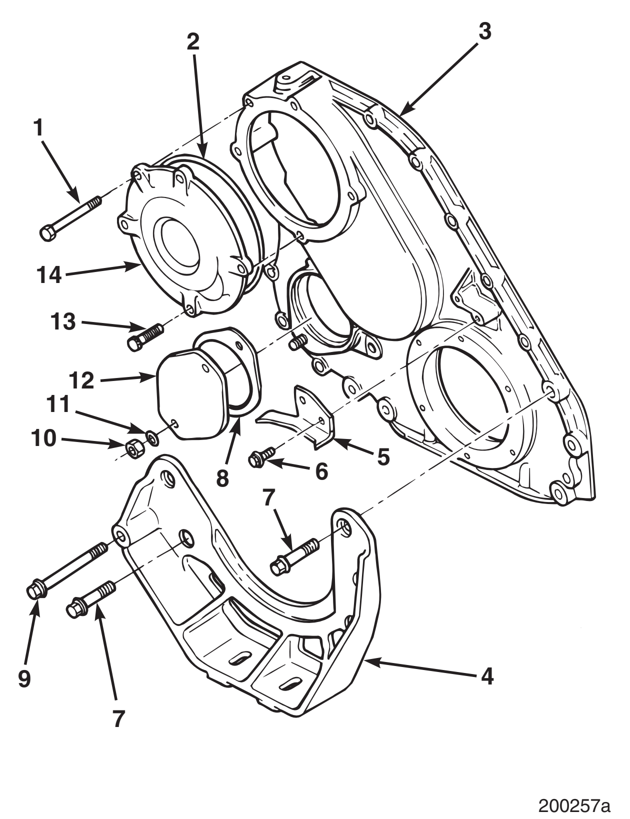


Figure 4-27 — Timing Gear Cover Removal

1. Capscrew	8. Gasket
2. O-ring	9. Capscrew
3. Timing gear cover	10. Nut
4. Front engine mount pedestal	11. Washer
5. Timing indicator	12. Cover
6. Capscrew	13. Capscrew
7. Capscrew	14. Injection pump timing cover

[212 CV] AUXILIARY DRIVESHAFT

Refer to Figure 4-28.

1. Remove auxiliary driveshaft gear retaining nut (1).
2. Using a hub puller such as J 21834-4A, remove auxiliary driveshaft gear (2) from the splines (5) on the end of shaft.
3. Remove two retaining capscrews (3) from auxiliary driveshaft captured thrust washer (4). Remove washer.

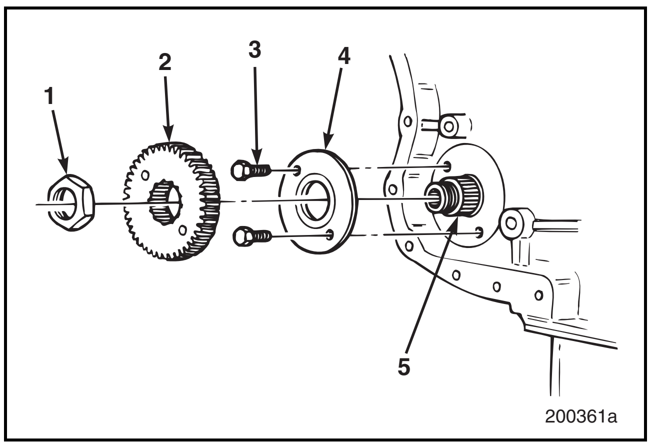


Figure 4-28 — Auxiliary Driveshaft Gear Removal

1. Nut 2. Auxiliary driveshaft gear 3. Capscrew	4. Captured thrust washer 5. Shaft splines

Refer to Figure 4-29.

CAUTION

Be very careful to avoid damaging the auxiliary driveshaft bushings or journals while removing the shaft.

Remove the auxiliary driveshaft (3) by pulling it rearward out of the air compressor mounting flange opening. With engine oil pump in position, a rotating motion may be necessary to clear the engine oil pump drive gear (5).

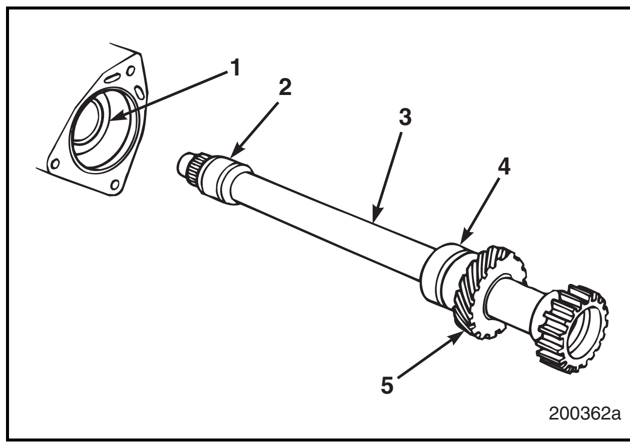


Figure 4-29 — Auxiliary Driveshaft Removal

1. Rear bushing 2. Front journal 3. Auxiliary driveshaft	4. Rear journal 5. Oil pump drive gear

[213 CH] CAMSHAFT

WARNING

Make sure all loose components are secured to, or removed from, the engine before rotating engine on the stand. Failure to do so may result in damage to components or severe personal injury.

1. Rotate engine so that the deck surface is downward and the oil pan rail is upward (engine inverted).

NOTE

When engine is rotated, the valve lifters will fall downward into the push rod holes but will be captured by their heads. They will be out of the way for camshaft removal.

Refer to Figure 4-30.

2. Remove the two 12-point capscrews (3) that retain camshaft thrust washer (1). Camshaft may have to be rotated slightly to make the capscrews accessible through openings (2) in the camshaft drive gear (4).

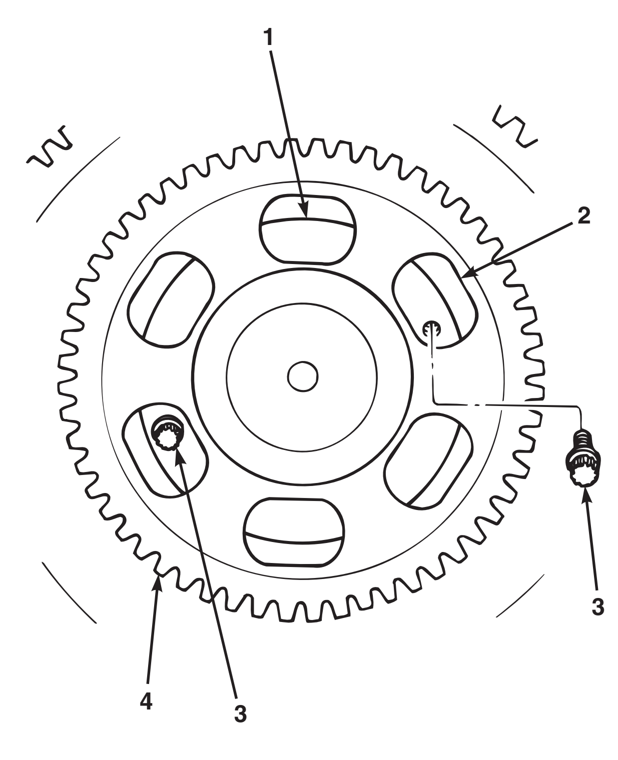


Figure 4-30 — Camshaft Thrust Washer Capscrews

1. Thrust washer 2. Openings	3. Capscrew, 12-point 4. Camshaft drive gear

Refer to Figure 4-31.

3. Install the camshaft removal/installation tool J 41461 (3) in position on the rear segment of the camshaft (1), securing it with the clip (2) to the shaft.

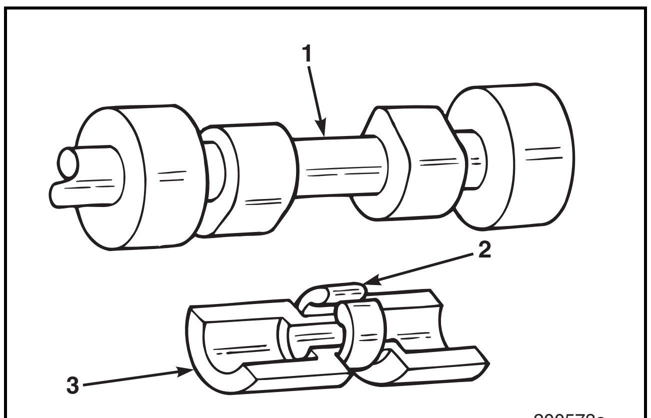


Figure 4-31 — Camshaft Removal/Installation Tool

1. Rear segment of camshaft 2. Tool retaining clip	3. Camshaft removal/ installation tool

4. Taking care not to damage camshaft or bushings, pull camshaft out of the front of the engine. Carefully guide rear of shaft through the journals. If shaft does not come out freely, ensure all valve lifters are clear of camshaft cams and journals.
5. Remove valve lifters.

SERVICE HINT

Valve lifters have established wear patterns and should be reinstalled in same locations. Label each valve lifter upon removal and place on a clean work surface.

[212 NP & LQ] PISTON AND CONNECTING ROD ASSEMBLY

WARNING

The crankshaft and related components are heavy, have sharp edges and many possible pinch points. Always be careful while working in this area to avoid serious personal injury.

NOTE

Before removing pistons, connecting rods and rod caps, ensure they are marked so they can be reinstalled in the same cylinders from which they were removed.

NOTE

Remove connecting rod and piston assemblies in companion cylinder sets: 1 and 6, 2 and 5, and 3 and 4.

1. Rotate engine stand 90 degrees so that pistons lie horizontally in the block with top of pistons and connecting rods accessible.
2. Rotate crankshaft so that pistons 1 and 6 are lowered in the cylinder at least two inches (51 mm) to allow adequate room to remove carbon from upper edge of sleeves.

Refer to Figure 4-32.

3. Using a sharp knife, carefully remove any carbon at the top of the sleeves. Remove any remaining carbon using crocus cloth or fine sandpaper, then wipe inside of sleeves with a clean cloth.

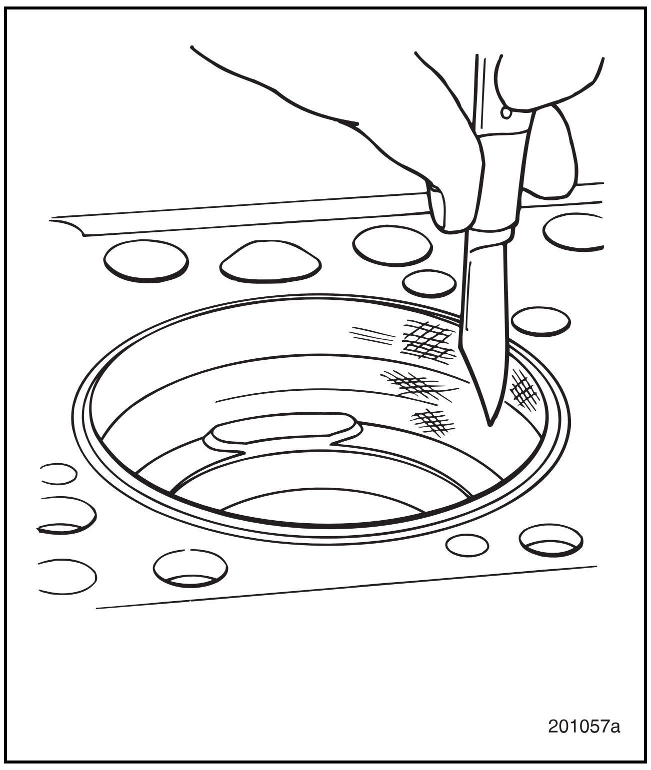


Figure 4-32 — Carbon Removal from Cylinder Sleeves

Refer to Figure 4-33.

4. Rotate crankshaft so that pistons 1 and 6 are at bottom dead center. Remove connecting rod capscrews and rod bearing caps.

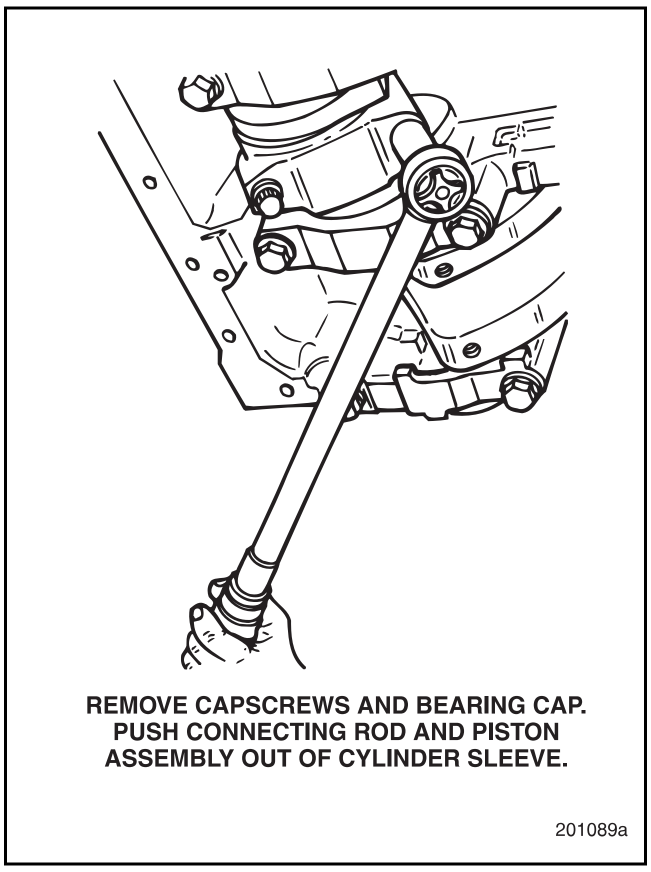


Figure 4-33 — Piston and Connecting Rod Assembly Removal

5. Using a hammer handle, push piston 1 from the cylinder bore. Remove piston 6 in the same manner.
6. After removing pistons 1 and 6, rotate crankshaft so that next set of pistons (2 and 5) is at bottom dead center.
7. Repeat steps 2 through 6 for removing piston sets 2 and 5, and 3 and 4.

[212 UC] FLYWHEEL

Refer to Figure 4-34.

1. With engine stand rotated so that engine is inverted (crankshaft horizontal), loosen all six flywheel retaining capscrews.
2. Remove two of the flywheel retaining capscrews that are opposite each other. Install two longer capscrews or studs to allow flywheel to be safely removed from the crankshaft.
3. Remove remaining capscrews.
4. Carefully tap flywheel by alternating from side to side to work it off the aligning dowel pins.

WARNING

The flywheel is heavy. Lifting the flywheel will require the help of an assistant or the use of a suitable lifting device (J 25026-A or equivalent). Attempting to lift a flywheel without such assistance may result in severe personal injury.

NOTE

Remove flywheel timing pointer, if present, to avoid damaging the pointer during flywheel removal.

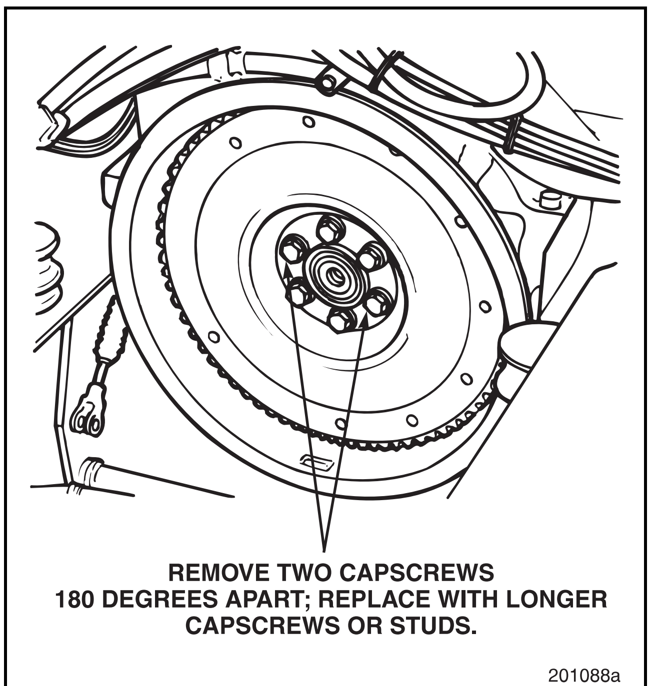


Figure 4-34 — Flywheel Removal

5. Support the flywheel and remove two guide capscrews.
6. Using a suitable lifting device such as J 25026-A, or adequate assistance, remove flywheel.

[211 HD] FLYWHEEL HOUSING

Refer to Figure 4-35.

1. Remove eight mounting capscrews (3) from flywheel housing (2).
2. Remove flywheel housing. It may be necessary to tap lightly on the housing with a soft mallet to separate housing from engine block.

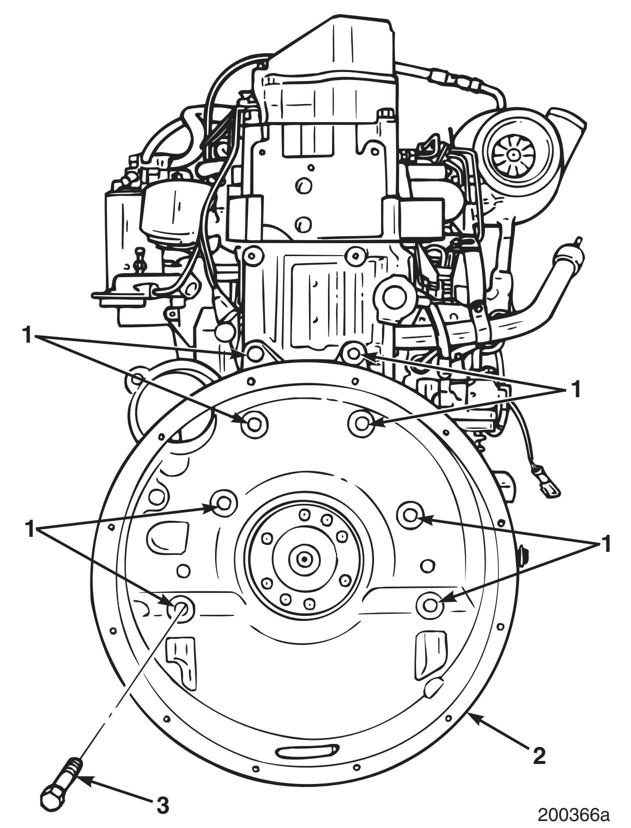


Figure 4-35 — Flywheel Housing Removal

1. Capscrew locations 2. Flywheel housing	3. Capscrew

[211 JA] MAIN BEARING CAP

NOTE

Before removing main bearing caps, ensure they are marked so they can be reinstalled on the same journals. Keep the bearings with the same cap and tag or mark them to identify the cam side of the bearings.

Refer to Figure 4-36.

1. Remove eight buttress capscrews (2 and 3).
2. Remove main bearing capscrews (1) from each of the seven bearing caps (4 and 5). The center main bearing cap (5) houses the thrust washers.
3. Position a lady-foot pry bar under the tabs provided on bearing caps and pry bearing caps upward. To work them loose, it may be necessary to tap the bearing caps alternately from side to side with a soft mallet.

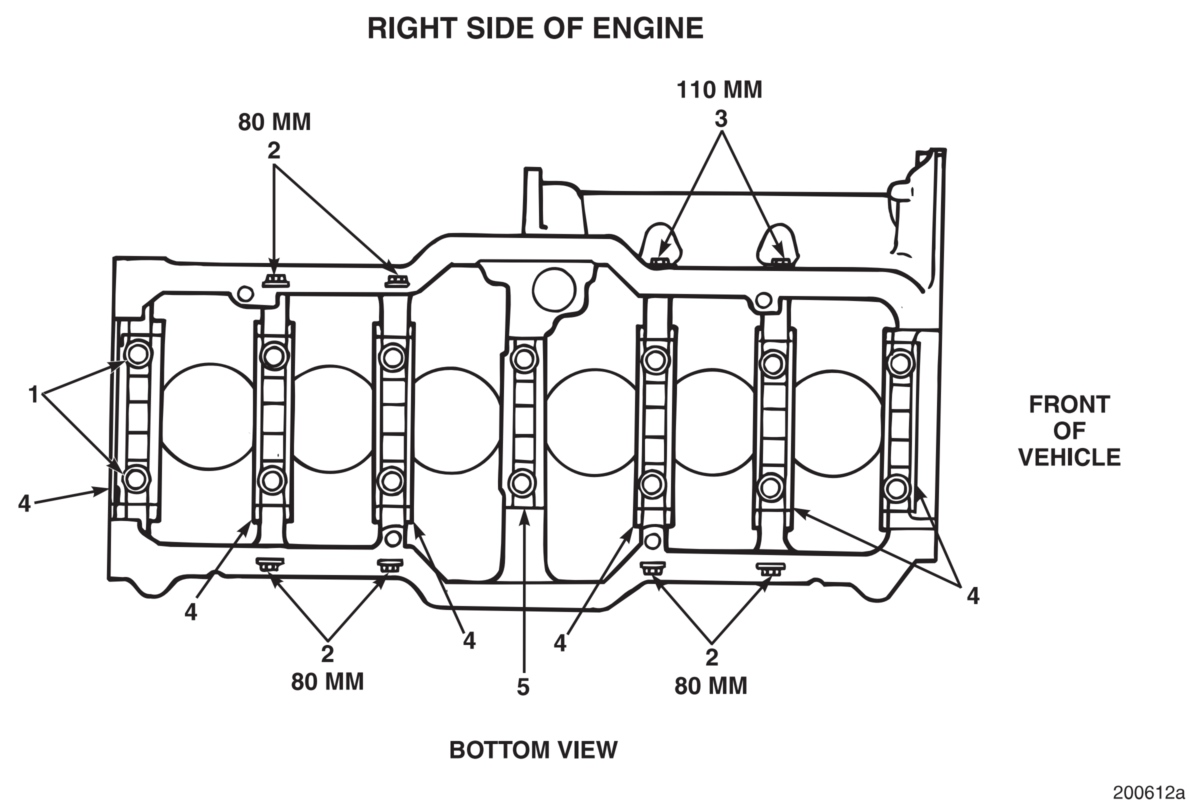


Figure 4-36 — Buttress Capscrew Installation

1. Main bearing cap capscrews 2. Buttress capscrews, 80 mm 3. Buttress capscrews, 110 mm	4. Main bearing caps 5. Center main bearing cap

[212 HP] CRANKSHAFT

Refer to Figure 4-37.

1. Using a suitable lifting device, secure a sling or crankshaft support tool around the crankshaft and lifting device hook. Ensure crankshaft is evenly balanced when lifted from the engine block.
2. Lift crankshaft from engine block and store in a secured stand, or horizontally on V-blocks.

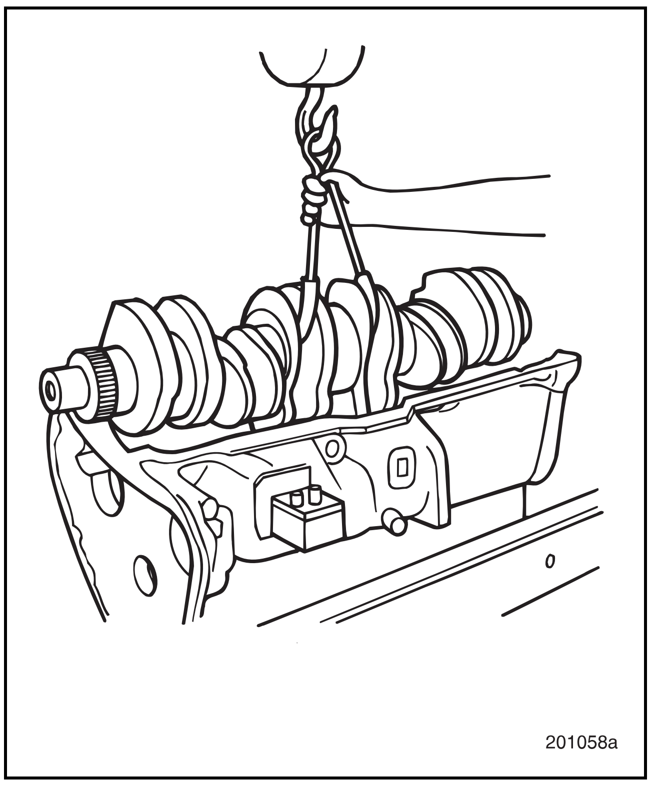


Figure 4-37 — Crankshaft Removal

[219 RV] PISTON COOLING SPRAY NOZZLE

CAUTION

To avoid damaging spray nozzles, remove them before removing sleeves.

SERVICE HINT

It is best to use a 10-mm, 6-point socket on a 12-inch extension to remove the nozzle retaining capscrews.

Refer to Figure 4-38.

1. Remove piston cooling spray nozzle (2) by removing retaining capscrew (3).
2. Carefully pull outward on the spray nozzle to remove it from the block.
3. Remove and discard elastomer seal (1).
4. Repeat steps 1 through 3 to remove remaining spray nozzles.

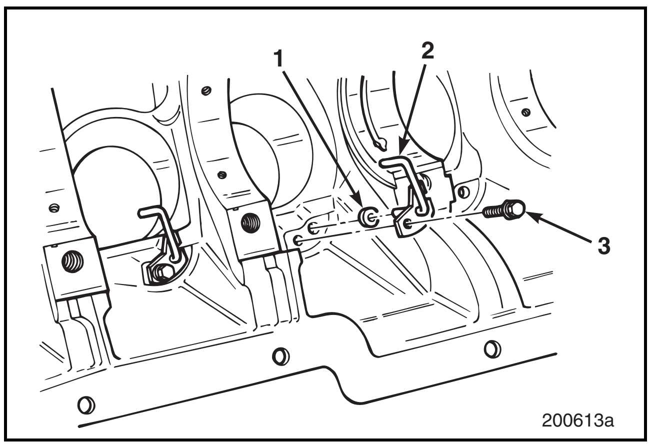


Figure 4-38 — Spray Nozzle Removal

1. Elastomer seal 2. Spray nozzle	3. Capscrew

[212 NC] CYLINDER SLEEVE

Special Tool Required

- Cylinder Liner/Sleeve Puller PT6435

Refer to Figures 39 and 40.

1. Rotate engine in stand so that it is upright (deck surface upward).
2. Use puller PT6435, or equivalent, to remove cylinder sleeve (2) from cylinder block (4).
3. Position puller above the sleeve and guide the puller shaft through the sleeve.

CAUTION

Extreme care must be taken to make sure the puller shoe is properly aligned in the bottom of the sleeve to prevent damage to the block.

4. Position puller shoe so that it catches the lower lip of the sleeve. Ensure that it does not extend beyond outside edges of the sleeve so it will not come into contact with the cylinder block as the sleeve is removed.
5. Tighten screw on the puller until sleeve comes free from cylinder block bore. Remove shims (3), if installed.

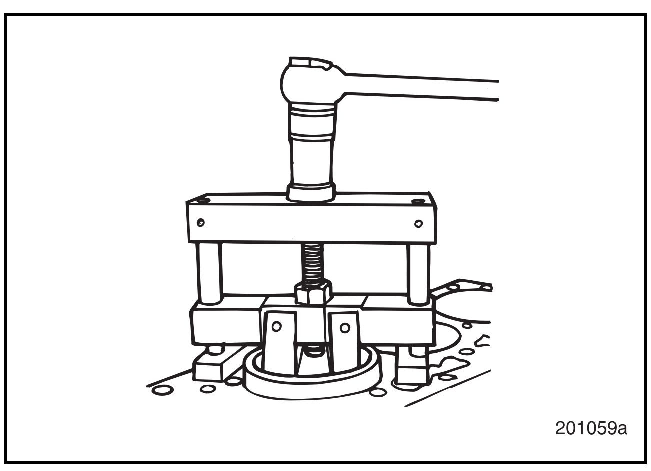


Figure 4-39 — Cylinder Liner/Sleeve Puller PT6435

6. Remove puller from sleeve.
7. Remove crevice seal (1) from sleeve.
8. Repeat steps 2 through 7 to remove remaining cylinder sleeves.

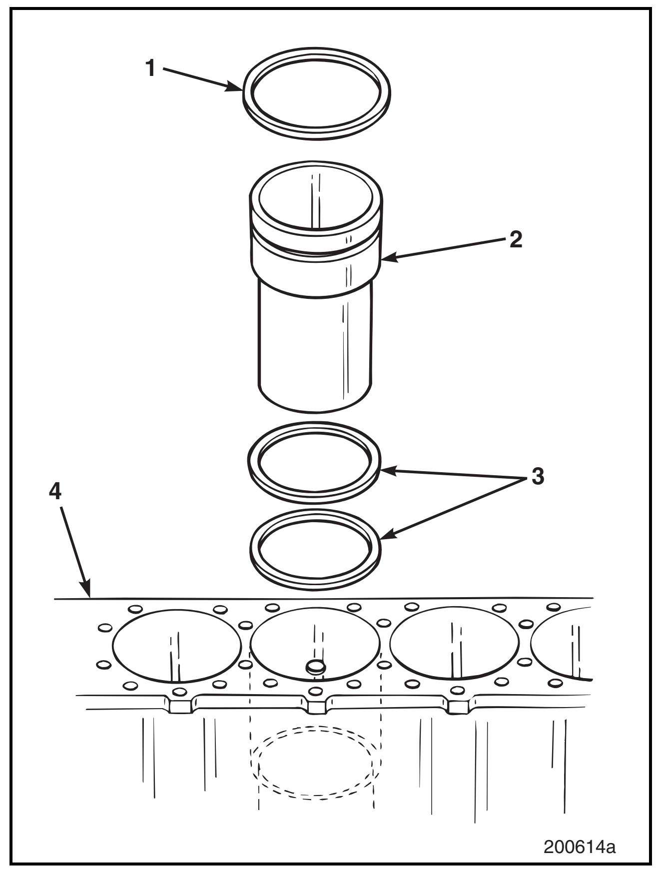


Figure 4-40 — Sleeve Removal

1. Crevice seal	3. Shims
2. Cylinder sleeve	4. Cylinder block

NOTES

BENCH PROCEDURES

[211 DB] CYLINDER BLOCK

Cylinder Sleeve Counterbore

SPECIAL TOOLS REQUIRED:

- Counterbore Tool PT2210
- Counterbore Cutter Plate PT2210-3A
- Universal Dial Depth Gauge PT5025
- Stylus Extension (3-Inch) PT5052-11
- Hex Key Wrench PT2210-14

INSPECTION AND REPAIR

If the cylinder block deck is resurfaced, the cylinder sleeve counterbore depth must be recut to specification. If the cylinder block deck was not resurfaced but cylinder sleeve counterbore surface shows excessive pitting or erosion, recut the counterbore as required.

Use shims to re-establish the correct liner flange height. Shims are available in the following thicknesses: 0.002, 0.003, 0.004, 0.008, 0.010, 0.012 and 0.014 inch.

To resurface the cylinder sleeve counterbore area of the cylinder block, use counterbore tool PT2210 with counterbore cutter plate PT2210-3A.

NOTE

This procedure can be performed either in or out of the chassis. If performing the procedure in the chassis, be sure to cover the crankshaft and any holes in the block to prevent contamination from machining chips.

CAUTION

Do not cut seats deeper than 4.034 inches (102.464 mm).

1. Make sure that the top of the deck is clean and free of burrs. Use a finish mill file and crocus cloth, if necessary, to create a smooth, flat surface for positioning the tool.
2. Using compressed air, thoroughly remove all debris.

NOTE

Universal dial depth gauge PT5025, with a 3-inch stylus extension PT5052-11, is recommended for measuring the counterbore.

3. Measure and record the counterbore in four places, 90 degrees apart. Using a depth gauge with a 3-inch extension, mark the shallowest point. Subtract the lowest number from the highest number. This is the minimum amount to be machined for cleanup.

SETTING UP COUNTERBORE TOOL PT2210 WITH CUTTER PLATE PT2210-3A

Refer to Figure 5-1.

1. Loosen the two cutter bit hold-down capscrews (9). Install cutter bit (11) into cutter plate PT2210-3A (13) by turning the cutter bit adjuster (10) counterclockwise. Cutter bit face must be facing a clockwise rotation cut.

CAUTION

Do not tighten the cutter bit hold-down cap (12).

The cutter point should not extend beyond the outer edge of the cutter plate. If the cutter bit does stick out, damage to the bit will occur when installing counterbore tool onto cylinder block.

2. Install the cutter plate on the main shaft (15). Use the large end of hex key wrench PT2210-14 (18) to hold the cutter plate and tighten securely. The hole in the side of the cutter plate accepts the large end of the tool.

CAUTION

Do not allow the cutter bit (11) to touch the cylinder sleeve bore wall.

SERVICE HINT

When the entire block must be counterbored, cut the deepest bores first. This way, the tool can be adjusted to the lowest depth and used for all cylinders, ensuring uniform depth on all cylinder counterbores.

3. Position the tool in the cylinder bore by backing the depth-set collars (5 and 16) off and lowering the cutter plate (13) into the counterbore to center the tool.
4. Secure the cutter plate to the cylinder block with four M16 x 2 x 90 hex-head capscrews (3) and special washers (4) from the counterbore tool kit PT2210.
5. Cross-torque the capscrews to 30 lb-ft (41 N•m) using torque wrench J 24406 or equivalent.

NOTE

Lift T-handle (2) slightly (so cutter plate is not in contact with the counterbore) and rotate the mainshaft (15) counterclockwise to ensure cutter plate turns freely without binding. If necessary, loosen the capscrews and relocate the tool.

6. Using the counterbore tool T-handle (2), raise the cutter plate approximately 1/2 inch (12.7 mm) from the counterbore ledge.
7. Using hex key wrench PT2210-14 (18), turn the cutter bit adjusting screw (10) clockwise until the cutter bit contacts the counterbore ledge. Do not touch the counterbore wall.
8. Back off the lower depth-set collar (16) and lower the cutter plate until the cutter rests on the ledge.
9. Rotate the lower depth-set collar down until the collar contacts the main housing.
10. Rotate the collar an additional five increments: 0.005 inch (0.127 mm). Each graduation of the collar is one-thousandth (0.001) of an inch (0.025 mm). This will lift the cutter bit 0.005 inch (0.127 mm) off the counterbore ledge, allowing an accurate setting of the cutter bit.

NOTE

It may be necessary to use a flashlight to see the cutter bit adjusting screw.

11. Using hex key wrench PT2210-14 (18), turn the cutter bit adjusting screw clockwise until the cutter bit rests on the counterbore ledge.
12. If the cutter bit will not adjust, adjust the lower depth-set collar (16) 0.005 inch (0.127 mm) more and recheck cutter bit hold-down screws for looseness.
13. Zero the depth-set collars:
    a. Back off the lower depth-set collar (16) and carefully lower the cutter plate (13) into the bore and allow the cutter to rest on the counterbore ledge.
    b. Rotate both depth-set collars (5 and 16) down until the bottom collar contacts the main housing (8).

CAUTION

Do not force the collar beyond this point, as it will lift the cutter plate and prevent an accurate zero reading.

14. Set the depth of the cut. Determine the final depth of the cut and back off the top depth-set collar accordingly. Each increment on the depth-set collar increases the depth of the cut by one-thousandth (0.001) of an inch (0.025 mm). Tighten the thumbscrew (17) on the upper collar (5) securely.

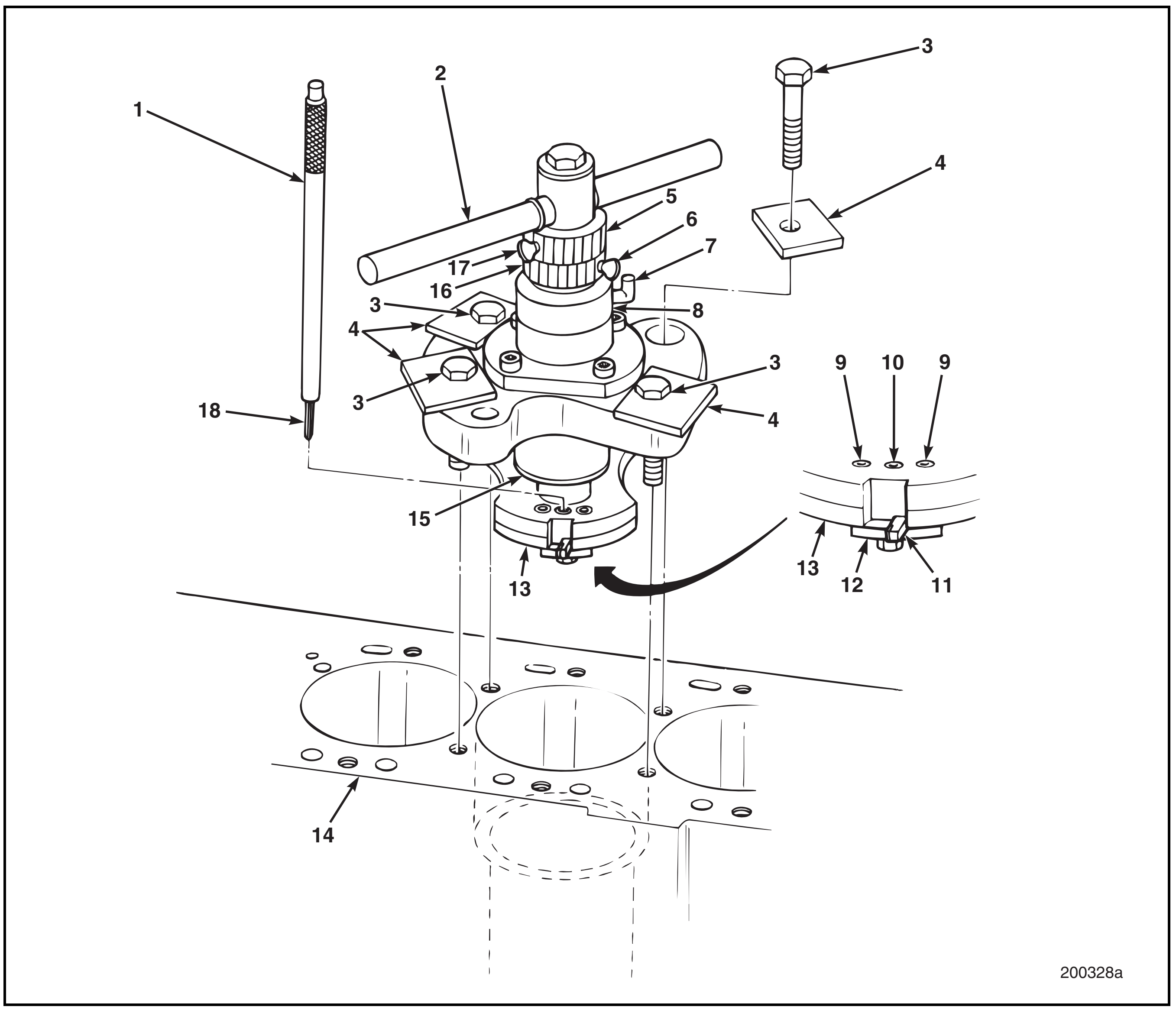


Figure 5-1 — Counterbore Ledge Tool Installation

1. Cutter plate holder	10. Cutter bit adjuster
2. T-handle	11. Cutter bit
3. Capscrews, M16 x 2 x 90	12. Hold-down cap
4. Special washers	13. Cutter plate
5. Upper depth-set collar	14. Cylinder block
6. Lower thumbscrew	15. Main shaft
7. Oil fill tube	16. Lower depth-set collar
8. Main housing	17. Upper thumbscrew
9. Hold-down capscrews	18. Hex key wrench

CUTTING THE COUNTERBORE

Refer back to Figure 5-1.

1. Fill the oil fill tube (7) with 30W nondetergent oil to maintain lubrication during use.
2. Back off the lower depth-set collar (16) two increments or less, and tighten the thumbscrew (6) securely.
3. Cut the counterbore by turning the T-handle clockwise while maintaining constant downward pressure on the tool. Stop the handle in a different position to avoid creating a ridge in the counterbore.
4. Continue backing off the lower depth-set collar, no more than two graduations per cut. Check the depth measurement between each adjustment. Plan to remove 0.001 inch (0.025 mm) on the final cut to meet the final predetermined counterbore depth. This ensures achieving a very fine machined finish.
5. Remove the tool from the cylinder bore.
   a. Loosen the two cutter bit hold-down capscrews (9) and rotate the cutter bit adjusting screw (10) counterclockwise until the cutter bit is retracted into the cutter plate (13).
   b. Remove the four machine hold-down bolts (3) and special washers (4).
   c. Remove the tool from the cylinder bore.
6. Follow steps 1 through 5 for the remaining cylinders.

[212 CV] AUXILIARY DRIVESHAFT

Description

All current production engines (effective February 27, 1992, serial No. 2E1233) are equipped with a “fast ratio” auxiliary driveshaft assembly and oil pump assembly. This arrangement raises oil pump speed to increase operating oil pressure 25%. Refer to Auxiliary Driveshaft Installation instructions in the ENGINE ASSEMBLY section for ratio information.

CAUTION

Do not mix “fast ratio” and “standard ratio” components. Serious damage may occur.

Inspection

1. Thoroughly clean auxiliary driveshaft.
2. Inspect auxiliary driveshaft journals and gear teeth for evidence of cracks, pitting, scoring or severe wear. If any of these conditions exist, replace the auxiliary driveshaft.

[212 LP] CONNECTING RODS

Description

Refer to Figure 5-2.

Early E7 engine connecting rods were machined to give rod cap bottoms a contoured appearance. Since mid-1992, connecting rod caps have had a flat, machined bottom. The rods are the same in strength and configuration, with the only difference being the rod cap bottom surface machining.

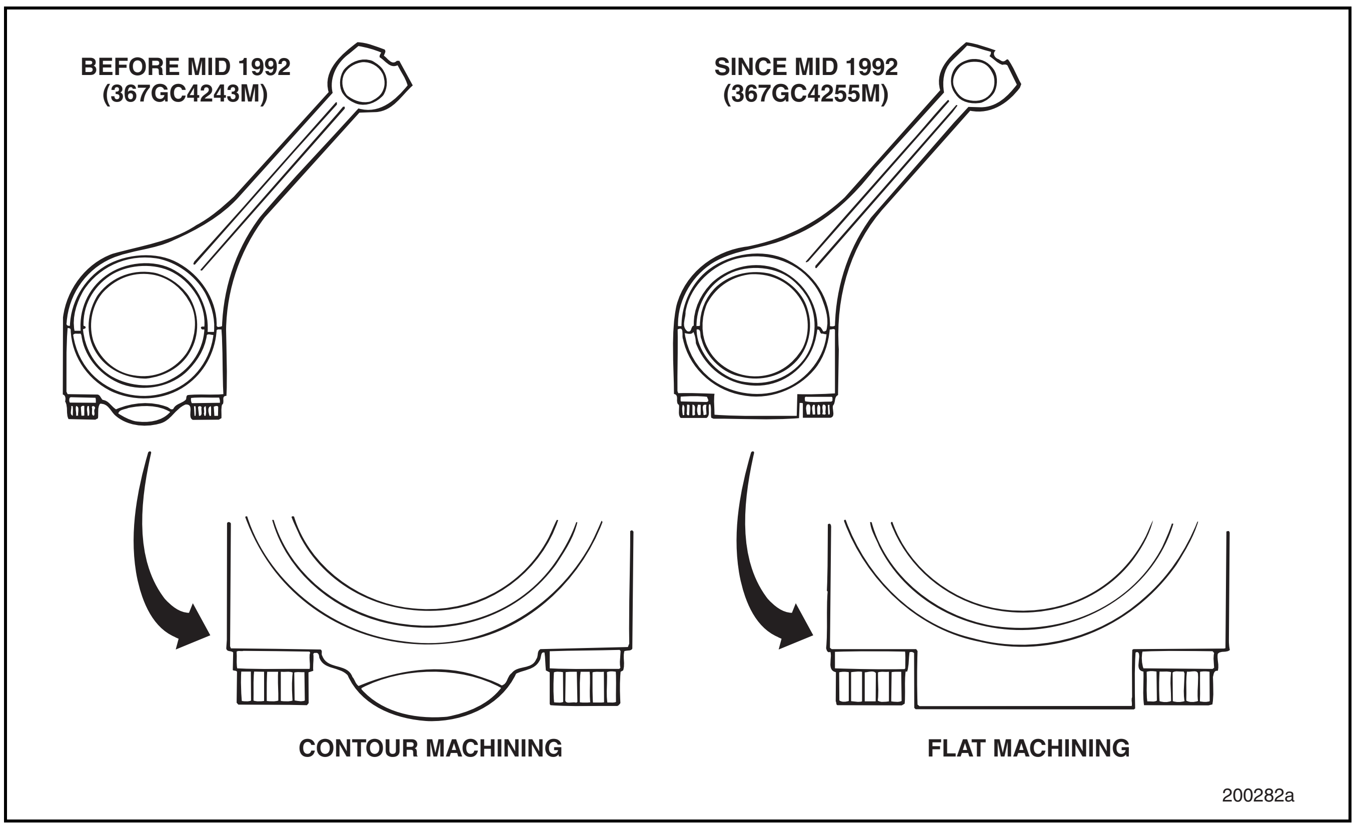


Figure 5-2 — Connecting Rod Identification

Refer to Figure 5-3.

A redesigned connecting rod assembly with an added alignment sleeve feature was introduced into E7 production engines in April 1995. This connecting rod assembly has two alignment sleeves (3), one sleeve in each capscrew hole of the rod cap (1) to locate and align the cap and rod thrust faces. These sleeves provide the best alignment when sleeve gaps are positioned at a location approximately 90 degrees to the tongue or groove (2). The sleeve gaps must not be in line with the tongue or groove.

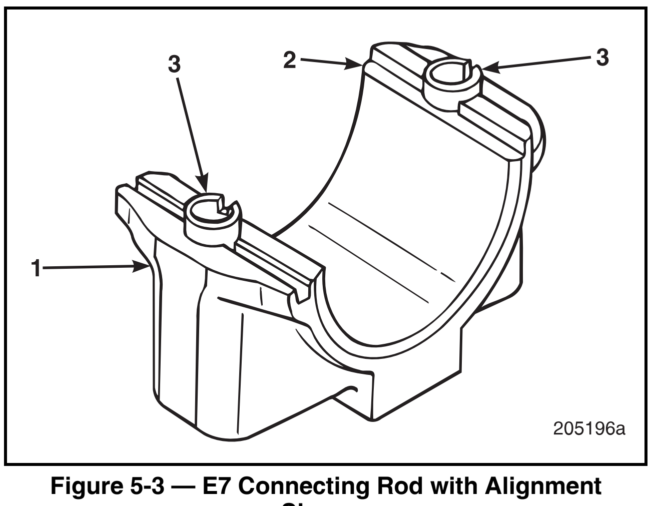


Figure 5-3 — E7 Connecting Rod with Alignment Sleeves

1. Rod cap 2. Bearing insert	3. Alignment sleeve

NOTE

During initial production, part numbers were stamped onto the through hole of the connecting rod bearing cap. In later production, the part number was forged into the I-beam of the rod.

NOTE

Old-style connecting rods (without alignment sleeves) and new-style connecting rods (with alignment sleeves) may be intermixed in an engine. However, the capscrews and alignment sleeves are not interchangeable between the two rod assemblies. The alignment sleeves will physically fit into either of the connecting rod assemblies, but the sleeve must be used in the new-style 367GC4267M or M2 connecting rods ONLY. The capscrews cannot be mixed. The difference in the thread size between the two rod assemblies is significant enough that the 14-mm threaded capscrews will not even engage the 16-mm tapped hole in the old-style (367GC4255M or M2) rod assemblies. The 16-mm threaded capscrew cannot be assembled into the 14-mm tapped hole of the new-style (367GC4267M or M2) connecting rod assemblies.

It is essential to closely control the weight of reciprocating parts. MACK E7 connecting rods fall into two weight classes. Prior to mid-1996 production, the weight classes are identified by an “M” number (M1 or M2) stamped onto the connecting rod bearing cap. Effective with mid-1996 production, the M2 connecting rod is no longer stamped with this weight designation. The M1 weight class rod will continue to be stamped on the rod cap. When installing a single rod, or less than a full set, examine removed rod for part number and M number. Installing parts with the same weight class is preferred.

Connecting rods can be weighed to ensure using proper weight class. Connecting rod weights for each engine, within each weight class, should not vary by more than 0.46 ounce (13.04 grams). The maximum weight difference between the heaviest possible M2 rod and the lightest possible M1 rod is 0.83 ounce (23.53 grams).

Special Tools Required

- Piston Pin Bushing Remover/Installer J 37717
- Piston Pin Burnishing Broach J 37718
- Connecting Rod Fixture 945-6041

Inspection

- Inspect connecting rods for nicks, cracks, signs of overheating, bends or twisting that can cause rod failure.
- Inspect bolt holes for elongation or pulled threads.
- Check mating surfaces between rod and cap for correct fit.
- Inspect the crankshaft journal bearing surface and wrist pin bushing.

If any of the above parts are suspected of being faulty, replace the connecting rod.

SERVICE HINT

If it is determined that the condition of any part or component is questionable or is at the limit of tolerance, throw it out; it may fail or become out of tolerance after a short time in operation. It is cost-efficient to replace components when rebuilding.

Always use genuine MACK replacement parts.

Wrist Pin Repair

WRIST PIN BUSHING REMOVAL

If the wrist pin bushing is found to be out of tolerance, it should be replaced.

Refer to Figure 5-4.

To replace bushing:

1. Position rod in a press with piston pin bushing remover/installer J 37717 inserted into wrist pin bushing.
2. Press bushing out of rod.

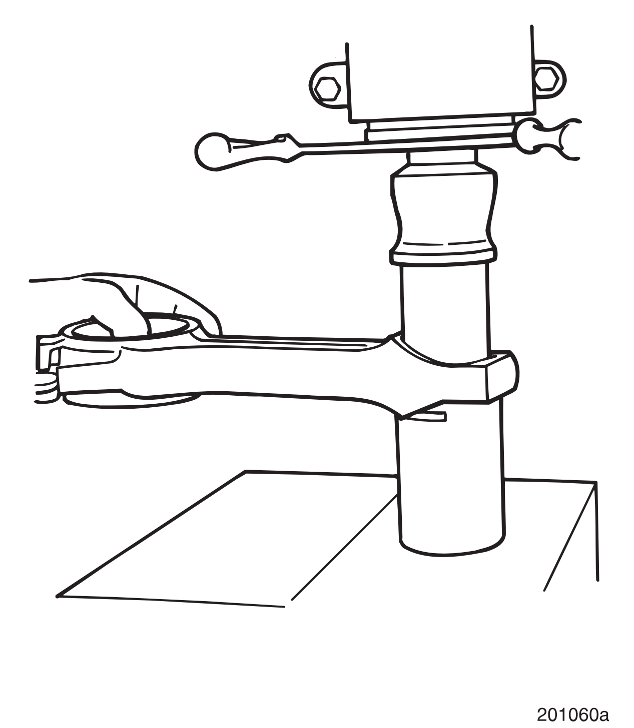


Figure 5-4 — Wrist Pin Bushing Removal

WRIST PIN BUSHING INSTALLATION

CAUTION

The wrist pin bushing has a lubrication hole through it. This hole MUST be aligned with rifle-drilled hole in rod to allow oil flow to wrist pin. If holes are not aligned, wrist pin, piston, and connecting rod failure will result.

1. Position rod, bushing and piston pin bushing remover/installer J 37717 in press, and press bushing into rod.
2. Align hole in bushing with rifle-drilled hole in rod.

CAUTION

Make certain that bushing is fully expanded in the connecting rod bore or it will loosen in service.

Refer to Figure 5-5.

3. Position rod assembly in press with piston pin burnishing broach J 37718.

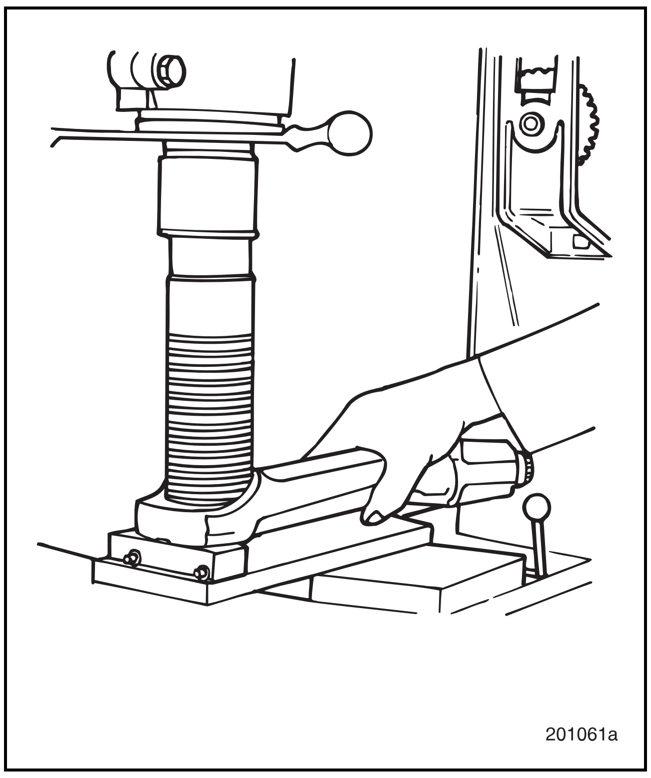


Figure 5-5 — Burnishing Wrist Pin Bushing

4. Using a suitable lubricant, press broach through bushing to expand bushing.

Refer to Figure 5-6.

5. After machining bushing, check connecting rod for twisting or bending. Use Sweeney connecting rod fixture 945-6041. Accessory mandrel and plunger extension assemblies for various engines are required for use with this fixture, and are also available from the Sweeney Company.

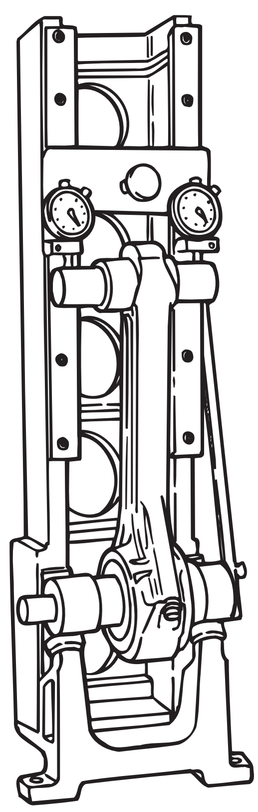


Figure 5-6 — Connecting Rod Fixture

NOTE

Maximum twist of connecting rod within 12 inches (30.5 cm) is 0.010 inch (0.254 mm). The maximum bend of connecting rod within 12 inches (30.5 cm) is 0.004 inch (0.102 mm). Distances are center to center.

[212 HP] CRANKSHAFT

Description

The crankshaft is fully counterbalanced and journals are induction-hardened. There are seven main bearings. Thrust washers located at the center main bearing (position No. 4) absorb fore and aft end thrust. Crankshaft extension at forward end carries the main drive gear, vibration damper and accessory drive pulleys. The main drive gear has a shrink fit and the vibration damper hub has a press fit. The main drive gear is keyed to the crankshaft and proper assembly is important for engine timing. The flywheel is mounted to a flange at rear of crankshaft. Two seals, one at the front and one at the rear, prevent engine lubricating oil from leaking around ends of the crankshaft.

Bearing caps are furnished with the crankcase and support the crankshaft in true alignment. Webs integral to the crankcase provide upper half of main bearing supports. Removable caps provide lower support. Capscrews hold the caps in position. The bearing caps are not interchangeable and each has a number stamped on it which signifies its correct location and alignment in the crankcase. The caps are numbered 1 through 7, with No. 1 main bearing cap in front of engine. The bearing inserts are precision designed. Bearings are inserted between the crankshaft and crankcase, and between the crankshaft and bearing caps. Thrust flanges to support thrust washers are located at the center main bearing (No. 4).

CAUTION

Extreme care must be taken to guarantee cleanliness of crankcase, crankshaft, and bearings during servicing and after service has been completed. Whenever possible, crankshaft should be removed when bearings are being installed in order to clean crankcase thoroughly.

All bearing surfaces must be free of grit and burrs. Small particles of dust and dirt left between crankshaft and bearings will cause rapid wear and scoring of crankshaft journal and inserts. Any foreign material left between bearings and crankshaft bearing caps will cause distortion of bearing and a reduction in operating clearance at that point. The resulting frictional heat will cause bearing material to melt away from steel backing of bearing at that point. Such melted material will create further hot spots until complete bearing failure occurs. Anything that interferes with operating clearance of any bearing, or proper heat dissipation, affects bearing life. Cleanliness cannot be overstressed.

Inspection

NOTE

If crankshaft journals are worn, out of round, or tapered, order a new crankshaft or exchange kit through the MACK parts system. New and exchange crankshafts are available through MACK distribution centers. When ordering an E7 crankshaft, be sure to note V-MAC or non V-MAC application, since crankshafts are not the same.

1. Inspect crankshaft journals for straightness, out-of-round, taper, and surface finish.
2. Visually check crankshaft for any apparent cracks, worn journals and damage to threads, dowel or main drive gear.
3. Magnaflux the crankshaft. This process requires special equipment and application methods.
4. Using standard machinist inspection practice, check crankshaft for straightness.
5. Measure crankshaft journals with a micrometer. Measure each journal in two locations, 90 degrees apart, and record measurements.
6. Check measurements against specifications in the FITS AND LIMITS section of this manual.

CAUTION

Crankshaft regrinding by anyone other than Mack Trucks, Inc. is NOT recommended due to the tight control required on maintaining geometrical tolerances, and the hardened characteristics of the crankshaft journals and journal fillets.

If the crankshaft is not serviceable, both new and reground crankshafts are available through the MACK Parts Distribution Centers.

If crankshaft main journals or rod journals are not a standard size, be sure to use properly sized bearing inserts. Bearing inserts are marked with a “P” which follows the part number, and is stamped on the back side of the bearing insert. For example, if a journal is 0.010 inch (0.254 mm) undersize, a 0.010-inch undersize bearing is required and will be stamped “P10”.

CAUTION

Some crankshafts may have journals which are 0.002 inch (0.0508 mm) undersize. They are marked by a streak of white paint adjacent to the journal. Always check journals to ensure using proper size bearing inserts.

[212 HA] Crankshaft Dowel Pin Replacement

The “diamond” locating dowel pins used for installing flywheel to crankshaft have been replaced by blade-style locating dowel pins. The diamond pins were dual diameter-type pins. There was a smaller diameter at the round end than at the diamond end. There are no changes in the size of the hole in the flywheel. However, the crankshaft will have larger holes to accept blade-style pins.

The blade-type dowel pin was introduced in May 1992, starting with serial No. 2K. You must use the dowel size that is appropriate for the crankshaft. (Service old with old, and new with new.)

Effective May 1993, all E7 engine crankshafts are equipped with flywheel-to-crankshaft dowel 183GC238 installed in the rear flange. Prior to this date, only V-MAC engine crankshafts had the 183GC238 dowel. Crankshafts in mechanically governed engines did not have a dowel pin hole in the rear flange. However, all E7 engine crankshafts have always had a crankshaft manufacturing locator hole in the rear flange. This hole is approximately 1/2 inch (12.7 mm) in diameter and 3/8 inch (9.52 mm) deep, and is used only in the manufacturing process.

The flywheel locating dowel hole — located directly opposite the manufacturing locator hole — is approximately 9/16 inch (14.29 mm) in diameter by 7/8 inch (22.23 mm) deep in crankshafts made since May 1992 using dowel 183GC238. V-MAC crankshafts made prior to May 1992 have a flywheel locating dowel hole 1/2 inch (12.7 mm) in diameter by 7/8 inch (22.23 mm) deep for dowel 183GC221.

All new service replacement crankshafts, short blocks or basic engines will have a dowel pin in the crankshaft rear flange. In nearly all cases, the flywheel will already have a hole in it to accept the dowel pin. If, in an earlier version, the flywheel or torque converter drive flange does not have a hole in it for a dowel pin, it must be reworked.

If it is necessary to rework the flywheel or torque converter drive flange, two holes must be added using a 19/32-inch drill bit. One hole is for the dowel pin, and another directly opposite the first hole is to maintain balance of the flywheel/torque converter drive flange.

Refer to Figure 5-7.

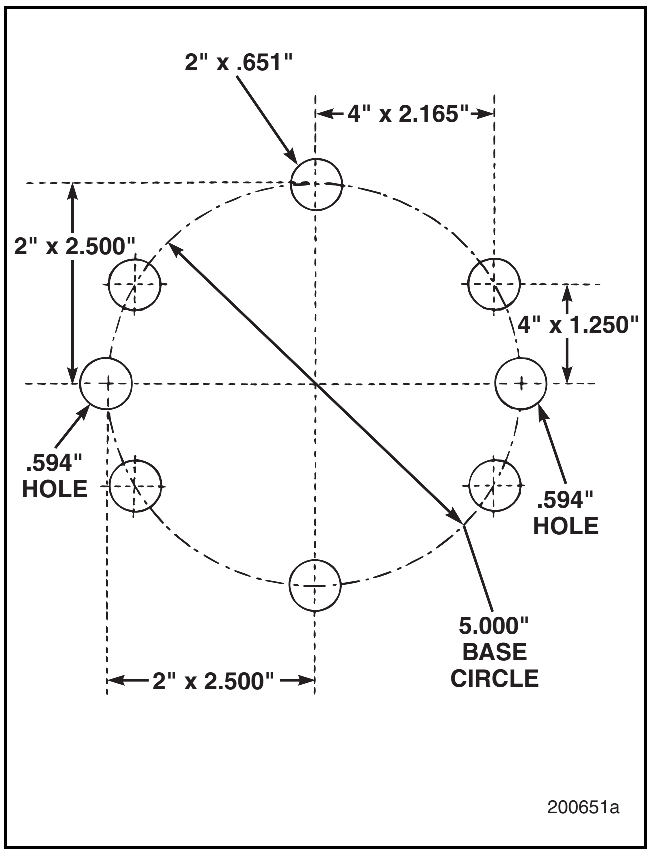


Figure 5-7 — Dowel Pin Hole Dimensions (Flywheel or Torque Converter Drive Flange)

Crankshafts used in early mechanically governed engines, part No. 4566C5127M, did not have a dowel pin or dowel pin hole. It is acceptable to use this early non-pinned crankshaft design in *any* mechanically governed engine, even when the original installation may have had dowel pins.

DOWEL PIN REMOVAL

To remove rear crankshaft dowel pin:

1. Using vise grips, securely grip dowel pin.
2. Rotate dowel pin back and forth while exerting outward pressure until pin is removed.

DOWEL PIN INSTALLATION

Refer to Figure 5-8.

To install a replacement crankshaft dowel pin:

1. Position dowel pin in a 0.5562-inch (14.1275 mm) diameter unthreaded hole in rear of crankshaft. The pin must be installed with the flat surface aligned parallel to the center of crankshaft, as shown in Figure 5-8.
2. Use a suitable tool to drive the pin into the hole. The pin must be firmly seated and protrude 0.77 inch (19.56 mm) from the crankshaft.

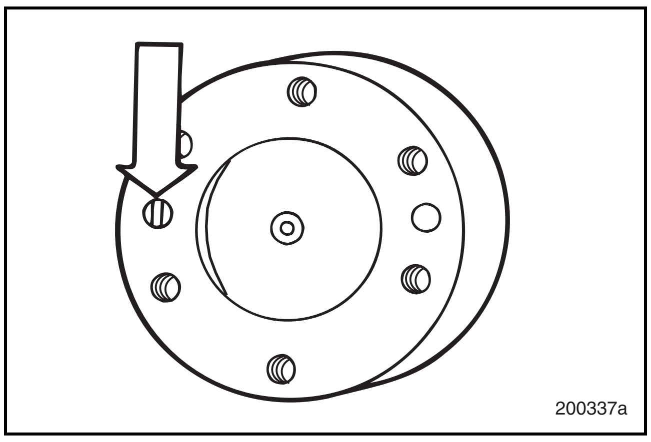


Figure 5-8 — Dowel Pin Alignment

[212 HV] Crankshaft Gear

INSPECTION

After inspecting the crankshaft and determining that it is serviceable, inspect crankshaft gear for cracks and broken, worn or chipped teeth. If crankshaft gear is defective, it must be replaced.

REPLACEMENT

Refer to Figure 5-9.

1. Using a suitable puller such as J 21834-4A, remove gear and key.

NOTE

The threads in the end of the crankshaft are M8 x 1.25.

2. Clean gear mounting surface. It should be free of grooves, scratches and burrs. Use a file, sandpaper or crocus cloth, as required.

CAUTION

Take care not to damage key slot while installing key.

3. Insert key (4) into key slot (3). Lightly tap key into slot with a soft metal hammer.
4. Heat replacement gear (1) to approximately 250°F (121°C) in a temperature-controlled oven or on a hot plate.

CAUTION

Wear protective gloves when handling heated crankshaft gear to prevent burns or personal injury.

CAUTION

Take care not to damage gear teeth while seating gear.

5. Position the gear over end of shaft (2) with timing mark outward, chamfer (6) toward rear of the shaft, and key slot aligned with key in shaft. In one rapid motion, push heated gear against flange (5). When gear is in place, immediately and carefully tap on gear to help seat it against flange.

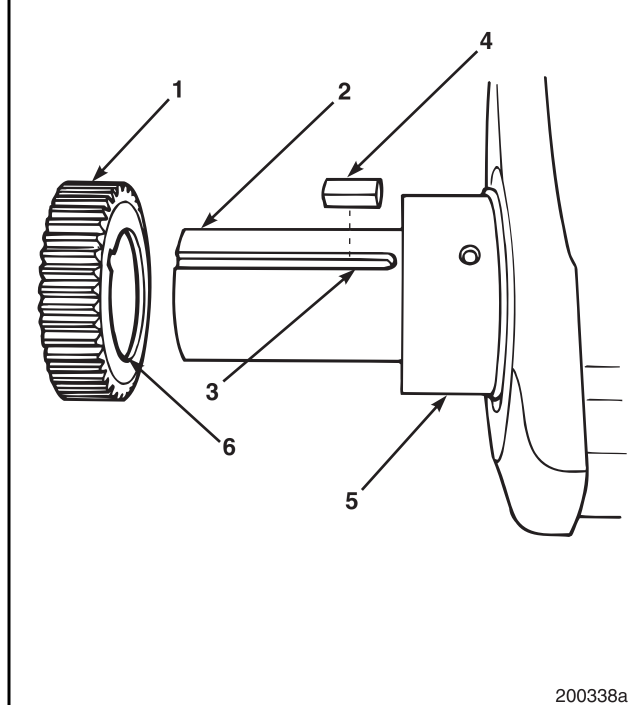


Figure 5-9 — Drive Gear Installation

1. Gear	4. Key
2. Shaft	5. Flange
3. Key slot	6. Chamfer

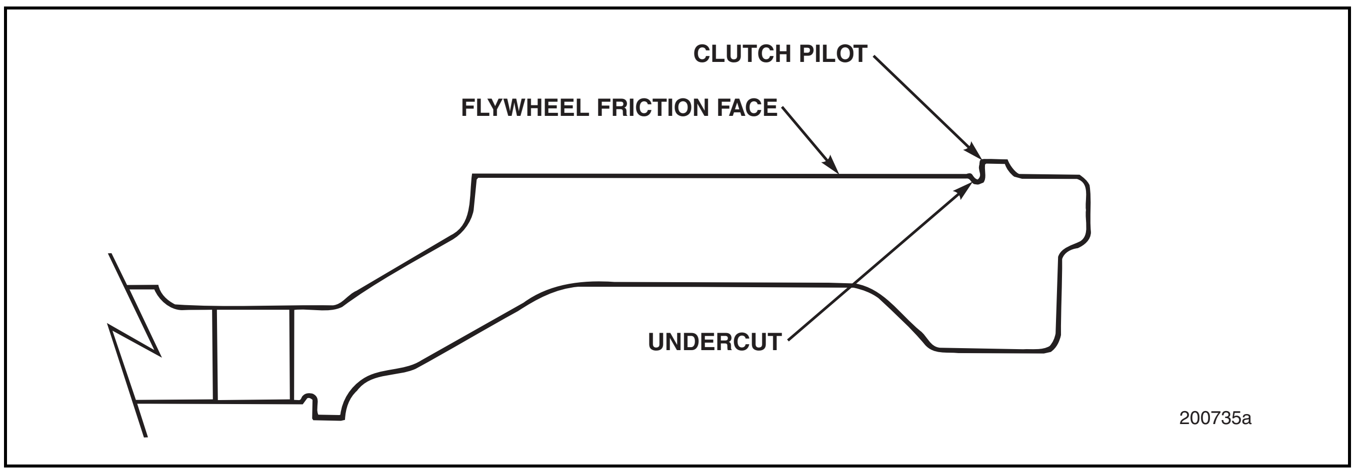


Figure 5-10 — Flywheel Resurfacing

[212 UB] FLYWHEEL

1. Inspect the flywheel to determine if it requires resurfacing. The wear areas should be measured using a straightedge across the friction face and a thickness gauge. If the wear measurement is 0.020 inch (0.508 mm) or less, the flywheel does NOT need to be machined when operated against ceramic clutch facings.
2. Resurface the flywheel as required.

NOTE

To ensure satisfactory life of the flywheel, the maximum amount of material that may be removed from the flywheel surface is 0.070 inch (1.78 mm).

When resurfacing a flat-style flywheel, it is very important that the machine shop NOT leave a step on the friction face outer diameter adjacent to the clutch locating pilot. There is an undercut relief in the corner between the friction face and the clutch locating pilot, and resurfacing must go up to this relief. If resurfacing is done to a depth which would eliminate the relief, a new relief must be recut. Refer back to Figure 5-10.

When resurfacing a flat-style flywheel and attempting to resurface as close to the clutch locating pilot as possible, keep in mind that the pilot must not be altered. The pilot controls location of the clutch; if the locating pilot is altered, imbalance will result.

NOTE

Some machine shop operations can adequately resurface a pot-type flywheel, but may not have the tooling and locating equipment necessary for resurfacing a flat-style flywheel in compliance with the above procedure.

[212 NP] PISTONS

Description

Since 1991, a two-piece piston has been required to aid in particulates control. To ensure a high level of durability, the piston crown is made from forged steel and the piston skirt is made of cast aluminum. The piston pin bore pedestal and piston skirt are stamped FRONT, and must be facing front of engine. One-piece pistons were used from 1989 through year end 1990. The procedures for installation are the same except as noted by “two-piece piston.” Current production parts are NOT interchangeable with 1989–1990 production parts.

CAUTION

A radius is cut in lower edge of piston skirt to provide clearance for piston cooling nozzle. The piston must be installed with the word FRONT facing front of engine.

The two-piece piston design incorporates two compression ring grooves and one oil ring groove. A plasma-faced, keystone-type ring is used in the top ring location. A tapered chrome, rectangular-type ring is used in the second ring groove. The oil control ring is located in the third (or lower) groove, nearest the piston pin bore. New piston rings are designed to further improve oil control, especially relating to particulates control.

NOTE

E7 piston crowns have been modified in the oil control ring groove area. During the second quarter of 1996, the oil drainback holes have been eliminated and replaced by an oil accumulator relief. The relief is machined into the lower half of the third ring land face, 360 degrees around the piston circumference.

CAUTION

Current E7 pistons are NOT interchangeable with 1989/1990 E7 pistons.

Special Tools Required

- Piston Ring Expander PT6587
- Keystone Ring Groove Gauge J 29510

Disassembly

Refer to Figure 5-11.

1. Using piston ring expander PT6587, remove piston rings.

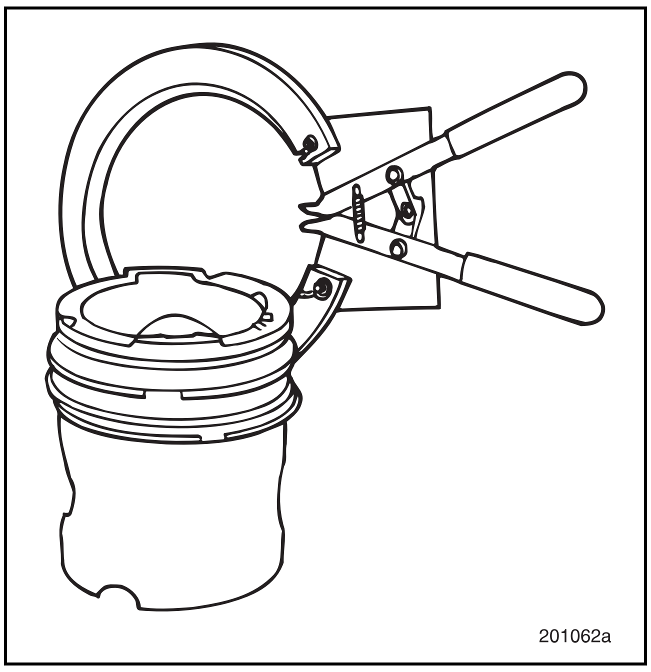


Figure 5-11 — Piston Ring Removal

2. Thoroughly clean ring grooves and combustion bowl area. All carbon must be removed. Carbon left in grooves will reduce ring clearance and prevent replacement rings from seating properly.

CAUTION

Be sure that cleaning solvent is approved for steel/aluminum. Incompatible solvent may cause damage to pistons or skirts.

3. Clean pistons with approved solution and a brass brush. Take care to avoid damaging pistons while cleaning.

Inspection

Inspect piston ring grooves, lands, piston skirt and combustion bowl for wear, scuffing, cracks or blow-by. Pistons are NOT repairable. Discard piston if it is damaged.

CAUTION

Do not stamp or engrave on TOP of piston. Doing so will reduce piston life.

To ensure that pistons are reinstalled in the same cylinders as removed, tag the piston with the corresponding cylinder number.

[212 NV] PISTON RINGS

NOTE

Before installing piston rings, check keystone ring groove wear and ring end gap.

1. Place a piston ring in the piston sleeve. Push it down into the sleeve with an inverted piston to ensure that it is positioned squarely in sleeve.
2. Using thickness gauges, check ring end gap. Refer to the Fits and Limits chart in the SPECIFICATIONS section for end gap specifications. All rings to be used should be checked in this manner.

CAUTION

Do not file or grind chrome-plated piston rings. This may cause chrome to flake, resulting in ring failure.

Keystone Ring Groove Check

Refer to Figure 5-12.

Keystone piston-ring groove gauge J 29510 consists of two 0.120-inch (3.048 mm) diameter pins (1) connected at ends by two springs (2).

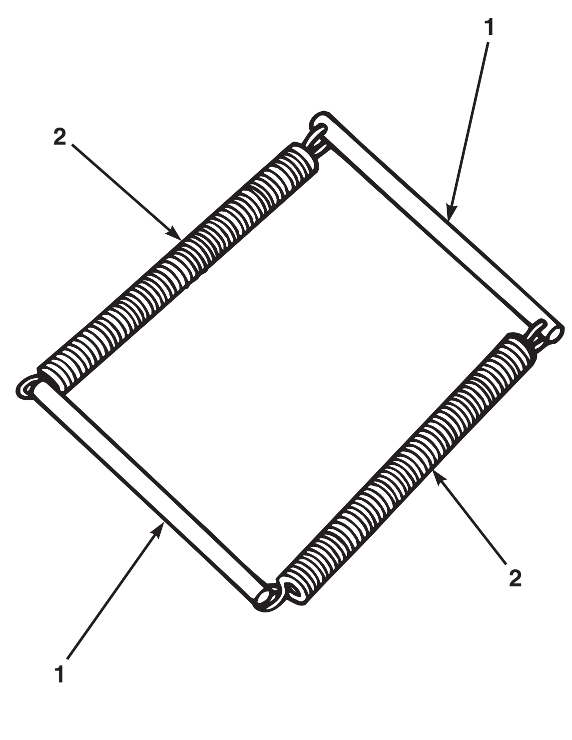


Figure 5-12 — Ring Groove Gauge

1. Pins	2. Springs

1. Place pins of keystone piston-ring groove gauge J 29510 opposite each other in groove to be measured, so they will be held in position by springs.

Refer to Figure 5-13.

2. Using a four- to five-inch micrometer, measure distance between outer edges of two parallel pins. Check each compression ring groove in two locations: parallel and perpendicular to wrist pin bore. Record both measurements.
3. Compare readings with specifications in Fits and Limits chart in the SPECIFICATIONS section.

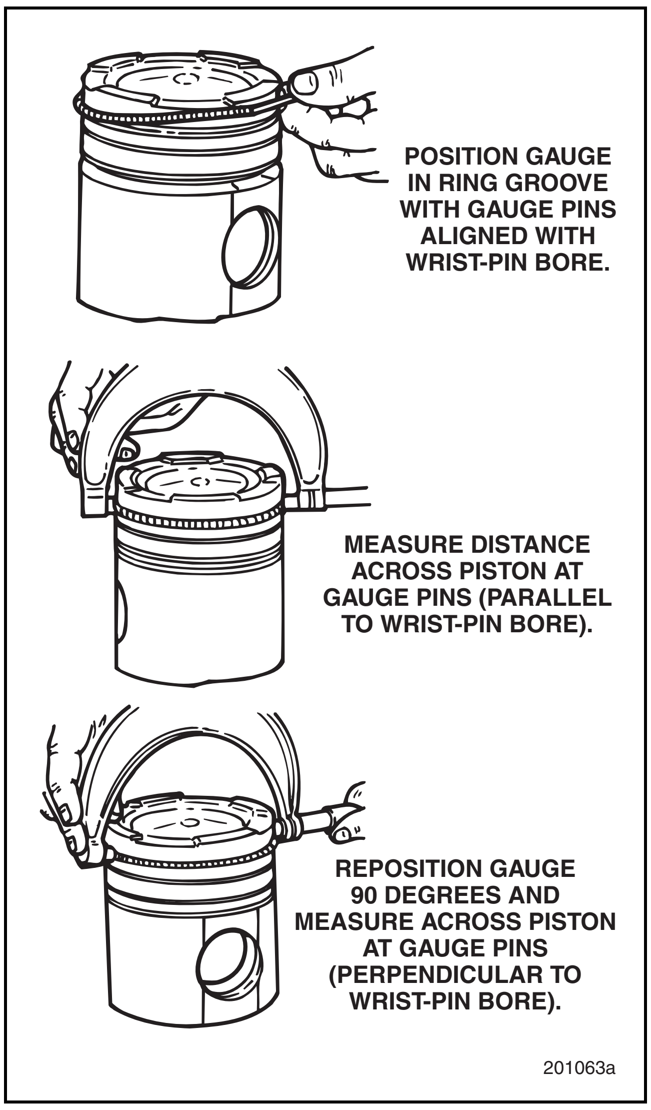


Figure 5-13 — Ring Groove Wear Measurement

4. Perform steps 1, 2 and 3 on each piston.

Refer to Figure 5-14.

5. Check oil control ring.
   a. Using a thickness gauge, check for excessive wear of oil control ring groove side clearance (1). Position a new oil control ring in groove and insert a thickness gauge between ring and upper land of groove.
   b. Record measurement and compare reading with Fits and Limits chart to see if it is within tolerance.

NOTE

For a new ring and piston, oil ring side clearance is 0.0016–0.0030 inch (0.0406–0.0762 mm). For an old ring and piston, the clearance should not exceed 0.0045 inch (0.1143 mm).

6. Perform step 5 on each piston.

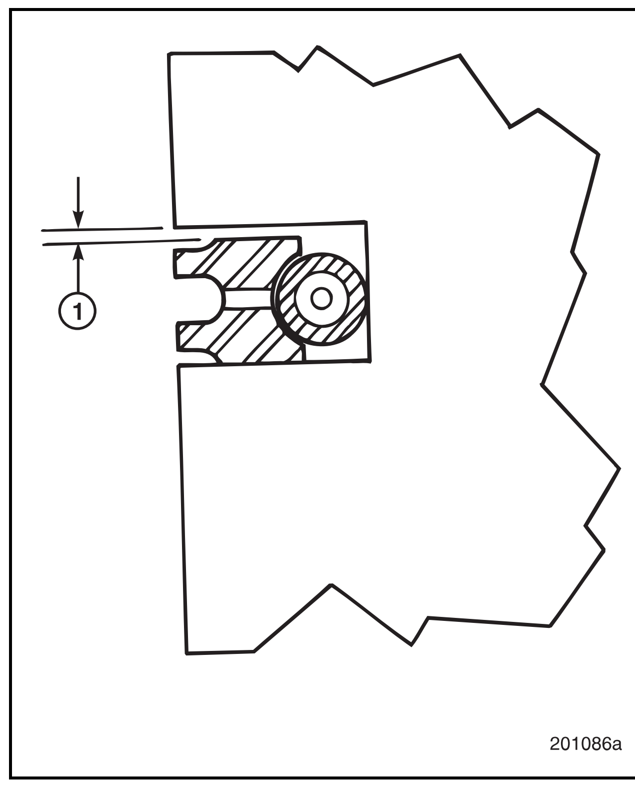


Figure 5-14 — Side Clearance Measurement

Ring Installation

NOTE

Identification markings on rings should face top of piston. The keystone ring goes in the top ring groove.

Follow the directions on each piston ring packet.

Refer to Figure 5-15.

1. To prevent distortion, use the proper size piston ring expander (PT6587) to place rings in piston grooves.

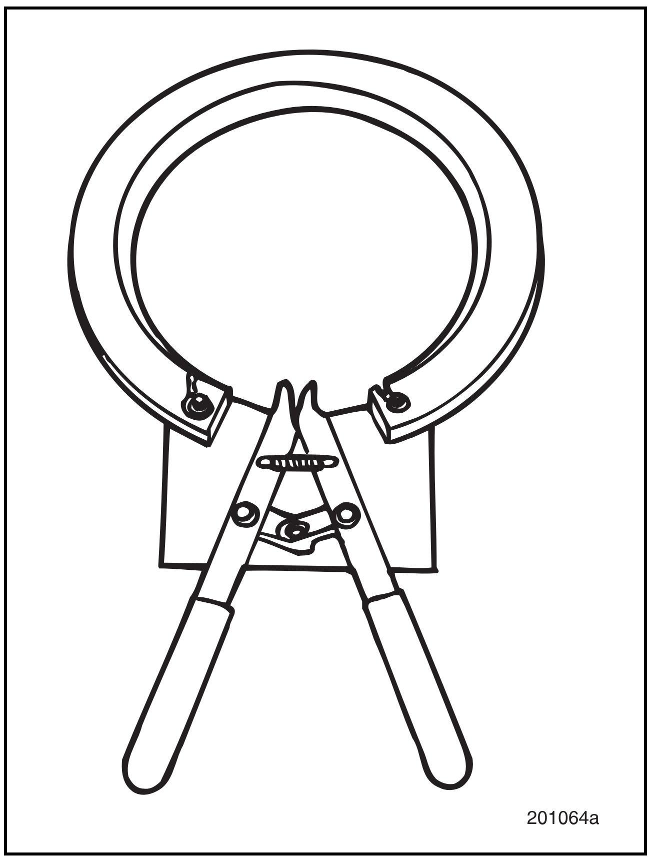


Figure 5-15 — Piston Ring Expander PT6587

Refer to Figure 5-16.

2. Stagger piston rings so that no ring gap is directly over wrist pin bore, and no ring end gaps are aligned over each other.

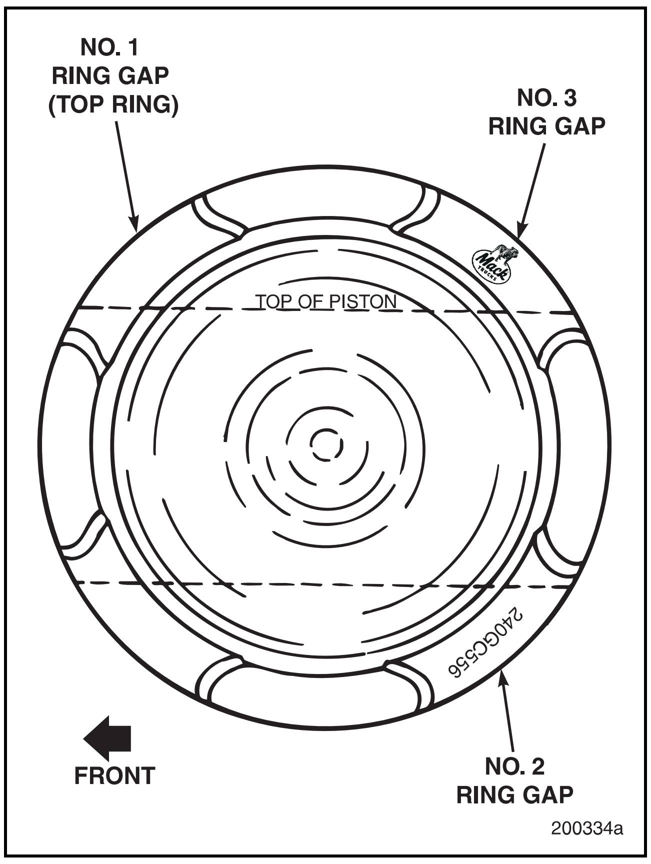


Figure 5-16 — Ring Gap Locations

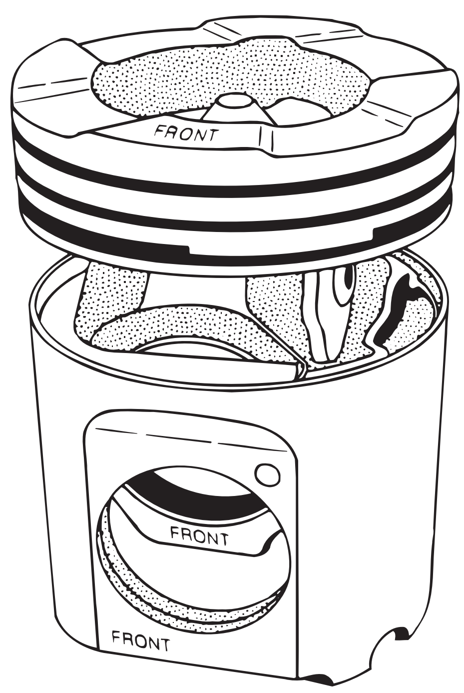
[212 LP & NP] CONNECTING ROD ASSEMBLY TO PISTON

Refer to Figure 5-17.

1. Install a retaining snap ring in one of the piston pin retaining grooves.
2. Position connecting rod in piston assembly. Make sure that the side of the rod marked FRONT is facing forward. Ensure that two-piece piston identification marks and connecting rod identification marks indicate that piston and rod are matched. They must be returned to same cylinder from which they were removed.

CAUTION

The piston crown, skirt and rod are marked FRONT. Be sure that rod, piston crown and skirt are properly aligned.



PISTON MARKINGS

200330a

Figure 5-17 — Piston Markings

3. Using a generous amount of clean engine oil, push piston wrist pin into piston wrist pin bore, aligning two piston sections and connecting rod.
4. Secure pin in position by inserting a snap ring in remaining piston snap ring groove.
5. Place the assembled piston in a clean location until it is needed for installation into sleeve.
6. Perform steps 1 through 5 on remaining pistons.

[213 CH] CAMSHAFT

Description

The gear-driven carbon steel E7 camshaft, with its large journal bearing diameter of 2.689 inches (68.301 mm), provides excellent bearing unit loading and allows the use of large, durable camshaft lobes. E7 engine camshaft gears are pressed onto the camshaft.

Disassembly

An extremely tight interference fit holds the cam gears onto the camshaft. Ten tons of force are required to remove the gears. When cam gear installation or removal is required, use the following procedures.

DANGER

A considerable amount of force may be necessary to remove damaged or spun gears. DO NOT apply more than 25 tons (22.7 metric tons) of force to gears. Doing so may shatter the gears and result in severe personal injury.

Refer to Figure 5-18.

1. Position two adequate steel plates on the press to support camshaft gears. The plates should have a 2-1/2 inch (63.5 mm) hole cut out in the center when placed side by side, or similar size V-grooves, to allow clearance for the shaft journals and greater support for the gears.
2. Set camshaft, supported by the gears, into the press.
3. Using a suitable arbor, press camshaft out of camshaft gear and fuel injection pump drive gear.

CAUTION

Make sure there is enough clearance between the end of the camshaft and the floor while removing the gears. Do not let camshaft fall or strike the floor when pressed from the gears. The camshaft can be bent easily, and the bend may go unnoticed. Installing a bent camshaft in the engine could result in cam bushing failure.

4. Remove the thrust washer.

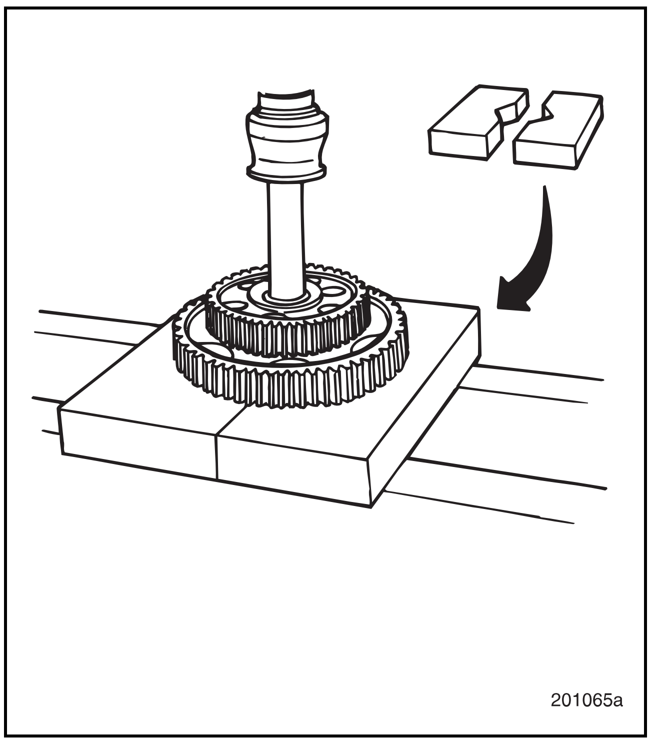


Figure 5-18 — Camshaft Gear and Fuel Injection Pump Gear Removal

Inspection

Refer to Figure 5-19.

1. Thoroughly clean camshaft (3).

NOTE

Use magnaflux (PT7190) inspection procedure to detect cracks.

2. Inspect camshaft lobes and journals for evidence of cracks, pitting, scoring or severe wear. If any of these conditions exist, replace camshaft.
3. Inspect camshaft gear (1), injection pump driving gear (5), and camshaft captured thrust washer (2) for cracks, pitting, scoring or adverse wear.
4. Visually inspect key (4) for signs of distortion or breakage.

Assembly

Two methods can be used to assemble camshaft gears on a camshaft.

- Use the heat method to install new gears on a new camshaft.
- Use the press method if reusing any service parts. Do not use heat method on used parts.

HEAT METHOD — CAMSHAFT/INJECTION PUMP DRIVING GEAR INSTALLATION

Refer to Figure 5-19.

1. Thoroughly clean camshaft (3) and gears (1 and 5) using a contact-type cleaner that dries rapidly and leaves no residue.
2. Insert key (4) into camshaft (3). It may be necessary to tap key with a rubber mallet to ensure proper seating of key.
3. Install a new camshaft captured thrust washer (2) on camshaft.

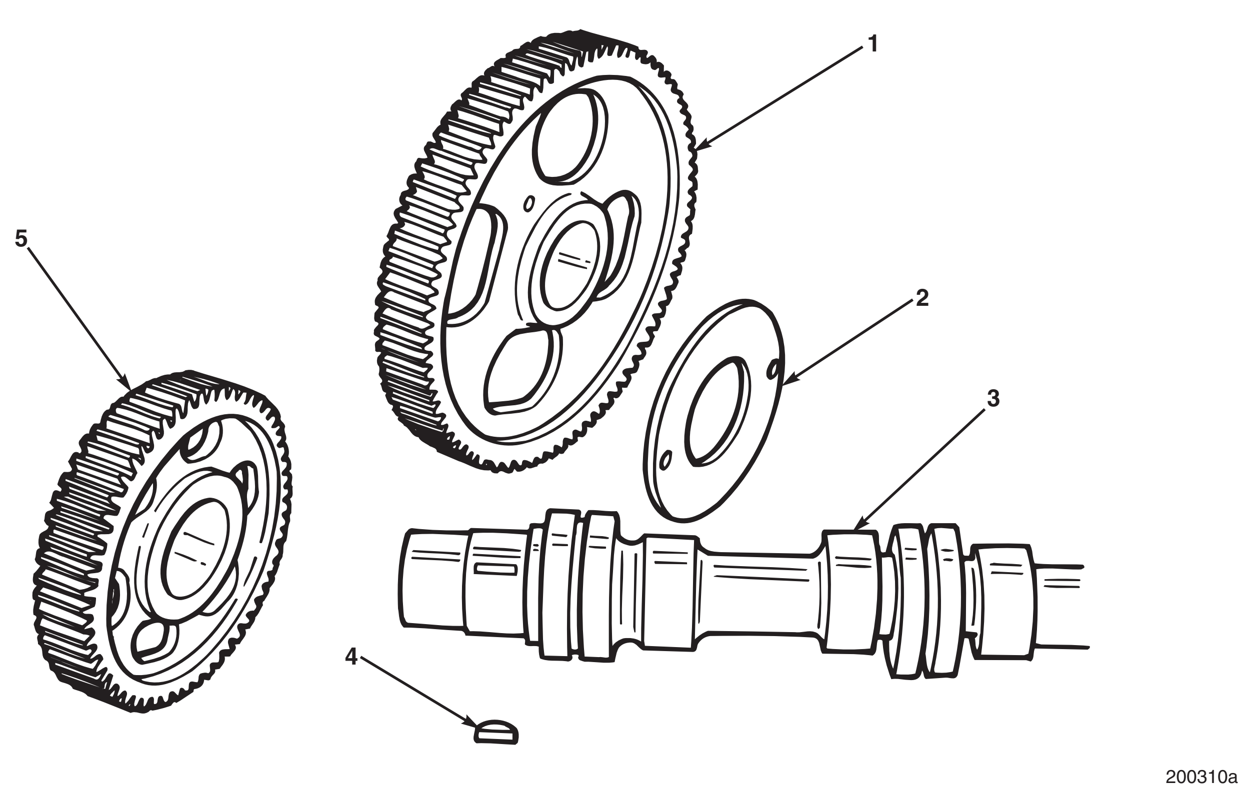


Figure 5-19 — Camshaft Assembly Components

1. Camshaft gear 2. Camshaft captured thrust washer 3. Camshaft	4. Key 5. Injection pump driving gear

DANGER

Wear protective gloves when handling heated gears.

Refer to Figure 5-20.

4. Using an oven (not a torch), heat new camshaft gear and new injection pump driving gear to 400°F (205°C). Do not exceed 400°F (205°C) and do not heat for more than one to two hours. Do not exceed two hours. Position camshaft gear with timing marks facing out, and align keyway with key.

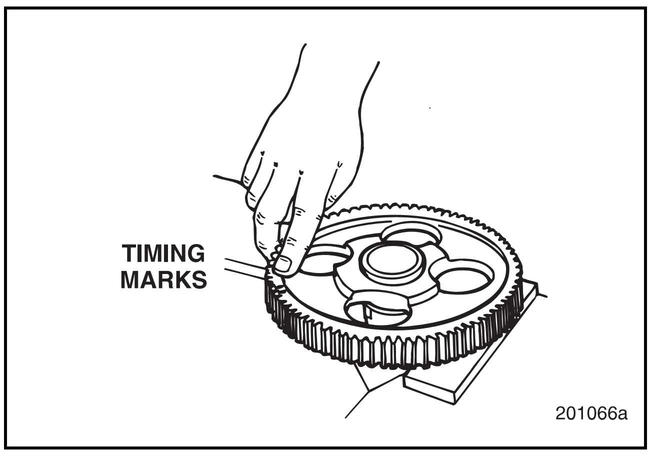


Figure 5-20 — Camshaft Gear Installation, Heat Method

5. Push downward with a quick, even pressure to install camshaft gear onto camshaft.

CAUTION

The heat-expanded gear bore will begin to transfer heat to the camshaft as soon as the gear bore and camshaft contact each other. This makes it absolutely necessary that the gear be installed in one very rapid motion to the fully seated position. If the gear is allowed to stop on the camshaft part way before fully seating, it will become immovable. If this occurs, do not press-install the gear. It should be press removed, allowed to cool, and re-installed using the press method.

6. There should be between 0.003–0.012 inch (0.076–0.305 mm) clearance between rear face of gear and thrust washer when measured with thickness gauge.
7. Install injection pump driving gear (5) by applying a quick, even pressure until gear bottoms onto camshaft gear. Make sure camshaft thrust washer holes are accessible through injection pump driving gear.

PRESS METHOD — CAMSHAFT/INJECTION PUMP DRIVING GEAR INSTALLATION

Refer to Figure 5-19.

1. Thoroughly clean and degrease camshaft (3) and camshaft drive gear (1) with a suitable contact cleaner that dries rapidly and leaves no residue.
2. Install a new key (4) in camshaft key slot.
3. Place camshaft in a press, making sure camshaft is supported by plates between journal and first lobe.

CAUTION

Approximately 5 tons (4.54 MT) of force is required to press each gear onto the camshaft. When in the press, use suitable plates to support the camshaft between the journal and first lobe. Do not allow camshaft to rest on the floor.

4. Position a new thrust washer (2) on the camshaft.
5. Prepare the gear bore with Locquic™ Primer T, or equivalent.
6. Apply a bead of Loctite® 609, or equivalent, to the gear bore.
7. Using a clean brush, spread Loctite 609 evenly onto the entire surface of the gear bore.

Refer to Figure 5-21.

8. Position gear on camshaft with timing marks facing upward and key slot in gear aligned with key in shaft.

CAUTION

Do not attempt to increase clearance between camshaft and gears by sanding gear bores or camshaft.

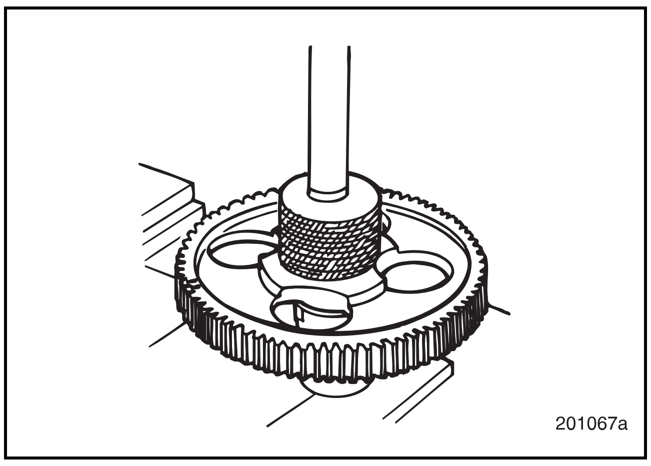


Figure 5-21 — Camshaft Gear Installation

9. Using a suitable press cup, press the gear onto the shaft until it is fully seated. The pressure gauge on the press should read approximately 5 tons (4.54 MT) as the gear is being pressed on. As the gear seats, allow the pressure to climb to, but not exceed, 10 tons (9.1 MT). This will ensure that gear is seated firmly on shaft.
10. When gear is properly seated, clearance between rear face of gear and thrust washer should be between 0.003–0.012 inch (0.076–0.305 mm).
11. Thoroughly clean and degrease injection pump driving gear with a suitable contact cleaner that dries rapidly and leaves no residue.
12. Prepare the gear bore surface with Locquic™ Primer T, or equivalent.
13. Apply a bead of Loctite 609, or equivalent, to the gear bore.
14. Using a clean brush, spread Loctite 609 evenly on the entire surface of the gear bore.
15. Position gear onto camshaft.
16. Using a suitable press cup, press the gear onto the shaft until it is fully seated. The pressure gauge on the press should read approximately 5 tons (4.54 MT) as the gear is being pressed on. As the gear seats, allow the pressure to climb to, but not exceed, 10 tons (9.1 MT). This will ensure that gear is seated firmly on shaft. The gear should be flush with the end of the shaft when fully seated.

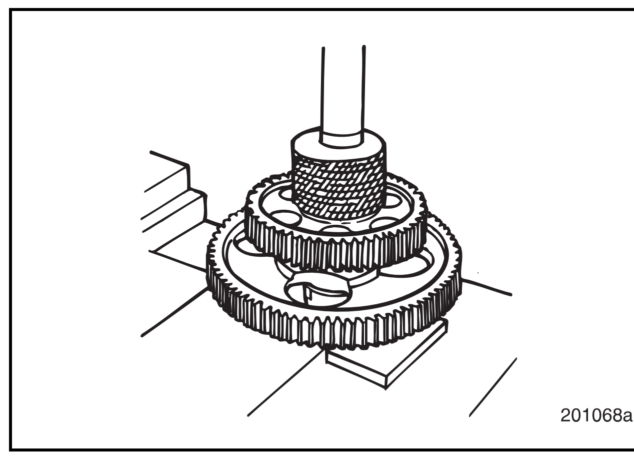


Figure 5-22 — Fuel Injection Pump Driving Gear Installation

[213 EV] CYLINDER HEADS

Description

Refer to Figure 5-23.

The cylinder heads featured on 1991 and later E7 engines incorporate internal design modifications that increase the swirl level of combustion air. To achieve the increase in air motion required, it was necessary to redesign the inlet port. Increased air motion, in conjunction with the eight-hole Valve Covering Orifice (VCO) nozzle tips, provides proper air/fuel atomization in the deeper bowl of the piston crown.

NOTE

1991 and later E7 cylinder heads are NOT interchangeable with 1989/1990 E7 cylinder heads.

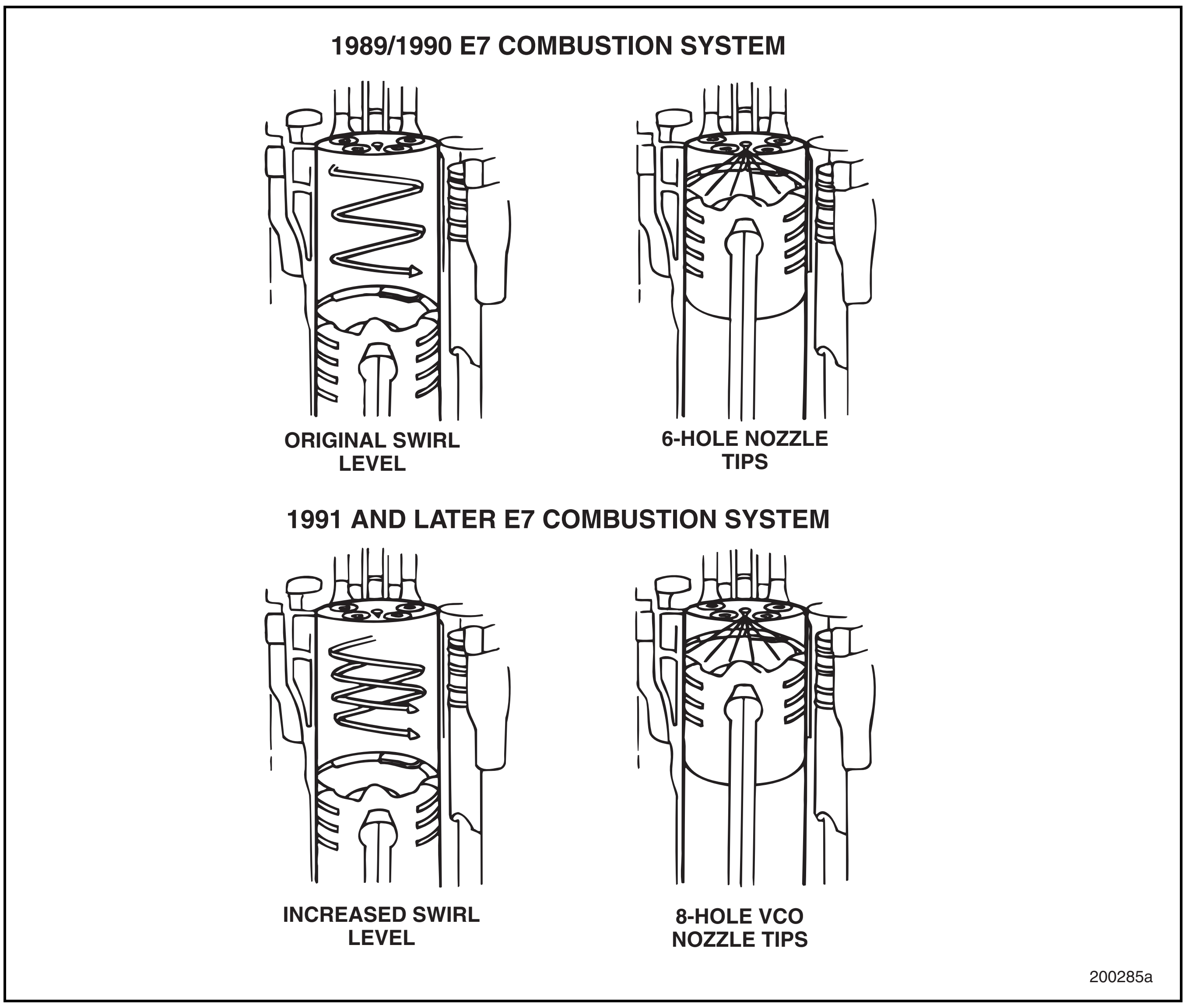


Figure 5-23 — Combustion Chamber Design

Refer to Figure 5-24.

The cast iron cylinder head is constructed using a special iron alloy. The head contains cored inlet, exhaust and coolant passages, drilled oil passages, replaceable inlet and exhaust guides and seats, various drilled passages and tapped holes. Each cylinder head covers three cylinders and has two inlet and two exhaust valves per cylinder. Circular grooves correspond with the fire ring bead on cylinder sleeves. This design sets the fire ring over the liner, the lip and into groove of the cylinder head while providing a positive combustion pressure seal. Use a rotary brass-wire brush to clean the circular groove.

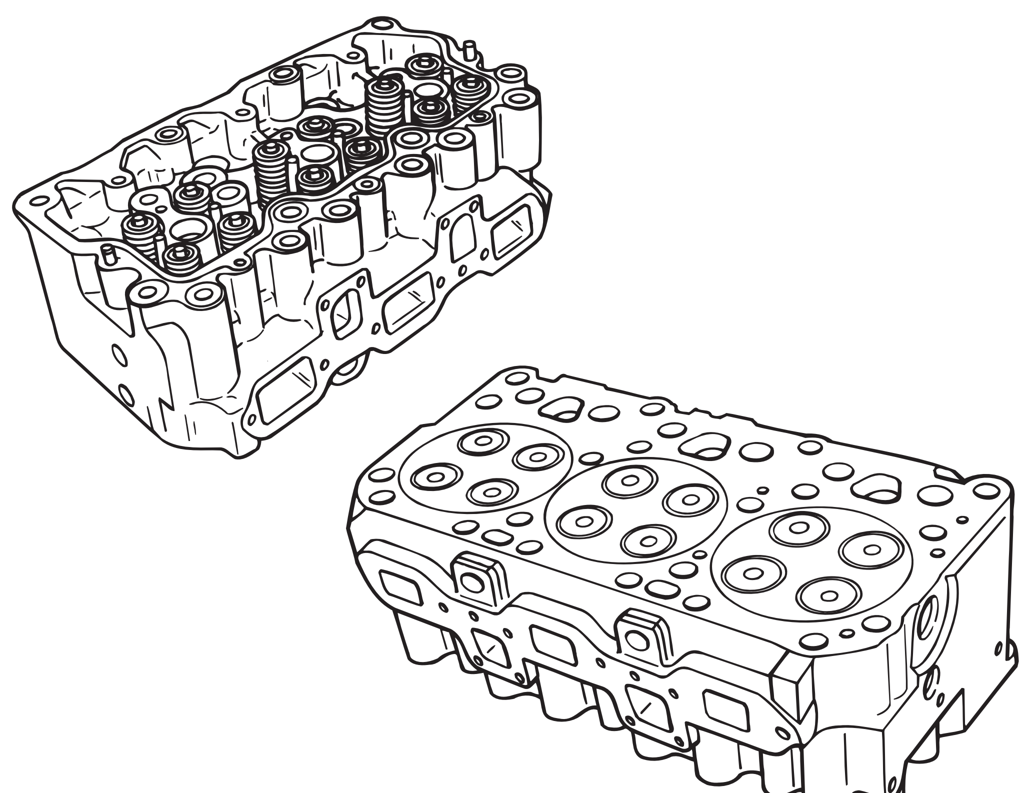


Figure 5-24 — E7 Cylinder Head

Special Tools Required

- Valve Spring Keeper Remover J 29294-B
- Fire Ring Groove Cutter J 29600-C
- E7 Cutter Head J 37719
- Depth Gauge J 26948
- Valve Guide Remover J 37482
- Valve Guide Installer J 37809
- Valve Guide Reamer J 37481
- Valve Seat Extractor Kit PT6391
- Collet PT6390-4
- Valve Seat Insert Counterbore HT77136
- Valve Insert Installer Set J 38586
- Driver Handle J 8092
- Prussian Blue
- Model MST 50 Universal Spring Tester J 22738-02
- Injection Nozzle Sleeve Extractor J 29880
- Basic Heavy-Duty Dowelout Kit PT6575
- Dowelout, Extractor (7/16 inch) PT6570-11
- Torque Wrench J 24407
- Slide Hammer J 2619-01
- Valve Yoke Guide Pin Installer J 29296
- Injection Nozzle Sleeve Installer J 29297
- Cylinder Head Core Plug Installer (13/16-inch cup plugs) J 34684
- Cylinder Head Core Plug Installer (1-1/16 inch cup plugs) J 34687
- Valve Seal Installer J 42453
- Valve Stem Seal Remover J 39460

[213 NB] Inlet and Exhaust Valve Removal

Refer to Figure 5-25.

1. Attach valve spring keeper remover J 29294-B to cylinder head.
2. Rest tool compression forks (4) on top of upper washer (3) and center forks above valve.
3. Depress tool handle until valve spring is compressed. Remove valve spring washer keys (2) using a magnet (1).

NOTE

Valve spring keeper remover J 29294-B must be repositioned for each series of valves (two inlet and two exhaust, per cylinder). Drilled and tapped holes are provided for each cylinder.

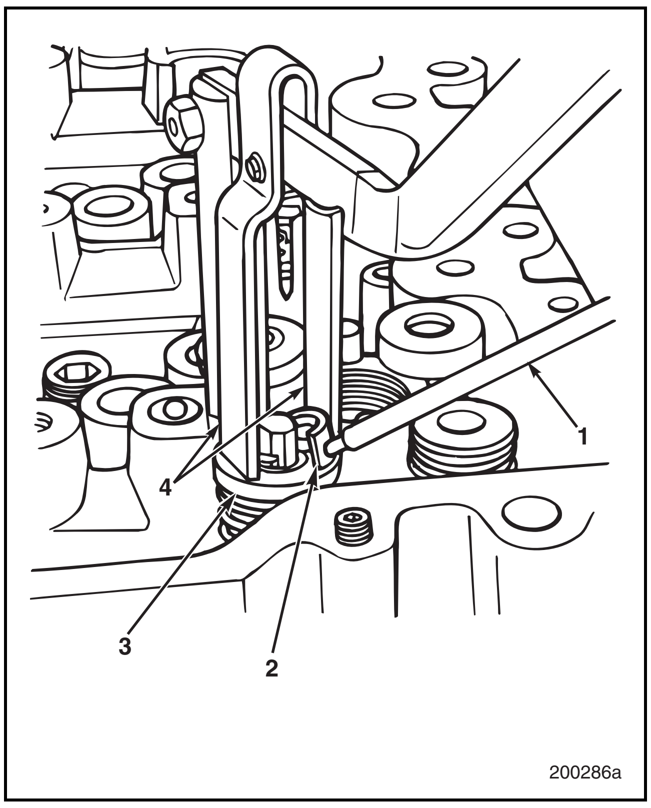


Figure 5-25 — Valve Spring Keeper Removal

1. Magnet 2. Valve spring washer keys	3. Upper washer 4. Tool compression forks (J 29294-B)

VALVE STEM SEALS

Refer to Figure 5-26.

A new valve stem seal was introduced into E7 engine production on 11/1/96, beginning with engine serial number 6S2657. The older valve stem seal has a single sealing lip, while the new-style seal incorporates a second lip that significantly reduces crankcase blowby. This new seal can easily be identified by the steel retainer band around the top of the seal lip.

To improve seal-to-guide retention, a change was made to the valve guides. The new-style guides have three sharp ridges machined into the upper outside diameter surface (refer to Figure 5-26). The new valve guides were phased into production during the first quarter of 1997.

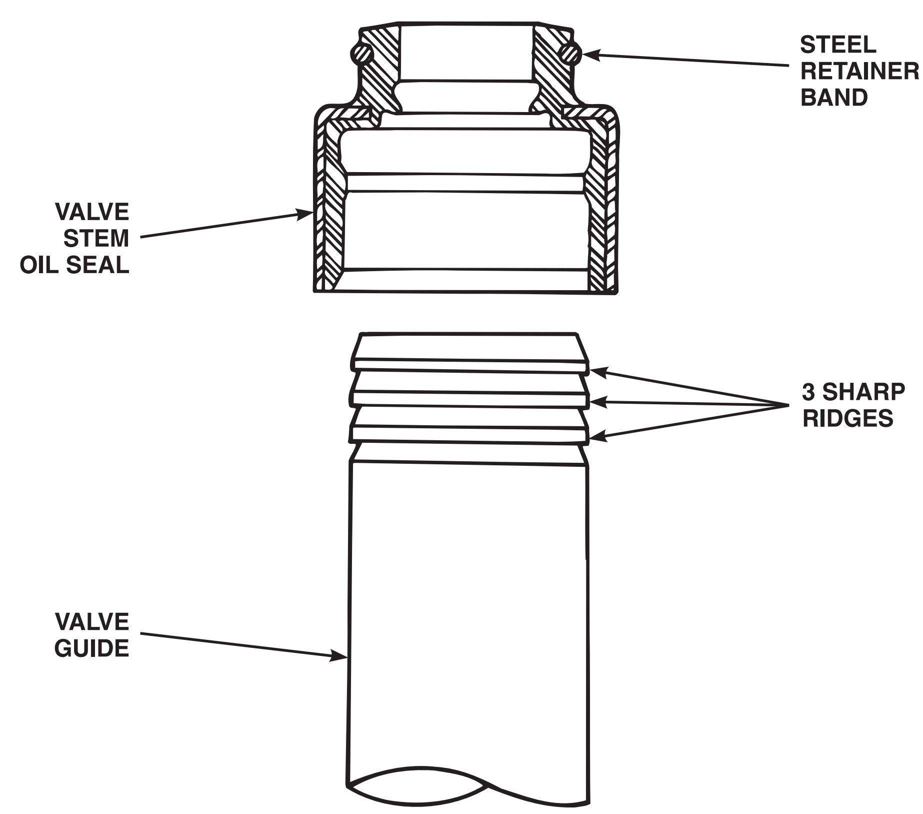


Figure 5-26 — New Valve Stem Seal

This new seal is recommended for all E7 engines. The single lip seal has been terminated, and as service stock is depleted, only the new seal will be available. This new seal can be used on the old-style valve guides.

Part Number	Description	Replaces
446GC328	Valve Stem Seal	446GC296
714GB3103	Valve Guide	714GB222

Refer to Figure 5-27.

4. With valve spring keepers (1) removed, remove upper washer (2), valve spring (3), oil seal (4), lower washer (Roto-Coil) (5) and valve (6).

NOTE

After removing the valve springs, removal of the existing valve stem seals can be accomplished easily and quickly by using the J 39460 Valve Stem Seal Removal tool. Failure to use this tool could make seal removal more difficult, and could result in damaging the outside diameter of the valve guides.

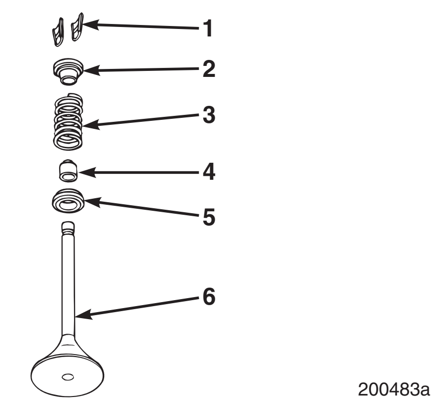


Figure 5-27 — Valve Assembly

1. Valve spring keepers 2. Upper washer 3. Valve spring 4. Oil seal	5. Lower washer (Roto-Coil) 6. Valve

[213 EX] Cylinder Head Inspection

SERVICE HINT

Pressure Test — It is recommended that cylinder heads be pressurized and checked for internal cracks and leaks. Refer to Cylinder Head and Cylinder Block Leak Test procedures in the TROUBLESHOOTING section of this manual.

Check cylinder head deck surface for warping, pitting or other imperfections. Deck surface flatness for a new head must not vary more than 0.0015 inch (0.0381 mm) over 18 inches (45.7 cm) of surface area. Resurface or replace as necessary.

When resurfacing, remove a minimum amount of material from deck to obtain a flat, uniform surface. Standard head height is 6.397–6.391 inches (162.483–162.310 mm). A maximum of 0.010 inch (0.254 mm) of material may be removed, making the minimum height of a resurfaced head 6.381 inches (162.077 mm).

NOTE

When the deck is resurfaced, fire ring groove and valve seat insert dimensions must be reestablished. Correct dimensions are shown in this section.

[213 EH] Fire Ring Groove

DESCRIPTION

Fire ring grooves are located in the machined flat surface of the cylinder head that mates with the engine block. These grooves correspond with the fire ring machined lip on cylinder liner. This design provides a locking groove for the fire ring to seat as well as a positive-combustion pressure seal.

After resurfacing the cylinder head deck, it is necessary to reestablish the fire ring groove depth using fire ring groove cutter J 29600-C.

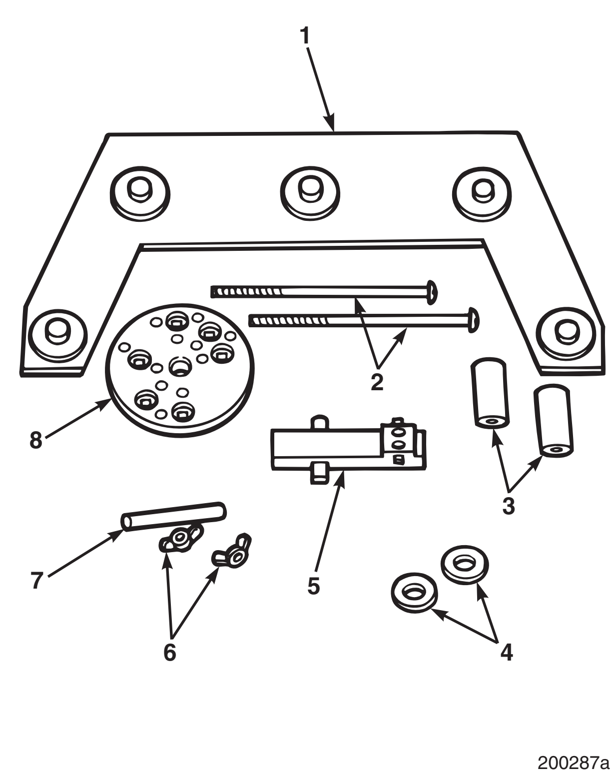


Figure 5-28 — Fire Ring Groove Cutter J 29600-C

1. Alignment fixture 2. Hold-down capscrews 3. Spacers 4. Washers	5. Cutter head (J 37719) 6. Wing nuts 7. Thickness gauges 8. Cutter base

FIRE RING GROOVE CUTTING PROCEDURE

Refer to Figure 5-29.

1. Place cutter base (1) on cylinder head (2). Insert hold-down capscrews into appropriate mounting holes (per application) until hold-down capscrews bottom out in mounting holes.

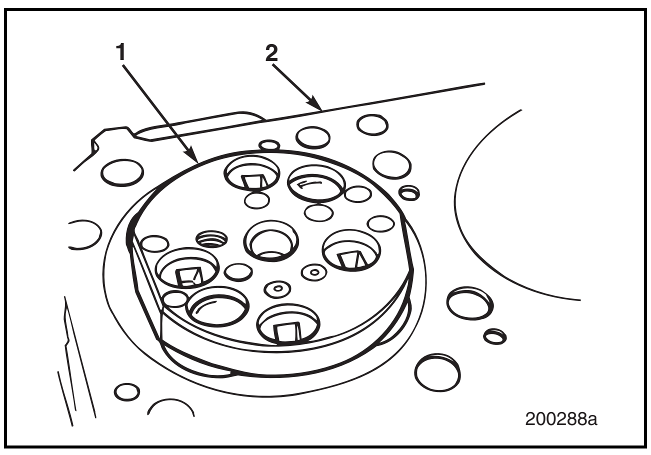


Figure 5-29 — Cutter Base Alignment

1. Cutter base	2. Cylinder head

Refer to Figure 5-30.

2. Position cylinder head so threaded section of hold-down capscrews can be reached. Install spacer (3), washer (2) and wing nut (1). Lightly tighten wing nut.

NOTE

The cutter base must be free to move.

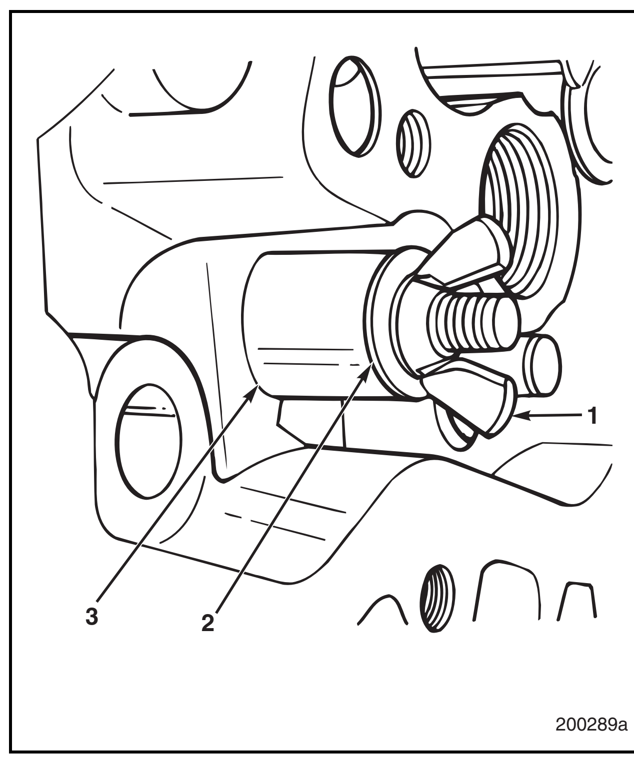


Figure 5-30 — Fastening Cutter Base

1. Wing nut 2. Washer	3. Spacer

Refer to Figure 5-31.

3. Place alignment fixture (1) over the cutter base (2) to ensure proper positioning. With fixture in place, tighten wing nuts on hold-down capscrews. Remove alignment fixture.

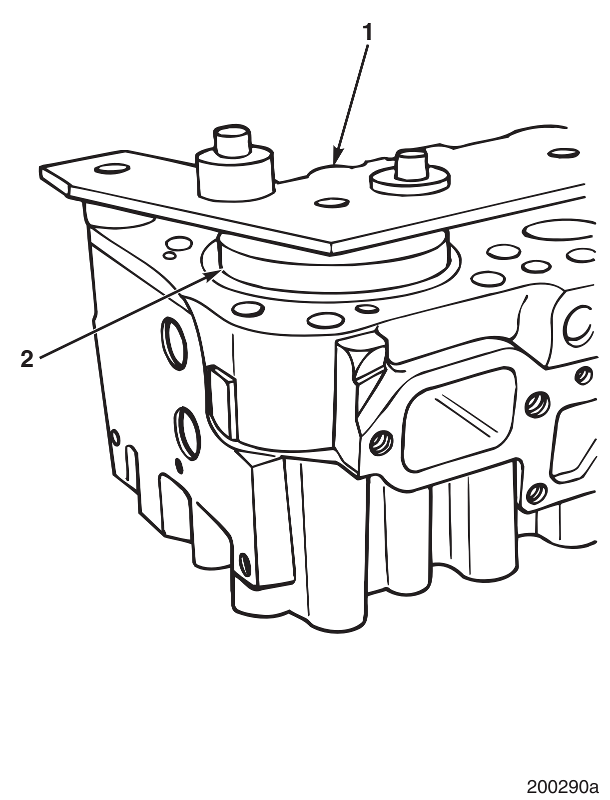


Figure 5-31 — Alignment Fixture Placement

1. Alignment fixture	2. Cutter base

Refer to Figure 5-32.

NOTE

The desired finished fire ring groove depth is 0.008 inch (0.203 mm).

4. Install cutter head J 37719 (1) on cutter base (4).
   a. If fire ring groove (3) is visible, check existing fire ring groove depth dimension with depth gauge J 26948. The difference between 0.008 inch and the actual remaining depth of fire ring groove is the amount to cut. Insert two appropriate thickness gauges (2) between cutter head (1) and cutter base (4).
   b. If fire ring groove (3) is not visible, insert two 0.008-inch thickness gauges (2) between cutter head (1) and cutter base (4).
5. Adjust cutter head J 37719 until it bottoms out on deck surface of existing fire ring groove. Tighten cutter head in this position and remove the two thickness gauges.

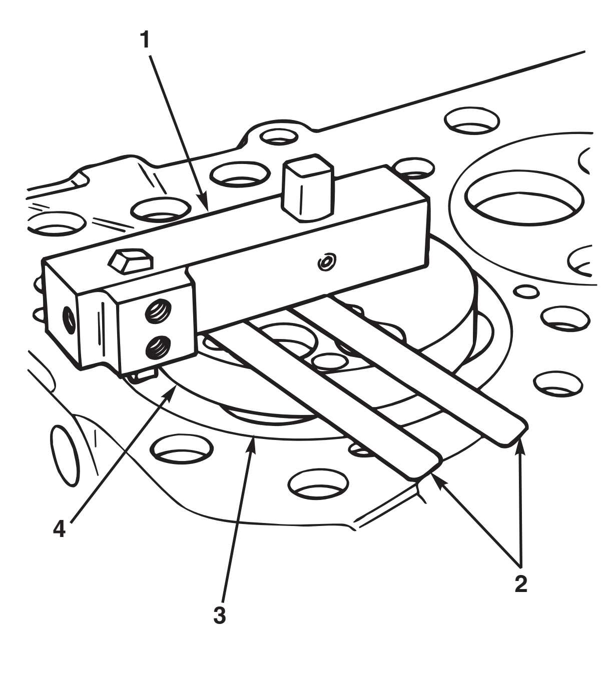


Figure 5-32 — Setting Cutter Depth

1. Cutter head (J 37719) 2. Thickness gauges	3. Fire ring groove 4. Cutter base

Refer to Figure 5-33.

6. Install a socket (1) and T-handle (2) on cutter head (3). Using T-handle, rotate cutter head in a clockwise direction only, applying an even downward pressure to cut fire ring groove.

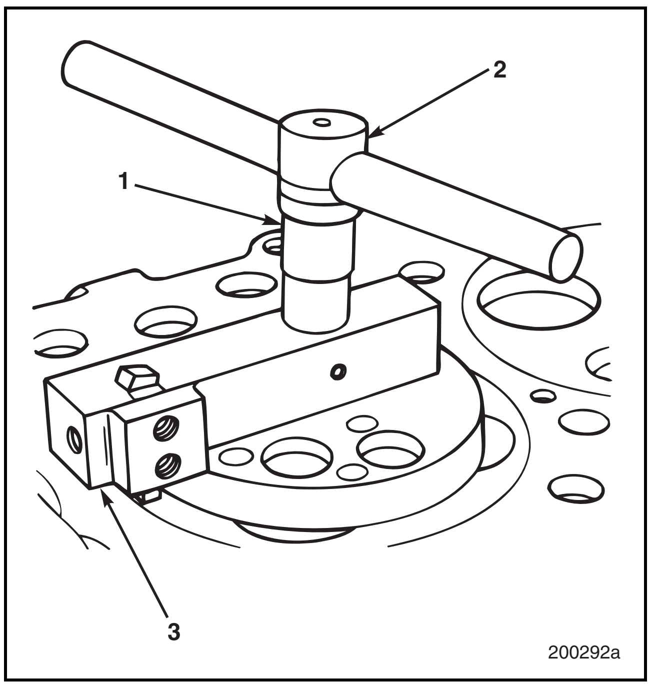


Figure 5-33 — Cutting Ring Groove

1. Socket 2. T-handle	3. Cutter head (J 37719)

7. After groove is cut, remove cutter head and cutter base from cylinder head.
8. Use a honing stone to remove any burrs around fire ring groove.
9. Check fire ring groove depth with depth gauge J 26948 to verify that groove depth meets specification. If groove depth does not meet specification, recut as necessary.
10. Repeat above procedure with each fire ring groove cut.

NOTE

To ensure proper groove depth, always adjust cutting tool height when cutting next groove.

[213 EP] Valve Guides

INLET AND EXHAUST VALVE GUIDE DIMENSIONS

Refer to Figure 5-34.

- Valve guide ID (3) — 3/8 inch (9.53 mm)
- Top end of guide to valve spring seat (4) — 0.959 ± 0.040 inch (24.36 ± 1.02 mm)
- Valve guide extension, fire deck to top of guide (5) — 5.24 ± 0.03 inch (133.10 ± 0.76 mm)
- Valve guide bore in head (6) — 0.687–0.686 inch (17.450–17.424 mm)
- Valve guide OD (7) — 0.6886–0.6881 inch (17.4904–17.4777 mm)

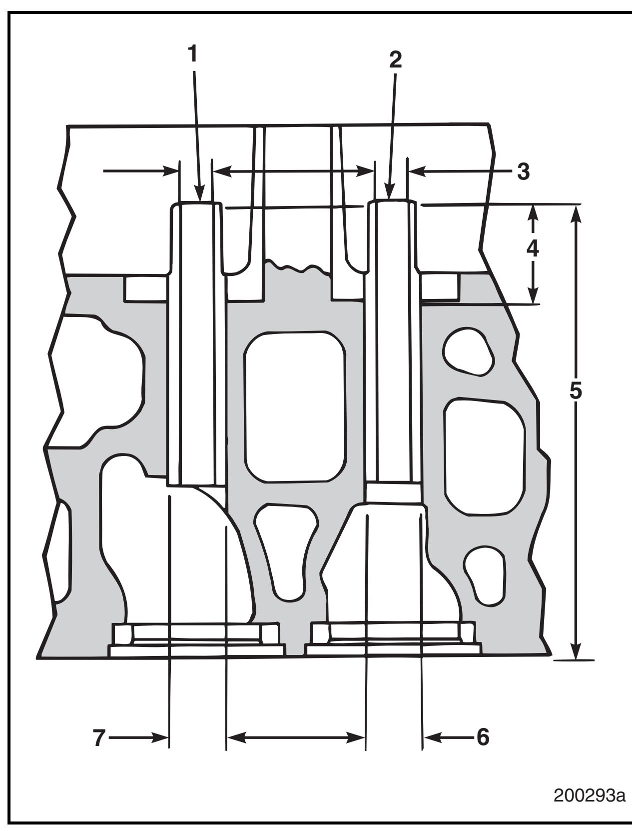


Figure 5-34 — Valve Guide Dimensions

1. Exhaust valve guide 2. Inlet valve guide 3. Valve guide ID 4. Top end of guide to valve spring seat	5. Valve guide extension, fire deck to top of guide 6. Valve guide bore in head 7. Valve guide OD

INSPECTION

NOTE

Worn valve guides may result in poor valve-to-seat contact, valve damage or oil consumption.

1. Inspect valve guides for wear, damage, cracks and looseness.

Refer to Figure 5-35.

2. Use a small bore gauge (1) to obtain an accurate valve guide bore (2) measurement.

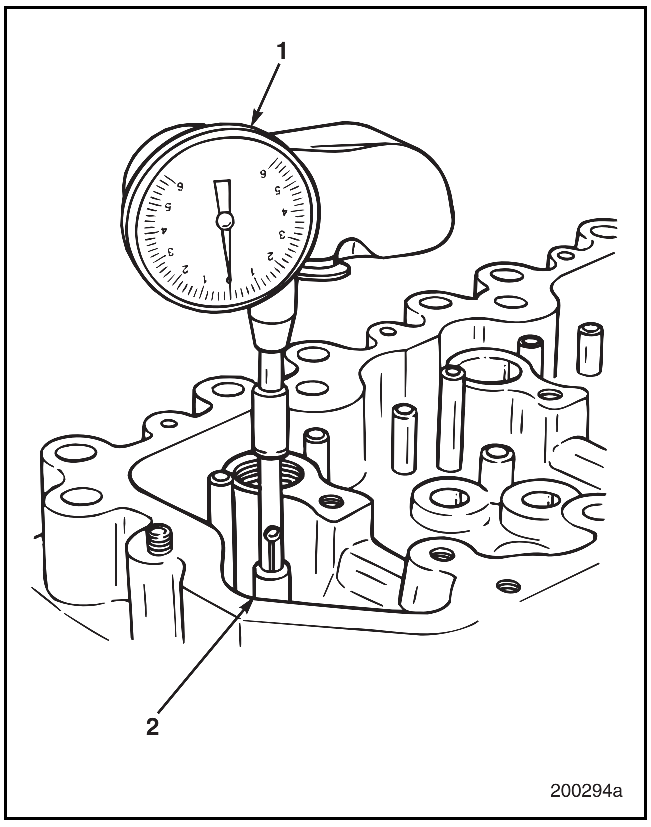


Figure 5-35 — Measuring Valve Guide Bore

1. Bore gauge	2. Valve guide bore

Refer to Figure 5-36.

3. Use a depth gauge to check valve guide extension.

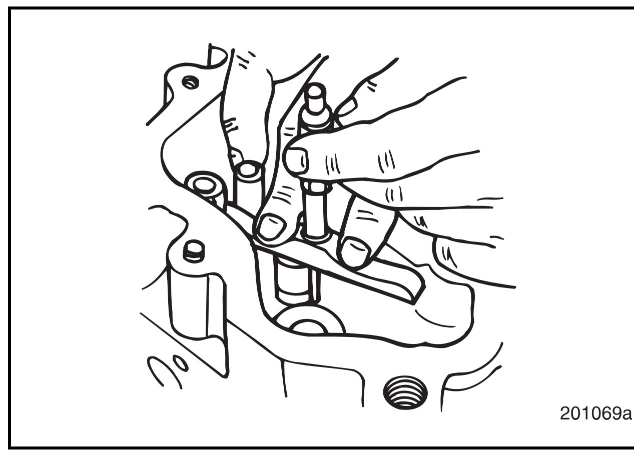


Figure 5-36 — Checking Valve Guide Extension

NOTE

When reconditioning the cylinder head, it is recommended that all valve guides be replaced.

VALVE GUIDE REMOVAL

SERVICE HINT

Clean exhaust valve guide OD (shoulder) before removal. Use a rotary brush to prevent scoring of exhaust valve guide bore.

Refer to Figure 5-37.

1. Insert valve guide remover J 37482 (1) into valve guide from deck side of the cylinder head (2).

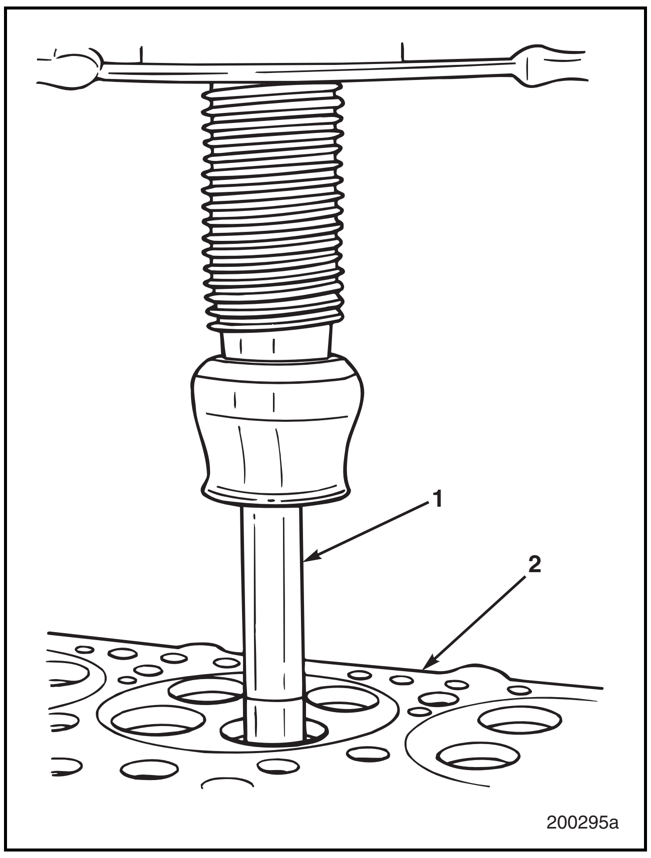


Figure 5-37 — Valve Guide Remover J 37482

1. Valve guide remover J 37482	2. Cylinder head

2. Press out old valve guides from cylinder head.
3. Check valve guide bore in the cylinder head for wear, cracks or other damage. Clean surfaces thoroughly and check ID measurement.

VALVE GUIDE INSTALLATION

1. Insert new valve guide into valve guide installer J 37809.
2. Oil OD of new guide before installation.
3. Press new valve guide into top of cylinder head using tool J 37809.

Refer to Figure 5-38.

4. Using depth gauge, check extension of valve guide from valve spring seat to top end of the guide.

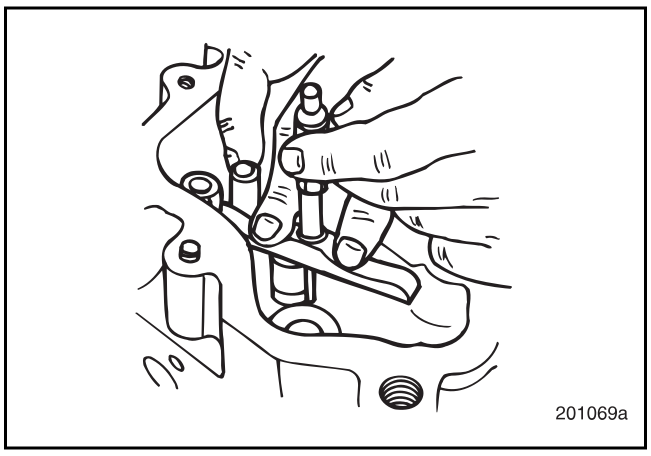


Figure 5-38 — Checking Valve Guide Extension

Refer to Figure 5-39.

5. Using valve guide reamer J 37481 (1), ream new valve guide (2) to dimension.

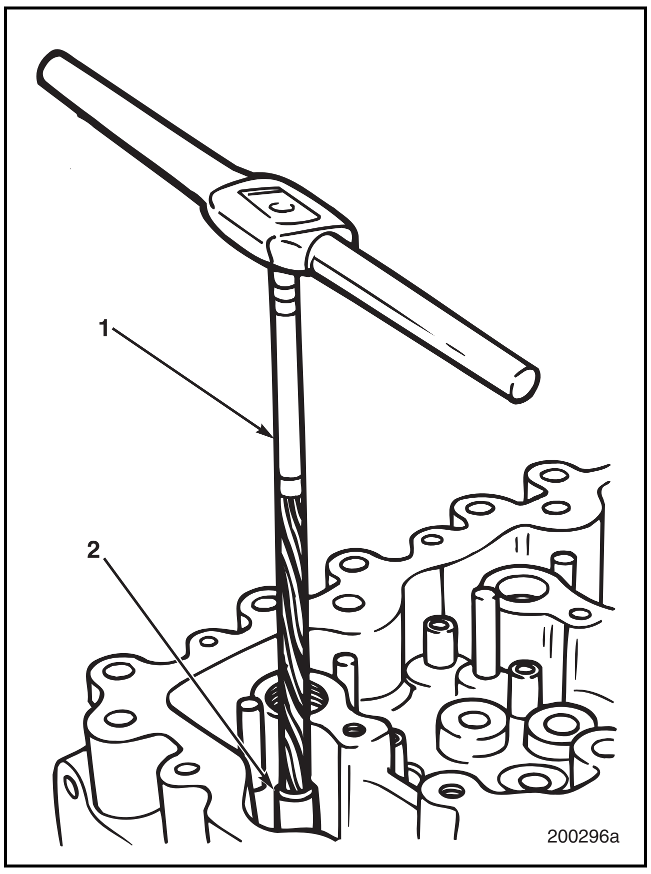


Figure 5-39 — Reaming Valve Guide

1. Valve guide reamer J 37481	2. Valve guide

6. Thoroughly clean all metal debris from valve guide and surrounding area.
7. Install valves in cylinder head and check for binding, looseness and other conditions that may result in premature valve or valve guide failure.

[213 FB] Inlet and Exhaust Valve Seat Inserts

INLET AND EXHAUST VALVE SEAT INSERT DIMENSIONS

Refer to Figure 5-40.

- Valve seat (3) insert face angle (1)
  - — Inlet:
    30° –0'/+ 30' (before November 1996),
    20° 30' ± 15' (November 1996 and later)
  - — Exhaust: 30° s0'/+ 30'
- Valve seat insert diameter (2)
  - — Inlet: 1.832–1.831 inches (46.533–46.507 mm)
  - — Exhaust: 1.693–1.691 inches (43.002–42.951 mm)
- Valve seat width (4) — 0.066 ± 0.015 inch (1.676 ± 0.381 mm)

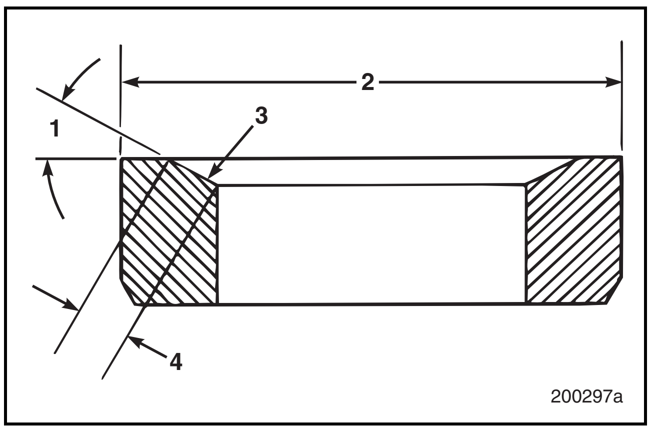


Figure 5-40 — Valve Seat Insert Dimensions

1. Valve seat insert face angle 2. Valve seat insert diameter	3. Valve seat 4. Valve seat width

INSPECTION

Visually inspect valve seat inserts for looseness, cracks or other conditions that may result in improper operation. Replace as necessary.

VALVE SEAT INSERT REMOVAL

Refer to Figure 5-41.

Valve seat extractor kit PT6391 and collet PT6390-4 are used to remove inlet and exhaust seat inserts.

NOTE

Collet PT6390-4 is not included in basic kit PT6391.

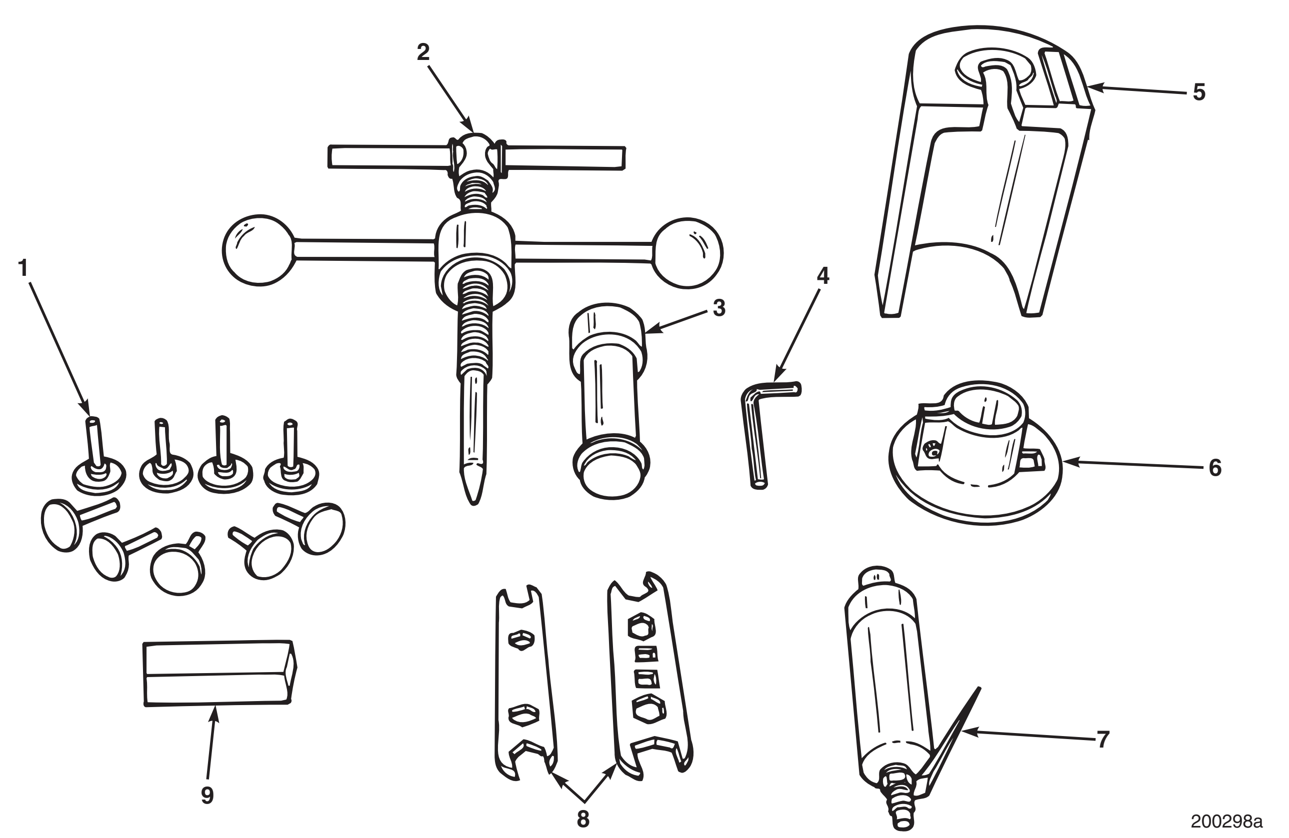


Figure 5-41 — Valve Seat Extractor Kit PT6391

1. Grinding wheels	6. Grinder base
2. T-handle and shaft assembly	7. Grinder
3. Collet	8. Wrenches
4. Allen wrench	9. Dressing stone
5. Lifting bridge	

Refer to Figure 5-42.

1. Using depth measurement tool (1), measure distance from cylinder head surface (2) to point on insert where groove will be ground.

N O T E

This point should be approximately 0.060 inch (1.524 mm) below any angular face on valve seat insert.

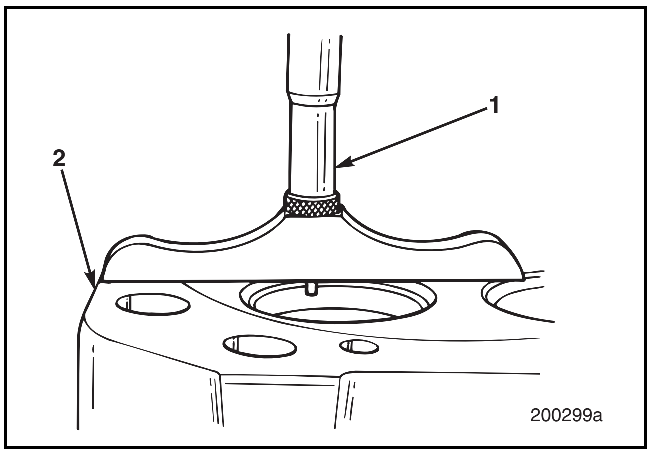


Figure 5-42 — Valve Insert Depth Measurement

1. Depth measurement tool	2. Cylinder head surface

Refer to Figure 5-43.

2. Install grinding wheel (2) into grinder (4) and set depth of grinder base (1) to dimension found in preceding step.
3. Secure base to grinder by tightening hex-head screw (3).

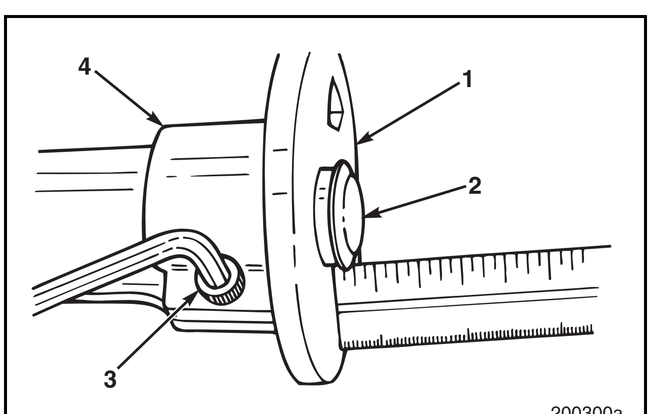


Figure 5-43 — Setting Depth of Grinder

1. Grinder base 2. Grinding wheel	3. Hex-head screw 4. Grinder

4. Grind a groove around inside circumference of valve seat insert. This groove should be approximately 0.030 inch (0.762 mm) deep.

C A U T I O N

Use care not to damage any machined surface of the cylinder head.

5. Attach collet to T-handle and shaft assembly.
6. Position collet in valve seat insert so ridge of collet will be inside groove. Turn T-handle to fully expand collet.

Refer to Figure 5-44.

7. Position lifting bridge (3) under crank handle (2). Turn crank handle clockwise to remove insert.
8. Release insert from collet (4) by slightly turning T-handle (1).

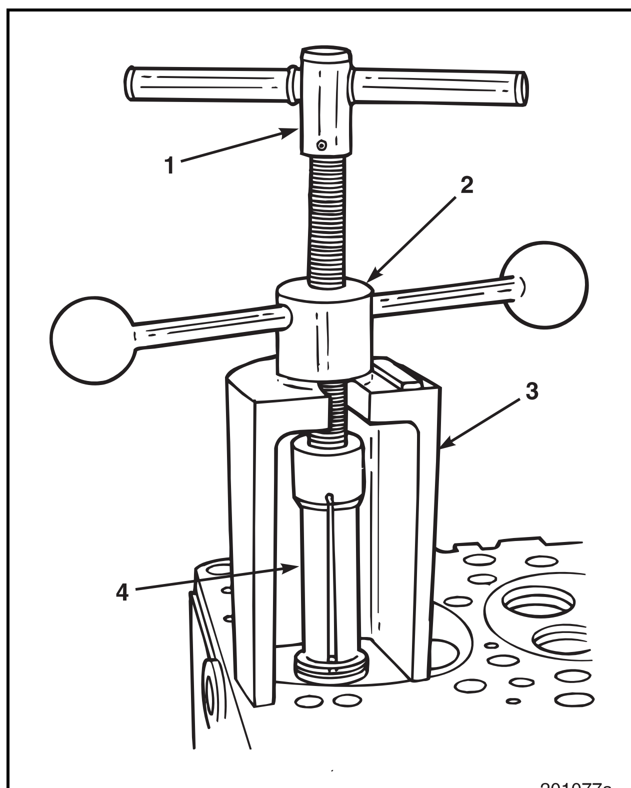


Figure 5-44 — Removing Valve Insert

1. T-handle 2. Crank handle	3. Lifting bridge 4. Collet

VALVE SEAT INSERT COUNTERBORE

Refer to Figure 5-45.

- Valve seat at counterbore depth (3):
  - — Exhaust: 0.376–0.372 inch (9.55–9.449 mm)
  - — Inlet: 0.364–0.360 inch (9.246–9.144 mm)
- Inlet valve seat insert counterbore diameter (4): 1.8295–1.8285 inches (46.4693–46.4439 mm)
- Exhaust valve seat counterbore diameter (5): 1.6885–1.6875 inches (42.8879–42.8625 mm)

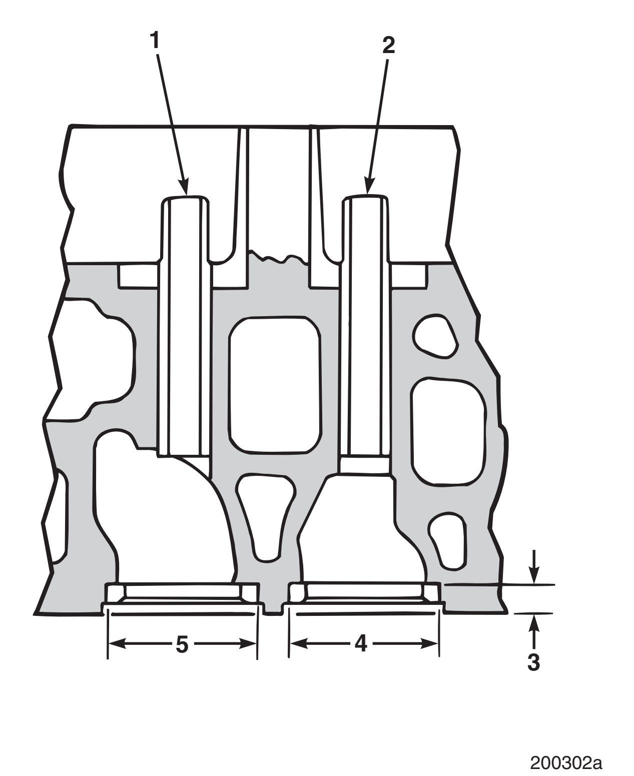


Figure 5-45 — Valve Seat Insert Counterbore Dimensions

1. Exhaust valve guide 2. Inlet valve guide 3. Valve seat at counterbore depth	4. Inlet valve seat insert counterbore diameter 5. Exhaust valve seat counterbore diameter

INSPECTION

Refer to Figure 5-46.

1. With valve seat insert removed from cylinder head (2), clean surfaces thoroughly with wire brush.
2. Check surface finish for smoothness. Check counterbore diameter with an inside diameter micrometer (1). Refer back to specifications listed in Figure 5-45.

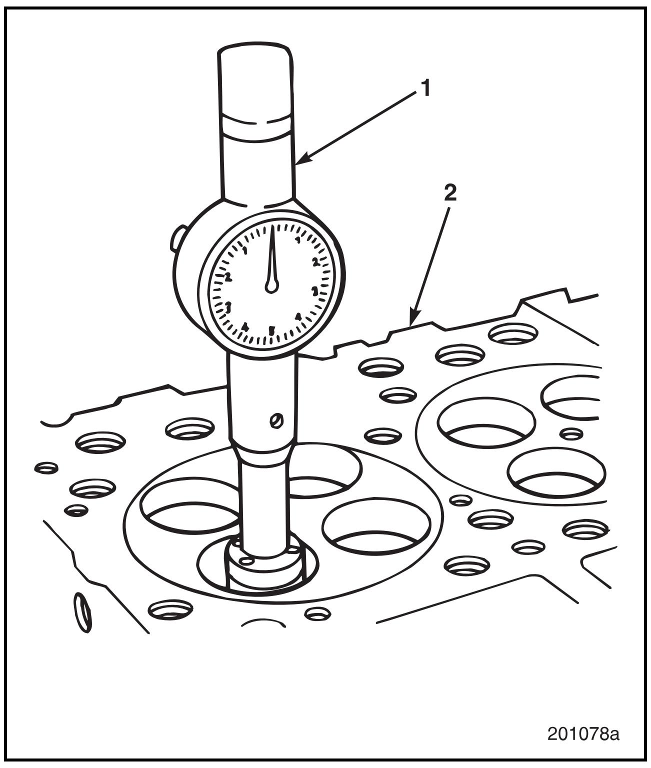


Figure 5-46 — Checking Counterbore Dimensions

1. Inside diameter micrometer	2. Cylinder head

VALVE SEAT INSERT INSTALLATION

NOTE

Oversize inlet and exhaust valve seat inserts are available in 0.005, 0.015, 0.031, 0.047 and 0.062 inch sizes if counterbore requires machining.

1. If required, machine the inlet and exhaust valve seat insert counterbores using tool HT77136.

Refer to Figure 5-47.

2. Position valve seat insert (1) over corresponding counterbore. Install inserts using valve seat insert installation set J 38586 (2). Use driver handle J 8092 (3) to drive valve seat insert into counterbore.

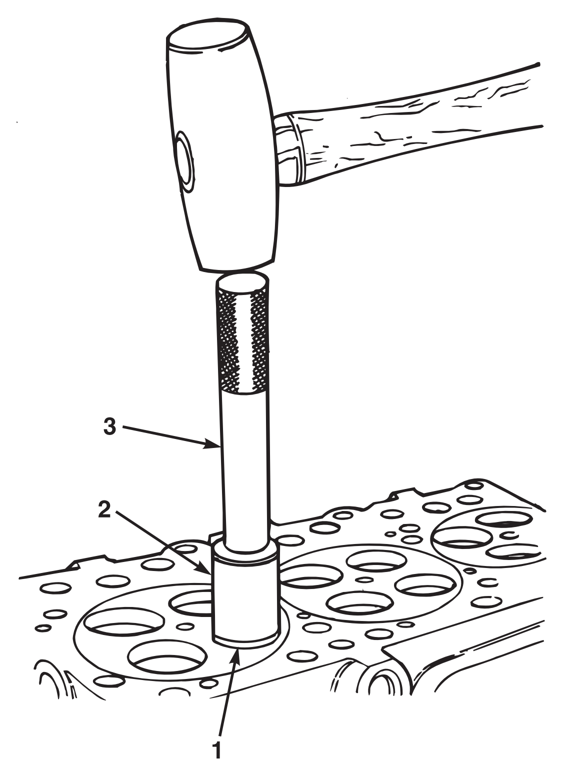


Figure 5-47 — Valve Seat Insert Installation

1. Valve seat insert 2. J 38586	3. J 8092

3. Grind inlet/exhaust valve seat inserts to specification.
   - Inlet valve inserts before November 1996: 30° –0'/+ 30' angle; November 1996 and later: 20° 30' ± 15' angle
   - Exhaust valve inserts: 30° –0'/+ 30'

CAUTION

Always use 30-degree valves with 30-degree valve inserts and 20-degree valves with 20-degree valve inserts. Excessive wear and possible failure will result if 30-degree parts are matched with 20-degree parts.

NOTE

If valve seat insert widths exceed specifications when grinding inserts, use a 15-degree angle grinding stone to obtain correct width.

Refer to Figure 5-48.

4. After grinding is completed, thoroughly clean valve seat insert.
5. Determine concentricity of each valve seat insert relative to valve guide. Valve seat runout is to be held within 0.001 (0.025 mm) FIM (Full Indicator Movement), with finished valve guide ID measurements made from snug-fitting arbor (1) and through-mounted into finished valve guides (2).
6. After valve insert has been ground and cleaned, determine position of contact area between valve and valve seat insert. Apply a dab of Prussian Blue to valve face at four points, 90 degrees apart.
7. Lower stem of valve into valve guide and allow valve face to rest on seat insert. Rotate valve 90 degrees on insert. Carefully remove valve without making contact with valve face. Properly ground inserts should have full pattern on insert.

NOTE

Thoroughly clean cylinder head after checking valve seat inserts and before installing valves.

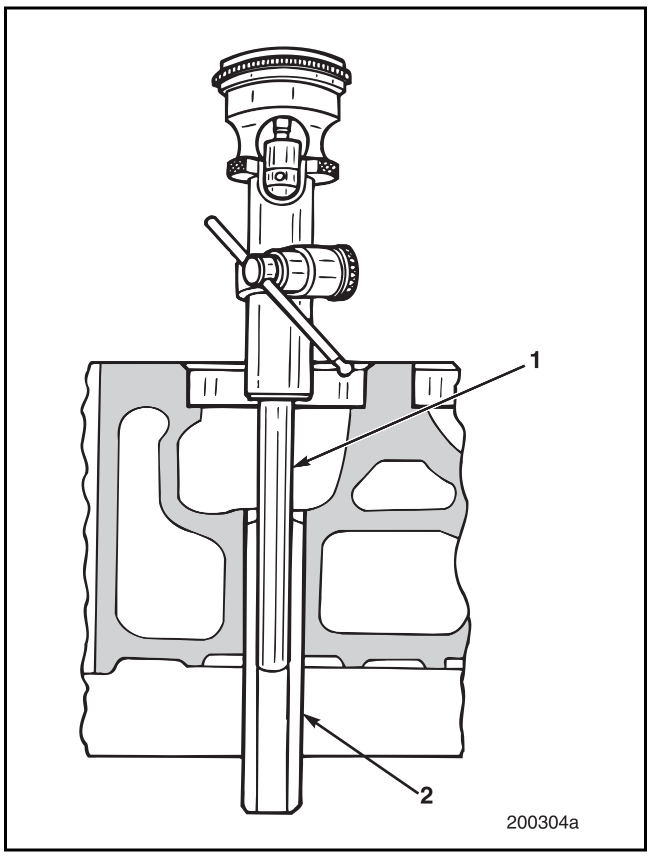


Figure 5-48 — Checking Valve Seat Runout

1. Arbor	2. Valve guides

[213 MB] Valve Springs

1. Visually inspect inside surfaces of coils. Also, feel inside surfaces of spring for any indication of roughness or grooving. If any of these conditions exist, replace spring.

Refer to Figure 5-49.

2. Check spring tension on universal spring tester J 22738-02.

   Part No. 575GC213 (E7)
   142.5–157.5 lb. at 1.435 inches
   (64.6–71.4 kg at 36.4 mm)

   Part No. 575GC35 (E7 with Extarder)
   190–210 lb. at 1.5 inches
   (86.2–95.3 kg at 38.1 mm)

NOTE

If spring force does not meet specification, discard and install new spring.

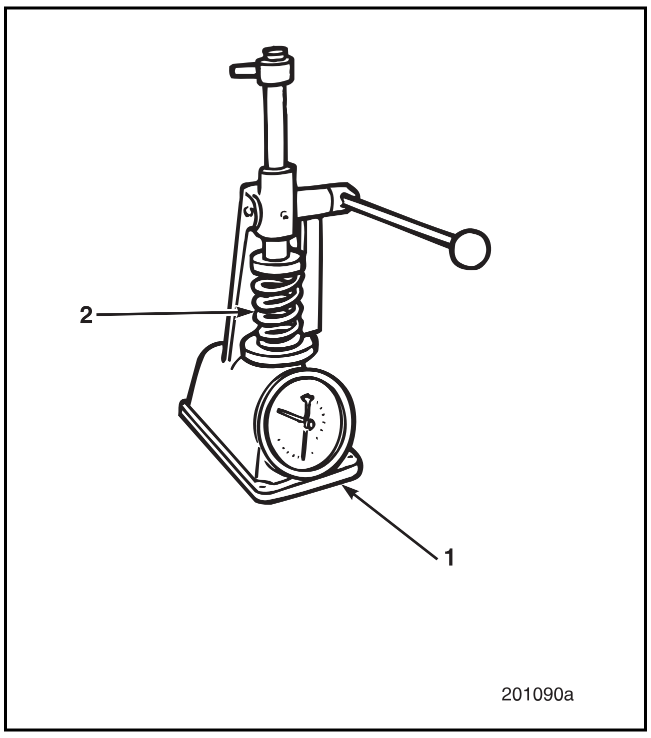


Figure 5-49 — Checking Valve Spring Tension

1. Spring tester J 22738-02	2. Valve spring

[213 GB] Injection Nozzle Holder Insert

The injection nozzle holder insert is machined to provide a press fit in cylinder head.

INJECTION NOZZLE HOLDER INSERT REMOVAL

1. To remove injection nozzle holder insert, tap ID with 3/4-10 tap.

Refer to Figure 5-50.

2. Install nozzle sleeve puller J 29880 (2) to slide hammer J 2619-01 (1) or equivalent.
3. Thread sleeve puller into end of injection nozzle holder insert. Use slide hammer to remove insert.

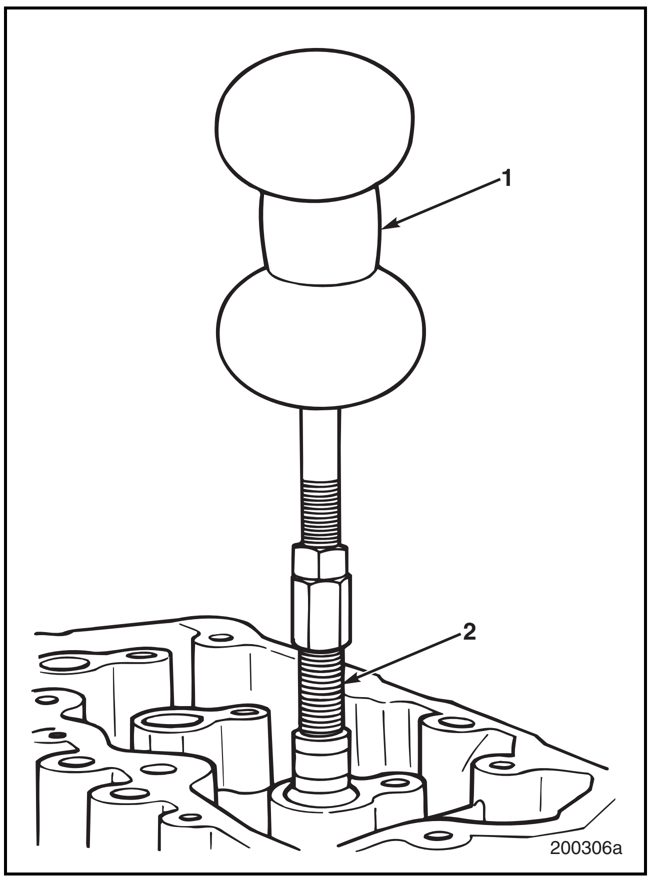


Figure 5-50 — Removing Injection Nozzle Holder Insert

1. Slide hammer J 2619-01	2. Sleeve puller J 29880

INJECTION NOZZLE HOLDER INSERT INSTALLATION

1. Thoroughly clean insert bore and surrounding area before installing insert.
2. Apply Loctite 620 completely around the center of all three sealing diameters of the new insert.

Refer to Figure 5-51.

3. Using nozzle sleeve installer J 29297 (2), drive insert (1) into cylinder head until it bottoms in lower counterbore face.

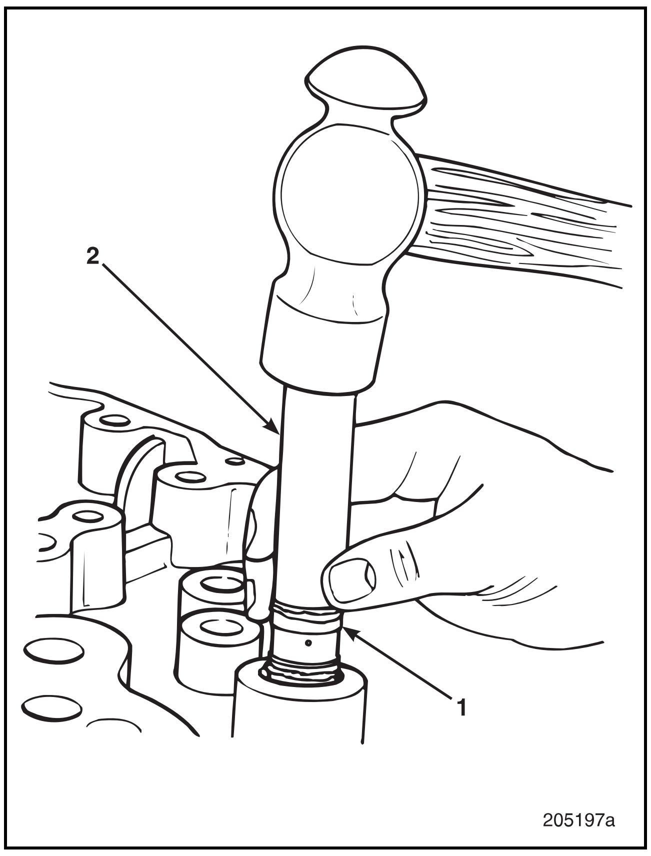


Figure 5-51 — Injection Nozzle Holder Insert Installation

1. Insert	2. Nozzle sleeve installer J 29297

[213 FH] Valve Yoke Guide Pins

The valve yoke guide pins are located between valve guides.

INSPECTION

Inspect valve yoke guide pin surface for cracks or other damage. Also check pin diameter and installed height.

VALVE YOKE GUIDE PIN REMOVAL

Refer to Figure 5-52.

1. To remove pin, use valve yoke guide pin puller kit PT6575 and extractor PT6570-11 (7/16 inch).
2. Install extractor over guide pin and position extractor lock over extractor.
3. Using slide hammer, remove pin.

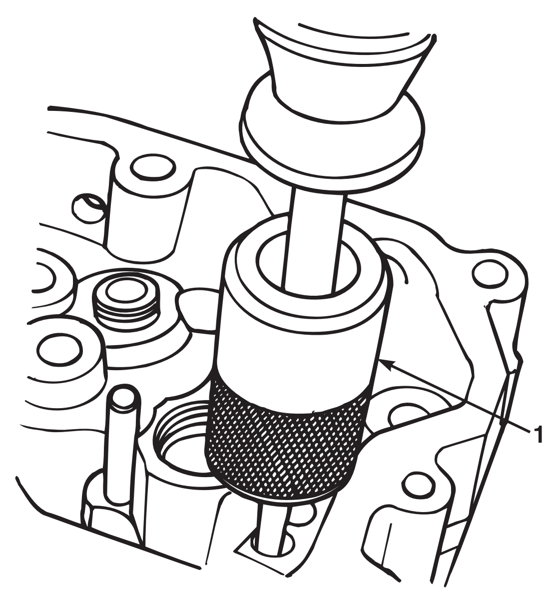


Figure 5-52 — Valve Yoke Guide Pin Removal

1. Extractor lock (part of PT6570-11)

VALVE YOKE GUIDE PIN INSTALLATION

Refer to Figure 5-53.

If new pin is required, use valve guide pin installer J 37809 to drive pin into cylinder head. Guide pin will be at correct height when tool bottoms on cylinder head.

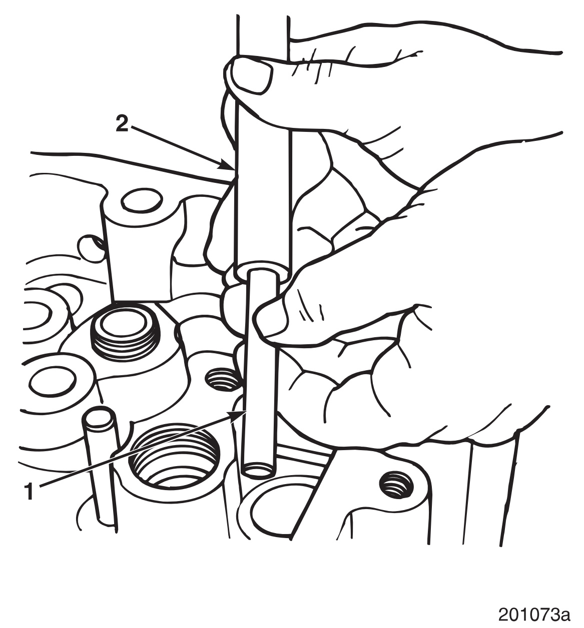


Figure 5-53 — Valve Yoke Guide Pin Installation

1. Valve yoke guide pin	2. J 37809

[213 FP] Cylinder Head Cup Plugs

DESCRIPTION

The cylinder head has two different-size cup plugs: 13/16 inch (20.64 mm) and 1-1/16 inch (26.99 mm).

CYLINDER HEAD CUP PLUG INSTALLATION

1. Clean cup bore thoroughly.
2. Use Loctite 277 sealer, or equivalent, and apply to cup plug and cup plug bore in head.

Refer to Figure 5-54.

3. Install cup plugs in cylinder head, using cylinder head core plug installer J 34684 for 13/16-inch cup plugs, and cylinder head core plug installer J 34687 for 1-1/16 inch cup plugs.

NOTE

Cup should be installed flush with machined surface to 0.020 inch (0.508 mm) below cylinder head.

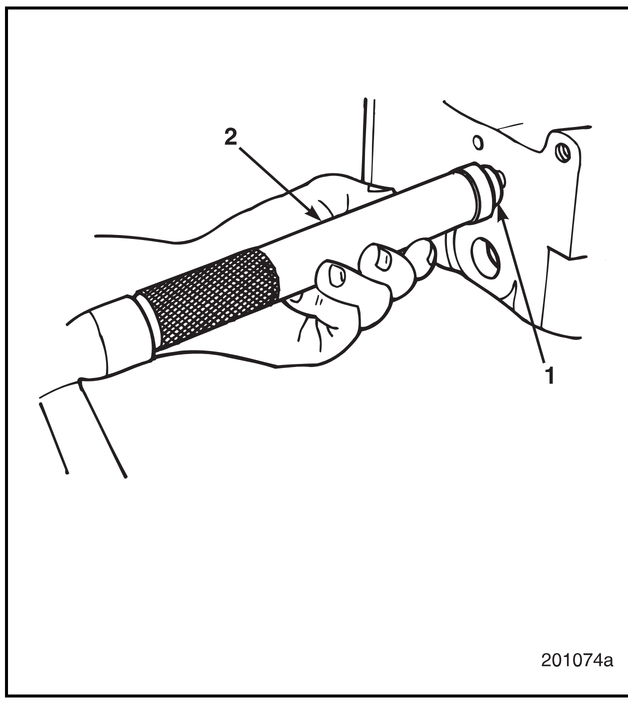


Figure 5-54 — Cylinder Head Cup Plug Installation

1. Cup plug	2. Cup plug installer

Cylinder Head Pipe Plugs

CYLINDER HEAD PIPE PLUG INSTALLATION

1. Apply dry pipe thread sealant to pipe plug and pipe plug bore in head.

Refer to Figure 5-55.

2. Install a 1/8-inch pipe plug in top of rear cylinder head.
3. Install two 3/4-inch core hole pipe plugs in cylinder head. Torque to 28 lb-ft (38 N•m).

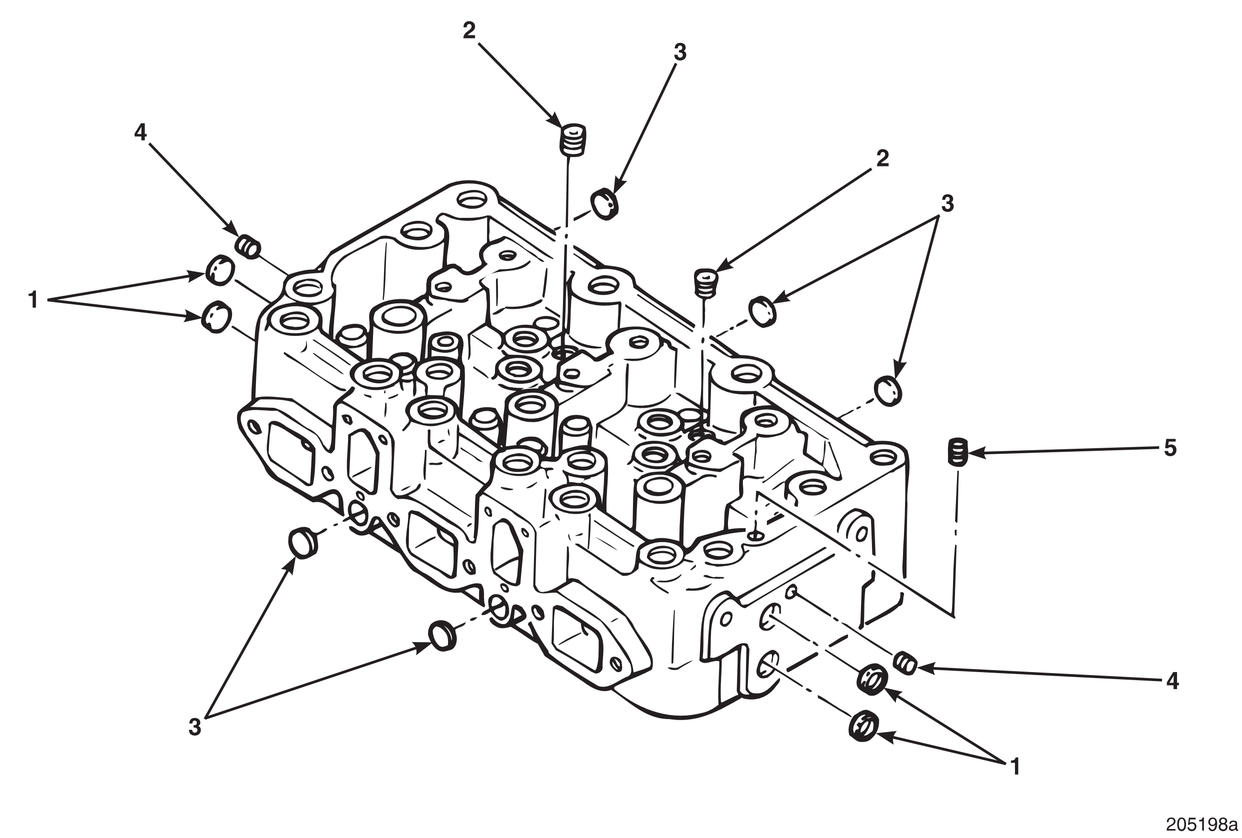


Figure 5-55 — Cylinder Head Pipe Plug Locations

1. 1-1/16 inch cup plug 2. 3/4-inch NPT plug 3. 13/16-inch cup plug	4. 1/16-inch NPT plug 5. 1/8-inch NPT plug

[213 NB] INLET AND EXHAUST VALVES

Inspection

Refer to Figure 5-56.

Visually inspect valves for cracks, pits or other conditions that may cause improper operation. Check valve seat angle. Also check stem length, diameter and condition.

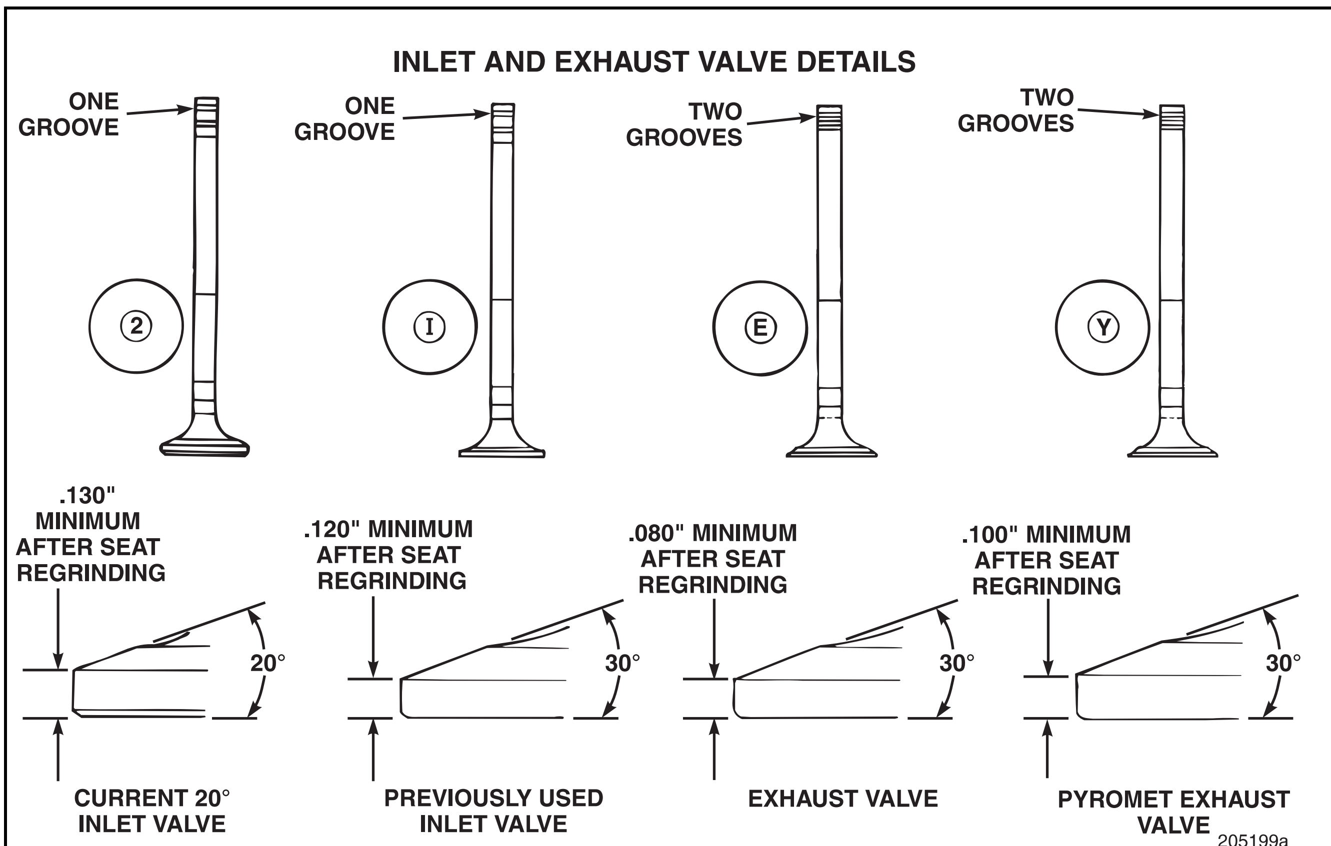


Figure 5-56 — Valve Dimensions (Through September 1996 Production)

Valve Identification

CAUTION

The Pyromet exhaust valve cannot be used on E7 engines equipped with a Dynatard® engine brake. The Pyromet exhaust valve head is 0.020 inch (0.508 mm) thicker than a conventional exhaust valve; therefore, valve-to-piston contact may occur when engine brake is activated.

To permit positive identification, exhaust valve has two stem grooves and inlet valve has one stem groove.

The valves are also identified by letters “I” (30-degree inlet), “2” (20-degree inlet), “E” (exhaust) or “Y” (Pyromet exhaust), which are forged in a slight depression on bottom face of valve head.

NOTE

New cylinder heads have been produced in November 1996 which have 20-degree intake valves and seats. These valves and seats replace the 30-degree intake valves and seats in all E7 cylinder heads. The 20-degree valves and seats are 100% interchangeable with the 30-degree valves and seats, provided the seat matches the valve (20-degree seat with 20-degree valve, 30-degree seat with 30-degree valve). Remanufactured assemblies will use either 20-degree or 30-degree valves and seats on certain applications (never mixed in one head). See the following chart and figures to identify your assembly.

Reman Part No.	Angle	Assembly ID	Valve ID	Applications
732GB3424X	20°	72	2	E6 4VH Engines
	30°	24	I	
732GB3452MX	20°	71	2	E7 engines (pre 1991)
	30°	52	I	
732GB3451MX	20°	70	2	E7 engines (1991/92/93)
	30°	51	I	
732GB3466MX	20°	66	2	E7 engines (1994/95/96)
732GB3469MX	20°	69	2	1995/96 E7 engines for Jacob® Stealth™ retarding system applications.

Refer to Figures 5-57 and 5-58.

The following (Figures 5-57 and 5-58) show a remanufactured cylinder head assembly ID and 20-degree intake valve ID.

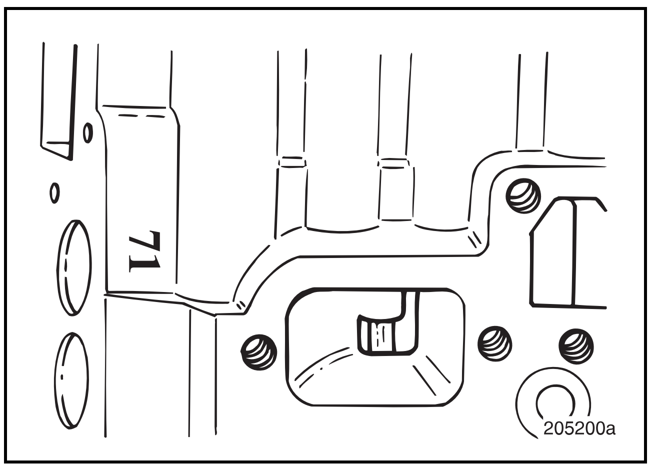


Figure 5-57 — Remanufactured Cylinder Head Assembly ID

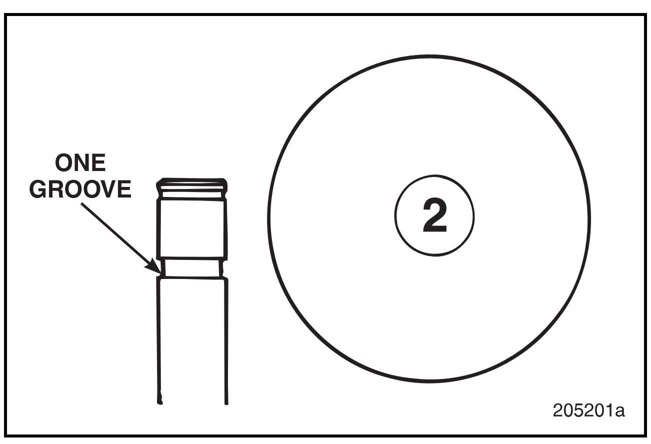


Figure 5-58 — 20-Degree Intake Valve ID

Refer to Figure 5-57.

Any remanufactured cylinder head produced prior to 12/13/96 will not have the assembly ID stamped on it. Heads which do not have assembly ID stamps are 30-degree intake valves and seats.

Inlet and Exhaust Valve Installation

CAUTION

The inlet and exhaust valve head diameters are nearly the same size. It is important, therefore, that extra care be taken when assembling these valves.

NOTE

With the new, more effective valve stem seals (446GC328), pre-lubing the seals and valve stems during installation is extremely important. Perform the following:

- Valve Stem to Guide — If valves are removed, lubricate the inside diameter of the valve guides by using a “bottle brush” coated with graphite grease. This is particularly important when both the valves and the valve guides are new. With an on-engine seal replacement, pre-lube the valve stems with engine oil while moving the valve up and down, prior to installation of the valve spring.
- Valve Stem to Seal Lip — The inside diameter of the seal lip and outside diameter of the valve stem should be well-lubricated with clean engine oil when installing the seal over the valve stem.

It is essential that the J 42453 Valve Stem Seal Installation tool be used to install the seals. This tool bottoms on the cylinder head rocker arm mounting bracket surface when the seal is installed to the proper depth on the valve guide. Using any non-bottoming type seal driver (such as a socket) may result in distorting the top surface of the seal casing which permanently distorts the seal lip and prevents proper sealing, or in the top rubber portion of the seal being cut off. Also, do not use seal installer J 41150, or seal damage will result. Tool J 41150 should be discarded immediately after receiving tool J 42453.

NOTE

Before installing valve stem seals, be sure the rotator has been installed. The rotator will not fit over the valve stem seal.

1. Lubricate the valve guides and valve stems with engine oil prior to installation.
2. Install valve spring lower washer (Roto-Coil), over valve guide.
3. Lubricate valve stem seals with engine oil and install seals using valve seal installer J 42453.
4. Install valve into cylinder head.
5. Check valve stem tip for nicks or burrs that may damage valve seal upon installation.
6. Install valve spring, upper washer and keepers. Use tool J 29294-B to install keepers.

Refer to Figures 5-59 and 5-60.

7. After valves are assembled, check each inlet valve for head height above cylinder deck. The protrusion dimension for inlet valves should be 0.0425 ± 0.007 inch (1.0795 ± 0.178 mm).

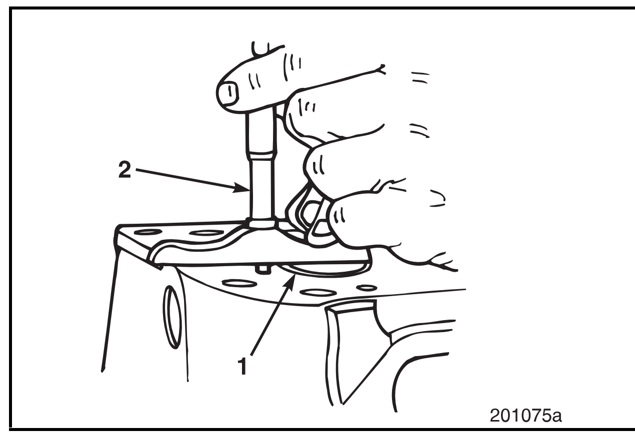


Figure 5-59 — Checking Valve Assembly Height

1. Inlet valve	2. Depth/height measurement tool

8. Check each exhaust valve for head depth below cylinder deck. The depth dimension for exhaust valve should be 0.0414 ± 0.007 inch (1.0516 ± 0.178 mm), or 0.021 ± 0.007 inch (0.553 ± 0.178 mm) for Pyromet valves.

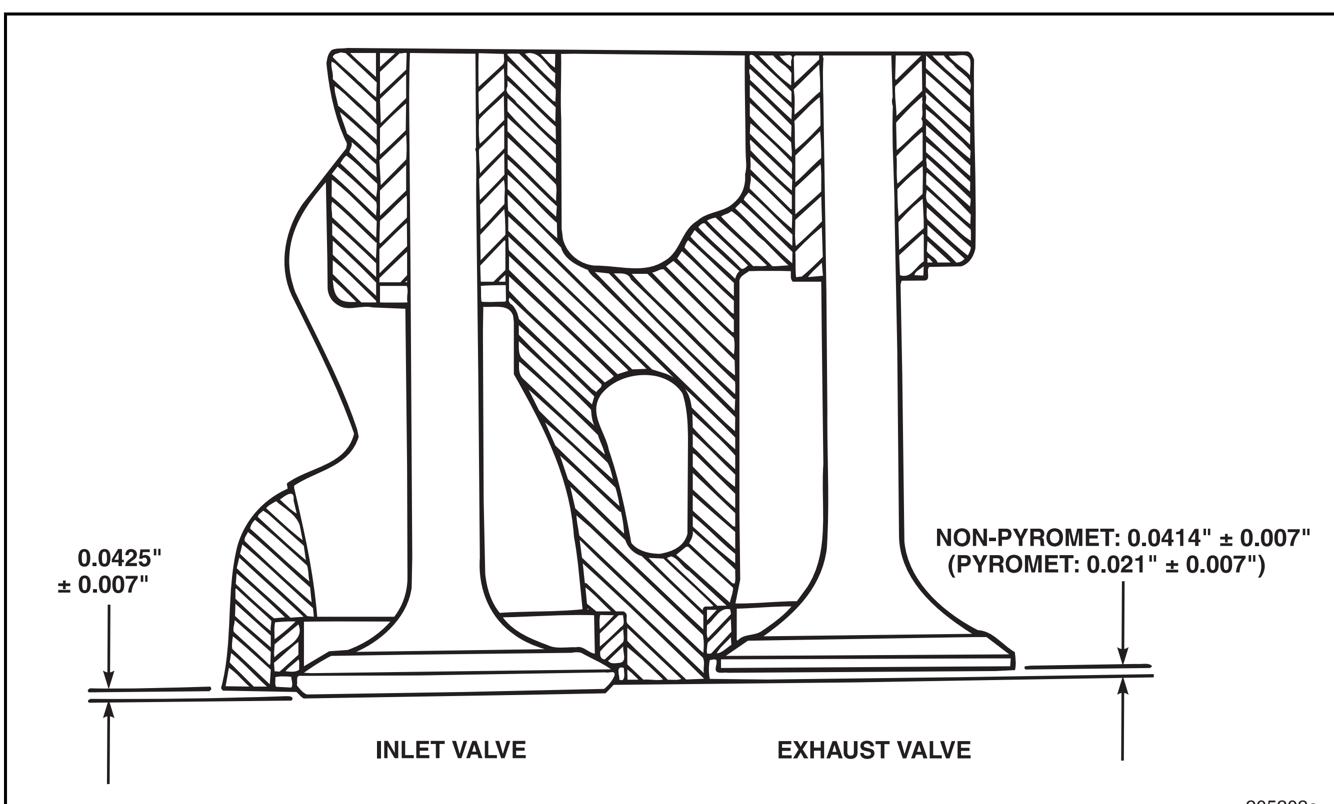


Figure 5-60 — Inlet/Exhaust Valve Head Depth Measurement

NOTE

If dimensions are not within specification, machine valve seat insert and/or valve face as necessary. Refer back to Valve Seat Insert Installation (page 36 in this section) for detailed specifications.

[213 LV] VALVE ROCKER ARM SHAFT

NOTE

There is a shouldered rocker arm mounting capscrew at one end of each rocker arm assembly to ensure proper alignment.

Inspection

Inspect all components of rocker arm and bracket assembly for evidence of damage or wear. Replace as necessary.

Rocker Arms

To date, E7 and E7 EUP (E-Tech™) engines use the same rocker arms. Effective second quarter 1997, both models use a newly designed rocker arm, where the slipper end wear surface is a hardened, headed pin, pressed into the rocker arm.

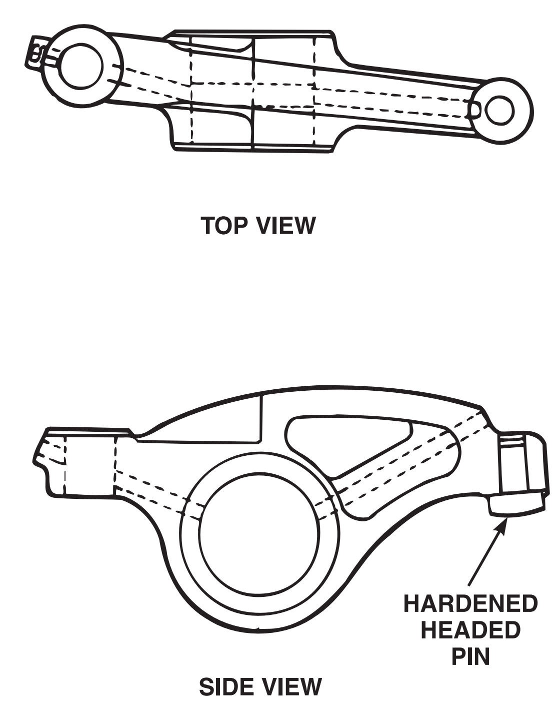


Figure 5-61 — New-Style Rocker Arm

Valve Rocker Arm Shaft Assembly (Except Jacobs Engine Brake)

Refer to Figure 5-62.

The assembly procedure for rocker arm shaft (includes Dynatard) without Jacobs engine brake is described below. The rocker arm bracket mounting dimensions are the same for both non-brake and brake assemblies. The rocker arm arrangement includes valve rocker arms (with lash adjusters) mounted on rocker arm shaft.

1. Position shaft (12) so that screw locating hole is in line with bracket locating screw hole.
2. The offset side of bracket must be positioned toward right side of engine.
3. Assemble bracket (8) on press table. Press shaft into bracket until oil hole in shaft is positioned under hole bracket. Install locating screw and lock washer (8) to secure bracket on shaft.
4. Lubricate inlet rocker arm (3) and install on rocker arm shaft.
5. Lubricate valve rocker arm adjusting screw and nut, and install into inlet rocker arm.

6. Assemble rocker arm retaining (coil) spring (6) on shaft.
7. Lubricate exhaust rocker arm (5) and install on rocker arm shaft.
8. Lubricate valve rocker arm adjusting screw and nut, and install into exhaust rocker arm.
9. Place center (second) rocker arm shaft bracket (4) and shaft (12) on a flat surface. This bracket does not have a threaded hole on top or an oil hole at bottom surface. Align mounting surface and offset of bracket with bracket already installed.
10. Press shaft into rocker arm bracket until center lines of mounting holes in brackets are spaced 5.750 inches (146 mm) apart.

SERVICE HINT

At this point, a used or scrapped cylinder head can be used as a template for proper bracket alignment and to ensure mounting surfaces of each bracket are parallel.

11. Lubricate inlet rocker arm (3) and install on shaft.
12. Assemble rocker arm retaining (coil) spring (6) on shaft.
13. Lubricate exhaust rocker arm (5) and install on shaft.
14. Place last (third) rocker arm shaft bracket (4) and shaft on a flat surface. This bracket does not have a threaded hole on top or an oil hole at bottom surface. Align mounting surface and offset of bracket with two brackets already installed.
15. Check for proper bracket alignment. Press bracket onto shaft. Ensure that mounting surfaces of each bracket are parallel.
16. Lubricate and install outermost inlet rocker arm (3).
17. Install flat spring and retaining snap ring on end of shaft to keep inlet rocker arm in place.
18. At opposite end of shaft, lubricate and install outermost exhaust rocker arm (5).

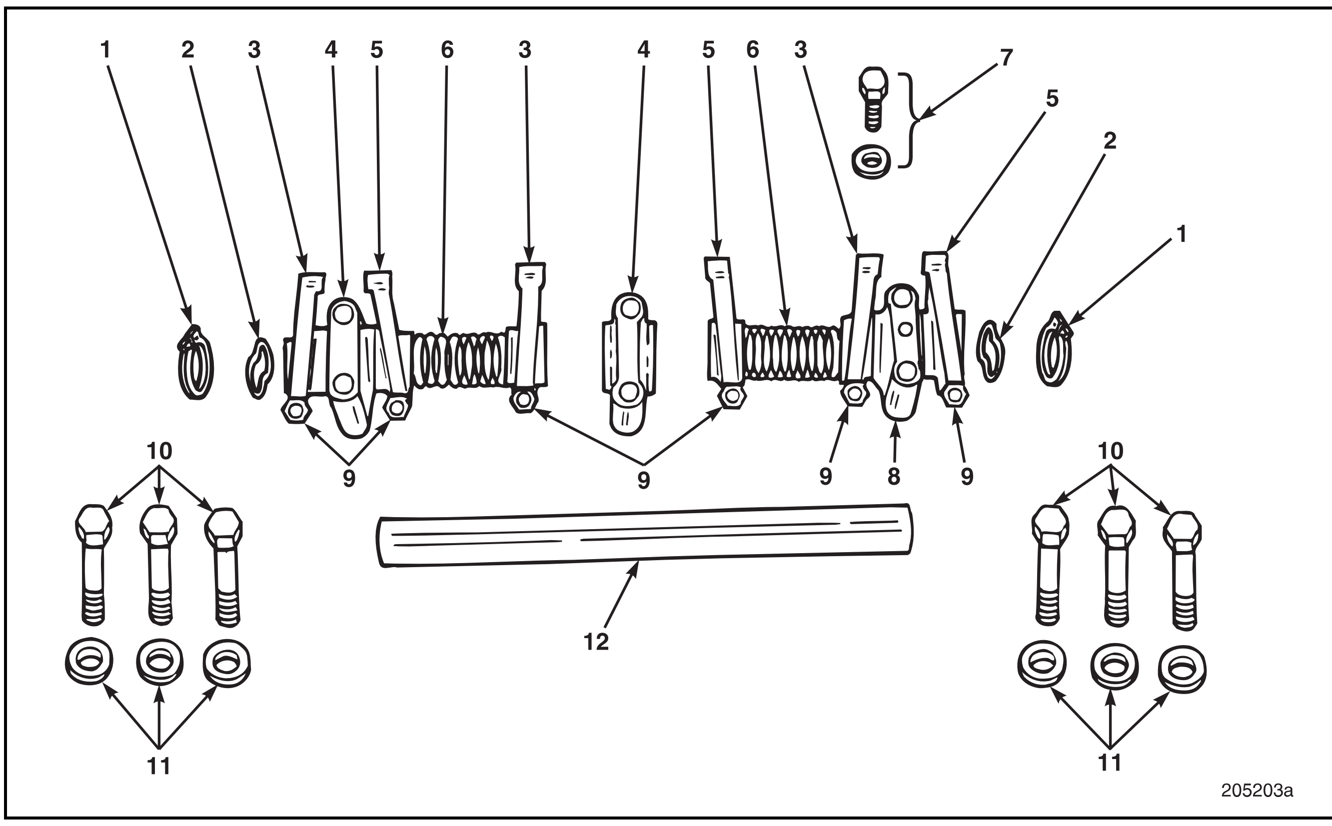


Figure 5-62 — Valve Rocker Arm Shaft Assembly (Without Engine Brake)

1. Snap ring	7. Locating screw and lock washer
2. Flat spring	8. Bracket with center threaded hole
3. Inlet rocker arm	9. Standard adjusting screws and jam nuts
4. Brackets	10. Capscrews
5. Exhaust rocker arm	11. Washers
6. Spring	12. Shaft

19. Install flat spring (2) and snap ring (1) on end of shaft. Some rocker arm shafts are equipped with threaded plugs and aluminum washers instead of flat springs and snap rings.
20. Check all rocker arms to make sure they rotate freely.

NOTE

Valve rocker arm shaft assembly will be installed during engine assembly by inserting capscrews (10) and washers (11) into holes in brackets (4) and (8).

Valve Rocker Arm Shaft Assembly (with Jacobs Engine Brake)

Refer to Figure 5-63.

The assembly procedure for rocker arm shaft with engine brake is described below. The engine brake arrangement includes exhaust valve rocker arms with lash adjusters and a solenoid mounted in the rocker arm shaft.

1. Position shaft (11) so that the oil supply screw locating hole is in line with bracket locating screw hole.
2. The offset side of bracket must be positioned toward the right side of engine.
3. Assemble bracket with center threaded hole (8) on press table. Press shaft into bracket until oil hole in shaft is positioned under threaded hole in bracket.

4. Thread oil supply screw and O-ring (7) into bracket and torque to 5 lb-ft (7 N•m) using torque wrench J 24405 or equivalent.
5. Lubricate inlet rocker arm (3) and install on rocker arm shaft.
6. Lubricate valve rocker arm adjusting screw and nut, and install into inlet rocker arm.
7. Assemble rocker arm retaining (coil) spring (6) on shaft.
8. Lubricate exhaust rocker arm (5) and install on rocker arm shaft.
9. Lubricate valve rocker arm adjusting screw and nut, and install into exhaust rocker arm (5).
10. Place center (second) rocker arm shaft bracket (4) and shaft (11) on a flat surface. This bracket does not have a threaded hole on top or an oil hole at bottom surface. Align mounting surface and offset of bracket with bracket that is already installed.
11. Press shaft into rocker arm bracket until center lines of mounting holes in brackets are spaced 5.750 inches (146.050 mm) apart.

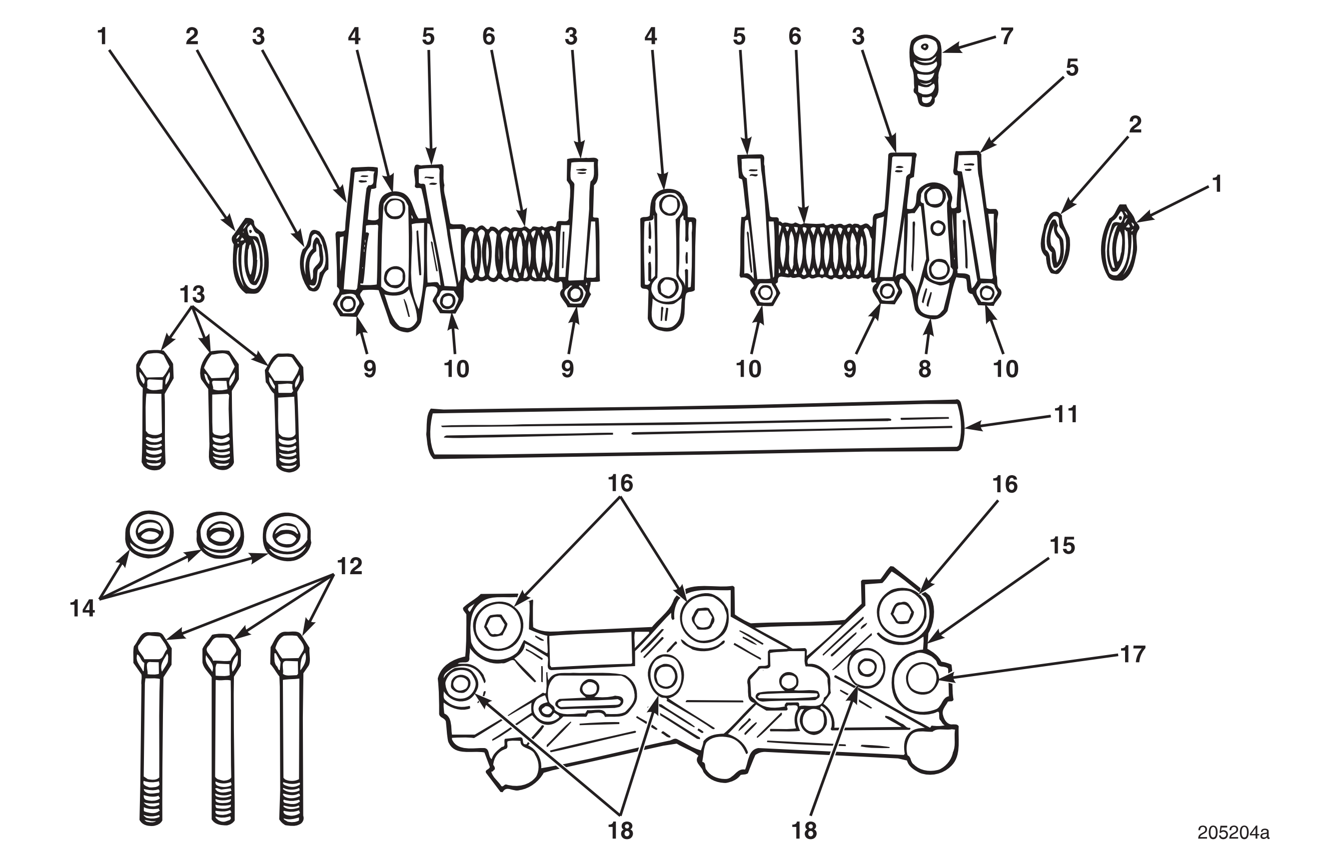


Figure 5-63 — Valve Rocker Arm Shaft Assembly (with Jacobs Engine Brake)

1. Snap ring	10. Jacobs adjusting screws and jam nuts
2. Flat spring	11. Shaft
3. Inlet rocker arm	12. Capscrews (long)
4. Brackets	13. Capscrews (short)
5. Exhaust rocker arm	14. Washers (for short capscrews)
6. Spring	15. Jacobs brake housing
7. Locating/Jacobs oil supply screw and O-ring	16. Slave piston adjusters
8. Bracket with center threaded hole	17. Solenoid
9. Standard adjusting screws and jam nuts	18. Locations for long capscrews

SERVICE HINT

At this point, a used or scrapped cylinder head can be used as a template for proper bracket alignment and to ensure mounting surfaces of each bracket are parallel.

12. Lubricate inlet rocker arm (3) and install on shaft.
13. Assemble rocker arm retaining (coil) spring (6) on shaft.
14. Lubricate exhaust rocker arm (5) and install on shaft.
15. Place last (third) rocker arm shaft bracket (4) and shaft on a flat surface. This bracket does not have a threaded hole on top or an oil hole at bottom surface. Align mounting surface of bracket and offset with two brackets already installed.
16. Check for proper bracket alignment. Ensure that mounting surfaces of each bracket are parallel. Press shaft into rocker arm bracket.
17. Lubricate and install outermost inlet rocker arm (3).
18. Install flat spring and retaining snap ring on end of shaft to keep inlet rocker arm in place.
19. At opposite end of shaft, lubricate and install outermost exhaust rocker arm (5).
20. Install flat spring (2) and snap ring (1) on end of shaft to keep rocker arm in place. Some rocker arm shafts are equipped with threaded plugs and aluminum washers instead of flat springs and snap rings.
21. Check all rocker arms to make sure they rotate freely.

Dynatard Engine Brake Solenoid

Refer to Figure 5-64.

1. On valve rocker arm shaft assemblies with a Dynatard engine brake, install solenoid mounting adapter seal (O-ring) in counterbore in rocker shaft.
2. Lubricate solenoid mounting threads with clean engine oil.

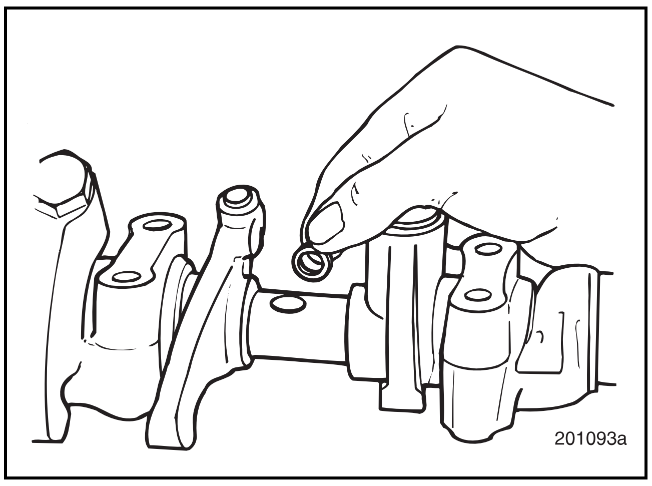


Figure 5-64 — Solenoid Mounting Adapter O-Ring

Refer to Figure 5-65.

3. Assemble solenoid mounting adapter into shaft and torque to 23–25 lb-ft (31–34 N•m) with crows-foot adapter and a calibrated torque wrench (J 24406 or equivalent).

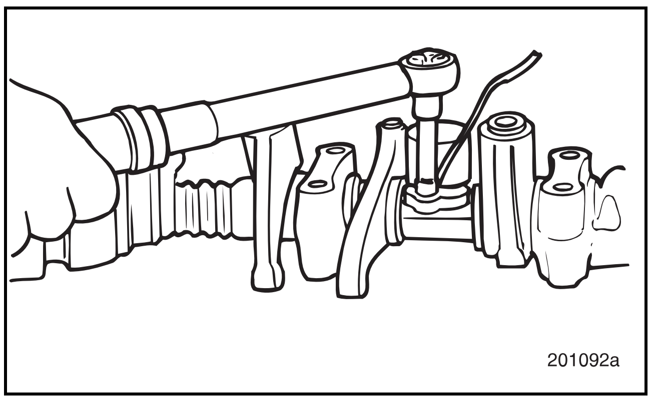


Figure 5-65 — Dynatard Engine Brake Solenoid Installation

[266 KD] DYNATARD ENGINE BRAKE

Dynatard Overload Protection (E7 Engines with Dynatard)

E7 engines built after January 1, 1992 and through mid-year 1993 are equipped with a Dynatard overload protection system. From mid-year 1993 through December 1993, E7 engines were built with either the Dynatard system or a Jake Brake®. Mack Trucks, Inc. recommends installing the Dynatard overload protection system on all E7 engines built prior to January 1, 1992. This system consists of a pressure relay switch and related hardware. Its purpose is to protect the Dynatard exhaust push rod from overload and from possibly bending during the transition from power mode to braking mode. An overload condition occurs when the turbocharger boost pressure in the inlet manifold is greater than 25 psi (172.4 kPa). The pressure delay switch momentarily restricts Dynatard engine brake activation if turbocharger boost inlet manifold pressure is above 24 psi (165.5 kPa).

PARTS REQUIRED FOR OVERLOAD PROTECTION

- Dynatard pressure switch assembly 1MR3532*
- Engine brake wiring harness 41MR4381*
- Engine brake switch jumper wire 41MR21252
- Cylinder head capscrew 400GC39M4*
- Pressure switch clamp screw 66AM2*
- Wiring harness strap 48RU2313P1*
- Wiring harness strap 48RU2313P2
- Pressure switch clamp 83AX894*
- Engine brake switch harness bracket 72RU11120
- Engine brake switch harness clamp 83AX922
- Engine brake switch harness screw 64AM1
- Engine brake switch harness washer 271AM5007
- Engine brake switch harness nut 157AM2

*Required parts for V-MAC applications.

NOTE

All parts listed are required for mechanical applications.

Dynatard Overload Protection System

INSTALLATION (E7 MECHANICAL ENGINES)

1. Remove air cleaner ducting.
2. Remove cylinder head covers.
3. Remove existing engine brake harness.
4. Remove No. 16 undrilled cylinder head capscrew.
5. Lubricate and install cylinder head capscrew, with a drilled hole, in No. 16 location.
6. Torque cylinder head capscrew to 205 lb-ft (278 N•m) using torque wrench J 24407 or equivalent.
7. Remove front 1/8 NPT pipe plug from inlet manifold.
8. Install new Dynatard pressure delay switch 1MR3532 into pipe plug opening and tighten with an open-end wrench.
9. Install new Dynatard wiring harness 41MR4381 using the following steps:
   a. Lubricate connector O-rings and snap connectors into cylinder heads.
   b. Connect Dynatard wire harness terminals to terminal post screws.
   c. Connect Dynatard wire harness terminal to Dynatard pressure delay switch connection and route wire through crossover loop connector between heads.
10. Install valve covers.
11. Reuse three clamps, 83AX922, from old engine brake harness and install on new brake harness at appropriate locations.
12. Install clamp to Dynatard pressure delay switch wire and position Dynatard engine harness ground wire on clamp.
13. Install capscrew through clamp to No. 16 drilled cylinder head capscrew to securely hold Dynatard pressure delay switch wire and ground wire.
14. Attach wire tie(s) around Dynatard pressure delay switch wire and fuel return jumper line as needed.
15. Remove diode from existing Dynatard injection pump throttle switch.
16. Install jumper wire No. 41MR21252 to Dynatard injection pump throttle switch.
17. Install fuel injection line L-shaped bracket to stud located on right side of engine block. Secure engine brake lead to this bracket.

18. Connect jumper wire to Dynatard engine brake harness connection.
19. Attach wire tie around jumper wire and Dynatard switch bracket.
20. Test engine brake and check for leaks.

INSTALLATION (V-MAC APPLICATIONS)

1. Connect engine brake wiring harness to connection located on right-hand side engine harness.
2. Secure connection to air compressor coolant line with wire tie.
3. Secure engine brake wiring to a clamp located on cylinder block near rear of injection pump.
4. Test engine brake and check for leaks.

[266] JACOBS® ENGINE BRAKE

E7 engines built from mid-year 1993 through December 1993 were equipped with either a Dynatard engine brake or a Jake Brake. Since January 1, 1994, the Jake Brake has been used exclusively.

The Model 680B Jake Brake engine retarder is a vehicle-slowing device designed and approved for use on MACK E7 engines. Energizing the Jake Brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished by opening the cylinder exhaust valves near the top of the compression stroke, releasing the compressed air to exhaust.

Releasing compressed air to exhaust prevents the return of energy to the engine piston on the power stroke. The result is a net energy loss used to slow the vehicle. For more detailed information, specifications and repair procedures, refer to the appropriate Jacobs service manual.

[266] ENGINE BRAKE SWITCH AND BRACKET ASSEMBLY

Description

Beginning in 1991, a cylinder block-mounted engine brake switch and mounting bracket assembly was released for E7 mechanically governed (non V-MAC) engines equipped with either a Jake Brake or Dynatard system (pre-1994). The bracket design improves the service life of the switch by significantly reducing the engine vibration levels that the switch is subjected to. This reduction in vibration levels is accomplished by relocating the mounting of the bracket from the rear of the injection pump to the auxiliary housing area of the cylinder block. Refer to Figure 5-65.

In mid 1992, an improved switch (part No. 1MR3529) was incorporated into the assembly. This new switch, along with relocation of the bracket, adds significantly to the service life of the assembly.

⚠ CAUTION

Proper adjustment is essential. Over-adjustment of this switch arrangement will cause accelerated switch wear or switch failure.

Adjustment (E7 Mechanically Governed Engine with Engine Brake)

1. Loosen the two screws holding the throttle switch to the switch bracket.
2. Check the continuity by connecting a volt-ohmmeter across the switch terminals.
3. Insert an 0.008-inch (0.203 mm) thickness gauge between the low idle screw and the idle lever.
4. Secure the throttle lever in the low idle position.
5. Slide the switch toward the throttle lever to the point where continuity is obtained.
6. Torque the two screws that hold the throttle switch to the switch bracket to 10 lb-in using torque wrench J 24405 or equivalent.

7. Remove the 0.008-inch (0.203 mm) thickness gauge and insert a 0.014-inch (0.356 mm) thickness gauge. There must be NO continuity with the 0.014-inch thickness gauge.
8. Apply locking compound to the switch assembly nut after adjustment is correct.

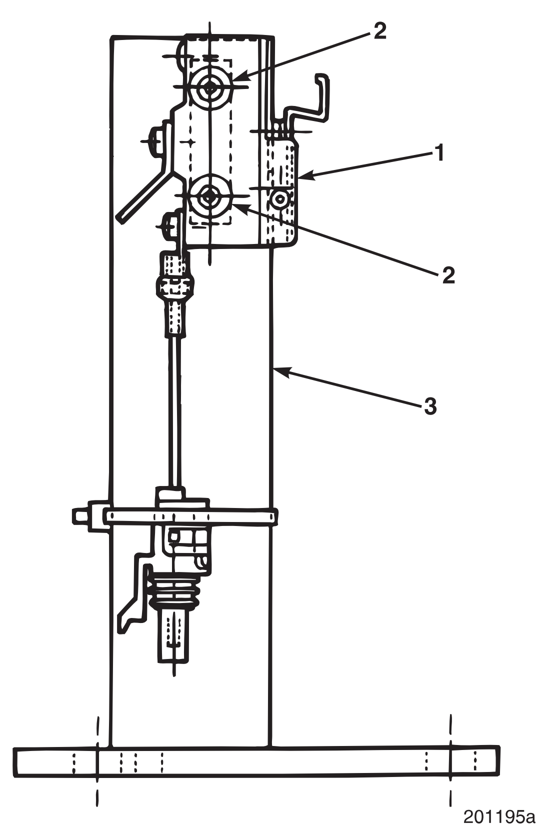


Figure 5-66 — Engine Brake Switch and Bracket (Non V-MAC Engines)

1. Engine brake switch 2. Screw	3. Bracket

[215 DW] OIL COOLER ASSEMBLY

Description

The oil cooler assembly is located near the left front of the engine. Engine coolant from the radiator flows through the lower radiator hose, into a chamber in the oil cooler. The coolant then flows into the water pump.

The oil pump sends engine oil through the inlet port of the oil cooler into the cooling chamber. Heat from the engine oil is transferred through the chamber walls to engine coolant. Cooled oil exits the oil cooler through the oil outlet port, flows through oil filters, and then into the engine.

E7 engines feature a “removable-bundle” type oil cooler. Periodic visual inspection of the oil cooler will indicate condition of gaskets, O-ring and core. If a problem exists, these components can be serviced separately rather than replaced as an assembly.

NOTE

The presence of engine oil in the engine coolant may indicate internal engine problems or worn, loosened or damaged parts within the oil cooler. Continued operation under these conditions may result in severe engine damage.

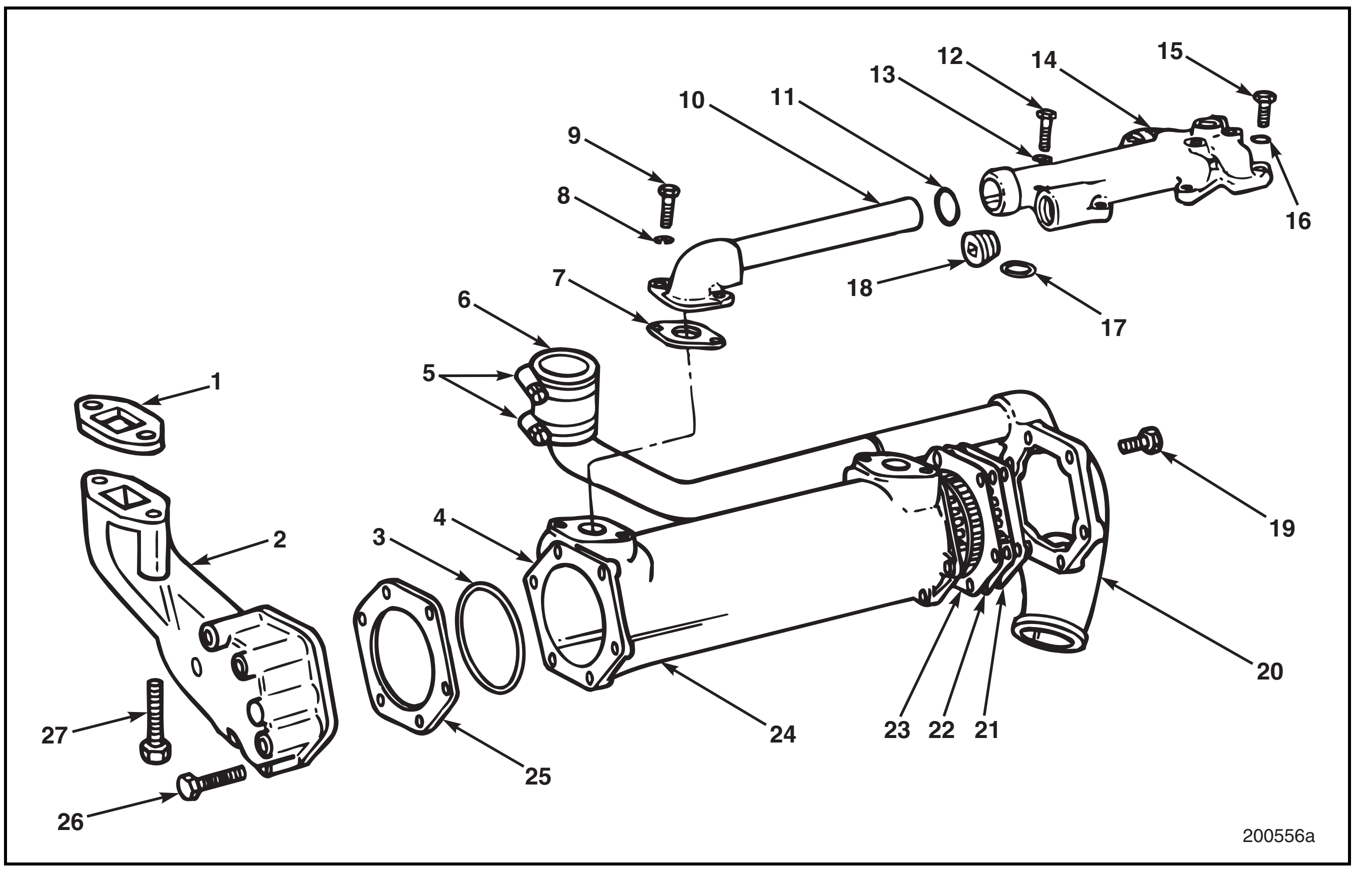


Figure 5-67 — Oil Cooler Assembly

1. Gasket	15. Capscrew
2. Coolant outlet end cap	16. Washer
3. O-ring	17. O-ring
4. Mounting flange	18. Pipe plug
5. Clamps	19. Capscrew
6. Coupler	20. Coolant inlet cap
7. Gasket or O-ring	21. Gasket
8. Washer	22. Bundle
9. Capscrew	23. Gasket
10. Oil outlet tube	24. Housing
11. O-ring	25. Gasket
12. Capscrew	26. Capscrew
13. Washer	27. Capscrew
14. Oil supply head	

Disassembly

Refer to Figure 5-67.

1. Remove coolant inlet end cap (20) by removing six capscrews (19).
2. Remove coolant outlet end cap (2) by removing six capscrews (26).
3. Remove bundle (22) from coolant inlet end of housing (24).
4. Remove O-ring (3) from coolant outlet end of housing.
5. Clean gasket material from all surfaces.

Inspection

Refer back to Figure 5-67.

1. Visually inspect housing (24) for cracks which may cause a leak. Replace housing if damaged.
2. Check oil cooler bundle (22) for leaks by pressurizing with air to 80 psi (552 kPa) and submerging it in water. If a leak is detected, replace with new bundle.

Assembly

Refer back to Figure 5-67.

Lubricate and install O-ring (3) in groove at coolant outlet end of oil cooler housing (24).

1. Apply Permatex® gasket sealer on coolant inlet flange before installing gasket (23).
2. Install gasket (23) on coolant inlet end of housing (24).
3. Apply Permatex gasket sealer on top of gasket.
4. Install bundle (22). If necessary, tap bundle with soft-faced hammer to seat bundle past O-ring (3).

N O T E

The alignment notch in the bundle end flange must be positioned at the top for proper installation.

5. Apply Permatex gasket sealer on bundle end.
6. Place gasket on bundle end.
7. Apply Permatex gasket sealer on top of gasket (21) before installing inlet cap (20).
8. Install coolant inlet end cap and secure with six capscrews (19).
9. Torque coolant inlet end-cap capscrews to 20 lb-ft (27 N•m) using torque wrench J 24405 or equivalent.
10. Apply Permatex sealant to both sides of gasket (25) and install on mounting flange (4) of housing.
11. Install coolant outlet end cap (2) with six capscrews (26).
12. Torque coolant outlet end-cap capscrews to 20 lb-ft (27 N•m) using torque wrench J 24406 or equivalent.

Refer to Figure 5-68.

13. Pressure-check oil cooler for leaks by installing a test plate (4) with air fitting (3) as follows:
    a. Position a rubber gasket (5) and test plate (4) on mounting flange (1) and secure with mounting capscrews (2).

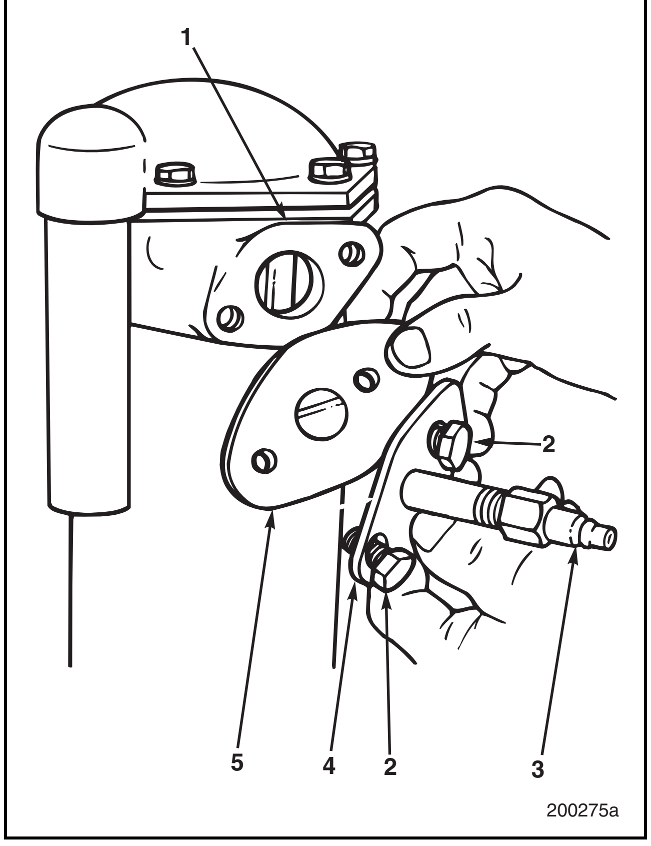


Figure 5-68 — Installing Test Plate

1. Mounting flange 2. Capscrews 3. Air fitting	4. Test plate 5. Rubber gasket

Refer to Figure 5-69.

b. Install a steel plate (2) with a rubber gasket on oil outlet opening. Secure to housing (1) with two capscrews (3).

c. Connect air line and pressurize to 80 psi (552 kPa). Submerge in water to check for leaks.

NOTE

When pressure-testing complete oil cooler assembly using an in-line pressure regulator, apply pressure at 2–5 psi (14–34 kPa) maximum. Then gradually increase pressure, checking for leaks until 80 psi (552 kPa) is reached.

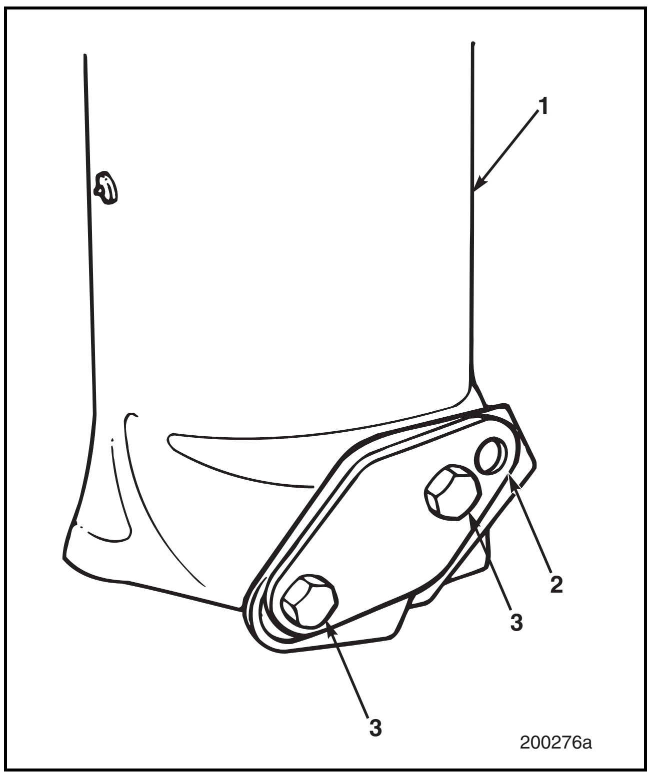


Figure 5-69 — Sealing Oil Outlet

1. Housing 2. Plate	3. Capscrews

[215 SW] WATER PUMP

The water pump is a belt-driven centrifugal or impeller type, and is located on the front of the engine. The water pump pulley is belt-driven by the crankshaft pulley.

During engine operation, the impeller spins in proportion to engine speed. The spinning impeller blades create a negative pressure (suction) at the water pump inlet port and a positive pressure at the outlet port. Engine coolant is drawn into the water pump from the radiator, through the lower radiator hose. The impeller motion forces coolant to circulate through the engine block, cylinder head, and back to the radiator.

To perform water pump service other than replacement, refer to the COOLING 7.0 manual.

[219 MU] OIL PUMP

The shaft and pumping gear on oil pumps manufactured after February 1996 are a one-piece design. Earlier models have a gear pressed onto a keyed shaft. The shafts are interchangeable and replacement with a new (one-piece) shaft is recommended as oil pump gear-to-housing contact is reduced, resulting in longer pump life.

Disassembly

Refer to Figure 5-70.

1. Remove pick-up tube and screen assembly (not shown).
2. Remove oil pump housing cover (7) from oil pump housing (4).
3. Remove oil pressure relief valve cap (13).
4. Remove oil pressure relief valve spring (12) and plunger (11).
5. Slide oil pump idler gear (14) off shaft.
6. Turn oil pump upside down and remove oil pump shaft nut (1) and washer (2).
7. Using a press, remove drive gear (3) and key (5) from pumping gear and shaft assembly (6).
8. Remove pumping gear and shaft assembly from housing.
9. Remove oil pump inlet flange plate (9) and gasket (8) from housing by removing capscrews (10).

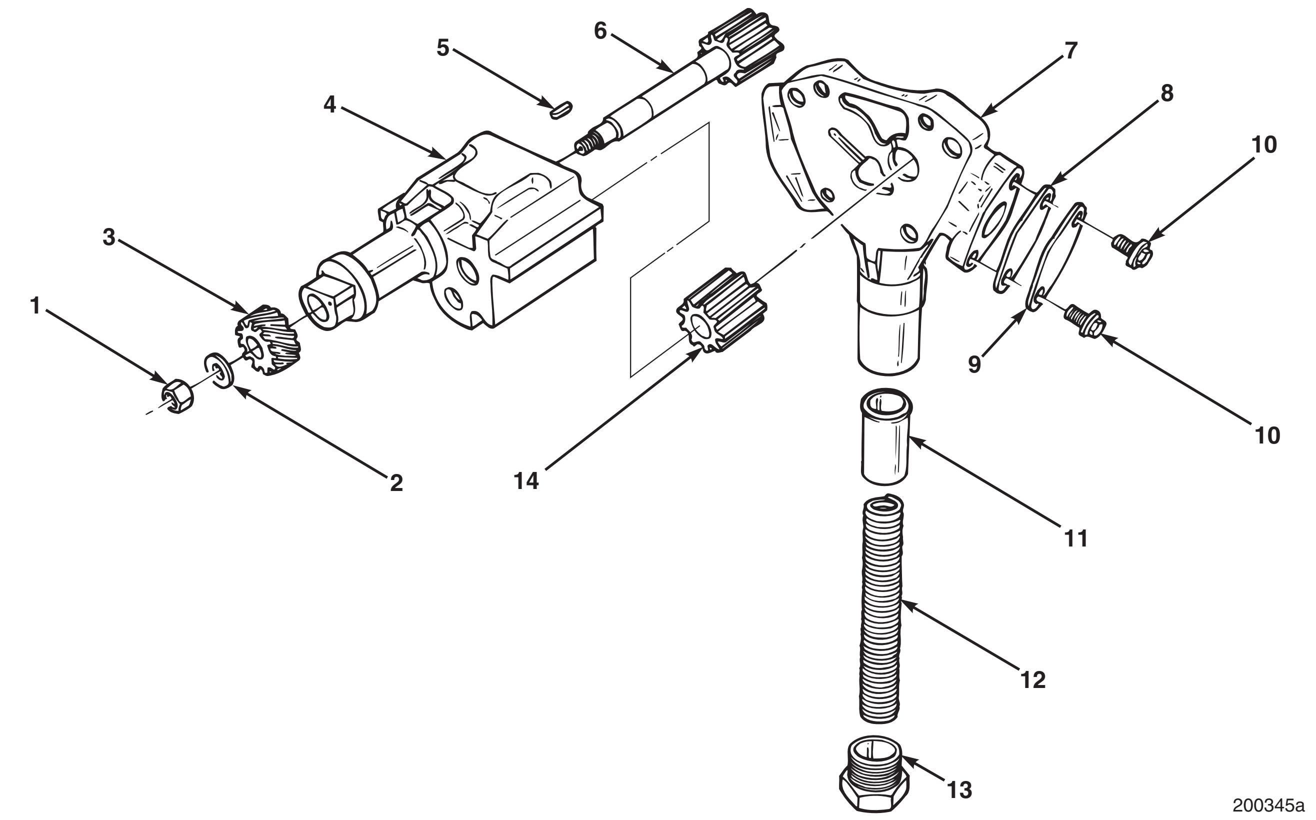


Figure 5-70 — Lubrication Oil Pump

1. Self-locking nut	8. Gasket
2. Washer	9. Inlet flange plate
3. Drive gear	10. Capscrews
4. Housing	11. Plunger
5. Key	12. Relief valve spring
6. Pumping gear and shaft assembly	13. Relief valve cap
7. Oil pump housing cover	14. Idler gear

Inspection

Refer to Figure 5-70.

1. Clean and inspect oil pump housing (4) for scoring, cracks or other damage. If any of these conditions exist, replace oil pump.
2. Check bushings in oil pump housing for burrs, nicks, or cracks.

NOTE

The bushings are an integral part of the oil pump housing. If bushings are damaged, replace oil pump housing.

3. Clean and inspect relief valve spring (12) for breaks. Replace as necessary.
4. Clean and inspect plunger (11) seating surface for burrs or nicks. If seating surface contains burrs or nicks, repair seat as follows:
   a. Place valve lapping compound on plunger seat.
   b. Insert plunger in relief valve housing and rotate plunger against seat to smooth seat.
   c. Remove plunger and clean.
5. Check oil pump idler gear (14) for free play by spinning it on its shaft. If any binding occurs, check housing bore and gear teeth for burrs, nicks, or other damage. Replace as necessary.

6. Insert pumping gear in housing and check for free play by spinning. If any binding occurs, check housing and gear teeth for burrs, nicks, or other damage. Replace as necessary.

NOTE

Before proceeding with assembly, check end clearance, side clearance, and backlash of drive gears as follows.

END CLEARANCE CHECK

Refer to Figure 5-71.

1. Low Limit — Place a straightedge across face of gears and run a 0.001-inch (0.025 mm) thickness gauge under straightedge. Gauge should move freely without binding. If binding occurs, check gears for nicks or burrs. Replace as necessary.
2. High Limit — With straightedge in place (as in step 1), run a 0.007-inch (0.178 mm) thickness gauge under straightedge. Gauge should be very tight. If gauge moves freely, replace gears.

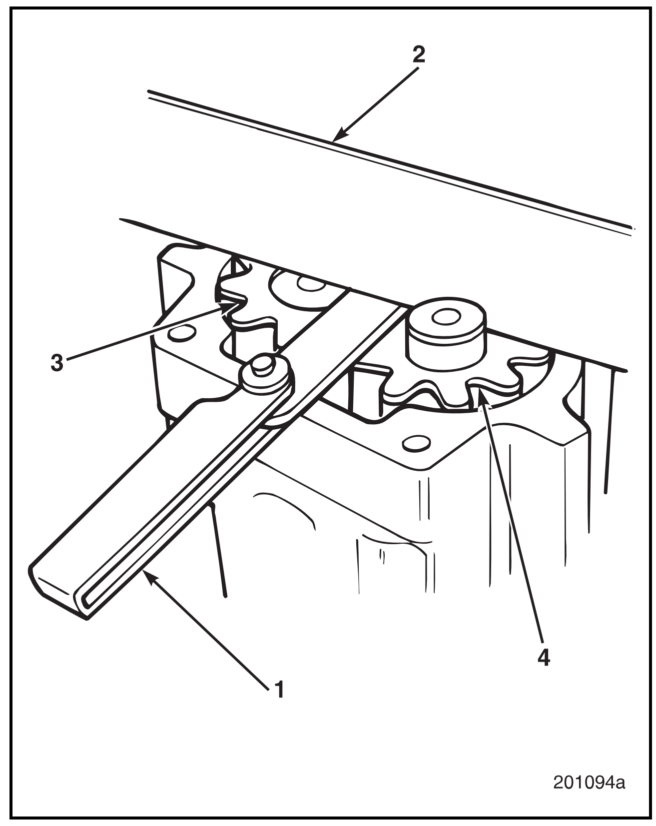


Figure 5-71 — Oil Pump Driving/Idler Gear Assembly End Clearance Check

1. Thickness gauge	3. Pump driving gear
2. Straightedge	4. Pump driven gear

SIDE CLEARANCE CHECK

Refer to Figure 5-72.

1. Low Limit — Insert a 0.002-inch (0.051 mm) thickness gauge between side of gears and housing. Gauge should pass between gears and housing without drag. If it drags, check housing and gears for nicks or burrs. Replace as necessary.
2. High Limit — Insert a 0.006-inch (0.152 mm) thickness gauge between gears and housing. Gauge should not pass through. If gauge passes through, replace housing.

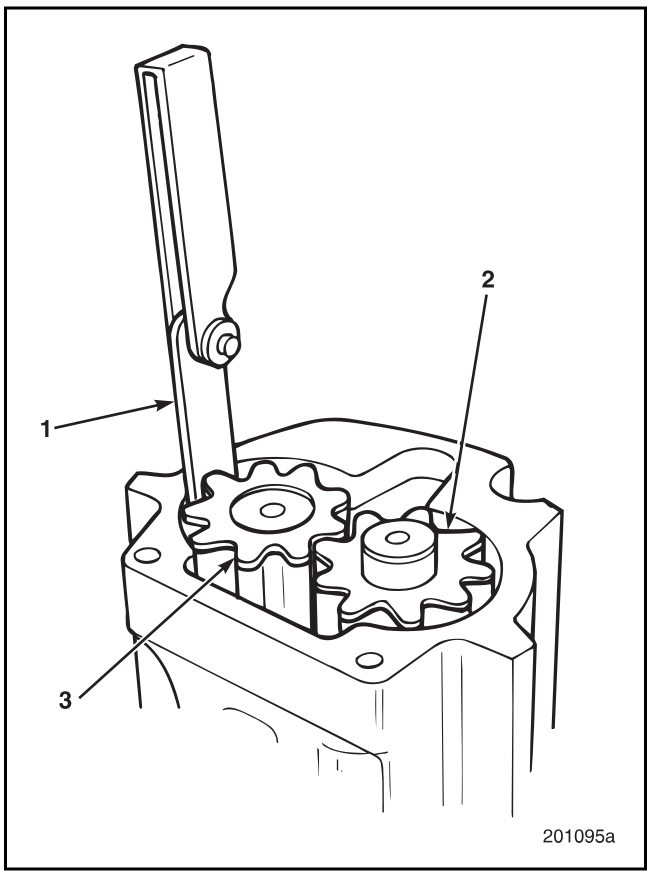


Figure 5-72 — Oil Pump Driving/Idler Gear Assembly Side Clearance Check

1. Thickness gauge 2. Pump driven gear	3. Pump driving gear

BACKLASH CHECK

Refer to Figure 5-73.

1. Check backlash between driving gear (3) and driven gear (2) with thickness gauge (1).
   a. Low Limit — Insert a 0.013-inch (0.33 mm) thickness gauge (1) between pump driven gear (2) and pump driving gear (3). Gauge should pass between gears without binding. If binding occurs, check for nicks or burrs. Replace as necessary.
   b. High Limit — Insert a 0.028-inch (0.711 mm) thickness gauge (1) between pump driven gear (2) and pump driving gear (3). Gauge should not pass through. If gauge passes through, replace gears.

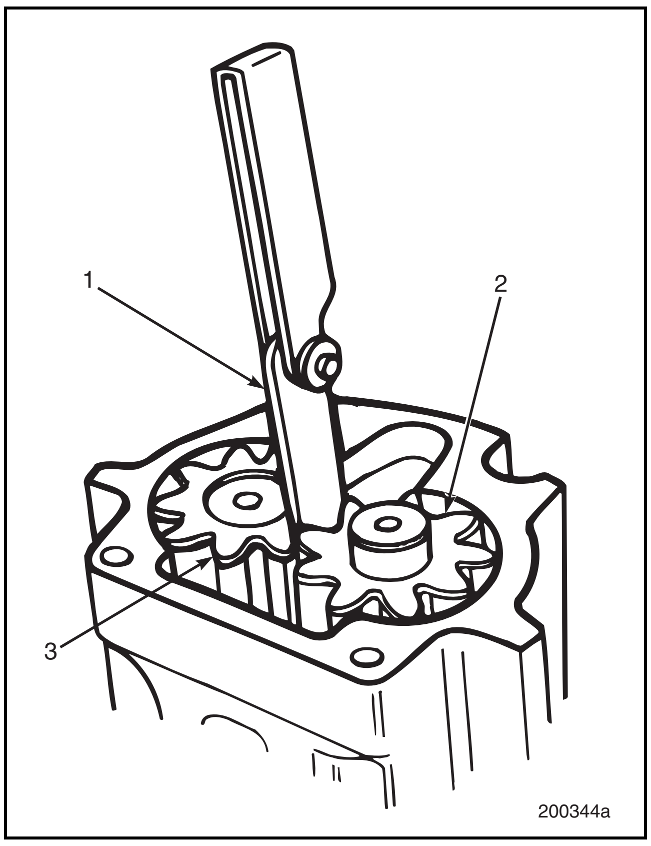


Figure 5-73 — Checking Oil Pump Gear Backlash

1. Thickness gauge 2. Pump driven gear	3. Pump driving gear

Improved "Fast Ratio" Auxiliary Driveshaft

An improved "fast ratio" auxiliary driveshaft assembly and oil pump assembly are in current production engines (effective February 27, 1992, serial No. 2E1233) and are available for service. These arrangements increase operating oil pressure by approximately 25%.

- Current "fast ratio" oil pump:
  - — With rear sump, part No. 315GC459AM
  - — With front sump, part No. 315GC459AM2
  - — Drive gear (12 teeth), part No. 683GB284
- Former "standard ratio" oil pump:
  - — With rear sump, part No. 315GC460AM
  - — With front sump, part No. 315GCA460AM2
  - — Drive gear (13 teeth), part No. 683GB287

⚠ CAUTION

Do not mix "fast ratio" and "standard ratio" components. Serious damage may occur.

Short (quarter) blocks are stamped with the date of manufacture on the right rear side pad (for example, "2G": 2G =199**2**, March). Short blocks stamped with "2G" or later (2H, 2K, 2L, etc.) are equipped with a 1.5 fast ratio auxiliary driveshaft assembly. It is critical that the matching oil pump also be fitted with a 1.5 fast ratio oil pump driveshaft gear.

A noncurrent 1.3 standard ratio E7 oil pump can be reused in combination with a 1.5 fast ratio auxiliary driveshaft assembly; however, several steps are necessary to modify the pump.

Refer to Figure 5-74.

1. Obtain a 1.5 fast ratio oil pump driving shaft gear (683GB284).
2. Restamp or etch new number on oil pump housing.
   - — "459M" on rear sump oil pumps
   - — "459M2" on front sump oil pumps

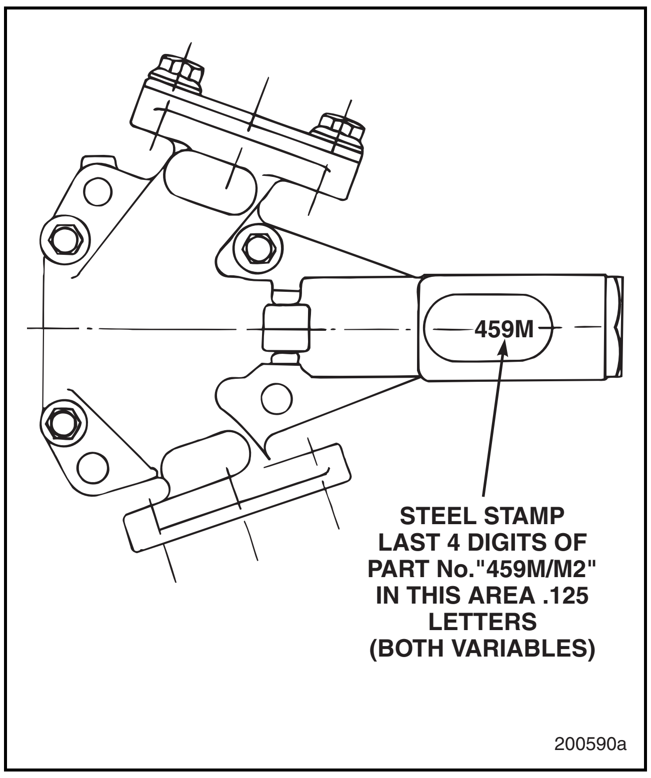


Figure 5-74 — Marking Oil Pump

3. Install a 1.5 fast ratio oil pump driving shaft gear on an old E7 oil pump. Torque retaining nut to 60 lb-ft (81 N•m). Torque cylinder block mounting screws to 40 lb-ft (54 N•m).

⚠ CAUTION

It is possible to bolt a current 1.5 fast ratio oil pump driving gear in an engine with a noncurrent 1.3 standard ratio auxiliary driveshaft gear; however, serious damage will occur.

It is not physically possible to bolt a noncurrent 1.3 standard ratio oil pump driving gear in an engine with a current 1.5 fast ratio auxiliary driveshaft gear.

Assembly

Refer back to Figure 5-70.

1. Install oil pressure relief valve plunger (11) in relief valve housing (4).
2. Install oil pressure relief valve spring (12) in relief valve housing.
3. Clean oil pressure relief cap (13) and install in relief valve housing.

CAUTION

To maintain correct oil pressure for various oil system arrangements, the proper oil pressure relief valve spring and cap combination must be used. Using incorrect components may result in either high or low oil pressure, and contribute to premature engine damage.

4. Install oil pump inlet flange cover (9) and gasket (8) on housing. Secure with capscrews (10).
5. Install driving shaft and gear assembly (6) in housing and check for free spin.
6. Install idler gear (14) on housing shaft.

CAUTION

It is extremely important that pump application be checked prior to drive gear assembly. Several drive gears are available to establish correct oil pump-to-auxiliary drive gear ratio combination. Failure to select proper drive gear for application will result in gear and engine damage. Refer to Improved “Fast Ratio” Auxiliary Driveshaft in this section.

CAUTION

Apply Loctite® 271 to all capscrews used to assemble the oil pump.

7. Install cover (7) on pump and secure with capscrews. Torque to 15 lb-ft (20 N•m).
8. Install key (5) in driving shaft and gear assembly (6).
9. Place gear (3) on shaft aligning slot with key on shaft. Press drive gear on shaft.
10. Install washer (2) and self-locking nut (1) on shaft. Torque to 60 lb-ft (81 N•m) using torque wrench J 24407 or equivalent.
11. Install pickup tube and screen assembly.

[221 CD] ECONOVANCE

Econovance Control Valve Assembly

Refer to Figure 5-74.

The Econovance control valve assembly consists of a valve housing (7) and a solenoid valve assembly (6).

The valve housing (7) contains oil passages to direct engine oil pressure to the Econovance, enabling the Econovance to perform the function of dynamically varying injection pump timing.

The solenoid valve assembly (6) consists of a proportional solenoid controlled by the V-MAC module, which can position the solenoid anywhere within its range of travel; and a hydraulic spool valve, the position of which determines engine oil flow to the Econovance. The spool valve is not affected by the oil pressure it controls. The three O-rings on the spool valve are replaceable.

Econovance Disassembly

Refer to Figure 5-75.

1. Place scalloped drive hub (5) in a vise equipped with brass jaws. Remove drive-hub retaining capscrew (10) and washer (9) while holding inner shaft assembly (2) at rear of Econovance. This will prevent assembly from dropping out of housing when retaining capscrew is removed.
2. Using snap-ring pliers, remove snap ring (1) from rear of Econovance housing (8).
3. Remove inner shaft assembly from rear of Econovance housing by manually guiding gear assembly outward.
4. Remove inner sleeve (4) from inner shaft assembly.
5. Remove and inspect Econovance spring (3) for cracks or signs of wear.
6. Remove outer shaft drive hub (5) from housing (8).

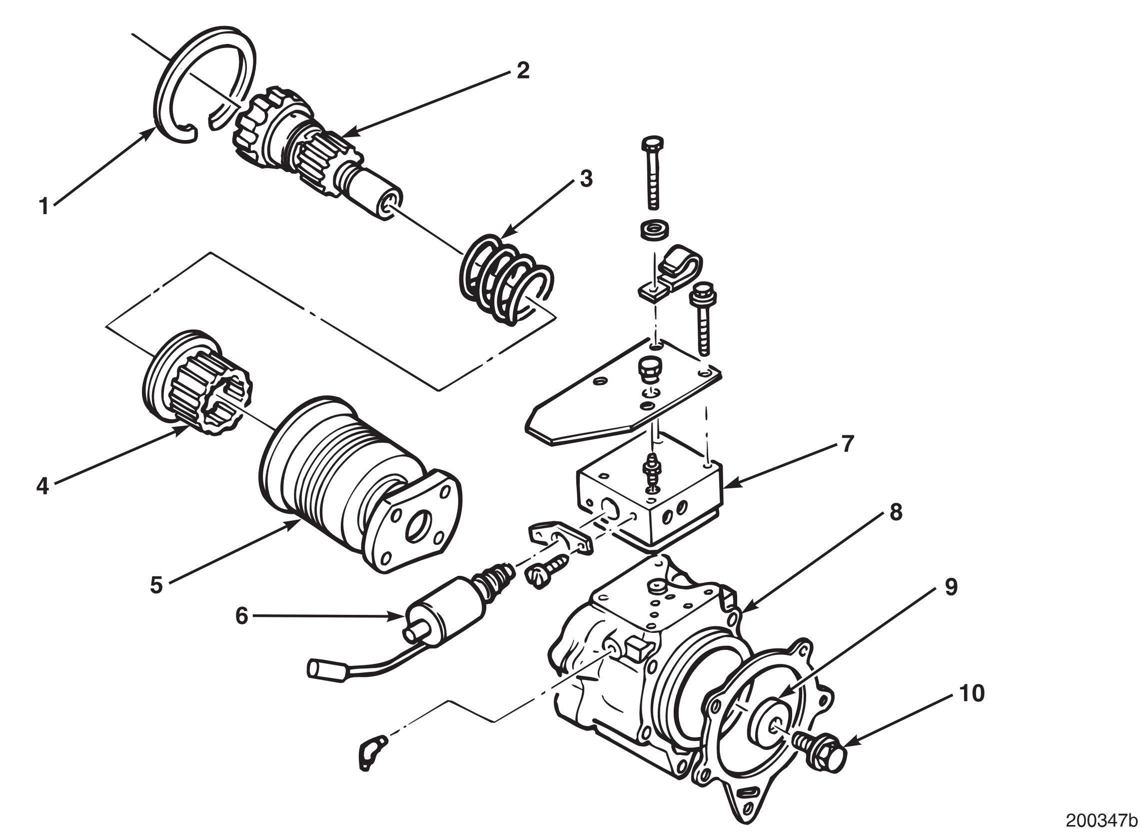


Figure 5-75 — Econovance Assembly

1. Retainer ring	6. Solenoid valve
2. Inner shaft assembly	7. Valve housing
3. Econovance spring	8. Econovance housing
4. Inner sleeve	9. Washer
5. Outer shaft drive hub	10. Drive hub retaining capscrew

Cleaning and Inspection

1. Thoroughly clean inner sleeve and inner shaft with solvent and dry with compressed air.
2. Inspect inner sleeve and inner shaft for extreme wear, cracks or other damage. Replace as necessary.
3. Inspect outer shaft drive hub and seals.
4. Inspect Econovance housing.

Econovance Assembly

1. Using clean engine oil, lubricate all gear surfaces.
2. Install Econovance spring (3) on inner shaft assembly (2).

CAUTION

Make sure spring is properly seated. If not, binding will occur, causing damage to Econovance assembly.

3. Reinstall inner sleeve (4) on inner shaft assembly. Push down on inner sleeve until flush with lower seat. To accomplish this, spring must be properly seated. Make sure sleeve does not bind on shaft.
4. Reinstall inner sleeve and inner shaft assembly into outer shaft drive hub. Install outer shaft drive hub into Econovance outer housing (8), using new seal if needed.
5. Reinstall retainer ring (1) in rear of Econovance assembly.
6. Apply Loctite 242 to drive-hub retaining capscrew (10) threads.

NOTE

Grooved side of hub retaining capscrew washer must face outer shaft drive hub (5).

Refer to Figure 5-76.

7. Install outer shaft drive-hub retaining capscrew (10) and washer (9). Torque to 150 lb-ft (203 N•m) using torque wrench J 24407 or equivalent.

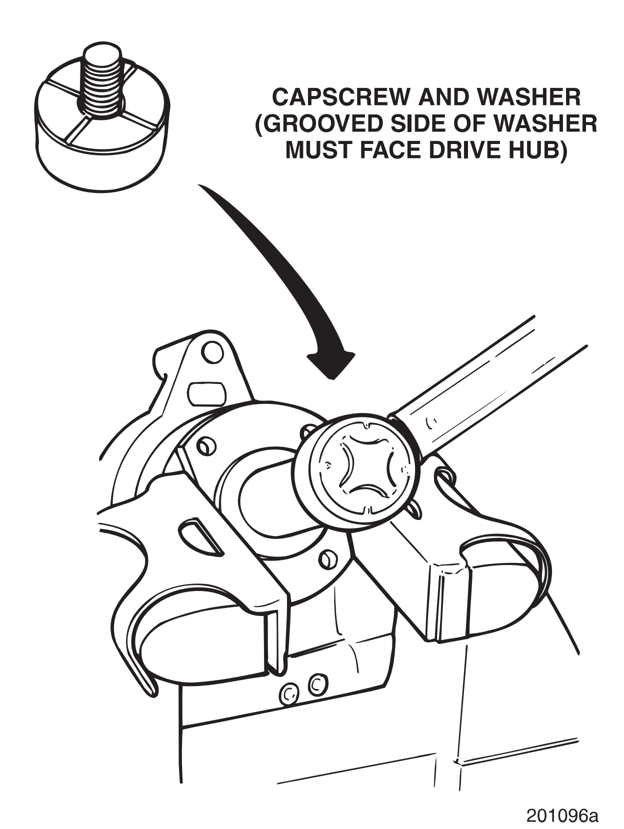


Figure 5-76 — Drive Hub Installation

[221 KU] INJECTION PUMP DRIVE HUB

Description

For mechanically governed engines, a scalloped-type drive hub is installed directly on the fuel injection pump camshaft. For V-MAC engines, the outer shaft drive hub, along with inner sleeve, spring and inner shaft assembly, is part of the Econovance unit. It is linked to the fuel injection pump with a Celeron coupling or a two-piece metal-type coupling, depending on the date of production.

Special Tools Required

- Pump Holding Fixture J 37078
- Injection Pump Drive Coupling Holder J 28452-A

Cleaning

Degrease tapered surfaces of injection pump camshaft and drive hub with Stoddard No. 303 or Loctite 75559, or an equivalent degreasing agent.

CAUTION

Failure to degrease drive components prior to assembly may result in drive hub slippage.

Installation of Drive Hub (Mechanically Governed Engines)

Refer to Figure 5-77.

1. Place injection pump into pump holding fixture J 37078. Turn pump drive hub to allow pump to be slid forward, engaging alignment pins until pump mounting surface is flush with fixture bracket.

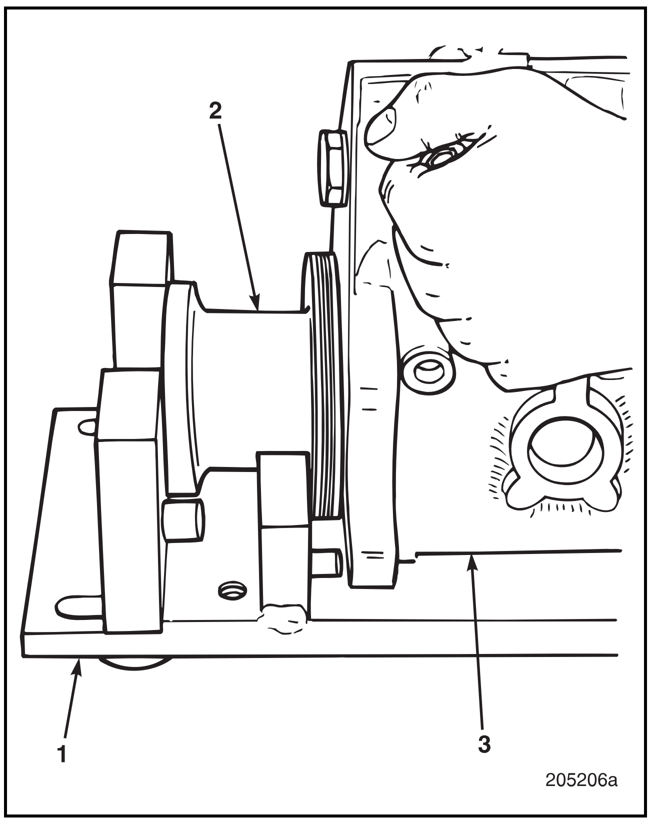


Figure 5-77 — Positioning Drive Hub and Pump in Fixture

1. Holding fixture J 37078 2. Drive hub	3. Fuel injection pump

NOTE

MACK E7 engines equipped with Bosch P7100 Series close-coupled injection pumps require a longer drive pump hub.

CAUTION

Do not install a key in the driveshaft. A key is not required and no keyway is provided in the hub.

Refer to Figure 5-78.

2. Install the flat washer and drive hub nut. Torque to 200 lb-ft (271 N•m) using torque wrench J 24407 or equivalent.
3. Remove injection pump from holding fixture.

NOTE

The recess in the drive hub is now in position to clear the camshaft gear during installation.

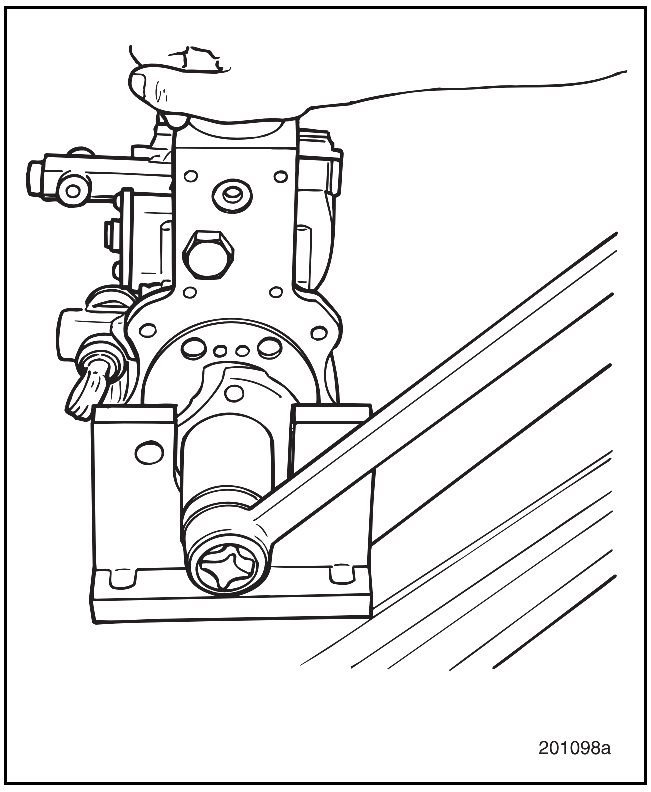


Figure 5-78 — Drive Hub Retaining Capscrew Installation

Installation of Drive Hub (V-MAC Engines)

DRIVE COUPLING REMOVAL

A metal two-piece style drive coupling was introduced into production on certified E7 V-MAC engines built after July 1, 1992 — beginning with serial No. 2P and above. When the Celeron drive coupling requires replacement, replace with the two-piece style drive coupling.

Refer to Figure 5-79.

1. Using injection pump drive coupling holder J 28452-A, securely hold injection pump outer coupling from turning while loosening coupling retaining nut. Remove outer coupling.

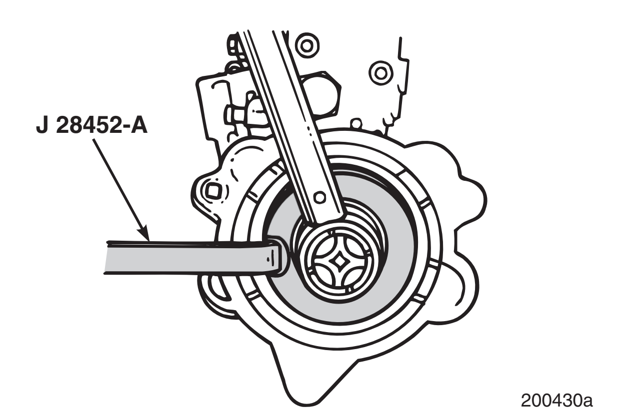


Figure 5-79 — Loosening Coupling Retaining Nut

Refer to Figure 5-80.

2. Remove coupling (inner hub) retaining nut and washer.

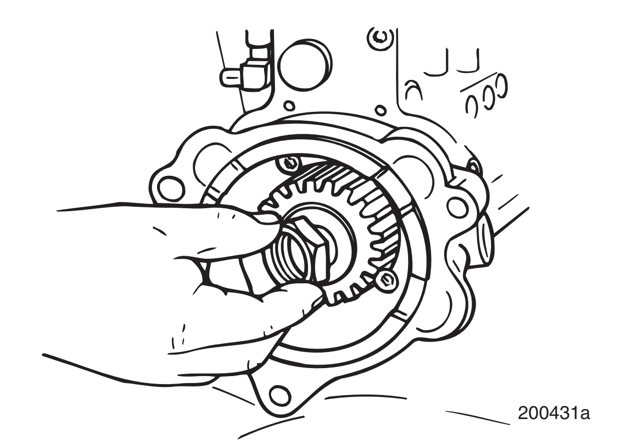


Figure 5-80 — Removing Retaining Nut and Washer

Refer to Figure 5-81.

3. Using a suitable two- or three-jaw puller, remove the inner hub from the injection pump camshaft.

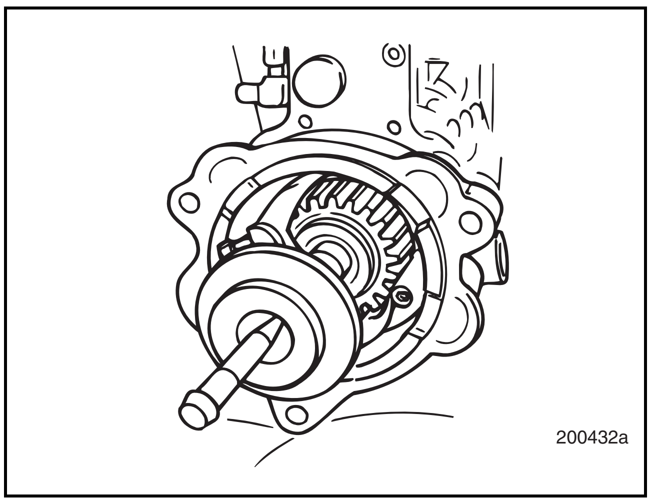


Figure 5-81 — Removing Inner Hub

DRIVE COUPLING INSTALLATION

1. Install inner hub on injection pump camshaft.

CAUTION

Do not install a key in injection pump camshaft. Keying of drive coupling (inner hub) to injection pump camshaft is not required and, if used, may result in damage.

2. Install coupling (inner hub) washer and retaining nut. Hand tighten.
3. Insert outer coupling on inner hub so hub-holding tool can be used to hold inner hub. The coupling may be installed in either direction.

NOTE

A snap ring is installed in the splined bore of the outer coupling. Its function is to keep the outer coupling in proper position between the injection pump inner hub and the Econovance mating gear.

4. Using injection pump drive coupling holder J 28452-A, securely hold outer coupling. Torque coupling (inner hub) retaining nut to 200 lb-ft (271 N•m) using torque wrench J 24407 or equivalent.

[222 KG] INJECTOR NOZZLES

1991 and later MACK E7 engines require different fuel injection nozzles, nozzle holders and nozzle holder assemblies than previous E7 engines.

These later nozzles (with eight spray holes) are a Valve Covering Orifice (VCO) configuration and are hydroground for proper fuel flow and atomization.

NOTE

Nozzles used for 1989/1990 MACK E7 production engine models feature six spray holes and are not hydroground.

These parts are not interchangeable with eight-spray-hole nozzles used in 1991 and later engines. Refer to the following engine tune-up publications for pertinent E7 specifications.

5-301 1989

5-302 1990

5-303 1991

5-304 1992

5-305 1993

5-306 1994

5-307 1995

5-308 .... 1996/1997

Nozzle Cleaning

When servicing nozzle holder assemblies, cleaning of nozzle tips may be necessary. Special care must be taken when cleaning nozzle tips to avoid damaging nozzle spray holes.

- Preferred cleaning method: ultrasonic cleaning
- Acceptable cleaning method: brass brush/ wire wheel

ULTRASONIC CLEANING METHOD

Ultrasonic cleaning units such as J 29653-A, use sound waves or mechanical vibrations, approximately 55,000 cycles per second above human hearing range. Sound waves are generated by the transducer, which changes high-frequency electrical energy into mechanical energy.

CAUTION

The nozzles will be damaged if a steel-wire wheel is used for cleaning. Damage can also occur if an improper size and/or speed of brass-wire wheel is used.

NOTES

ENGINE ASSEMBLY

GENERAL

This section includes step-by-step procedures for complete assembly of the MACK E7 engine. Major components that were overhauled in the BENCH PROCEDURES section of this manual are reinstalled here as assemblies.

CAUTION

Failure to follow the sequence of operations listed may result in damage to components or personal injury.

NOTE

After cleaning the components, properly store them where they will remain clean until needed for assembly.

The purpose of component inspection is to determine which parts can be reused and which parts must be replaced. Use considerable judgment to make this determination.

[211 DB] CYLINDER BLOCK

Special Tools Required

- Camshaft Bushing Installation/Removal Kit J 37713
- Camshaft Bushing Remover/Installer J 21428-01
- Counterbore Tool PT2210
- Counterbore Cutter Plate PT2210-3A
- Hex Key Wrench PT2210-14
- Universal Dial Depth Gauge PT5025
- 3-Inch Stylus Extension PT5025-11

Cleaning and Inspection

The engine should have been thoroughly steam cleaned prior to component removal and the block should be relatively clean. If heavy accumulations of dirt and grease are still present, steam clean the block as thoroughly as possible before attempting to clean with solvents.

WARNING

Cleaning solvent is flammable and toxic to the eyes, skin and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well-ventilated area.

WARNING

Compressed air used for cleaning can create airborne particles that may enter the eyes or irritate the skin. Pressure must not exceed 30 psi (207 kPa). Eye protection is required. Use only with effective chip guarding and personal protective equipment (goggles/ shield, gloves, etc.).

NOTE

Cleaning the cylinder block is important. While cleaning the cylinder block, carefully inspect the areas around the cup plugs and the coolant jacket. If cup plugs or pipe plugs show signs of leaking, they should be replaced.

Cleaning the cylinder block is a good time to inspect it for cracks or other possible defects that may be reason for rejection. Refer to TROUBLESHOOTING section of this manual for information on testing for leaks in the cylinder head and cylinder block. If damage is not found until after the engine is assembled, the engine must be disassembled and rebuilt again.

SOLVENT TANK CLEANING

NOTE

Use a cleaning tank large enough to accommodate the largest component to be cleaned. Fill the tank with a suitable solvent and always use caution while cleaning parts. Parts may be dried with compressed air.

1. Scrape any remaining gasket material from the block.

2. Using a wire brush or rotary wheel, remove any rust, corrosion or other debris from the block.
3. Clean all other block surfaces with mineral spirits or other suitable solvent.
4. Using due care and caution, clean and dry the block with compressed air.

INSPECTION

NOTE

A complete discussion of the proper methods of precision measuring and inspection is outside the scope of this manual. However, every shop should be equipped with standard gauges such as bore gauges, dial indicators, outside and inside micrometers, thickness gauges and straightedges.

Check the cylinder block for indications of cracking or coolant leakage. If any damage is suspected, use a standard dye penetrant or magnaflux procedure to determine if cracks exist. A cracked engine block must be replaced and never reused.

Refer to Figure 6-1.

Using a straightedge (PT5027 or equivalent) and thickness gauges, check the cylinder head mounting surfaces for flatness. The cylinder block mounting surface, on a service block, should be flat within 0.004 inch (0.102 mm).

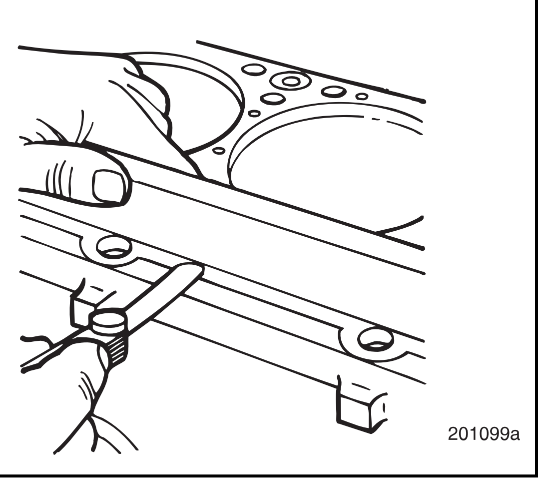


Figure 6-1 — Checking Flatness of Cylinder Block Deck

SERVICE HINT

If the cylinder block is determined to be serviceable after thorough cleaning and inspection, reassemble the engine. Use replacement or original parts, as determined during component inspection.

Cup Plug Replacement

REMOVAL

Refer to Figure 6-2.

1. Using a hammer and punch, drive one edge of the plug inward. The plug should rotate causing the opposite edge to move outward. When the edge moves out far enough, grab it with a pair of pliers and pull it out.

CAUTION

If, after several taps with a hammer, the plug does not rotate and is being driven inward, stop tapping. Drill a hole approximately 1/8 inch (3.2 mm) in diameter in the center of the plug. Insert a sheet-metal screw in the hole. Leave enough of the screw protruding from the plug to allow a pry bar to be inserted under the head of the screw and pry the plug out.

2. Clean the plug hole(s) with a wire brush or wire wheel. After cleaning, visually check the surface for cracks. When satisfied that there are no cracks *anywhere* in the block, replace the plug(s).

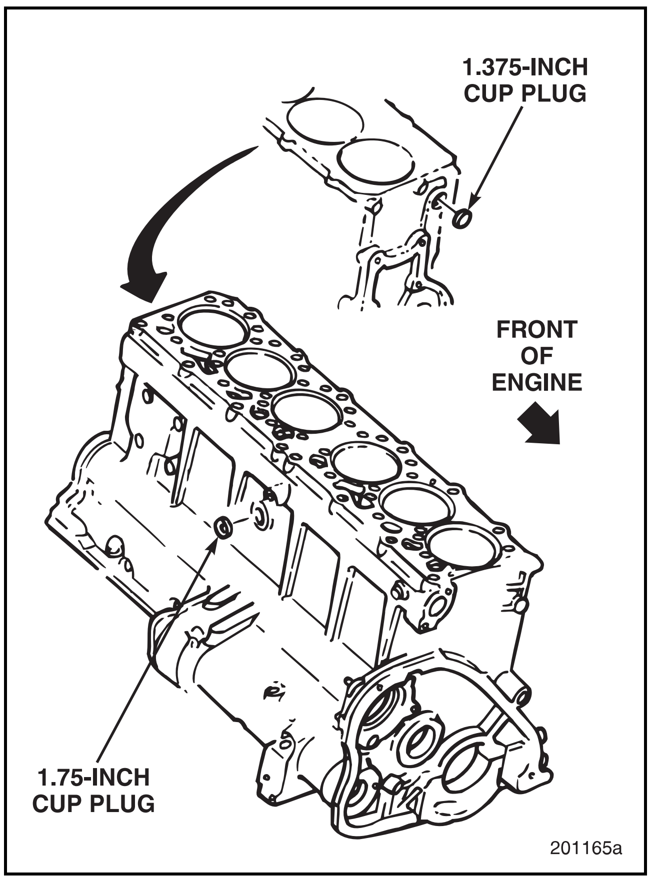


Figure 6-2 — Cylinder Block Cup Plugs

INSTALLATION

1. After cleaning the plug hole, apply a thin coat of Loctite® 277 to both the surface of the hole and the outer edge of the plug.
2. Using a proper driver, align the plug in the hole and drive it inward until the outer lip of the plug is flush with the cylinder block. Refer to Figure 6-3.

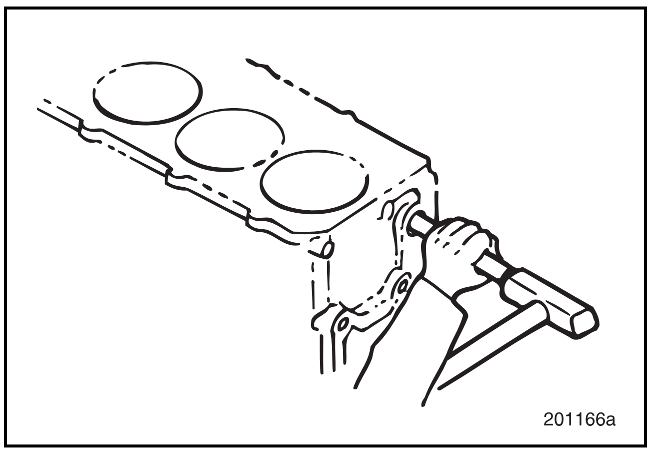


Figure 6-3 — Cylinder Block Cup Plug Installation

Pipe Plug Replacement

NOTE

Any rust around a pipe plug is an indication of a leak and the plug should be replaced.

REMOVAL

1. Using an appropriate wrench, remove the plug.
2. Clean the threads in the block by running a tap into the hole, just far enough to remove any rust on the threads without expanding the diameter of the hole. Use compressed air to remove any chips from the block.

NOTE

It is best to replace a leaking pipe plug. However, if reusing the same plug, clean thoroughly, paying special attention to the threads.

3. Using a wire wheel, clean the threads of the plug. Visually check the thread surfaces for burrs or damage. Then clean and check the remaining surfaces.

NOTE

New plugs already have a sealer applied to the threads. Applying a Teflon sealer to the threads will not adversely affect the precoating.

INSTALLATION

Apply appropriate Teflon thread sealant to the threads and install the plug. Torque to specification. Refer to Torque Chart in the SPECIFICATIONS section of this manual.

NOTE

When checking or assembling engine components, refer to the Fits and Limits Chart and Torque Chart in the SPECIFICATIONS section of this manual for specified dimensions and torque settings.

[213 CC] Camshaft Bushings

DESCRIPTION

Lubrication oil is pumped into the cylinder block main oil gallery. Oil from the gallery flows to each main bearing bushing bore and then on to the respective camshaft bushing bore, providing lubrication for both the crankshaft and camshaft bushings. Camshaft bushing bores No. 1, 2 and 5 are grooved to supply oil to other components as well. Oil from the No. 1 camshaft bushing bore flows on through a drilled passage to lubricate the front auxiliary driveshaft bushing. Oil from the No. 2 and 5 camshaft bushing bores flows on through vertical drilled passages to lubricate the rocker arm assemblies. Oil from the No. 4 camshaft bushing bore flows through a cast groove in the cylinder block bushing bore to lubricate the fuel injection pump, the rear auxiliary driveshaft bushing, and the air compressor.

INSPECTION

N O T E

During in-chassis overhaul, check the inside diameter of the camshaft bushings. If overhauling out-of-chassis, replace camshaft bushings.

1. Using a telescope gauge or suitable inside micrometer, measure the ID of each camshaft bushing in the cylinder block. Record the dimensions. Refer to Figure 6-4.

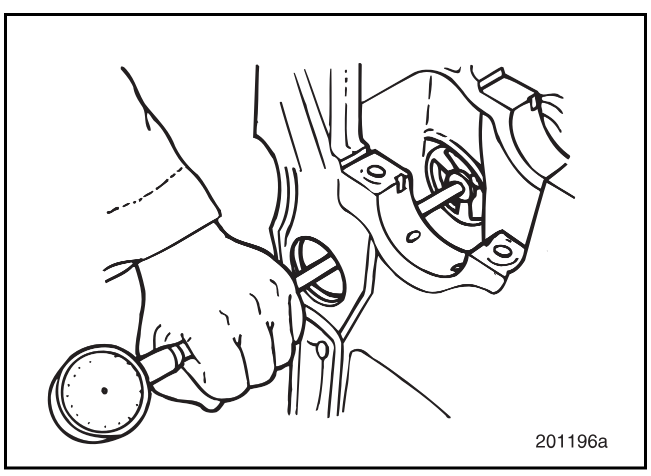


Figure 6-4 — Measuring Camshaft Bushing ID

2. Refer to the Fits and Limits chart for camshaft bushing measurement specifications. Check the recorded dimensions against the specifications.
3. If bore size exceeds tolerance or if there is any evidence of scratching or scoring, replace the bushings.

REMOVAL

Refer to Figure 6-5.

N O T E

Use camshaft bushing remover/installer kit J 37713 (use with J 21428-01 kit) for camshaft bushing removal.

Camshaft bushings are identified in sequence from 1 to 7, starting from the front of the engine.

1. Using camshaft bushing remover/installer kit J 21428-01 (2), with the correct pilot adapter (J 37713 kit) and a hammer (3), remove the No. 1 camshaft bushing (4) from the cylinder block (1).
2. Remove the remaining six bushings in sequence.

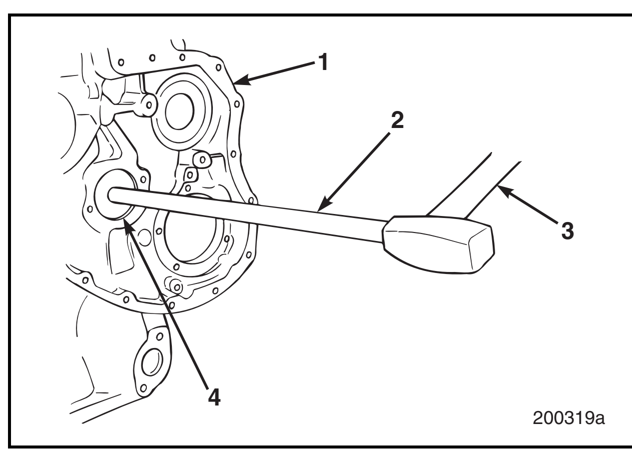


Figure 6-5 — Camshaft Bushing Removal

1. Cylinder block 2. Camshaft bushing remover/installer (J 21428-01 kit)	3. Hammer 4. No. 1 camshaft bushing

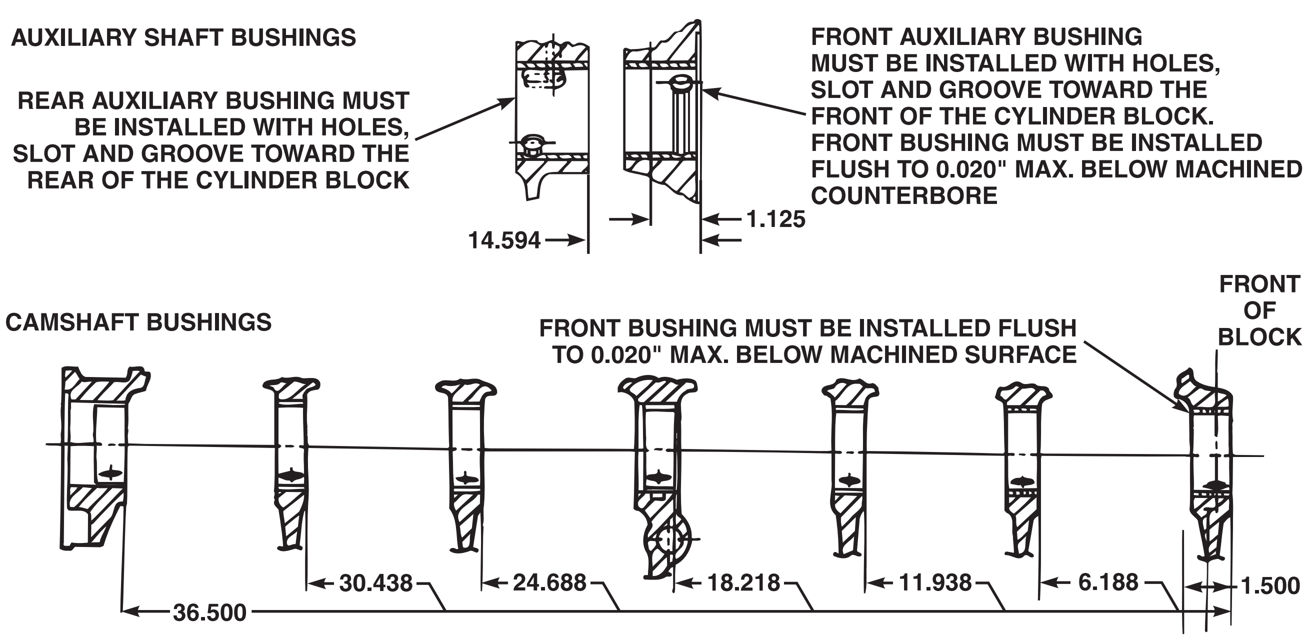
INSTALLATION

Refer to Figure 6-6.

Each camshaft bushing is located at set distances from the thrust washer mounting surface to the forward edge of the bushings.

CAUTION

Correct installation of each camshaft bushing is very important. If a bushing is not properly aligned with both its oil supply and oil feed passages in the cylinder block, either the camshaft bushing will fail or the components lubricated by the bushing feed will fail from inadequate lubrication.



NOTE
CENTER BUSHING
The 18.218-inch dimension for the center bushing represents the typical installation with a "wide" center bushing. Narrow center bushings with an installation dimension of 18.312 inches were used in approximately 300 pilot production engines built from September 1988 through January 1989. When servicing the early pilot production engines, use wide center bushings, either part No. 596B218 or 596B219, installed at the 18.218-inch dimension.

205207a

Figure 6-6 — Camshaft and Auxiliary Shaft Bushing Locations

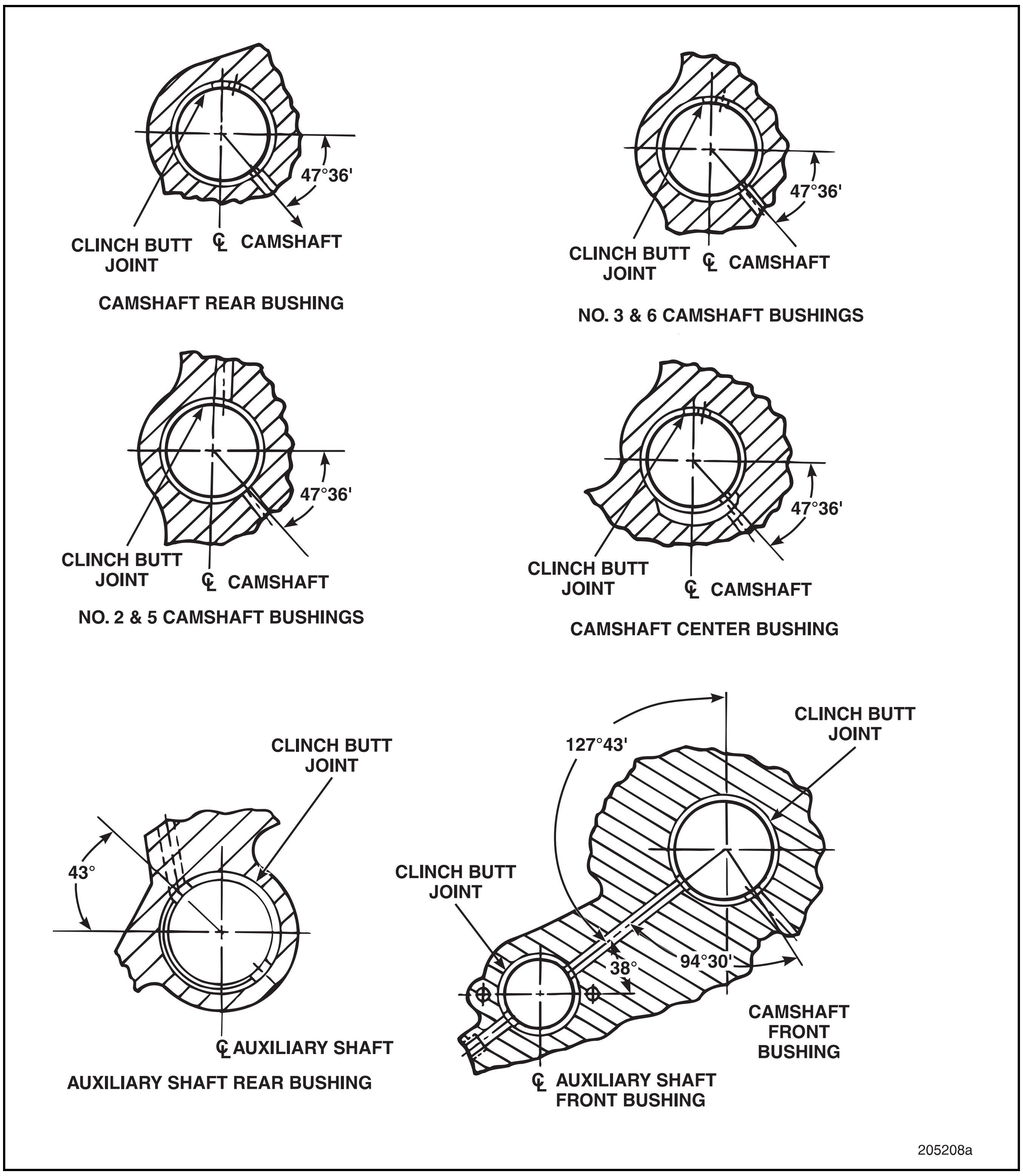


Figure 6-7 — Camshaft and Auxiliary Shaft Bushing Alignment

Refer to Figure 6-8.

1. Position a replacement bushing (2) against the side of the block at the No. 7 (rear) bushing bore. Align the oil hole in the bushing (1) with the oil passage (7) in the block.
2. Using a dark-colored felt-tip marker, mark the block and the bushing with a line (5) to facilitate correct alignment at installation.
3. Clean the surfaces of the bushing and the bore. Dry both surfaces with compressed air.
4. Using bushing remover/installer J 21428-01 kit (4) and the appropriate pilot adapter J 37713 (3), install the bushing.

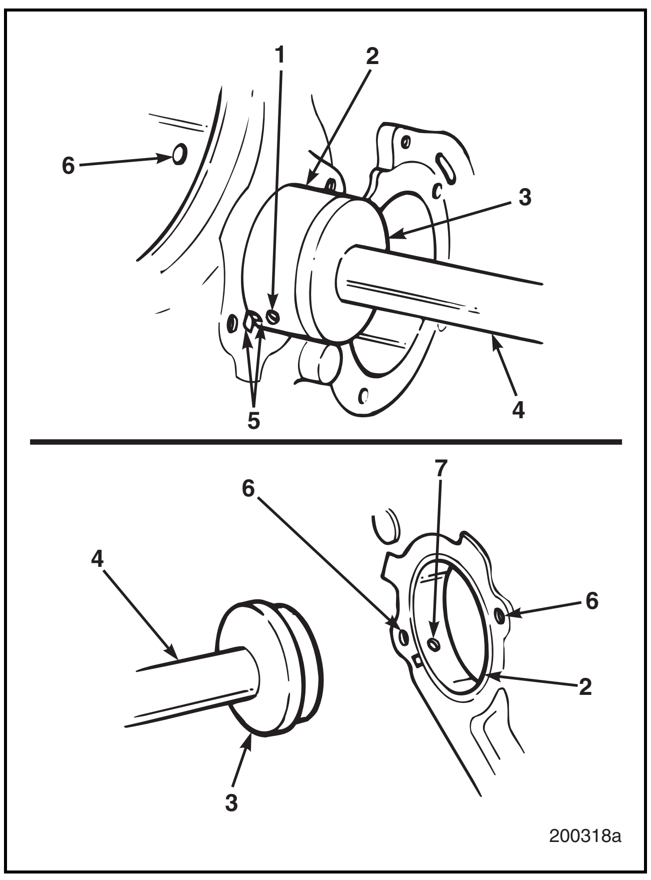


Figure 6-8 — Camshaft Bushing Installation

1. Bushing oil hole 2. Bushing 3. Pilot adapter (J 37713) 4. Bushing remover/ installer J 21428-01 kit	5. Alignment mark 6. Mounting hole 7. Block oil passage

5. Check the surface of the bushing for burrs caused by installation.

NOTE

Refer to Fits and Limits chart for correct bushing ID dimensions.

Refer to Figure 6-9.

6. Using an inside micrometer or telescope gauge, measure the ID of the bushing to ensure against an undersize bushing. An undersize bushing may cause the camshaft to seize in the bushing during installation.

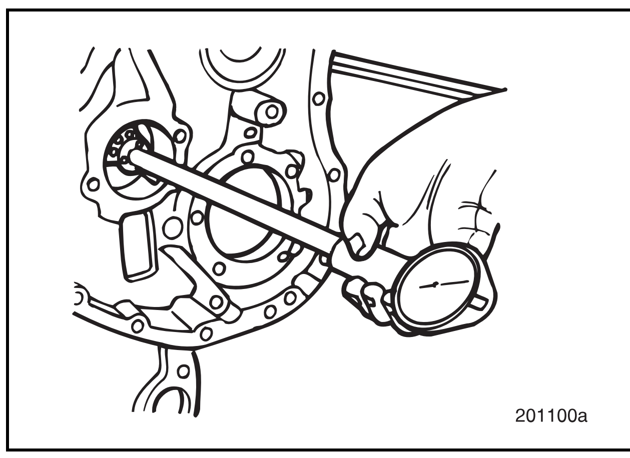


Figure 6-9 — Camshaft Bushing ID Check

7. Repeat steps 1 through 6 for all of the remaining bushings in sequence.

[212 CB] Auxiliary Driveshaft Bushing Replacement

DESCRIPTION

The front and rear auxiliary driveshaft bushings are identical. Engine lubrication oil passing through the No. 1 camshaft bushing supplies oil to the front auxiliary driveshaft bushing. Oil passing through the No. 4 camshaft bushing supplies oil to the rear auxiliary driveshaft bushing. A groove in the rear auxiliary driveshaft journal, in conjunction with a rifle-drilled hole in the auxiliary driveshaft and a small oil feed tube, supplies lubrication to the air compressor.

INSPECTION

1. Using a telescope gauge or inside micrometer, measure the auxiliary bushing bores. Take two readings, perpendicular to each other, in each bore. Record the readings. Refer to Figure 6-10.
2. Compare readings with the tolerances listed in the Fits and Limits chart in this manual.

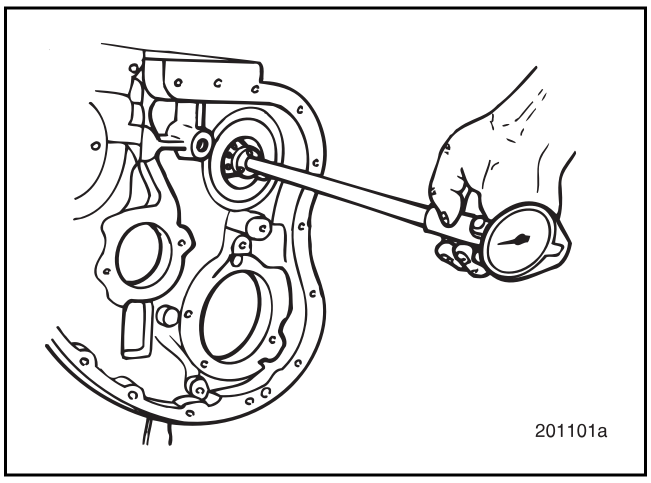


Figure 6-10 — Auxiliary Driveshaft Bushing ID Check

INSTALLATION

CAUTION

Correct installation of auxiliary driveshaft bushings is very important. If bushings are misaligned, lubrication oil will not be allowed to lubricate the auxiliary driveshaft journal. This will also cause the component lubricated through that journal to run without lubrication and prematurely fail.

If the approximately 1.25 inches long (32 mm) oil feed tube, which connects the oil feed hole in the rear of the auxiliary shaft to the oil feed hole in the front of the air compressor crankshaft, is accidentally lost during air compressor or auxiliary shaft service work, the compressor will fail from oil starvation. Also, the loss of oil pressure resulting from the missing tube can cause damage and problems in other components and parts.

Refer to Figure 6-11.

1. Position a replacement bushing (2) against the side of the block at the rear bushing bore. Align the oil hole in the bushing with the hole in the block.
2. Using a dark-colored felt-tip marker, mark the block and the bushing with a line (1) to facilitate correct alignment during installation.
3. Clean the surfaces of the bushing and the bore. Dry both surfaces with compressed air.
4. Using camshaft bushing remover/installer kit J 21428-01 (4) and the appropriate pilot adapter J 37713 (3), install the bushing.

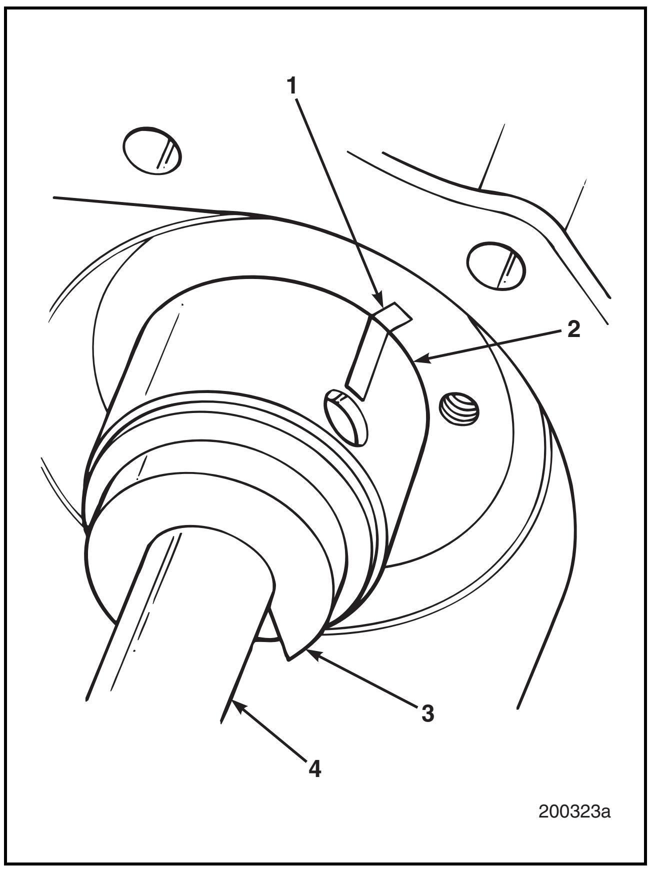


Figure 6-11 — Auxiliary Driveshaft Bushing Alignment

1. Alignment mark 2. Bushing 3. Pilot adapter J 37713	4. Camshaft bushing remover/installer kit J 21428-01

5. Check the bushing surface for burrs caused by installation.

NOTE

Refer to the Fits and Limits chart in this manual for correct bushing ID dimensions.

6. Using an inside micrometer or telescope gauge, measure the ID of the bushing to ensure against using an undersize bushing. An undersize bushing may cause the auxiliary driveshaft to seize in the bushing during installation.

CAUTION

The front auxiliary driveshaft bushing must be flush or recessed within 0.020 inch (0.508 mm) of the front of the cylinder block. Incorrect recess will cause misalignment of the oil supply hole, resulting in insufficient lubrication of the journal.

7. Working from the front of the cylinder block, repeat steps 1 through 6 to install front bushing.

[212 NC] CYLINDER SLEEVE

Description

The cylinder sleeve works with the piston, piston rings, cylinder head, and cylinder head gasket to seal combustion pressure. It transfers combustion heat to engine coolant and guides piston travel during engine operation. Correct extension of sleeve flange above top deck and uniform cylinder block counterbore are essential for satisfactory sleeve life and head gasket seal.

The cylinder sleeves are a wet-dry design, made of centrifugal cast iron. A crevice seal is needed for sealing purposes.

Special Tools Required

- Depth Gauge J 26948
- Dial Bore Gauge J 5347-B
- Cylinder Hone and Glaze Breaker J 5902-01

Installation

Refer to Figure 6-12.

1. Thoroughly clean and dry the prepared cylinder block (6), counterbore ledge (5) and cylinder sleeves (3). Refer to cylinder block cleaning procedures in this section.
2. Install the crevice seal (2) into the cylinder sleeve groove with the pointed face toward the cylinder block (6) (outward). Lubricate with ethylene glycol.
3. If the counterbore ledges (5) have been cut, place the shims (4) on the cylinder block counterbore ledges. If more than one shim is necessary, use the fewest number of shims required to achieve the proper cylinder sleeve flange height. Always place the thickest shim on the bottom.

CAUTION

The crevice seal groove (1) must be clean and free of any oil residue. Under no circumstances should oil contaminate the crevice seal groove or crevice seal. Damage to the seal will result.

NOTE

Applying a Silastic bead is now standard assembly procedure whenever cylinder sleeves are installed.

To prevent partial curing and questionable sealing and bonding, apply Silastic just before installing the sleeves.

4. Apply approximately a 1/8-inch (3.18 mm) bead of RTV silicone (Mack Silastic 342SX32, Dow Corning Silastic RTV732, or General Electric RTV130) around the cylinder block sleeve seat and completely around the cylinder wall. Do not use excessive amounts of RTV.

CAUTION

The cylinder block counterbore ledges and the cylinder sleeve must be kept clean and free of any oil residue to ensure that the Silastic bead seals and bonds properly.

5. Position the cylinder sleeve (3) in the cylinder bore until it contacts the crevice seal (2).
6. Placing the palms of the hands on the upper end of the cylinder sleeve 180 degrees apart, push downward with a quick, even pressure. Using a large plastic-faced hammer, tap the sleeve close to the inside diameter. Tap alternately from one side to the other, gradually working around the entire circumference of the sleeve.

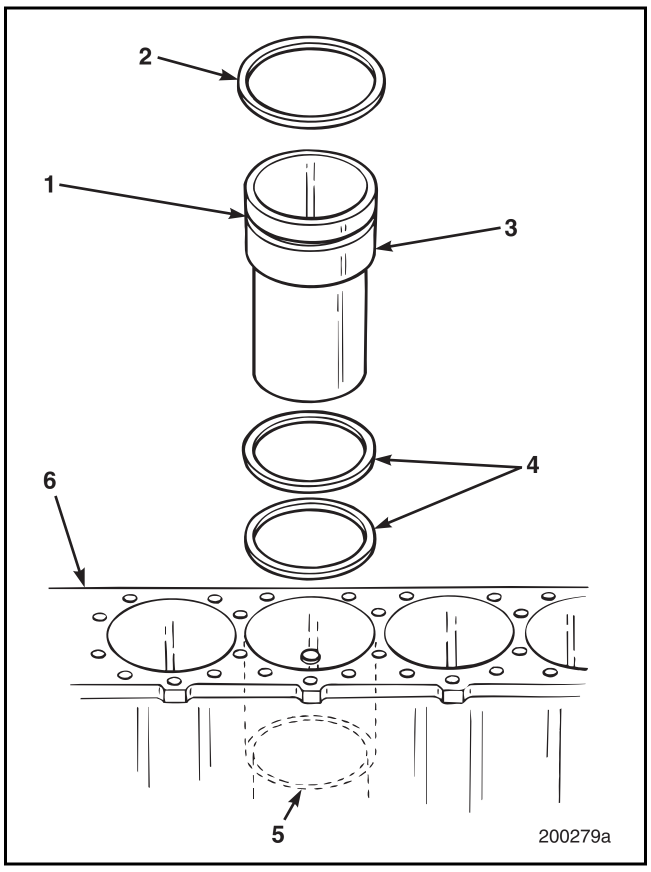


Figure 6-12 — Sleeve Installation

1. Crevice seal groove 2. Crevice seal 3. Sleeve	4. Shims (as required) 5. Counterbore ledge 6. Cylinder block

NOTE

Clean any RTV from around the bottom of the cylinder sleeve and the block which may have been pressed between the block and sleeve during installation.

7. After the cylinder sleeve is fully seated, use depth gauge J 26948 or equivalent to check flange height above the deck dimensions. The specified flange height above-deck dimension is 0.022–0.027 inch (0.559–0.686 mm). The measurement should be taken in the channel between the sleeve top lip (fire dam) and the coining bead. Refer to the TROUBLESHOOTING section, Figures 9-1 and 9-2.

NOTE

The height of the cylinder sleeves above the cylinder block deck (under the same cylinder head) can vary as long as all are within the 0.022–0.027 inch specification.

Refer to Figure 6-13.

8. Using dial bore gauge J 5347-B or equivalent, check the cylinder sleeve for out-of-round and taper limit. Take readings in two directions, 90 degrees apart, at each of three levels.

   Cylinder sleeve ID maximum: 4.877 inches (123.876 mm).

   Cylinder sleeve ID minimum: 4.875 inches (123.825 mm), cylinder sleeve ID may be minimum 4.872 inches (123.749 mm) due to close-in from press fit.

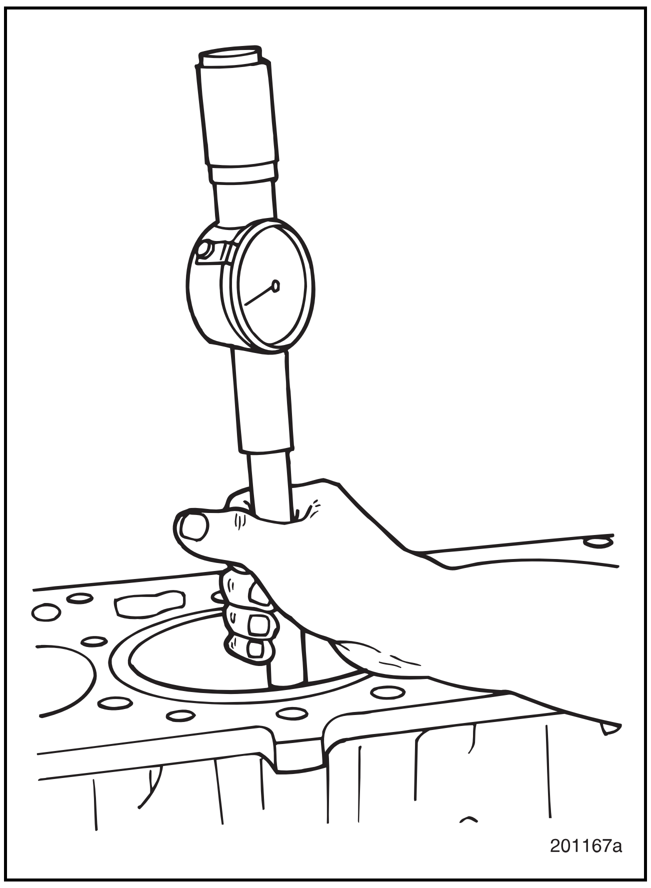


Figure 6-13 — Checking Cylinder Sleeve for Out-of-Round or Taper

HONING THE CYLINDER SLEEVE BORE

CAUTION

Engines produced since mid-year 1992 have finer, more precisely finished cylinder sleeves. Because of the finer finish, honing is NOT recommended. Particles from the honing process which become wedged in the pattern are impossible to completely remove and can cause further damage.

[219 RV] PISTON COOLING SPRAY NOZZLE

Description

Refer to Figure 6-14.

The piston cooling system consists of an oil pump, oil passages drilled in the cylinder block, and an oil spray-nozzle assembly for each piston. The piston cooling nozzles are attached to the main oil gallery. Oil is discharged through the nozzles and into the underside of each piston. This spray provides additional piston cooling. The oil returns, by gravity, to the crankcase oil pan. Inside the crankcase at each cylinder is a drilled oil passage from the main oil gallery and one threaded hole for the retaining screw.

Beginning with 1991 E7 engine production, piston cooling nozzle hardware and nozzle spray positioning tool changes have been made. The two-piece piston design uses two types of cooling. A unique splash and forced piston cooling system first appeared on the 1991 E7 engine. Precise targeting of the piston cooling spray provides adequate cooling to the piston crown and fills the four oil reservoirs located in the top of the piston skirt.

The piston cooling nozzle bracket is thicker on the piston cooling nozzles beginning on 1991 E7 production engines. Also, "310" is etched on the pre-1991 piston cooling nozzle, and "316" began in 1991 E7 production. These parts are not interchangeable with 1989/1990 production.

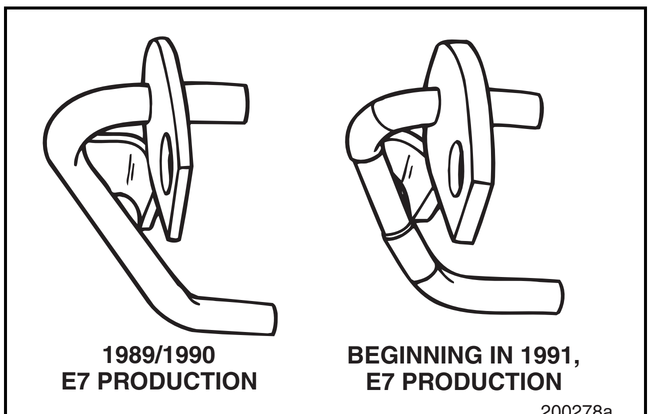


Figure 6-14 — Spray Nozzle Comparison

Special Tools Required

- Piston Cooling Nozzle Spray Position Set J 37721-A (for 1989/1990 production)
- Two-Piece Piston Cooling Nozzle Aimer J 39045 (for 1991 and later production)

Installation

Refer to Figure 6-15.

1. Using a liberal amount of lubricant, install elastomer sleeve (7) on locator tube (6).
2. Install a retaining screw (4) in the spray nozzle bracket (3).
3. Position spray nozzle locator tube (6) in cylinder block oil passage (2) and torque retaining screw to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.

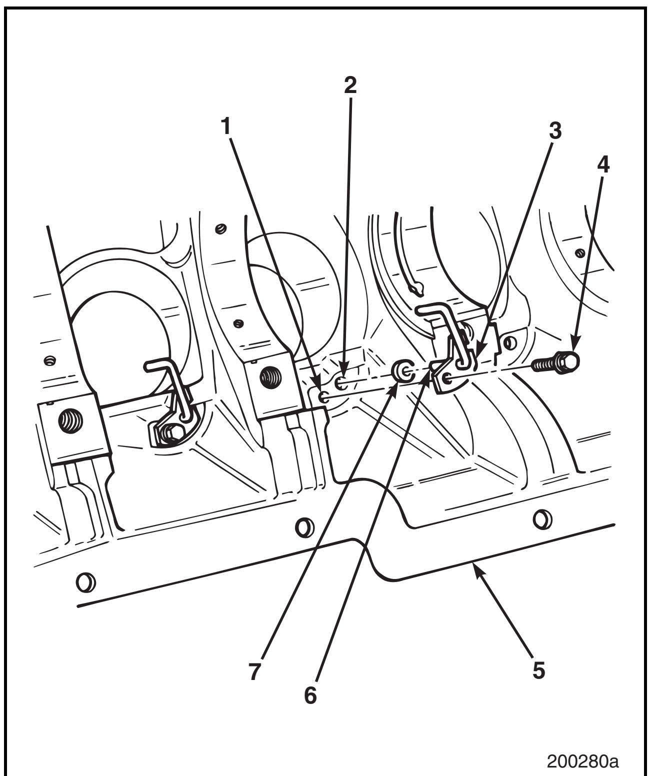


Figure 6-15 — Spray Nozzle Installation

1. Threaded hole 2. Oil passage 3. Spray nozzle bracket 4. Retaining screw	5. Cylinder block 6. Locator tube 7. Elastomer sleeve

Piston Cooling Nozzle Spray Positioning

Refer to Figure 6-16.

The piston cooling oil spray location on the underside of the piston is important; it ensures adequate heat dissipation from the piston and makes certain that the crankshaft counterweights of the connecting rods do not strike the nozzles.

CAUTION

Always replace a badly deformed spray nozzle. Do not attempt to realign it. Precise targeting is necessary to adequately cool the piston crown.

SERVICE HINT

For ease of installation and to reduce the amount of crankshaft rotation needed to facilitate access to the spray nozzles, install the spray nozzles in the following order: cylinders 1 and 6, 5 and 2, 3 and 4.

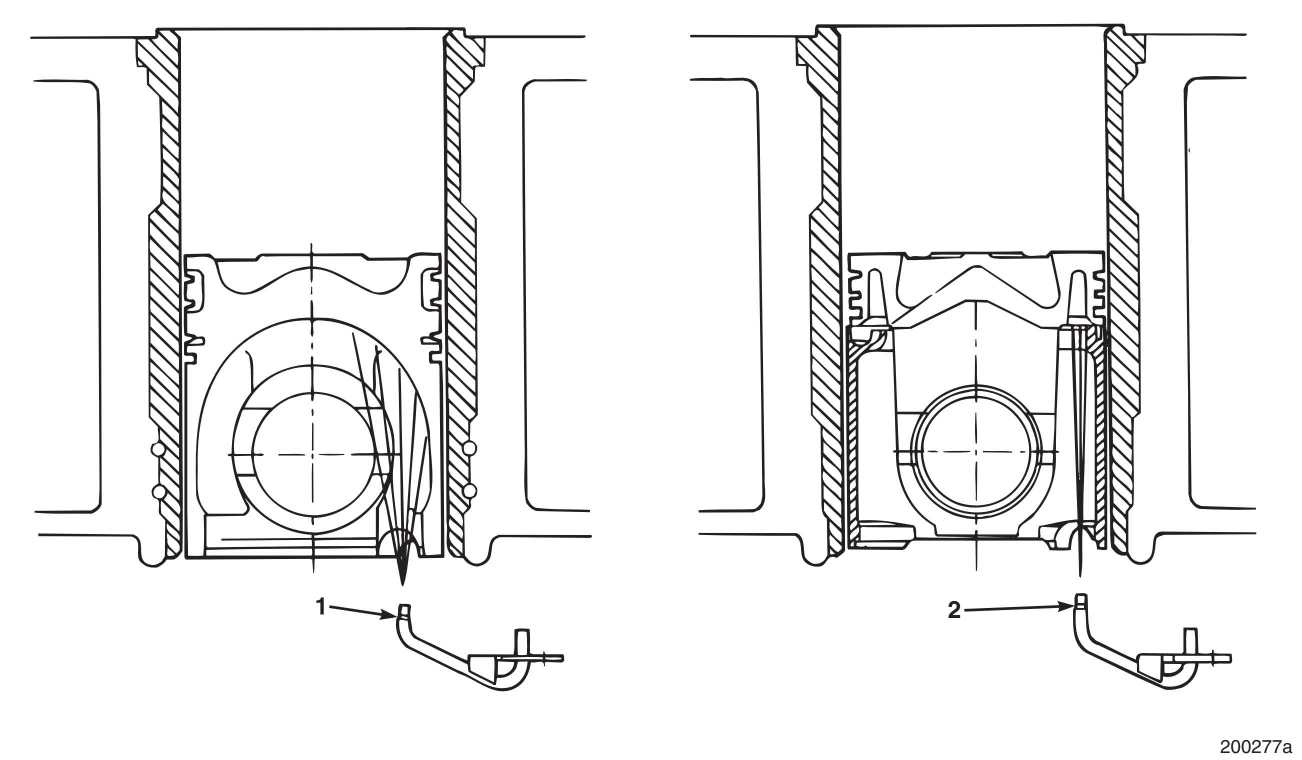


Figure 6-16 — Spray Nozzle Patterns

1. Old pattern (pre-1991)	2. New pattern (1991 and later)

Refer to Figure 6-17.

1. Using piston cooling nozzle spray position set J 37721-A (pre-1991) or J 39045 (1991 and later), check the direction of the spray from the nozzles.
2. Position rod (6) in end of spray nozzle (7).
3. Place the applicable plastic target (1) on the cylinder block (2) over the cylinder to be tested.
4. Install a cylinder head bolt through the target alignment hole (3) and into the cylinder block capscrew hole (4) to align the target.
5. The rod (6) should now be aligned in the target area (5). If rod is at edge of target area, two methods may be tried to center the rod into the target area.
   a. Preferred — Loosen nozzle set screw. A slight adjustment can then be made to center the rod within the target area. Following adjustment, retorque set screw to 15 lb-ft (20 N•m).
   b. Alternate (pre-1991 only) — It is permissible to bend the hooked end of the nozzle tube ***only slightly*** to bring the rod fully within 1/8 inch of the target area. If more than 1/8 inch out of target area, replace nozzle.

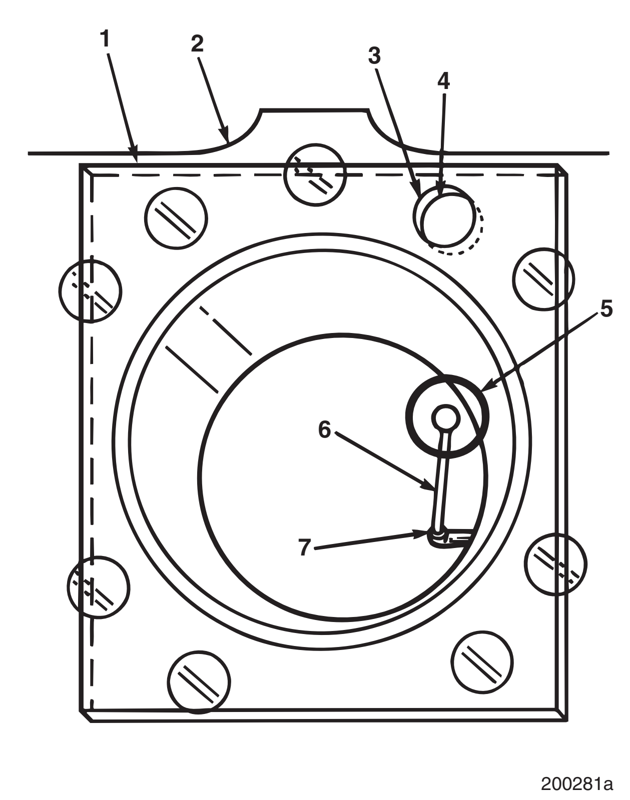


Figure 6-17 — Spray Nozzle Targeting

1. Plastic target 2. Cylinder block 3. Alignment hole 4. Cylinder block hole	5. Target area 6. Rod 7. Spray nozzle

[211 HA] CYLINDER BLOCK DOWEL PINS

Description

The diamond locating dowel pins used to install the front timing gear cover, flywheel and flywheel housing, have been replaced in production by blade-style locating dowel pins. The diamond pins were dual-diameter type pins with a smaller diameter at the round end that goes into the cylinder block. The blade-style pins are the same diameter at the round end and the blade end. There are no changes in the size of the hole in the front timing cover. However, the cylinder block has a larger hole to accept the blade-style dowel pins. The cylinder block timing gear cover old pin number is 183GC221 and the new number, starting with serial number 2T (August 1992), is 183GC238.

Use a dowel size and type that is appropriate for the block being used. (Service old with old and new with new.) Install the blade-style dowel with the blade in a vertical direction (pointing up and down).

Special Tools Required

- Flywheel Housing Diamond Dowel Aligner J 37711
- Flywheel Housing/Timing Cover Locating Pin Driver J 37712

Removal

If it is necessary to remove the timing cover or flywheel housing locating dowel pins, do so as follows:

1. Securely clamp the pin with a pair of vise-grip pliers.
2. While exerting an outward force, rotate pin back and forth until the pin works free from the hole.

Installation

Two precision-made dowel pins are used to locate the flywheel housing to the cylinder block. One dowel is round, the other is a diamond shape or blade type, as described earlier, depending on the production date.

NOTE

The dowels used for timing gear cover installation are similar except for the size. The smaller dowels are used for the timing cover. The larger dowels are used for the flywheel housing.

ROUND DOWEL PIN INSTALLATION

Refer to Figure 6-18.

1. Insert round dowel pin (2) into the flywheel housing/timing cover locating pin driver J 37712 (1). The pin must be positioned in the driver with tapered end of the dowel facing outward.
2. Position exposed end of dowel into the left dowel pin hole (4) in cylinder block (3).
3. Using a hammer, drive the pin into the block until the driver contacts the cylinder block. When the driver has made contact with the block, the dowel pin will be at the correct dimension above the block.

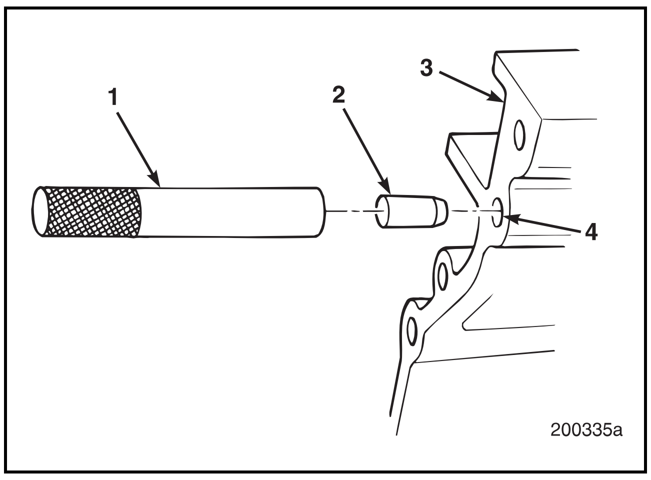


Figure 6-18 — Round Dowel Pin Installation

1. Locating pin driver	3. Cylinder block
2. Round dowel pin	4. Dowel pin hole

DIAMOND-SHAPED DOWEL PIN INSTALLATION

Refer to Figure 6-19.

1. Position the two alignment studs (3) in the threaded holes (2) nearest the right dowel location hole (6) in the cylinder block (1).
2. Position the diamond-shaped dowel pin (5) in the diamond dowel aligner J 37711 (4).
3. Position the diamond dowel aligner with the pin in position on the two alignment studs (3).
4. Using a hammer, drive the dowel pin into the hole until it bottoms out in the block.
5. Remove the diamond dowel aligner and the two alignment studs. The dowel pin will be at the correct height above the block.

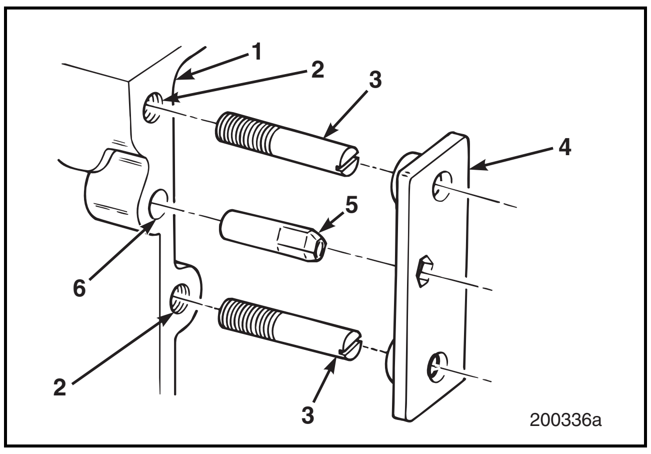


Figure 6-19 — Diamond-Shaped Dowel Pin Installation

1. Cylinder block 2. Threaded holes 3. Alignment studs 4. Diamond dowel aligner	5. Diamond-shaped dowel pin 6. Dowel location hole

BLADE-TYPE DOWEL PIN INSTALLATION

1. Position the round end of the blade-type dowel pin into the dowel pin hole in the cylinder block. The blade end must be aligned vertically with the block.
2. Using a hammer, drive the dowel pin into the block until the shoulder of the pin is flush with the cylinder block surface.

[212 HP] CRANKSHAFT

Installation

1. Clean the crankshaft and crankcase area.
2. Thoroughly clean each main bearing bore and the back of each bearing insert before installation. The inserts must be installed dry.

CAUTION

The hole in the insert should line up with the drilled hole in the block or the bearing will fail due to lack of lubrication. The upper bearing insert is stamped on the back with the word UPPER.

3. Place the upper half of the bearing insert in the block bore, making sure that the locating tab fits into the notch provided.
4. Repeat above step to install the remaining upper inserts. Refer to Figure 6-20 for the part number and location of each bearing insert.

CAUTION

A bearing insert installed at the wrong location can cause engine failure.

5. Apply a light coat of clean engine oil on the insert surfaces and on the crankshaft main bearing journals.

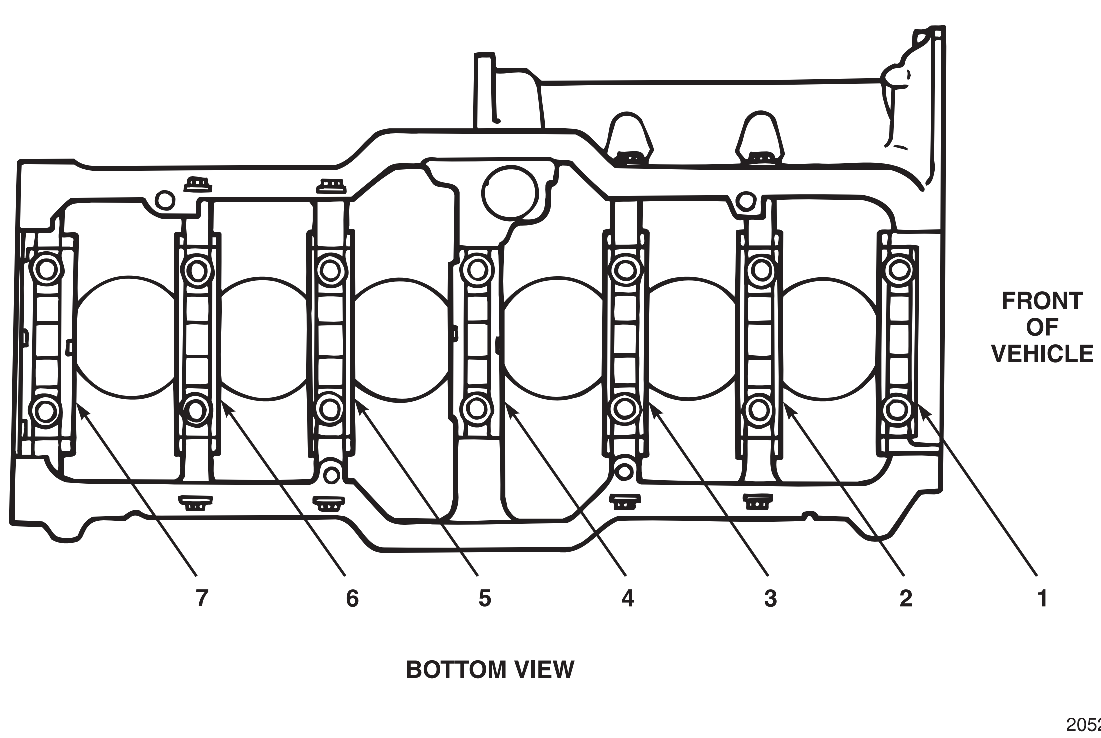


Figure 6-20 — Main Bearing Insert Part Numbers and Locations

1. Upper insert — 646B348; Lower insert — 646B343	5. Upper insert — 646B345; Lower insert — 646B343
2. Upper insert — 646B345; Lower insert — 646B343	6. Upper insert — 646B345; Lower insert — 646B343
3. Upper insert — 646B345; Lower insert — 646B343	7. Upper insert — 646B350; Lower insert — 646B344
4. Upper insert — 646B349; Lower insert — 646B344	

WARNING

Due to the considerable weight of the crankshaft, extreme care must be observed during installation. No nicks, scratches, burrs, or any other kinds of distress are acceptable on the main bearing and/or crankshaft journals and fillets.

6. Using a suitable lifting device, position the crankshaft in the crankcase.

[212 HH] MAIN BEARING CAP

NOTE

Unfinished main bearing caps are available for servicing of E7 engines. These are undersize bore bearing caps for service rebore:

- Cap, Intermediate and Front Main Bearing (Semi-Finished), No. 223GB2131M
- Cap, Rear and Center Main Bearing (Semi-Finished), No. 223GB2132

Special Tool Required

- Magnetic Base Indicator Tool J 7872

Installation

1. Clean bore in bearing cap and back of the lower bearing inserts.
2. Install bearing insert in bearing cap bore. The inserts must be installed dry.

NOTE

The lower bearing inserts do not have a hole or a notch. They are stamped with the word LOWER.

CAUTION

Do not mix caps or inserts. The caps are numbered from 1 through 7, front to rear.

3. Lubricate threads of the bearing capscrews with clean engine oil and place bearing capscrews in the bearing cap holes.
4. Position cap in the correct location and start the screws in the threads.
5. Using a plastic-faced mallet, tap bearing cap down until it contacts the machined mounting surface.
6. Tighten the screws until they contact the bearing cap. At this time, tighten them only to finger tight.
7. Repeat above steps for remaining main bearing caps, except the center main bearing cap. Torque bearing cap capscrews to 210 lb-ft (285 N•m) using torque wrench J 24407 or equivalent.

NOTE

Use standard thickness thrust washers initially.

Refer to Figure 6-21.

8. Place upper thrust washer sections in position at the center bearing. The steel side of the thrust washer goes toward the block, the bronze side goes toward the crankshaft (this applies to upper and lower thrust washer sections).

NOTE

Beginning with October 1996 production, new-style thrust washers were introduced. These thrust washers are steel backed with an aluminum facing material on the side that goes against the crankshaft. As with the previous bronze-style thrust washers, the aluminum-faced thrust washers have oil reservoir grooves cut into the aluminum surface as well as tip face reliefs. The aluminum thrust washers can easily be installed incorrectly because of the similarity of color between the steel backing and aluminum face. When installing aluminum-faced thrust washers, make sure the oil reservoir grooves and tip relief cuts are facing against the crankshaft.

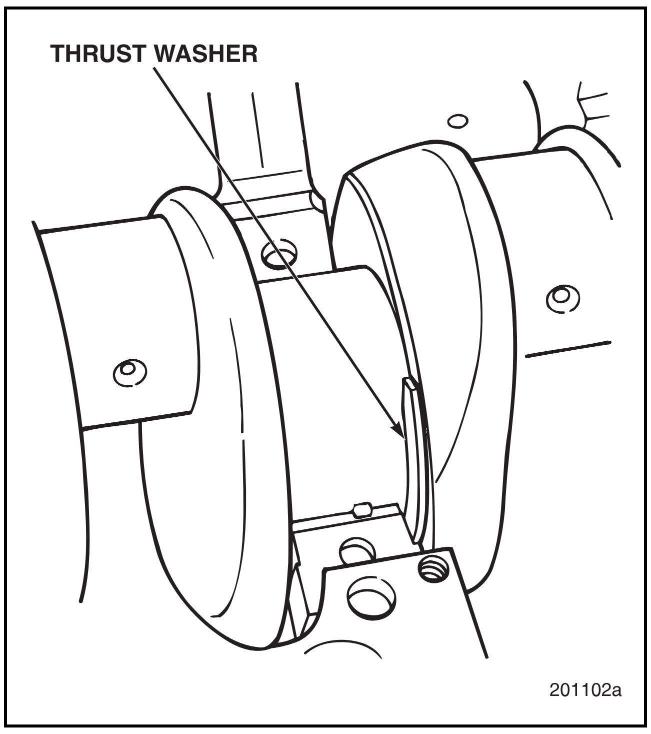


Figure 6-21 — Crankshaft Thrust Washer Installation

9. Position the lower section thrust washers on the center bearing cap (bronze/aluminum faces crankshaft) and install the cap. Torque capscrews to 210 lb-ft (285 N•m) using torque wrench J 24407 or equivalent.
10. Install magnetic base indicator tool J 7872, or equivalent, on the block with the plunger against a crankshaft counterweight to check for crankshaft end play.
11. Using a suitable pry bar, move crankshaft either forward or rearward until it stops. Tap end of the crankshaft with a plastic-faced hammer to seat the thrust washer.
12. Using pry bar, move crankshaft in the opposite direction. Tap end of the crankshaft with a plastic-faced hammer to seat the other thrust washer.
13. Set dial on the indicator to zero.
14. Using pry bar, move crankshaft in the opposite direction and read the dial indicator. Refer to the Fits and Limits chart for specifications.
15. If end play is out of specification, remove thrust washers and install standard or oversize thrust washers, as required, to bring the end play into specification.

CAUTION

The thickness of the thrust washers used in the bearing cap must match the thickness of the thrust washers in the block. Be sure to put the bearing surface of the thrust washer against the crankshaft when installing thrust washers.

16. Install the center main bearing cap, with bearing insert and the correct thrust washer sections in place, and torque the bearing capscrews to specification.
17. Recheck end play to make sure thrust washers have been installed correctly and end play is within specification. Rotate crankshaft to make sure there is no binding.

CHECKING RUNNING CLEARANCE

CAUTION

When using the Plastigage method of checking running clearance, do not turn the crankshaft. Doing so will destroy the Plastigage.

NOTE

If checking the main bearing clearance with engine in the upright position (such as in the chassis), the weight of the crankshaft must be removed from the lower half of the bearing being checked. To do this, place cardboard under the crankshaft journal in the main caps adjacent to journal to be checked and tighten the adjacent caps until the journal to be checked seats against the upper bearing. Do not fully torque screws. Capscrews on bearing being checked should be torqued to specification after Plastigage strip has been positioned on the bearing shell. Support crankshaft at No. 1, 4 and 7 main journals, while checking No. 2, 3, 5 and 6 bearings. Support crankshaft at No. 3 and 5 while checking No. 1, 4 and 7 bearings.

Refer to Figure 6-22.

1. Use Plastigage to check the main bearing clearance. Check each bearing, one at a time, by placing a piece of Plastigage on the journal and tightening the cap in place. The bearing clearance is determined by measuring the width of the crushed Plastigage with the supplied gauge.
2. Place a section of Plastigage (2) on the journal to be checked and assemble main bearing cap (1) to cylinder block.
3. Apply a light coat of oil on threads of the bearing cap capscrews and secure cap.
4. Torque capscrews to 210 lb-ft (285 N•m) using torque wrench J 24407 or equivalent. The Plastigage strip will be crushed between the bearing insert (3) and the crankshaft journal (4).

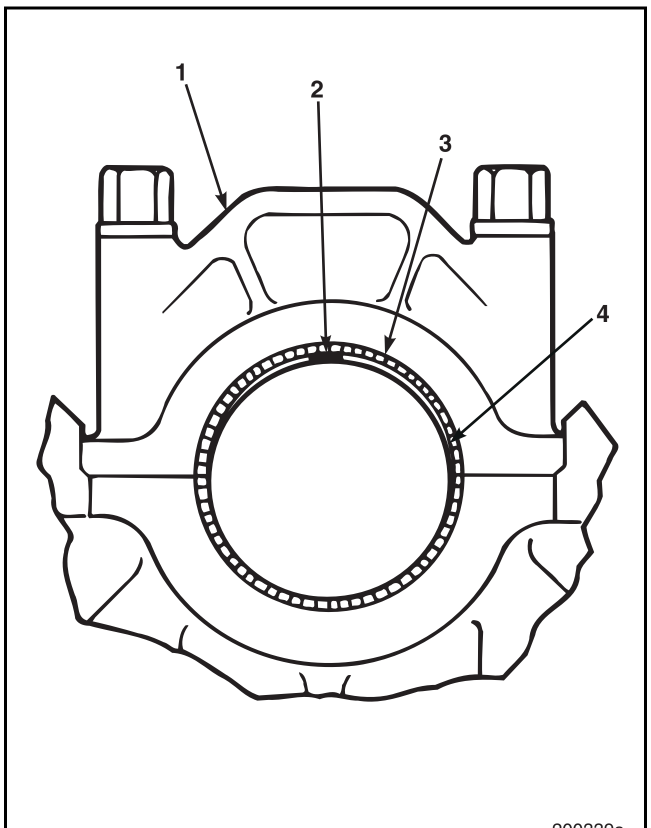


Figure 6-22 — Checking Running Clearance with Plastigage

1. Main bearing cap 2. Plastigage	3. Bearing insert 4. Crankshaft journal

5. Remove capscrews and cap, and check the bearing running clearance.
6. Check width of the Plastigage using a Plastigage width chart. After measuring width, remove Plastigage from bearing.
7. If clearance is not within specification, correct as required. Be sure to use the correct size bearing.
8. If clearance is less than specified, also check behind bearing for dirt, chips or burrs which would prevent the bearing from seating properly.
9. Reposition cap on journal. Lubricate capscrews with clean EO-L specification engine oil. Lubricate and install the bearing cap buttress capscrews as required, and leave finger tight. Install the bearing cap capscrews and torque to 210 lb-ft (285 N•m) using torque wrench J 24407 or equivalent.

Refer to Figure 6-23.

NOTE

There are two buttress capscrew dimensions:

- LH side 2, 3, 5, 6; RH side 5, 6 (6 each) are 80 mm long (1)
- RH side FRT 2 and 3, engine bulkhead (2 each) are 110 mm long (2)

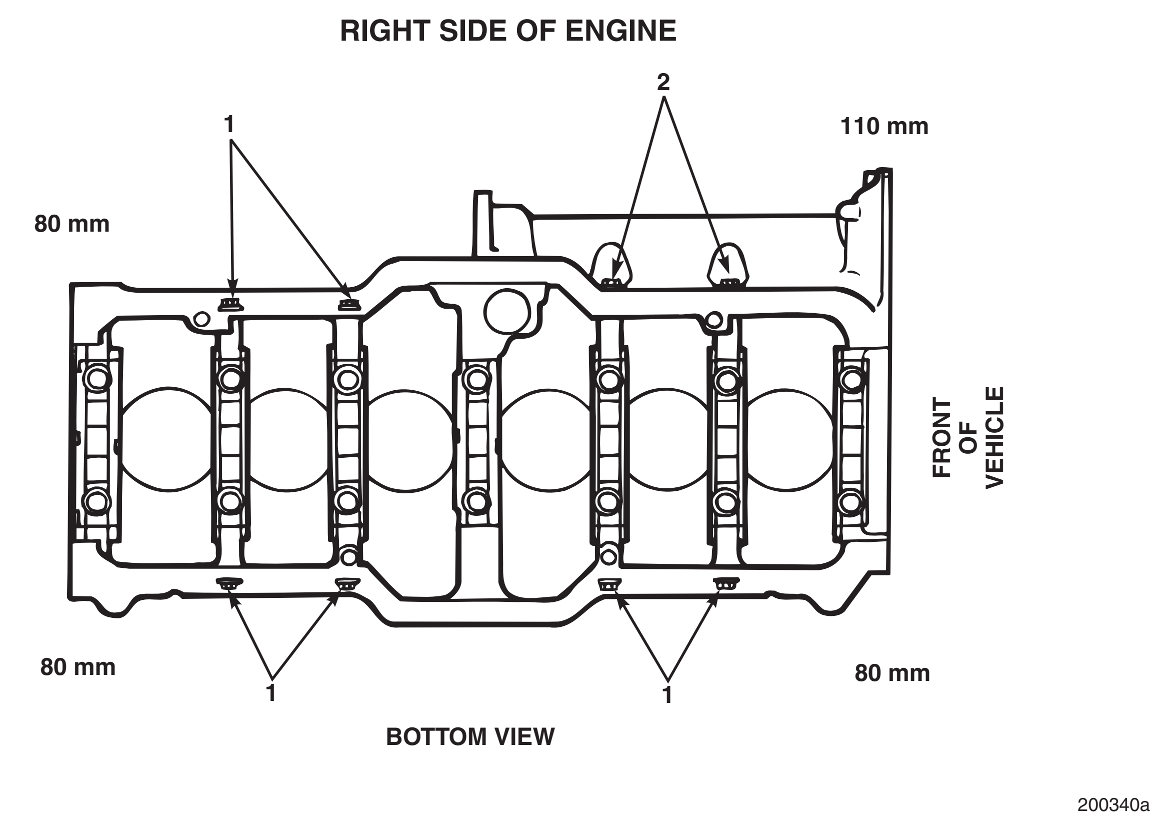


Figure 6-23 — Buttress Capscrew Locations

1. 80-mm buttress capscrews	2. 110-mm buttress capscrews

After obtaining proper main bearing clearance:

1. Check torque of main bearing capscrews: 210 lb-ft (285 N•m) using torque wrench J 24407 or equivalent.
2. Torque the buttress capscrews to 90 lb-ft (122 N•m) using torque wrench J 24407 or equivalent.

[212 NP & 212 LP] PISTONS AND CONNECTING RODS

Description

Since 1991, all E7 engines have used a two-piece piston. To ensure a continued high level of piston durability, the piston crown is made of forged steel and the piston skirt is made of cast aluminum. The piston pin bore pedestal and skirt are stamped FRONT and must face the front of the engine. These production parts are not interchangeable with 1989/1990 production.

The piston design incorporates two compression ring grooves and one oil control ring groove. A plasma-faced keystone type ring is used in the top location. A tapered chrome rectangular-type ring is used in the second ring groove. The oil control ring is located in the third or lower ring groove, nearest the piston pin bore. The new piston rings are designed to further improve oil and particulate control.

Special Tools Required

- Piston Ring Compressor J 23442 or Piston Ring Compressor PT7070-A

Installation

Refer to Figure 6-24.

1. Rotate crankshaft so that the journals for the No. 1 and No. 6 cylinders are at bottom dead center.
2. Place piston, marked No. 1, on a clean, flat surface. Rest the piston and rod assembly on the piston crown with the rod upward.
3. Apply a light coat of clean engine oil to piston and rings.
4. Apply a light coat of clean engine oil to inside surface of the piston ring compressor J 23442 or PT7070-A.
5. Install ring compression tool by slipping it over the rod and down over the piston skirt with tapered end downward.

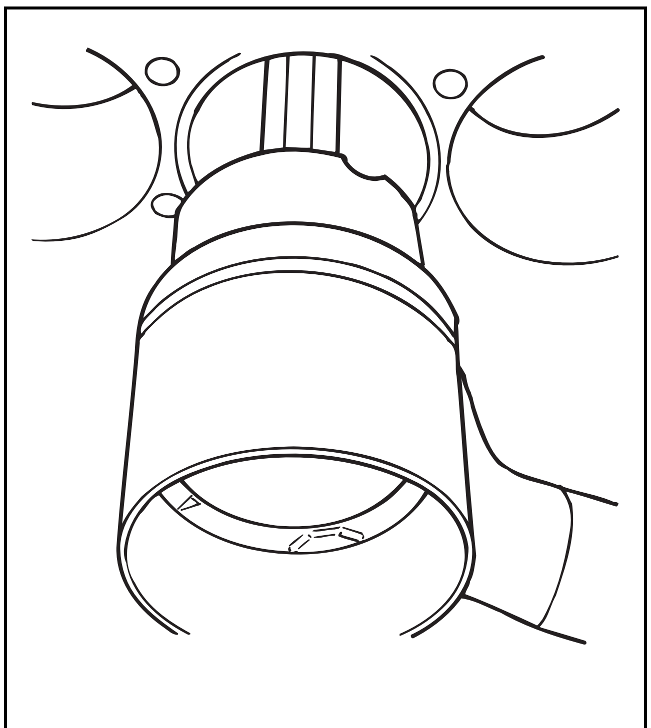


Figure 6-24 — Piston and Connecting Rod Installation

6. Carefully slide tool downward while guiding rings into the ring grooves.
7. Continue sliding tool downward until it contacts the surface on which the piston crown is resting.

NOTE

MACK E7 6-cylinder engines use a special type of connecting rod bearing. Each bearing half has a different thickness. The upper (rod) bearing half is thicker than the lower (cap) half. This design increases the load-carrying capacity of the upper bearing and provides longer bearing life.

CAUTION

The hole in the upper connecting rod bearing must be aligned with the oil passage in the connecting rod. Otherwise, damage to the bearing, rod and crankshaft journal will result.

8. Position an upper (rod) bearing into the connecting rod. Align tab in the bearing with notch in the rod. Be sure that the hole in the bearing aligns with the oil passage in the rod.
9. Apply a light coat of clean engine oil to bearing surface.
10. Apply a light coat of clean engine oil to inside surface of the No. 1 cylinder sleeve.
11. With the ring compression tool in place, position piston and rod assembly into the No. 1 cylinder. The arrow and word FRONT on both the piston crown and the connecting rod must be facing the front of the engine.

CAUTION

Apply downward pressure to the ring compression tool, keeping it in contact with the cylinder sleeve, until the top ring has passed into the cylinder sleeve. Otherwise, damage to the rings may result.

12. Make sure connecting rod aligns with journal and, using a hammer handle, carefully push piston into cylinder until piston crown is below the surface of the sleeve.

CAUTION

Do not force the piston. This indicates an incorrectly aligned ring. Remove piston, correct the problem, and reinstall.

Before pushing piston all the way down in the sleeve, check to see if piston cooling nozzle is aligned with the nozzle clearance notch provided in the lower end of the piston skirt. If it is not aligned, damage to piston or spray nozzle may result.

13. Align rod with the journal and continue pushing piston into sleeve while guiding rod end (to clear piston cooling nozzle), until rod is in position on the crankshaft journal.
14. Ensure that the correct mate to the upper rod bearing and alignment sleeves, if applicable, are positioned in the rod cap. Perform a running clearance check at this connecting rod journal before installing the next piston in Step 15.

CAUTION

Perform running clearance check after installing each piston. Damage to engine may result if clearance is not within specification.

15. After performing running clearance check, repeat above installation procedures to install the No. 6 piston.
16. Rotate crankshaft so that the journals for the No. 2 and No. 5 cylinders are at bottom dead center. Follow above installation procedures to install the No. 2 and No. 5 pistons. Repeat procedures to install the No. 3 and No. 4 pistons.

CHECKING RUNNING CLEARANCE

1. Place a section of Plastigage on the cap bearing and assemble cap to rod.
2. Apply a light coat of oil on threads of the rod cap capscrews and secure cap.
3. Torque capscrews to 150 lb-ft (203 N•m) using torque wrench J 24407 or equivalent.
4. Remove capscrews and cap, and check the bearing running clearance.
5. Using a Plastigage width chart, measure width of the Plastigage and remove it from bearing.
6. If clearance is not within specification, correct as required. Make sure to use the correct size bearing.
7. If clearance is less than specified, also check behind bearing for dirt, chips or burrs which would prevent the bearing from seating properly.
8. Reposition cap on journal. Lubricate new capscrews with clean engine oil, install the capscrews and torque to 150 lb-ft (203 N•m) using torque wrench J 24407 or equivalent.

CAUTION

If cap and rod are not properly aligned, bearing and rod damage may result.

Refer to Figure 6-25.

9. Check rod side clearance by installing a thickness gauge between rod and side of journal at the entire parting line area.

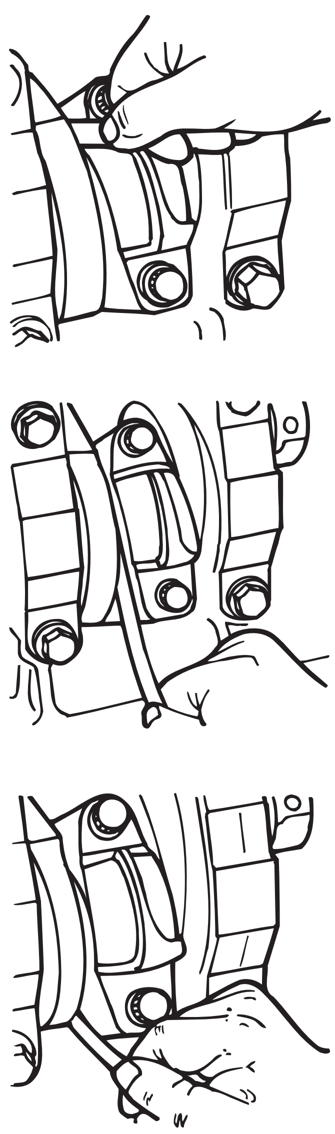


Figure 6-25 — Connecting Rod Side Clearance Check

10. The clearance must be within specification shown in the Fits and Limits chart. If not, recheck for proper cap and rod alignment.

[211 HD] FLYWHEEL HOUSING

Description

Beginning in 1991, flywheel and flywheel housings for E7 engines equipped with standard transmissions incorporate engine timing and engine turnover features. In addition, new procedures and tools were introduced and must be used to ensure optimum performance, engine durability and emission compliance.

Inspection

Inspect the flywheel housing machined surfaces, capscrews, holes and dowel locations for cracks or wear. Replace if cracks are evident.

CAUTION

Before installing flywheel housing, examine crankshaft flange for any cracks, surface damage or presence of foreign particles. This type of damage could ruin the sealing capabilities of the new seal and lead to oil leakage.

Dowel Pins

The diamond locating dowel pins, used to install the front timing gear cover, flywheel, and flywheel housing, have been replaced in production by blade-style locating dowel pins. The diamond pins were dual-diameter type pins with a smaller diameter at the round end that goes into the cylinder block. The blade-style pins are the same diameter at the round end and the blade end. There are no changes in the size of the hole in the flywheel housing. However, the cylinder block has a larger hole to accept the blade-style dowel pins. The old cylinder block flywheel housing pin number is 183GC219 and the new number, starting with serial No. 2T (August 1992), is 183GC237.

Use a dowel size and type that is appropriate for the block being used. (Service old with old and new with new.) Install the blade-style dowel with the blade in a vertical direction (pointing up and down).

Capscrews (Flywheel Housing)

A variety of lengths of flywheel housing-to-cylinder block capscrews are used. Also, different sized flat washers are used depending upon whether a ductile iron or aluminum flywheel housing is being installed. The following illustrations show where the different length capscrews should be installed in various flywheel housings.

Refer to Figure 6-26.

NOTE

On flywheel housing-to-cylinder block capscrew, No. 429GC23M, the dash suffix denotes the length of the capscrew.

- -M3 is 3 inches long, -M2 is 2-9/16 inches long, -M5 is 2-3/8 inches long, -M is 2 inches long, and -M4 is 1-3/4 inches long.

Flat washers:

- 271AM5008, approximately 3/16-inch thick. Use with ductile iron flywheel housing.
- 711GC1100P7, approximately 5/16-inch thick. Use with aluminum flywheel housing.
- 35AX1489, used with newer standardized aluminum flywheel housing.

NOTE

For standardization purposes, the E7 E-Tech™ flywheel housing castings are now being used on the E7 engine. Production phase-in began mid-October 1996. Along with the new flywheel housing, a standardization of the flywheel housing mounting hardware also took place. For all new-style housings used on the E7 engine, use the following mounting hardware:

- Two upper external mounting location capscrews — M3 (3 inches long).
- Six internal mounting location capscrews — M (2 inches long).
- Eight washers used with aluminum housing — Part No. 35AX1489.
- Eight washers used with ductile iron housing — Part No. 271AM5008.

CAUTION

Service replacement flywheel housings will be the standardized flywheel housing. If an existing, older E7 flywheel housing is replaced with the newer standardized housing, the six (429GC23M) two-inch capscrews must be used at the internal mounting locations. If the older, various-length mounting bolts are used to mount the new-style housing, thread engagement is insufficient for some of the shorter bolts, and the longer bolts bottom in the cylinder block mounting holes, causing damage to the threads. The new appropriate mounting hardware comes with the new-style flywheel housing supplied by the MACK Truck Parts System.

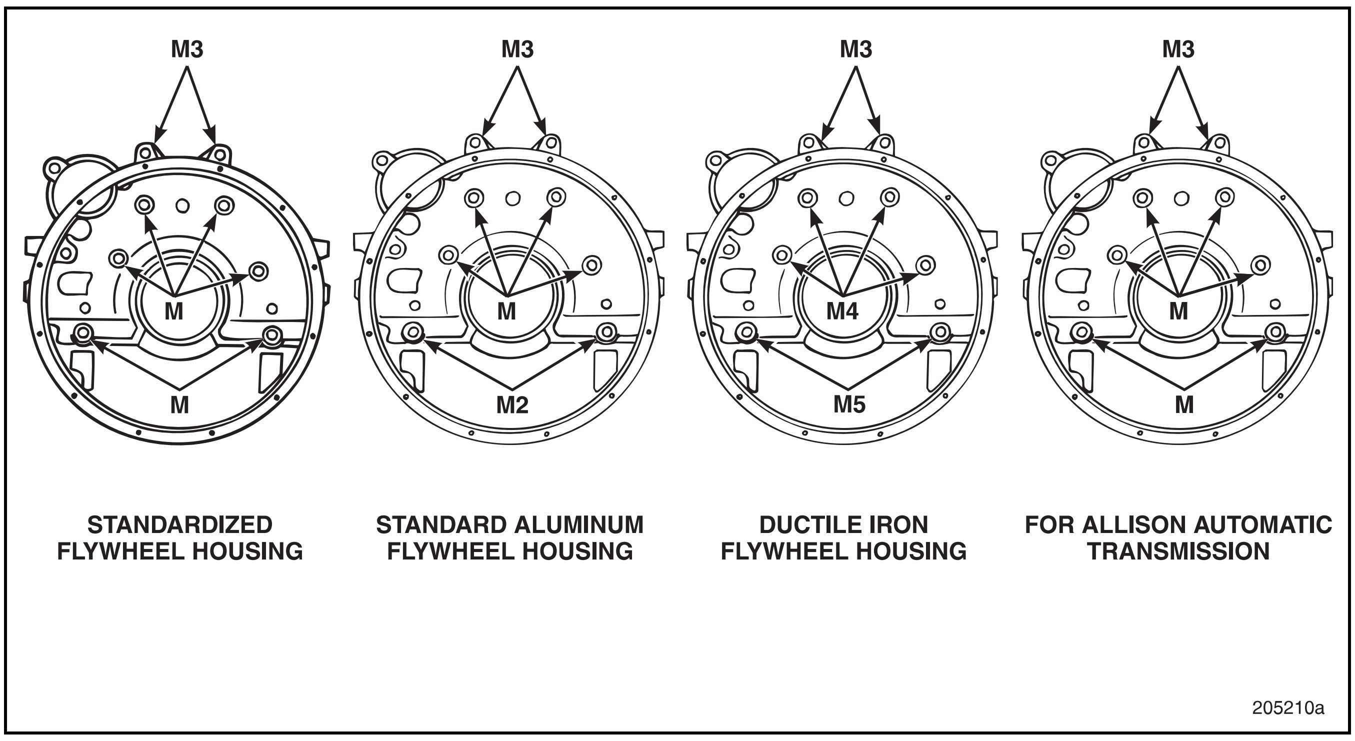


Figure 6-26 — Flywheel Housing Bolts

Installation

1. Remove the rear crankshaft oil seal from the flywheel housing by drilling two 3-mm holes 180 degrees apart into the outer edge of the seal. Remove the seal with a slide hammer fitted with a No. 10 sheet-metal screw. Thread it into each of the holes alternately and work the seal free.
2. Using standard shop cleaning procedures for aluminum, clean the seal mounting surface.
3. Insert the two dowel pins in the cylinder block if they were removed. Refer to Figure 6-27.

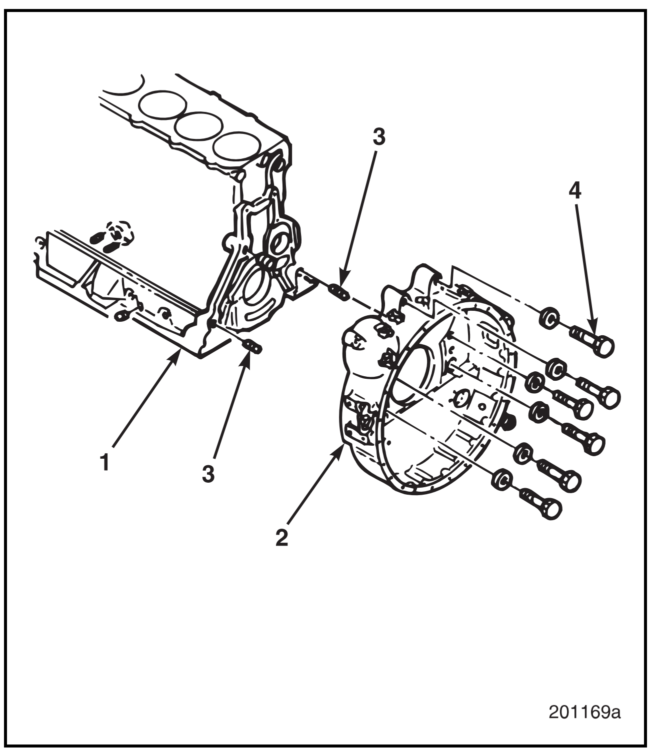


Figure 6-27 — Flywheel Housing Installation

1. Cylinder block 2. Flywheel housing	3. Dowel pin 4. Capscrews

NOTE

The flywheel housing dowels maintain the alignment of the flywheel housing on the engine. This is necessary to center the transmission with respect to the engine flywheel and crankshaft.

4. Apply an even coat of Silastic (approximately a 1/16-inch [2 mm] bead) to the flywheel housing mounting surface of the cylinder block. Refer to Figure 6-28.

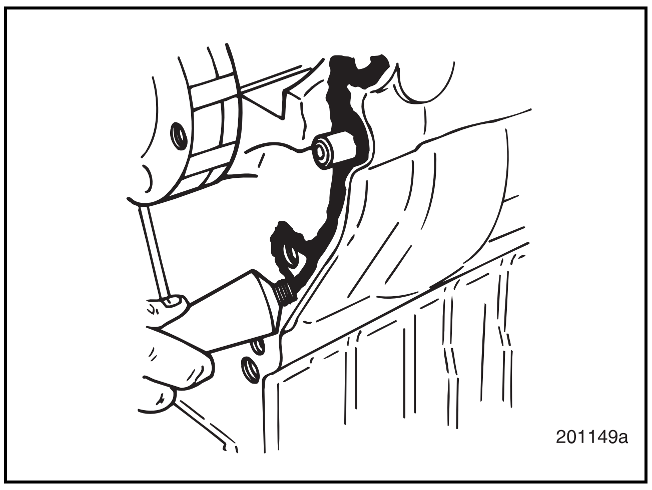


Figure 6-28 — Applying Sealant

5. Align the flywheel housing on the dowels and position it flush against the cylinder block surface. Refer to Figure 6-29.

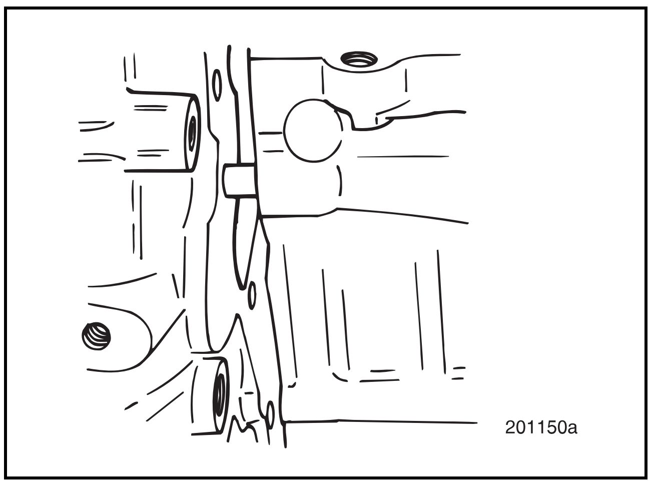


Figure 6-29 — Positioning Flywheel Housing

6. Install the exposed flywheel mounting capscrews and tighten them finger tight.
7. Torque all flywheel housing capscrews to 170 lb-ft (231 N•m) using torque wrench J 24407 or equivalent. Refer to Figure 6-30.

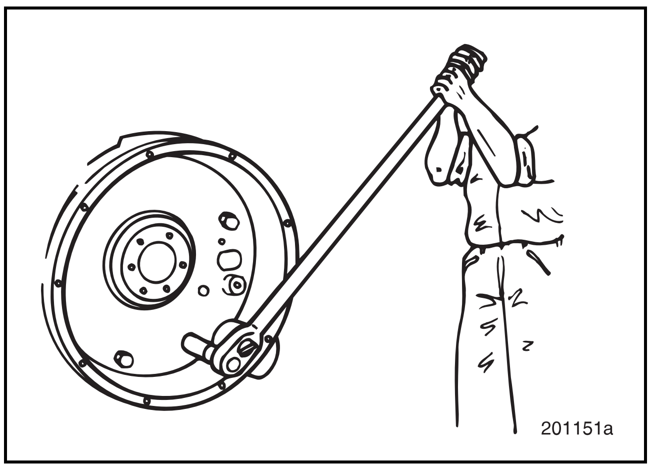


Figure 6-30 — Torquing Flywheel Housing Capscrews

Runout

With the machined dowel method of installation, flywheel housing runout is well within the old service specification of 0.010 inch (0.254 mm) Total Indicated Runout (TIR), when checked with an alignment bar through the cylinder block main bearing bores. However, when checking flywheel runout using a dial indicator on the crankshaft rear flange or the flywheel, results may exceed 0.010 inch (0.254 mm) due to factors such as crankshaft movement within the bearing clearances and other variables.

Flywheel housing runout specifications are as follows:

- Runout checked with an alignment bar installed through the cylinder block main bearing bores: 0.010 inch (0.254 mm) TIR maximum. Refer to Figure 6-31.
- Runout checked with a dial indicator mounted on the crankshaft rear flange or flywheel: 0.020 inch (0.508 mm) TIR maximum. This way, the runout may appear to be excessive due to crankshaft movement within bearings and other variables. Refer to Figure 6-32.

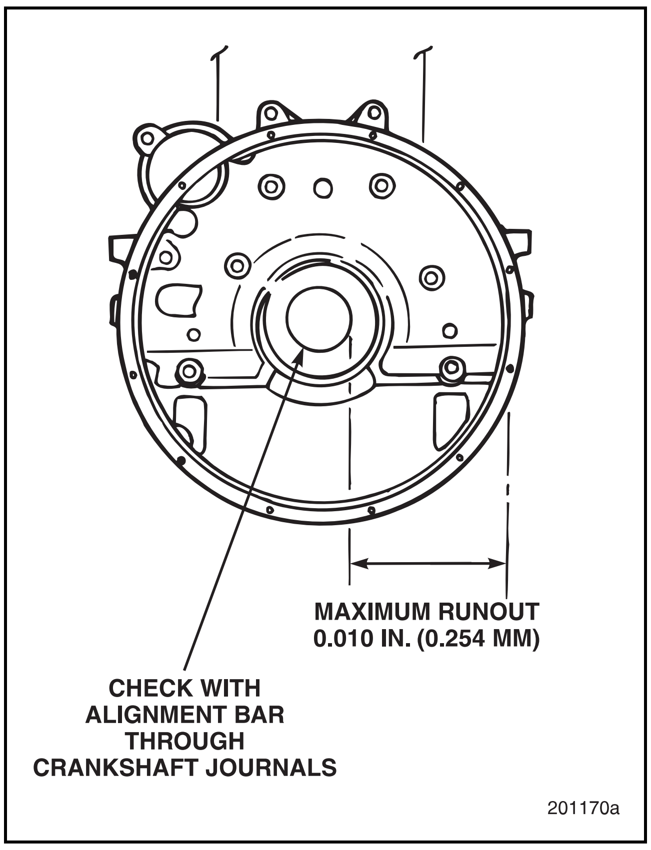


Figure 6-31 — Flywheel Housing Runout Check with Alignment Bar

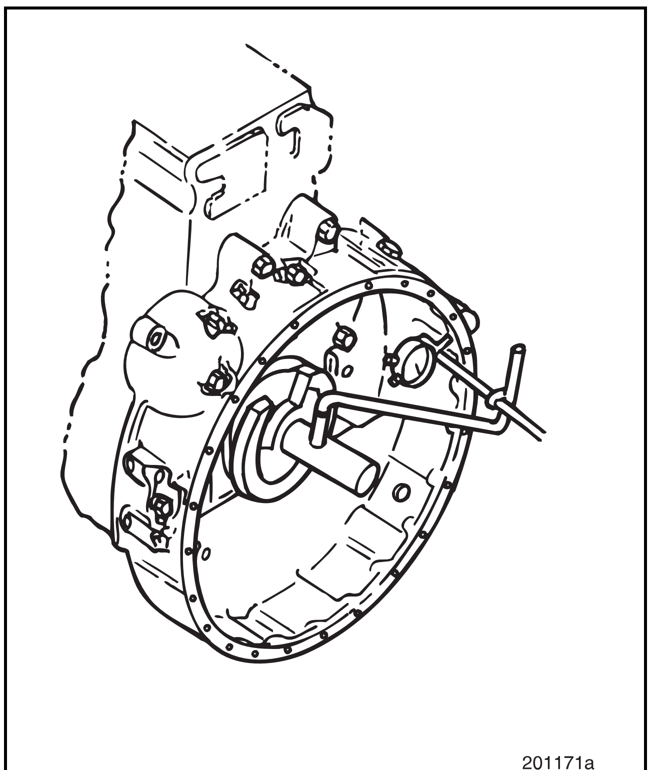


Figure 6-32 — Flywheel Housing Runout Check with Dial Indicator (PT5035) and Z adapter (PT5035-1)

[212 JH] CRANKSHAFT WEAR RING

When the service oil seal is to be replaced and the crankshaft flange is worn, the crankshaft can be salvaged by installing a crankshaft wear ring. An oil seal with a larger inside diameter is used with this wear ring.

Special Tools Required

- Crankshaft Rear Seal Installer J 37716-A
- Wear Ring Installer J 38880
- Universal Driver Handle J 8092

Removal

CAUTION

A limited number of crankshafts were manufactured with a repair sleeve installed on the flange. The repair sleeve is usually not noticeable and is finish ground to standard flange size. If the repair sleeve is damaged or becomes loose, the crankshaft must be replaced.

Special care must be taken not to damage the crankshaft flange during wear-ring removal.

Refer to Figure 6-33.

1. The wear ring can be removed by carefully applying heat, using a ball-peen hammer to expand the diameter, or by using a chisel to split the wear ring. Use extreme care not to damage the crankshaft flange.

CAUTION

Place chisel face squarely on wear ring. Use careful blows to cut wear ring only and not damage crankshaft flange. The wear ring will become loose enough to remove without cutting it completely through. The goal is to carefully remove the wear ring in this manner and not cut, nick, or damage the crankshaft flange.

2. Thoroughly clean the flange area of the crankshaft. Check for nicks or scratches and repair any damaged areas with crocus cloth as necessary.

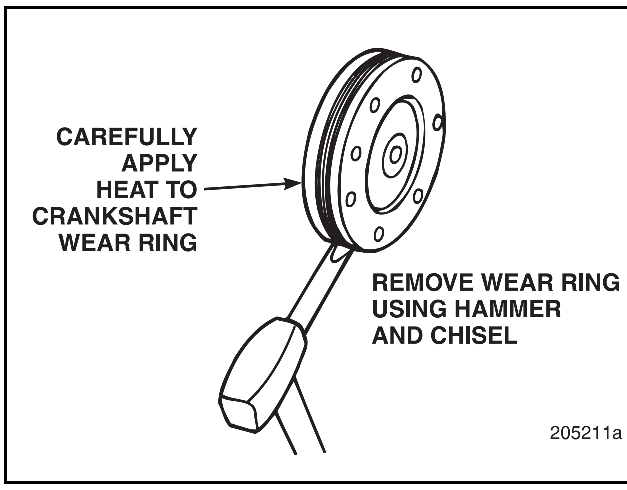


Figure 6-33 — Crankshaft Wear Ring Removal

Installation

Refer to Figure 6-34.

CAUTION

On some wear rings it may be difficult to determine the direction of the arrow on the inside diameter. In this case, ensure proper installation by installing the wear ring with the chamfer on the inside diameter toward the engine. The chamfer on the outside diameter of the wear ring must face away from the engine.

NOTE

The crankshaft wear ring is shrink fit on the crankshaft flange. Use wear ring installer J 38880 and universal driver handle J 8092 to install the ring to the proper depth.

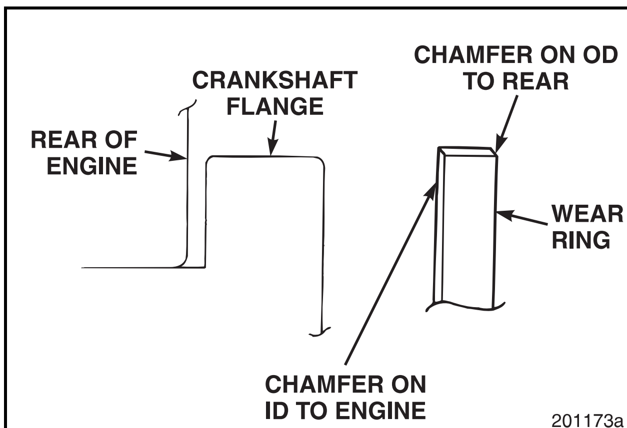


Figure 6-34 — Proper Crankshaft Wear Ring Installation

1. Position wear ring in the spring clips of the wear ring installer J 38880 with the arrow pointing away from the installer tool.

CAUTION

Do not heat the wear ring with a torch. This type of heat source will not heat the ring evenly.

2. Heat the wear ring and wear ring installer together in a temperature-controlled oven or on a hotplate, with the wear ring on the bottom and installed in the spring clips of the installer. Work as close as possible to the engine to avoid heat loss after heating ring. Heat to 400°F (205°C). Do not install the driver handle at this time. This allows the wear ring to maintain sufficient heat until it is fully installed on the crankshaft flange.
3. Thoroughly clean and dry the crankshaft oil seal mounting flange.
4. After the wear ring is sufficiently heated, use heat-resistant gloves to install the universal driver handle J 8092 into the threaded hole in the center of the installation tool.
5. Remove the wear ring and installation tool from the oven or hot plate and immediately position the wear ring and installation tool over the crankshaft flange until the installation tool is fully seated against the end of the flange. As the wear ring cools, it will shrink fit onto the crankshaft flange. Refer to Figure 6-35.
6. Allow the wear ring to cool completely. Then remove the installation tool.

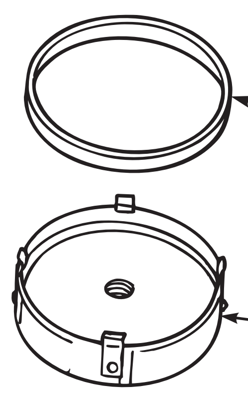


Figure 6-35 — Crankshaft Wear Ring Installation

Wear Ring with Double-Lip Teflon Seal (Automatic Transmission)

The oversize inside diameter lip seal and wear ring are shipped as an assembly, with the seal installed on the wear ring. Do not remove the seal from the wear ring prior to installation. The wet clutch wear ring and seal installer J 35529 is required for installation. This tool presses both the wear ring and the oil seal onto the crankshaft flange.

SPECIAL TOOL REQUIRED

- Wear Ring and Seal Installer J 35529

INSTALLATION

Refer to Figure 6-36.

1. Remove existing wear ring from crankshaft before installing new wear ring.
2. Thoroughly clean and dry the crankshaft flange.
3. Apply a thin, even layer of Loctite 609 to the circumference of the crankshaft flange.

NOTE

Do not lubricate the lips of a Teflon seal before installation. Teflon seals function most effectively when installed dry.

4. The lip of one side of the seal is yellow. Install the oil seal with the yellow lip toward the transmission. Position the oil seal and wear ring assembly onto the recessed side of the installation tool adapter plate with the yellow lip facing away from the direction of installation (toward the transmission).
5. Using the three guide pins, attach the oil seal installation tool adapter plate to the crankshaft flange.
6. Install the press cup over the guide pins, then install the press cup driver hex nut.

7. Tighten the hex nut until a positive stop is felt. At that point, the oil seal and wear ring are properly installed on the crankshaft flange.
8. Remove the installation tool.

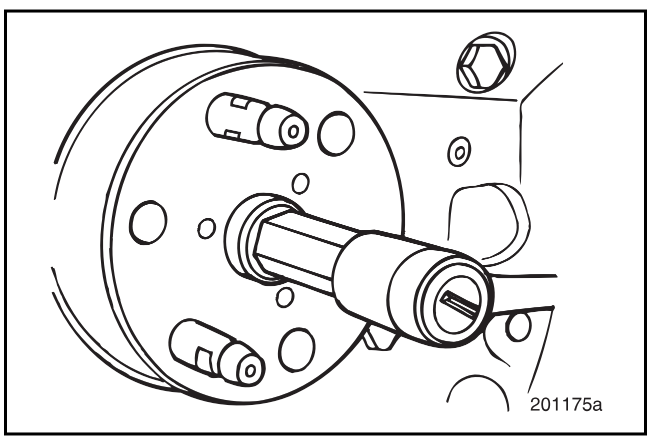


Figure 6-36 — Crankshaft Wear Ring (with Double-Lip Teflon Seal) Installation Using J 35529

[212 JH] CRANKSHAFT REAR OIL SEAL

In November 1992, MACK introduced Teflon oil seals into E7 production. E7 engines with dry flywheel housings (standard transmission) use single-lip seals. Replacement seals are available in Viton or Teflon. Viton seals are available with an oversized inside diameter and the wear ring is installed in the seal. E7 engines with wet flywheel housings (automatic transmission) use double-lip seals, which are available in Teflon only.

Installation

Standard-size Teflon seals are shipped on a plastic installation sleeve. Do not remove the sleeve from the seal before installation. The installation sleeve provides a smooth surface for the seal as it moves from the tool to the crankshaft flange.

Crankshaft design allows the single-lip seal to be installed at the production depth of 0.344 inch ± 0.005 inch (8.74 mm ± 0.127 mm), or a service depth of 0.250 inch ± 0.005 inch (6.35 mm ± 0.127 mm) from the outer edge of the crankshaft flange.

The double-lip seal must be installed to a depth of 0.250 inch ± 0.005 inch (6.35 mm ± 0.127 mm) only. This is the only installation depth specified for a double-lip seal.

Special handling precautions must be taken while installing Teflon seals. Do not lubricate the lips of a Teflon seal before installation. Teflon seals function most effectively when installed dry.

1. Thoroughly clean the surface of the crankshaft flange.
2. Position the oil seal (2) and installation sleeve (3) onto the recessed side of the J 37716-B oil seal installation tool adapter plate (1). The single-lip seal must be installed with the lip toward the engine. Refer to Figure 6-37.

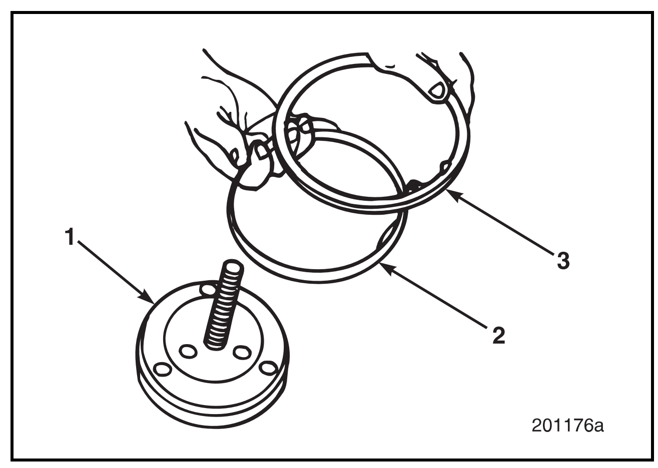


Figure 6-37 — Crankshaft Rear Oil Seal Installation

1. J 37716-B 2. Oil seal	3. Installation sleeve

3. Using the three guide pins, attach the adapter plate to the crankshaft flange. Refer to Figure 6-38.

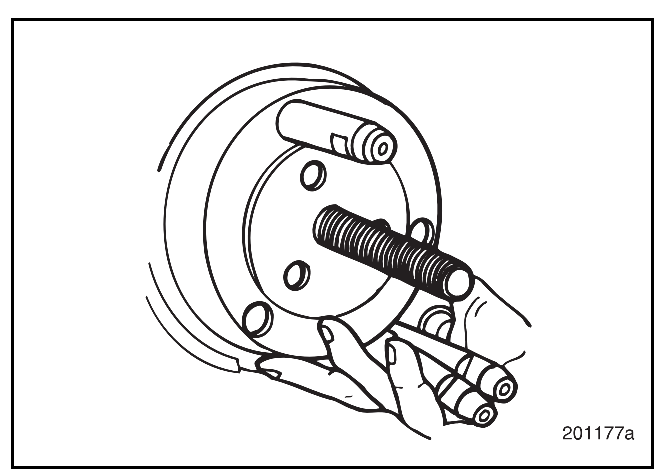


Figure 6-38 — Adapter Plate J 37716-B Installation

4. Determine the seal and wear ring installation depth:
   - New seal on new crankshaft — Install to initial production depth of 0.339–0.349 inch (8.611–8.865 mm).
   - New seal on service crankshaft — Install to service depth of 0.245–0.255 inch (6.223–6.477 mm).
   - Wear ring installation depth — 0.15–0.220 inch (5.461–5.588 mm).
   - Service oil seal installation depth with new wear ring — 0.339–0.349 inch (8.611–8.865 mm).
   - Service oil seal installation depth with used wear ring — 0.245–0.255 inch (6.223–6.477 mm).

Refer to Figure 6-39.

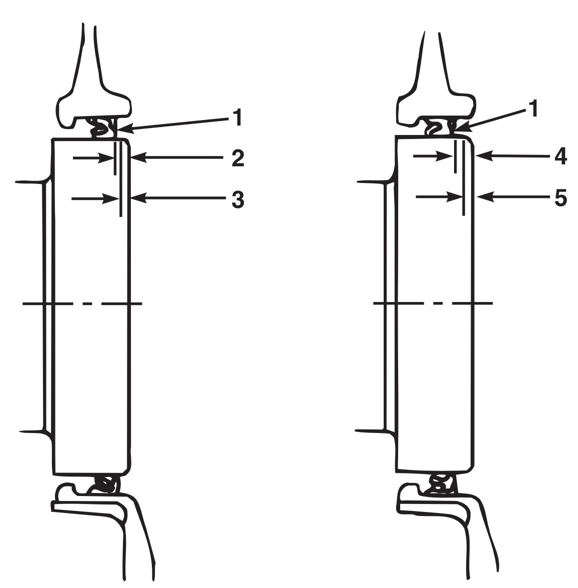


Figure 6-39 — Crankshaft Rear Oil Seal

1. Crankshaft rear oil seal 2. Production installation depth 3. Service oil seal installation depth	4. Service oil seal installation depth with wear ring 5. Wear ring installation depth

5. The two installation depths are stamped above two of the guide pin bores of the installation tool press plate. To install the seal to the desired depth, position the press plate so that the guide pins go through the bore stamped with the desired depth.
6. Install the press plate driver hex hut and continue tightening until a positive stop is felt. At this point, the seal is installed to the proper depth.
7. Remove the installation tool.

[212 VC] FLYWHEEL (E7 ENGINE WITHOUT POINTER ON TIMING COVER)

Description

The flywheel has a stamped timing scale of TDC to 45 degrees of engine travel for setting and checking injection pump to engine timing. It also has three stamped locations, 120 degrees apart, for valve settings.

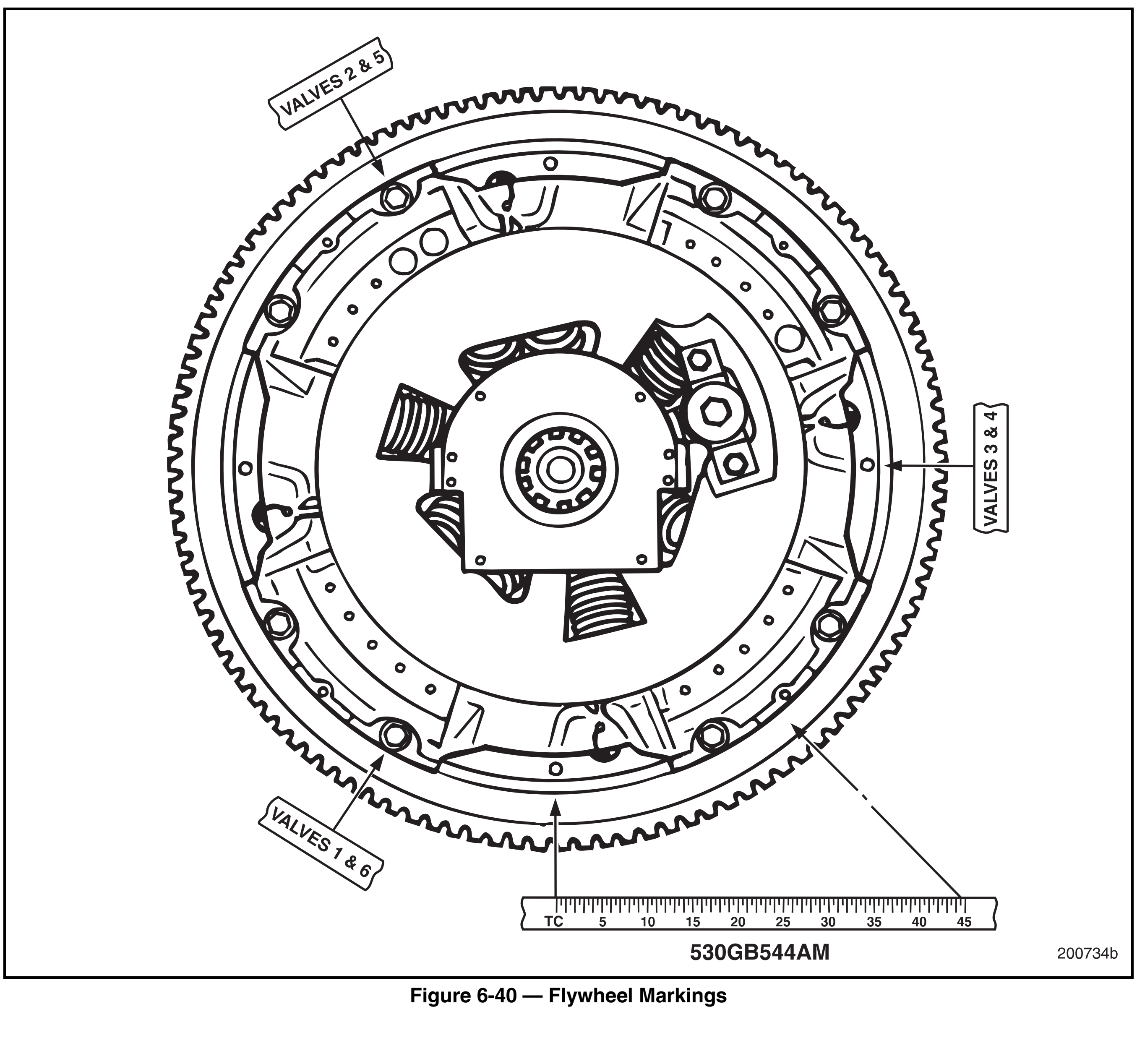


Figure 6-40 — Flywheel Markings

Installation

⚠ CAUTION

After resurfacing, any flywheel with drilled balance holes on the clutch side requires rebalancing by a machine shop.

SERVICE HINT

When installing the flywheel, insert two alignment studs into the flywheel mounting holes to aid in installation.

Refer to Figure 6-41.

1. Position the flywheel on the rear of the crankshaft at the flywheel mounting surface.
2. Install flywheel mounting capscrews in the exposed mounting holes. At this time, tighten the capscrews finger tight only.
3. Remove the two alignment studs and insert the remaining mounting capscrews.

⚠ CAUTION

Do not torque capscrews adjacent to each other in sequence as uneven flywheel alignment may result. Alternately torque capscrews on opposite sides of the flywheel.

4. Torque the capscrews to 185 lb-ft (251 N•m), alternating from opposite sides to apply even pressure to the flywheel (use torque wrench J 24407 or equivalent).

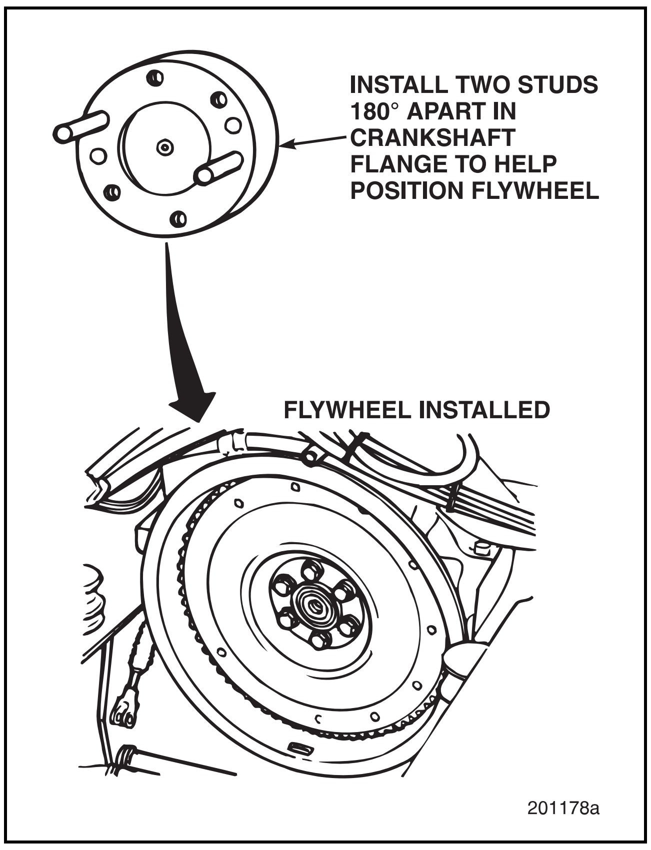


Figure 6-41 — Flywheel Installation

[213 CH] CAMSHAFT

Description

Refer to Figure 6-42.

The E7 camshaft design uses large journals to decrease bearing loading and to allow for larger, more durable cam lobes. In addition, the profile of the exhaust lobes has been changed (with part No. 5205) to increase the duration of exhaust valve opening. Both the camshaft driven gear and the fuel injection pump driving gear are pressed onto the shaft.

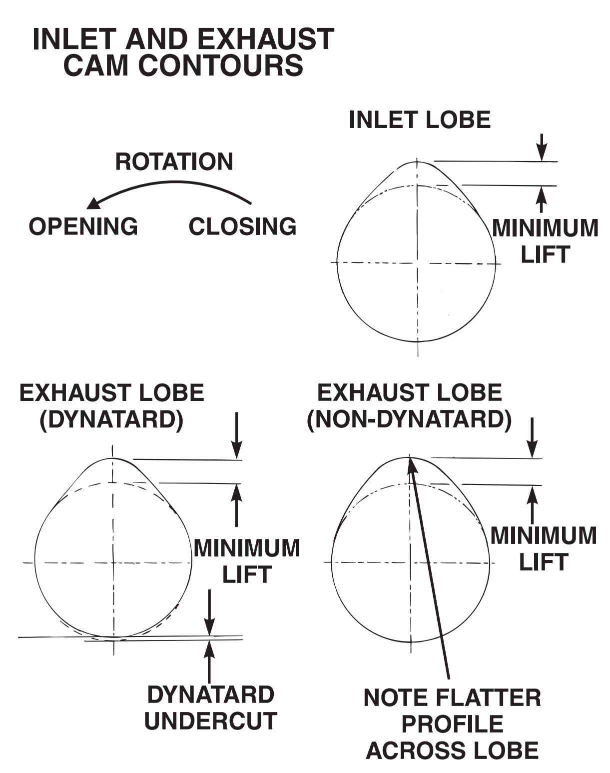


Figure 6-42 — Camshaft Contours

MINIMUM ACCEPTABLE CAM LOBE LIFT		
Camshaft Part No.	Exhaust Lobe	Intake Lobe
454GC583, 454GC583A	0.300 inch (7.62 mm)	0.300 (7.62 mm)
454GC5142	0.300 inch (7.62 mm)	0.270 inch (6.86 mm)
454GC5205	0.300 inch (7.62 mm)	0.280 inch (7.112 mm)

Special Tools Required

- Tappet Holders J 37720-B
- Camshaft Removal/Installation Tool J 41461

Inspection

1. Thoroughly clean the camshaft.
2. Inspect the camshaft cam lobes. Replace the camshaft if cam lobes show evidence of cracking, pitting or scoring.

NOTE

To provide increased duration for the exhaust valve opening, the exhaust lobe profile for cam part No. 5205 is flatter across the nose portion compared to traditional MACK cams. Do not misinterpret this flatter profile design as an improperly machined or worn lobe. The 5205 cams can be identified by the 3 grooves in the shaft between the No. 11 and No. 12 lobes. Refer to Figure 6-43.

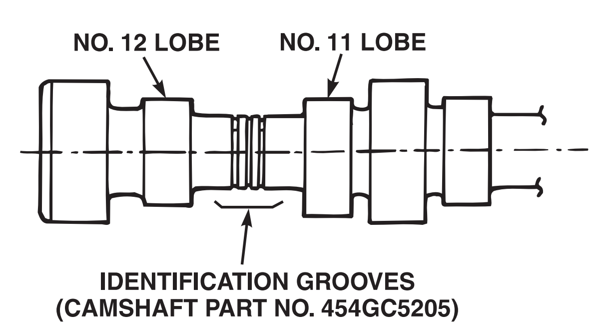


Figure 6-43 — Camshaft Identification, Part No. 454GC5205

3. Inspect the journals. Replace the camshaft if the journals are scored or worn.
4. Use standard magnaflux inspection procedures to detect cracks.

Installation (Engine in Stand)

1. With the cylinder block in the stand, rotate the stand so that the crankcase is upward (engine inverted).
2. Rotate the crankshaft so that the drive gear timing mark is aligned with the camshaft opening. Refer to Figure 6-44.

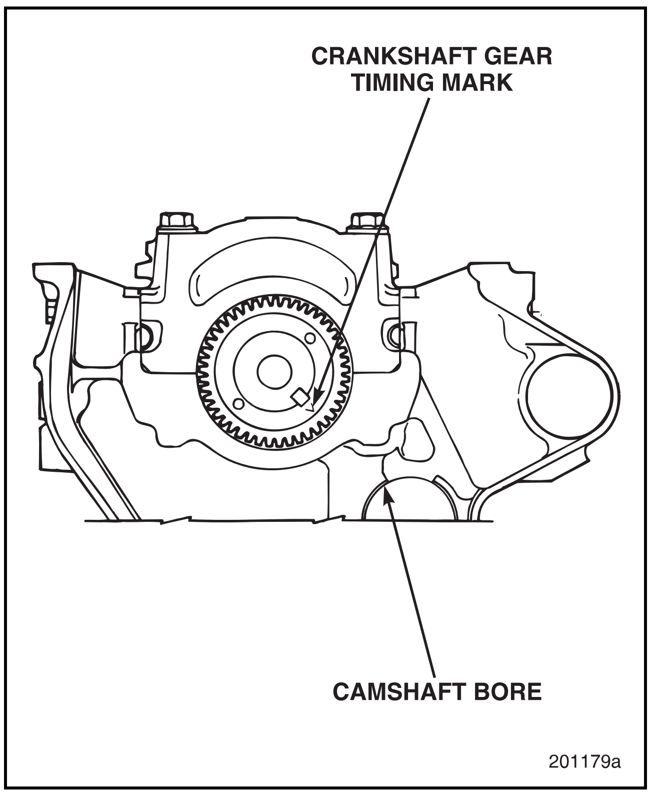


Figure 6-44 — Crankshaft Drive Gear Alignment

NOTE

Arrange valve lifters so that they can be identified and reinstalled into the same hole from which they came.

3. Clean the valve lifters, lubricate by dipping the shaft of the valve lifter in clean engine oil, and insert into the valve lifter holes in the block.

NOTE

Visually check the camshaft to be sure that the two camshaft gears and the captured thrust washer are in place on the shaft.

4. Lubricate the camshaft journals and the camshaft bearing surfaces with clean engine oil.

Refer to Figure 6-45.

5. Carefully insert the camshaft into the block using installation guide tool J 41461. Align the timing marks on the camshaft with the timing mark on the main crankshaft drive gear.

NOTE

The use of the installation tool will make it easy to slide the camshaft into the block while protecting the cam and bushings from damage.

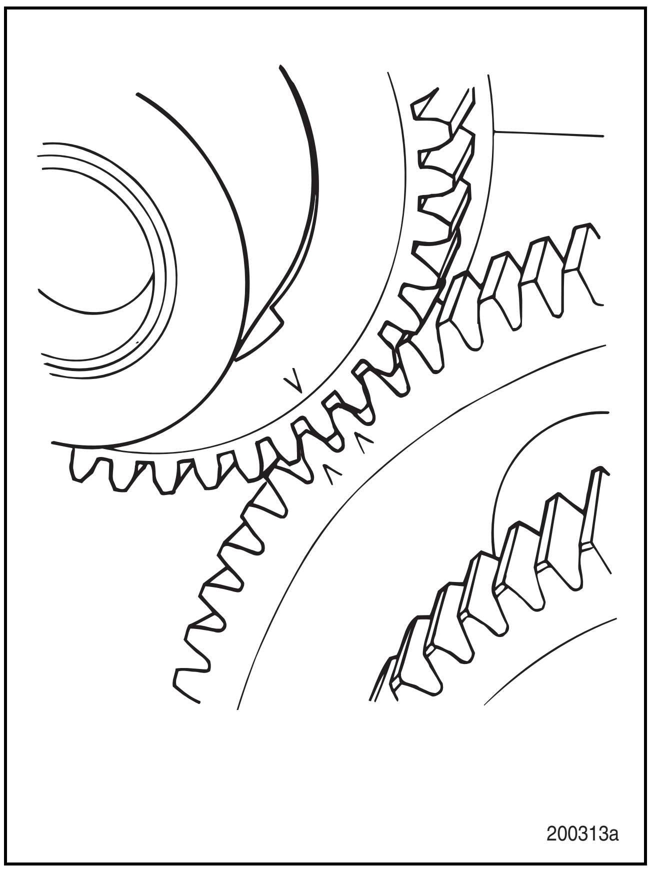


Figure 6-45 — Alignment of Timing Marks

6. Secure the camshaft captured thrust washer to the block using the two patch-lock 12-point capscrews and hardened washers. Torque to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.

Installation (Engine in Chassis)

NOTE

In order to use the valve lifter tool to hold the valve lifters in position, the cylinder heads must be installed on the engine.

Arrange valve lifters so that they can be identified and reinstalled into the same hole from which they came.

1. Rotate the crankshaft so that the drive gear timing mark on the drive gear is aligned with the camshaft opening. Refer back to Figure 6-44.
2. Clean the valve lifters. Lubricate valve lifters by dipping the shaft in clean engine oil.

CAUTION

With the engine in the chassis, the valve lifters must be held in the UP position, using tappet holders J 37720-B.

3. Insert the valve lifter into the valve lifter holes provided in the block. As the lifter is installed, it must be held in position by inserting a tappet holder into the opening through the top of the cylinder block. The tappet holder must be positioned so that the magnetic head of the tool holds the lifter in position. Check to see if the tool has captured the valve lifter by drawing upward on the tool. A resistance will be felt that cannot be felt if the magnet has contacted something other than a valve lifter.
4. Secure the lifter in the UP position with grommets provided in the tappet holder. The holding tool shafts of two adjacent valve lifters can be prevented from dropping by wrapping a rubber band around the two shafts. This draws the shafts together and holds them in position. Refer to Figure 6-46.

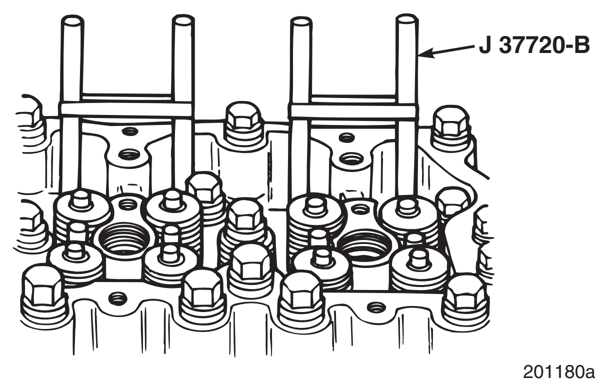


Figure 6-46 — Tappet Holder Tool

5. Perform steps 3 and 4 on each of the remaining valve lifters.

CAUTION

Visually check the camshaft to be sure that the two camshaft gears and the captured thrust washer are in place on the shaft.

Refer to Figure 6-47.

6. Insert camshaft removal/installation tool J 41461 (3) into position on the rear segment of the camshaft (1) by snapping the clip (2) into position.

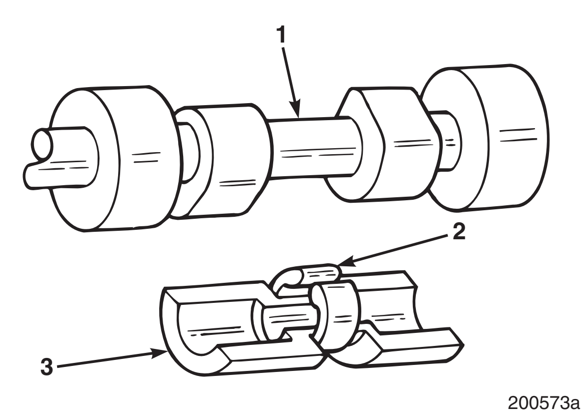


Figure 6-47 — Camshaft Removal/Installation Tool

1. Rear segment of camshaft 2. Tool retaining clip	3. Camshaft installation/ removal tool J 41461

7. Lubricate camshaft journals and camshaft bearing surfaces (in cylinder block) with clean engine oil.

NOTE

Do not rotate camshaft with the installation tool in position on the shaft. The tool must remain on the bottom of the shaft (6 o'clock position) or it will not function properly.

8. Carefully insert camshaft into the block with the camshaft installation tool in place. Align timing marks on the camshaft with timing mark on the main crankshaft drive gear. Refer back to Figure 6-45.

NOTE

The use of the installation tool will make it easy to slide the camshaft into the block while protecting the cam and bushings from damage.

Refer to Figure 6-48.

9. Secure camshaft captured thrust washer to the block using the two patch-lock 12-point capscrews (3) and hardened washers. Torque to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.

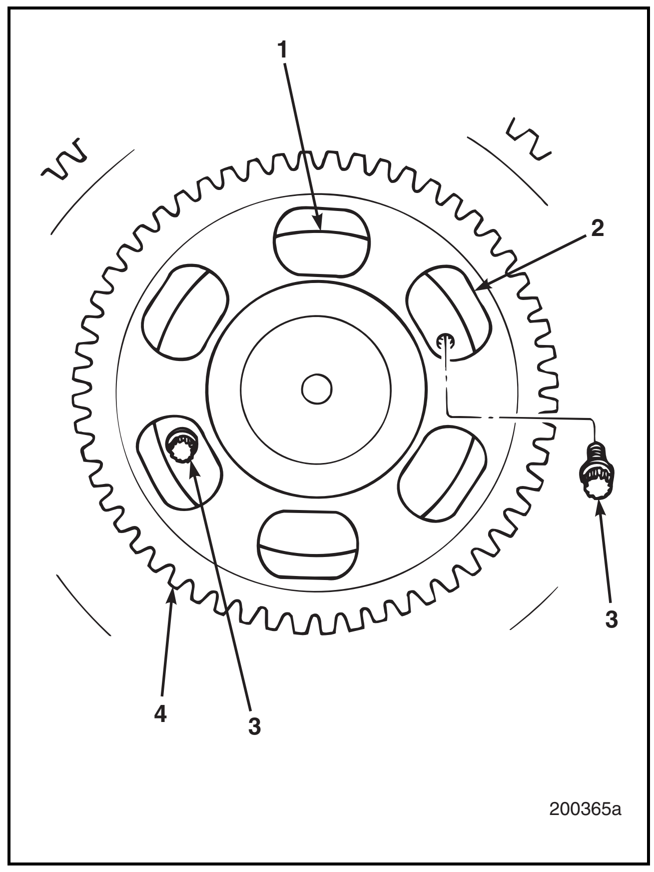


Figure 6-48 — Camshaft Installation

1. Thrust washer 2. Openings	3. Capscrew, 12-point 4. Camshaft drive gear

10. Remove the camshaft removal/installation tool.

[212 CV] AUXILIARY DRIVESHAFT

CAUTION

Current production engines (effective February 27, 1992, serial No. 2E1233) feature an improved "fast ratio" auxiliary driveshaft assembly and oil pump assembly. This arrangement increases operating oil pressure by approximately 25% and creates a change in the oil pump speed. Do not mix ratios. Refer to Oil Pump assembly procedures in this section for part number information.

Inspection

1. Using standard shop procedures, thoroughly clean auxiliary driveshaft.
2. Inspect auxiliary driveshaft journals, gear teeth and splines for evidence of cracks, pitting, scoring or severe wear. Replace auxiliary driveshaft if any of these conditions exist.
3. Use magnaflux (PT7190 or equivalent) inspection procedures to detect cracks.

Installation

- Fast Ratio, 1.5:1, part No. 453GC381M (18 teeth)
- Standard Ratio, 1.3:1, part No. 453GC379AM (17 teeth)

Refer to Figure 6-49.

CAUTION

Purchase the auxiliary driveshaft as an assembly only. Do not try to dismantle or rework as it may result in damage to the engine.

It is possible to assemble an auxiliary driveshaft with a fast ratio oil pump drive gear (5) and a standard ratio oil pump drive. Do not mix a 1.5 fast ratio assembly with a 1.3 standard ratio assembly. Damage to the engine will result.

1. Lubricate front auxiliary driveshaft journal (2), rear auxiliary driveshaft journal (4) and shaft bearings (in cylinder block) with clean engine oil.
2. Install shaft (3) into the rear of auxiliary driveshaft housing. Take care when aligning shaft through rear bearing (1).

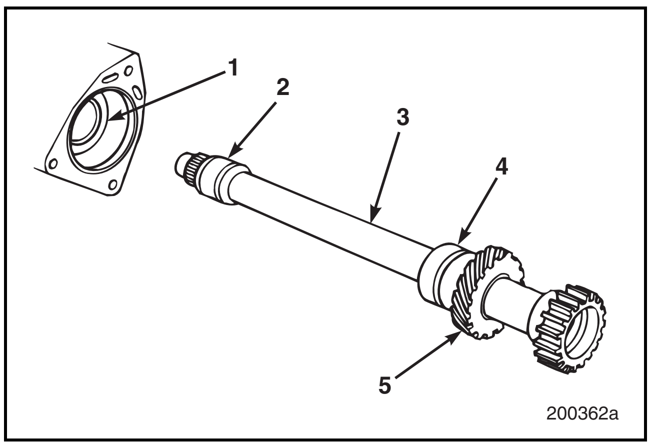


Figure 6-49 — Auxiliary Driveshaft Installation

1. Rear bearing 2. Auxiliary driveshaft front journal 3. Shaft	4. Auxiliary driveshaft rear journal 5. Oil pump drive gear

Refer to Figure 6-50.

3. Install thrust washer (4) and secure it in position with the patch-lock capscrews (3) and hardened washers.
4. Torque the thrust washer retaining patch-lock capscrews to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.
5. Install auxiliary driveshaft gear (2) on shaft splines (5).

NOTE

The auxiliary driveshaft and nut threads must be clean and dry before assembly. Clean the threads thoroughly with Brakleen® or electrical contact cleaner. Apply Loctite® 271 or 277 to the threads and install the nut.

6. Install auxiliary driveshaft nut (1) and torque to 300 lb-ft (407 N•m) using torque wrench J 23775-01 or equivalent.

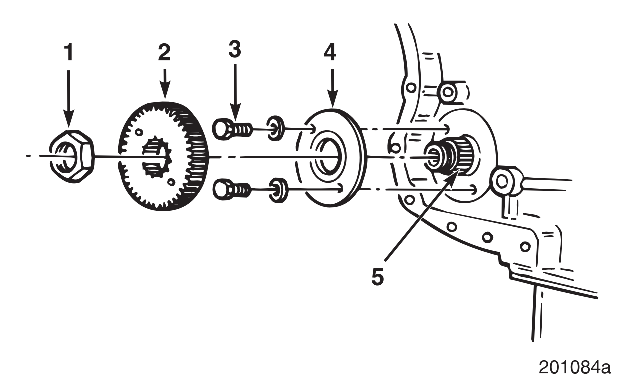


Figure 6-50 — Auxiliary Driveshaft Gear Installation

1. Nut 2. Auxiliary driveshaft gear 3. Capscrew	4. Thrust washer 5. Shaft splines

[219 MU] OIL PUMP

Description

The oil pump is a gear-type pump. As the pump rotates, a vacuum forms on the inlet side, drawing oil from the crankcase through the oil pump inlet pipe, and into the pump gear compartment. Oil then passes through the regulating valve. Regulated pressure then forces oil through the discharge port into a drilled passage in the cylinder block, which leads to the oil filter and cooler. The oil is then distributed to all main parts of the engine. If the oil filter is excessively contaminated, the filter bypass valve will open, allowing the unfiltered, contaminated oil to continue through the engine.

Oil fed to the main bearings also travels through the connecting rods into the piston wrist pins to lubricate the pistons and cylinder sleeve surfaces. Oil jets below the pistons, also fed by the oil pump, spray the bottom of the pistons with the pressurized oil to assist in removing some of the heat from the pistons produced by combustion. Oil is then returned, by gravity, to the crankcase.

CAUTION

Do not mix standard-ratio oil pumps with fast-ratio pumps. Damage to the engine will result.

Current fast-ratio oil pumps:

- Part No. 315GC459AM, with rear sump
- Drive gear, No. 683GB284 (12 teeth)

Former standard-ratio oil pumps:

- Part No. 315GC460M, with rear sump
- Drive gear, part No. 683GB287 (13 teeth)

NOTE

Make sure the oil pump is in satisfactory condition as described in the BENCH PROCEDURES section of this manual.

Installation

Refer to Figure 6-51.

1. Position the oil pump (1) on the cylinder block (3).
2. Secure the pump in position using the mounting capscrews (2). Torque the mounting capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

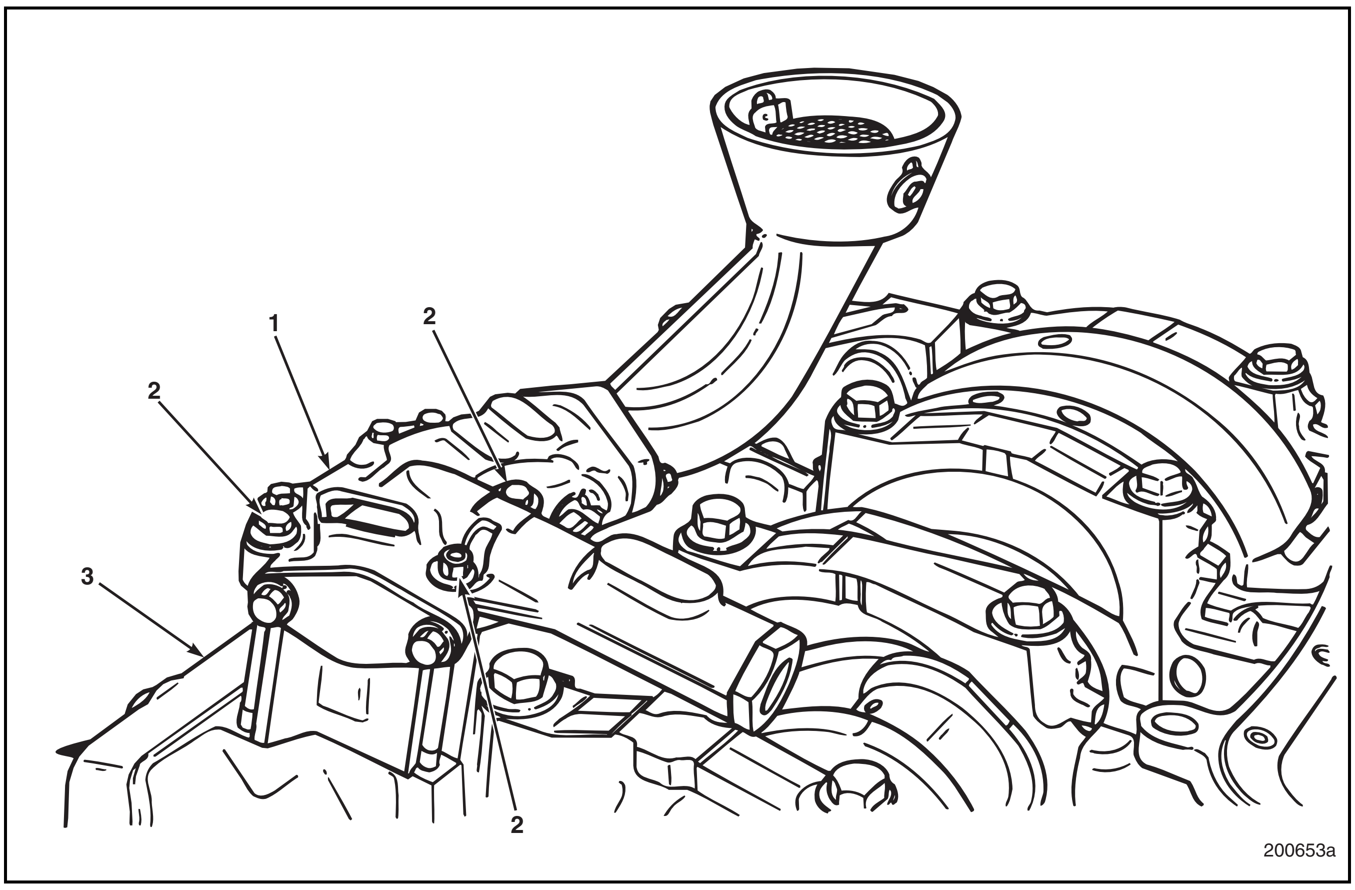


Figure 6-51 — Oil Pump Installation

1. Lubrication oil pump 2. Mounting capscrews	3. Cylinder block

CAUTION

Apply Loctite® 271 to all capscrews used to assemble the oil pump.

3. If the pump was disassembled and is now securely mounted in position, torque all capscrews on the pump as follows:
   — Plate, 15 lb-ft (20 N•m)
   — Sump, 35 lb-ft (47 N•m)
   — Relief valve cap, 80 lb-ft (108 N•m)
   — Housing cover, 15 lb-ft (20 N•m)

CAUTION

After the auxiliary driveshaft has been installed, check the backlash between the auxiliary driveshaft gear and the oil pump drive gear.

4. Check the oil pump drive gear to oil pump driven gear backlash, 0.0072–0.0138 inch (0.1829–0.3505 mm), using a thickness gauge between the auxiliary driveshaft gear and the oil pump drive gear.

[211 RP] TIMING GEAR COVER

With the crankshaft, camshaft and auxiliary driveshaft in place, install the timing gear cover. Remove the injection pump cover from the timing cover to allow access to the injection pump drive gear during injection pump installation.

NOTE

For all E7 engines that do not use the front timing boss, a new timing gear cover (No. 333GB5123M2) is available without the timing boss. The new timing gear cover has a reduced possibility of cracking. For E7 engines requiring front timing, the old timing gear cover (No. 333GB5123M) is still available.

1. Apply a light coat of Silastic to the timing-cover mounting surface.
2. Position the timing cover on the cylinder-block mounting surface.

NOTE

Some mounting capscrews cannot be installed until the injection pump is installed.

3. Secure the timing cover to the cylinder block using the mounting capscrews. Torque the capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
4. Position the front pedestal mount on the timing cover and secure with the mounting hardware. Torque the pedestal mounting capscrews to 70 lb-ft (95 N•m) using torque wrench J 24407 or equivalent.

[211 SB] TIMING GEAR COVER SEAL

Special Tool Required

- Crankshaft Front Seal Installer J 37715-A

Installation

Refer to Figure 6-52.

1. To install the lip-type seal, use crankshaft front seal installer J 37715-A. Position the seal on the tool, with the solid portion of the seal outward (toward the tool).
2. Position the tool over hub and into the seal opening.

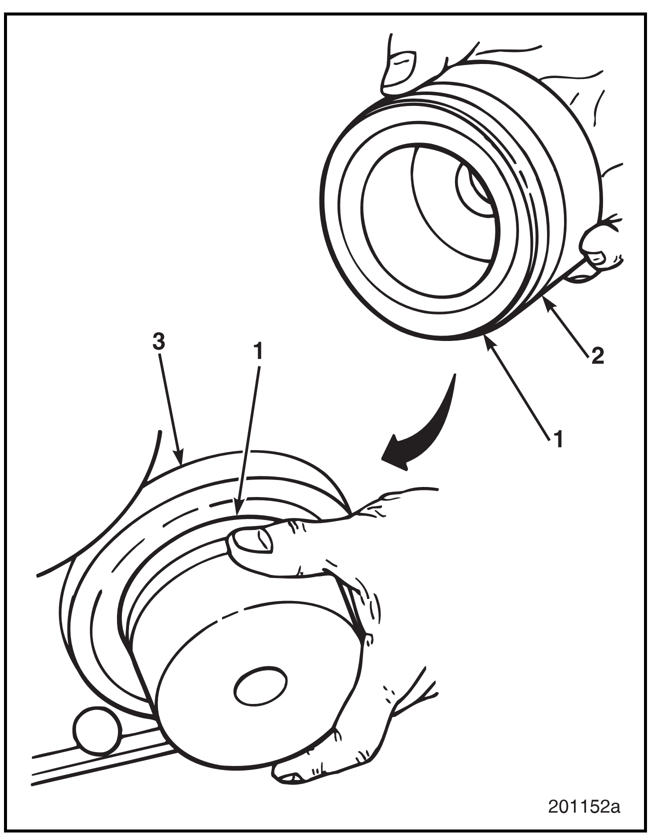


Figure 6-52 — Timing Gear Cover Seal Installation

1. Timing gear cover seal 2. Seal installer J 37715-A	3. Timing gear cover

3. Insert the hub capscrew into the hole in the seal installation tool and draw the seal in until the tool bottoms out on the face of the crankshaft.
4. Remove the tool and check the seal to make sure it has been evenly installed.

[221 GP] FUEL INJECTION PUMP INSTALLATION

Refer to SETUP AND ADJUSTMENTS section under Fuel Injection Fixed-Timing Procedures for pump installation procedure.

[212 RH] CRANKSHAFT HUB

Inspection

Inspect the crankshaft hub for scoring and condition of flange, threaded holes and keyway.

CAUTION

Replace the hub if the seal shows signs of wear. Mack Trucks, Inc. does not recommend the use of a service sleeve to repair the crankshaft hub when there is hub damage. When there is damage to the hub, replace it.

Installation

Refer to Figure 6-53.

1. Insert hub key in keyway of the crankshaft.
2. Using a suitable grease-type lubricant, coat the working surface of the seal in preparation for crankshaft hub installation.

NOTE

Teflon-type seals do not require greasing the seal working surface of the crankshaft hub.

3. Heat hub to approximately 250°F (121°C) prior to installation.
4. Using heat-resistant gloves, align keyway in the hub with key in the shaft.

NOTE

When engine has flywheel timing, the crankshaft hub will not have a keyway slot.

5. In a quick, even motion, push the hub onto to the crankshaft.
6. Install hub washer and capscrew. Tighten capscrew to 330 lb-ft (447 N•m) using torque wrench J 23775-01 or equivalent.

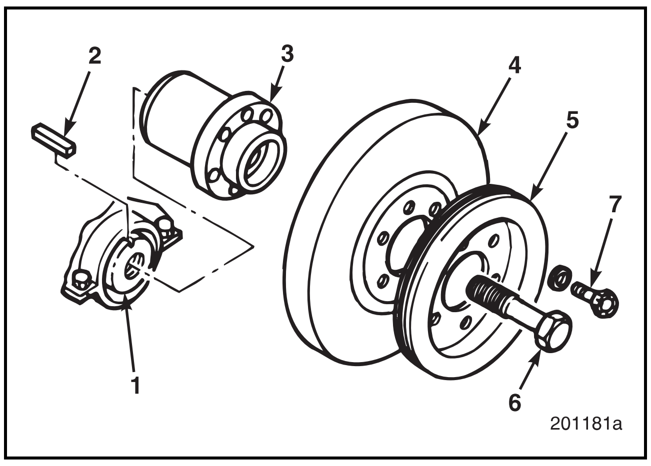


Figure 6-53 — Crankshaft Hub/Vibration Damper

1. Crankshaft 2. Key 3. Crankshaft hub 4. Vibration damper	5. Pulley 6. Hub capscrew 7. Damper/puller capscrews

[212 RB] VIBRATION DAMPER

Description

The vibration damper is mounted to the front of the engine crankshaft hub and secured with six capscrews. The viscous-type vibration damper consists of a flywheel (inertia mass) enclosed in a fluid-tight housing. The vibration damper flywheel and the housing are separated by a thin layer of viscous fluid that is not affected by temperature changes. Any movement of the inertia mass is resisted by the friction of the fluid, which tends to dampen excessive torsional vibrations in the crankshaft.

The vibration damper must be removed whenever the crankshaft front seal, timing gear cover or crankshaft are removed.

⚠ CAUTION

When removing or handling the vibration damper, be careful not to damage the housing. Any dents in the damper outer case may render the vibration damper ineffective. An ineffective vibration damper may result in crankshaft cracks. The vibration damper cannot be repaired.

Inspection

Inspect the vibration damper for dents, nicks or fluid leaks in the outer housing. If any of the above are evident, the vibration damper must be replaced. Due to the close clearances between the damper housing and its internal flywheel, dents or nicks may cause contact between the two components. Fluid loss will deteriorate the dampening effect of the damper.

Installation

1. Position the vibration damper and drive pulley on the crankshaft hub.
2. Secure with six mounting capscrews. Torque screws to 45 lb-ft (61 N•m).

[211 NB] OIL PAN

Description (Isolating Oil Pan Gasket on E7 Engines)

Reducing oil pan vibration is an important step in reducing engine noise and ensuring oil pan integrity, especially at the high power levels of today's engines. For this reason, the isolating oil pan gasket arrangement introduced early in 1994 will gradually be phased into all engine and chassis models.

Most noticeable among the changes in this arrangement are the use of a 1/4-inch (6.35 mm) thick rubber gasket and the elimination of the reinforcement strip on the pan rail and the belly bands on the oil pan. The thicker, more conformable isolating gasket will substantially improve sealing, especially over a long period of time.

Serviceability is also improved. When the oil pan is removed, unlike the fiber gasket, it is not necessary to scrape the gasket from the cylinder block and the oil pan. In fact, the new gasket, in most cases, can be reused.

Other changes include the use of new shouldered oil pan bolts which bottom on the cylinder block rather than the oil pan, and rubber isolators installed between the heads of the pan bolts and the oil pan. Together, these isolators and the isolating gasket eliminate metal-to-metal contact between the bolts and the oil pan, significantly reducing the amount of engine vibration transmitted to the pan.

The illustration below, Figure 6-54, shows both the fiber oil pan gasket arrangement and the new isolating gasket arrangement.

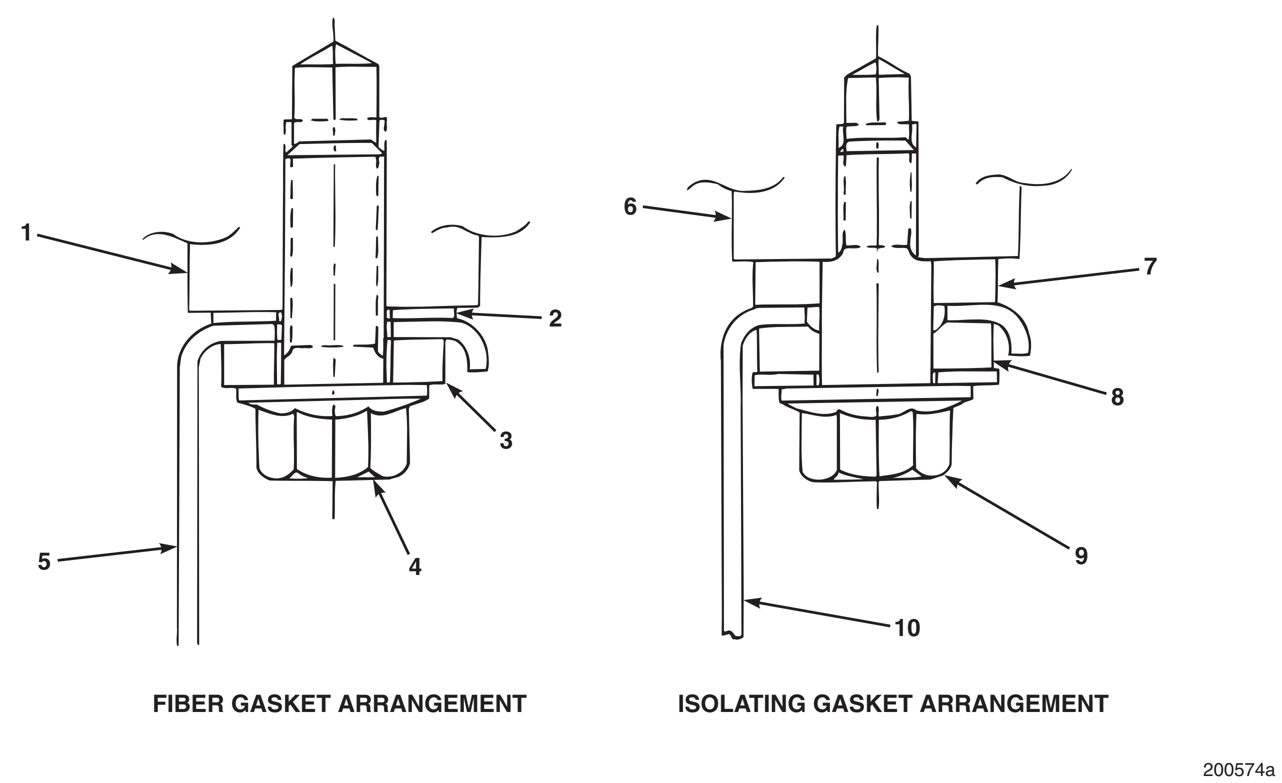


Figure 6-54 — Oil Pan Gasket Arrangements

1. Old cylinder block	6. New cylinder block
2. Fiber gasket	7. New thicker gasket
3. Steel reinforcement strip	8. Isolator
4. Flange head screw	9. New flanged bolt
5. Oil pan	10. Isolator oil pan

With the new isolating oil pan gasket arrangement, the mounting holes tapped into the cylinder block, timing gear cover, and flywheel housing are now 8 mm rather than 10 mm. The illustration below, Figure 6-55, shows the newer production arrangement.

NOTE

The fiber oil pan gasket can be used on engines with either 8-mm or 10-mm tapped mounting holes. The isolating oil pan gasket may only be used on cylinder blocks with 8-mm tapped holes.

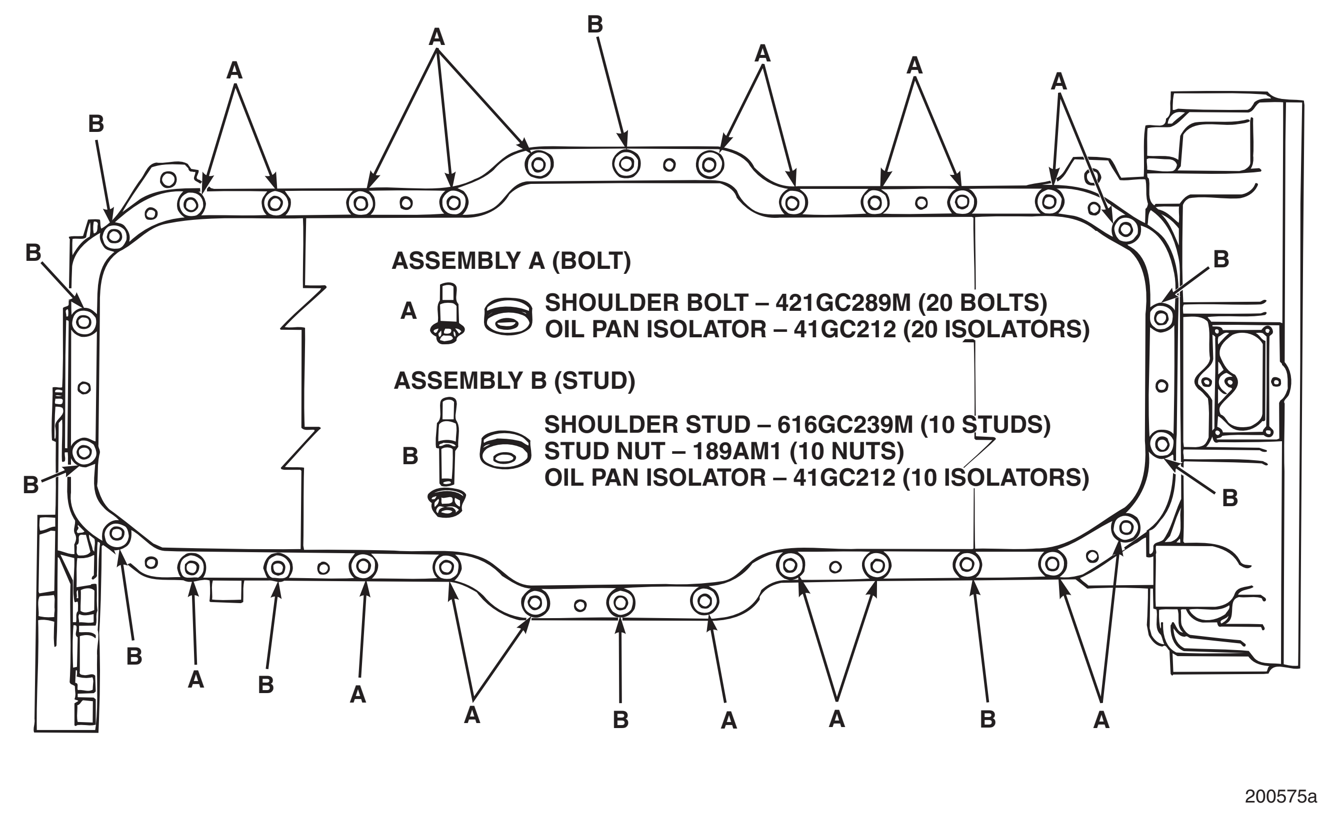


Figure 6-55 — Oil Pan Stud Identification

The isolating oil pan gasket contains 12 integral locating/retaining cones which lock into holes drilled through the oil pan rails, and two large rectangular tabs located directly across from each other on the inner perimeter of the gasket. The cones keep the gasket properly located during oil pan installation, and the rectangular tabs serve as a starting point for locating the gasket on the oil pan rail.

CAUTION

When servicing an E7 engine with an isolating oil pan arrangement, avoid using an engine stand that supports the engine on the oil pan rail while the oil pan is still installed. Damage to the oil pan, pan gasket or the isolators may result. If this type of stand must be used and the oil pan is to remain installed, support the engine on the pads provided at each corner of the cylinder block as shown in Figure 6-56.

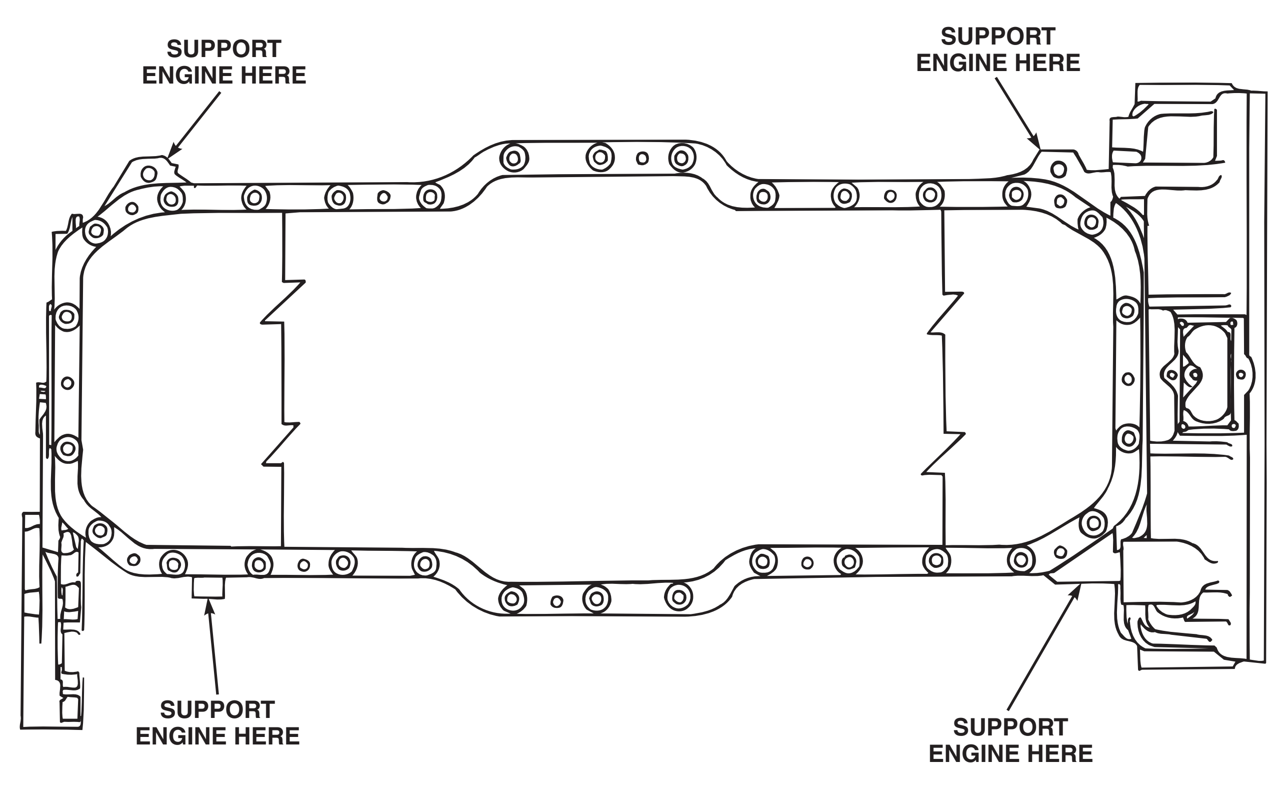


Figure 6-56 — Oil Pan Support Locations

Oil Pan Installation

1. Clean any oil from the cylinder block mounting surface and the oil pan rail. The oil pan must be installed dry.

CAUTION

Oil on the surface of the gasket or the rails of the cylinder block and oil pan during oil pan installation can cause the gasket to bulge out between any two bolts, particularly those at the mid-section corners. This condition may not occur immediately, but can do so at any time after installation. To avoid this occurrence, wipe any oil from the inner walls of the cylinder block crankcase and then clean the rails of the cylinder block and oil pan with a solvent such as lacquer thinner. Dry the cleaned surfaces completely.

2. Position the isolating oil pan gasket on the oil pan rails with ribbed side facing up.
3. Beginning at the center of the pan at one of the rectangular tabs, align rubber locating cones with corresponding holes in the oil pan rails.
4. In one motion, firmly press upper portion of the gasket with one hand while carefully pulling the rubber cone through the hole with the other hand until seated. Continue this procedure for the remaining locating cones.
5. After all cones have been installed, recheck to ensure they are all properly seated.

NOTE

During removal of the isolating oil pan from the engine, the studs may have backed out while loosening the stud nuts. Be sure they are fully seated prior to installing oil pan.

6. When installing oil pan onto the engine, center the pan before tightening fasteners so that the edges of the metal isolator washers do not touch the pan. Refer to Figure 6-57.

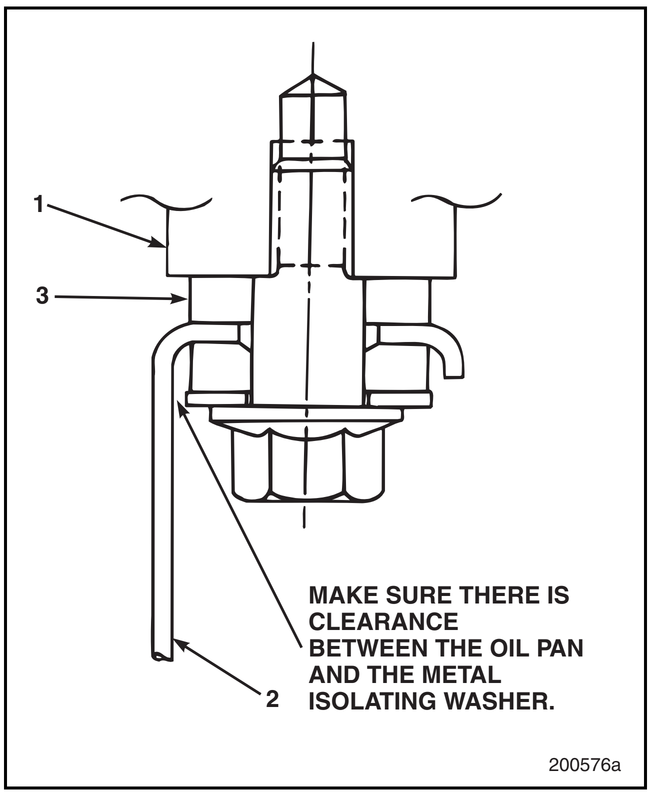


Figure 6-57 — Checking Clearance

1. Cylinder block 2. Oil pan	3. Rubber gasket

OIL PAN INSTALLATION WITH NEW E7 CYLINDER BLOCKS

Part numbers for E7 cylinder blocks with 8-mm tapped holes in the pan mounting rail are listed below. These are the service replacements for cylinder blocks with 10-mm tapped holes in the cylinder block oil pan rail.

- Cylinder Block Assembly No. 239GB5517M
- Cylinder Block Service Assembly No. 239GB5494C

With the introduction of these cylinder blocks, blocks with the 10-mm tapped holes in the cylinder block oil pan rail are no longer available.

NOTE

The isolating oil pan gasket arrangement can only be used with cylinder blocks, timing gear covers and flywheel housings that have 8-mm tapped holes in the oil pan rail.

OIL PAN INSTALLATION WITH NEW E7 TIMING GEAR COVER AND FLYWHEEL HOUSING

A new timing gear cover with 8-mm holes for oil pan mounting was introduced with the 1994 certified E7-427 and E7-454 engines. This timing cover is used in conjunction with the isolating oil pan arrangement, but is also the service replacement for timing covers with 10-mm tapped holes for oil pan mounting. The new style timing gear cover part No. is 333GB285AM.

New flywheel housings with 8-mm tapped holes for oil pan mounting were also introduced on engines with the isolating oil pan gasket. As with the timing gear cover, the new housings are service replacements for flywheel housings with 10-mm tapped holes for oil pan mounting.

Two types of 8-mm studs will be supplied with all new timing gear covers and flywheel housing service assemblies. One type of stud is used if the engine has a fiber oil pan gasket, and the other type is used for engines with the isolating oil pan gasket.

NOTE

When replacing a timing gear cover or a flywheel housing on an engine equipped with an isolating oil pan gasket, first remove the oil pan to prevent damaging the rubber isolating oil pan gasket.

To prevent damaging the threads in the aluminum timing gear cover and the aluminum flywheel housing, be sure to use the designated studs rather than capscrews.

- When servicing an old engine with 10-mm tapped holes in the oil pan mounting rail with a new cylinder block with 8-mm holes, reinstall the old oil pan and a new fiber oil pan gasket with 26 new 8-mm fasteners, No. 421GC293M, at the cylinder block and four 10-mm fasteners, No. 66AM4, at the timing gear cover and flywheel housing. Lubricate and torque fasteners No. 421GC293 to 24 lb-ft (33 N•m) using torque wrench J 24406 or equivalent.
- When servicing any engine with the fiber oil pan gasket (8-mm or 10-mm tapped holes in the cylinder block oil pan rail) and installing a new timing gear cover and/or a new flywheel housing, use the two standard studs, No. 107AM5019M, and two flange-head nuts, No. 191AM2, to attach the oil pan to the flywheel housing and/or the timing gear cover. Lubricate and torque stud nuts to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.
- When servicing any engine with the isolating oil pan gasket (8-mm tapped holes in the cylinder block oil pan rail), and installing a new timing gear cover and/or flywheel housing, use the two shouldered studs, No. 616GC239M, with two flange-head nuts, No. 189AM1, with which the engine was originally built. Lubricate and torque shoulder bolts to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.

[213 EV] CYLINDER HEADS

Description

Each cylinder head is a one-piece casting covering three cylinders and securely held to the top of the cylinder block by special-head bolts. The inlet and exhaust valves, fuel injection nozzles and the engine compression brake housing assemblies (if equipped) are located in the cylinder heads. Valve seat inserts and valve guides are replaceable.

Cast-iron sleeves pass through the coolant cavity of the cylinder head at the center of each cylinder. The fuel injection nozzle holder assemblies are installed in these sleeves. The sleeve design and installation provides effective cooling for the fuel injection nozzles, valves and cylinder head. This sleeve also provides a sealed passage for the nozzle return-to-tank fuel, which passes from the nozzle sleeve chamber into a drilled fuel return passage in the cylinder head and back to the fuel tank.

The air inlet, coolant and exhaust manifolds are secured to the cylinder heads. The fuel inlet lines also enter the engine at the cylinder heads.

Installation

Ensure that the cylinder heads are in acceptable condition. Refer to the cylinder head inspection procedures in the BENCH PROCEDURES section in this manual.

NOTE

All MACK head gaskets are precoated and do not require any type of additional sealing compound.

Refer to Figure 6-58.

1. Place the head gaskets in position on the locating pins in the cylinder block deck.
2. Place a fire ring carefully in position on top of each cylinder sleeve.

CAUTION

Check that the design of the fire ring used is the correct match for the cylinder sleeves installed. Refer to the TROUBLESHOOTING section for Proper Fire Ring/Cylinder Top Combinations.

3. Position the completely assembled cylinder heads on the cylinder block. Locate the heads into the guide pins in the cylinder block.

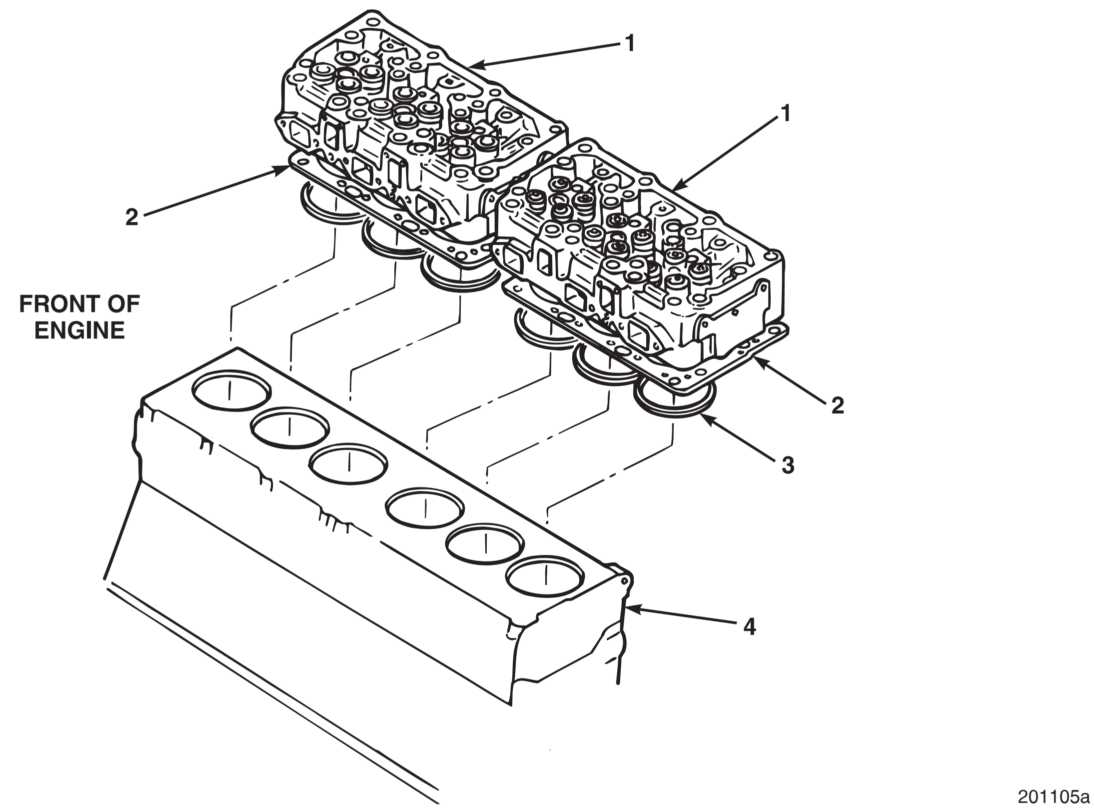


Figure 6-58 — Cylinder Head Gasket and Fire Ring Positioning

1. Cylinder head 2. Gasket	3. Fire ring 4. Cylinder block

NOTE

Several of the head mounting capscrews have threaded holes drilled in the heads for bracket-mounting purposes. The drilled capscrews must be located in the correct positions for proper bracket installation.

There are two cylinder-head capscrew lengths: 198.0 mm and 225.0 mm.

4. Check the condition of the capscrews, lubricate the capscrew heads (underside), threads and washers with clean engine oil, and insert the capscrews in the mounting holes. Tighten all cylinder head capscrews finger tight.

NOTE

Do not install painted capscrews at locations that are under the valve cover.

Refer to Figure 6-59.

5. Check the alignment of the cylinder heads by placing a straightedge against the exhaust manifold mounting surfaces. Using a feeler gauge, measure any gaps between the straightedge and manifold mounting surfaces. The heads should be in alignment within 0.005 inch (0.127 mm). If not, reposition the heads to achieve the specified alignment.

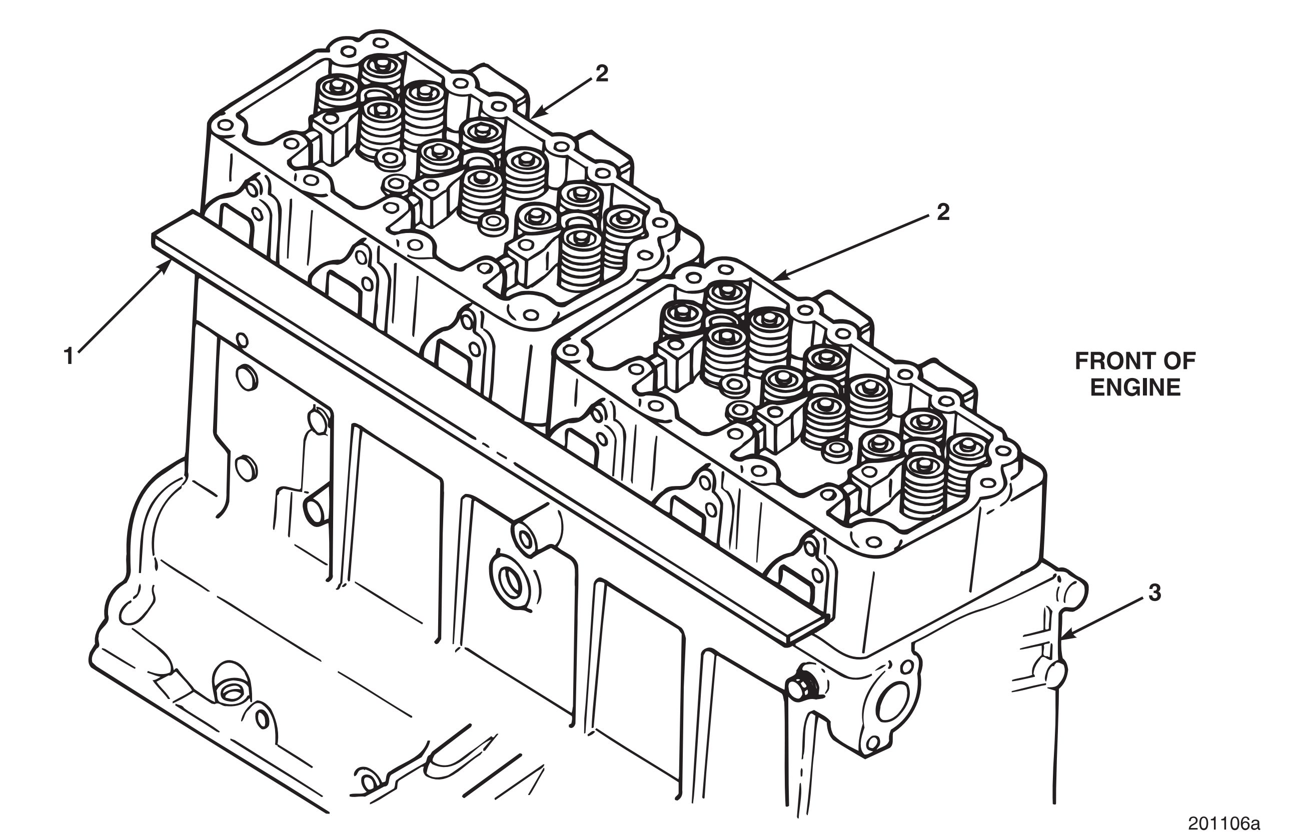


Figure 6-59 — Cylinder Head Alignment

1. Straightedge 2. Cylinder head	3. Cylinder block

Refer to Figure 6-60.

6. Torque all head mounting capscrews in three stages to the specified torque.
   a. Torque all head mounting capscrews in sequence to 50 lb-ft (68 N•m) using torque wrench J 24407 or equivalent.
   b. Torque all head mounting capscrews in sequence to 125 lb-ft (170 N•m) using torque wrench J 24407 or equivalent.
   c. Torque all head mounting capscrews in sequence to final torque value of 205 lb-ft (278 N•m) using torque wrench J 24407 or equivalent.
7. Perform the engine run-in procedure, bringing temperatures up to the normal operating range.
8. After completing the run-in procedure, retorque the cylinder head capscrews in sequence, breaking each loose one at a time and then bringing it up to the specified torque.

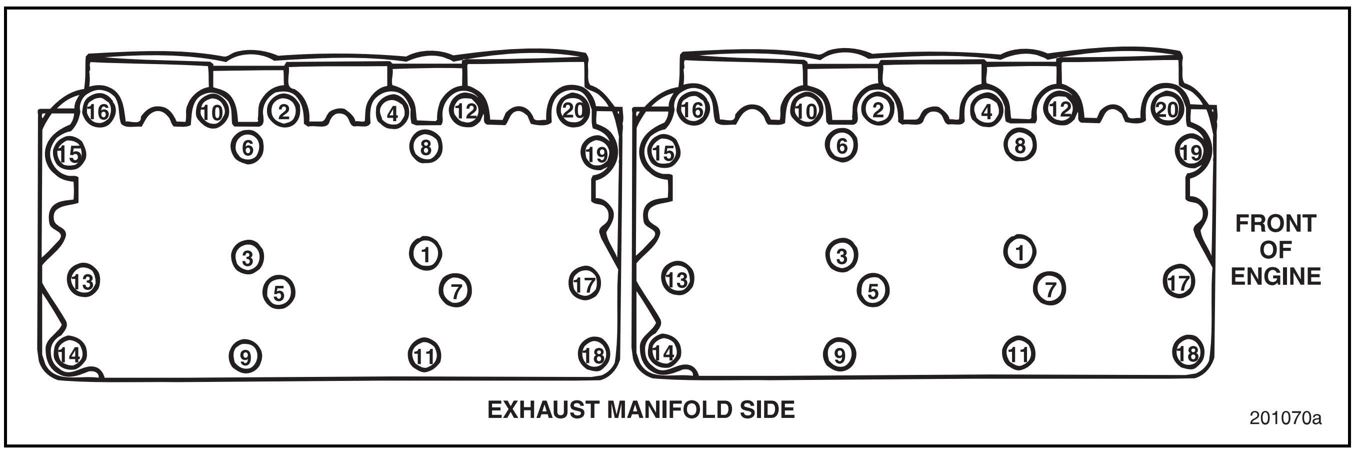


Figure 6-60 — Head Bolt Torque Sequence Chart

[222 KG] NOZZLE HOLDER ASSEMBLY

Description

Each cylinder has a nozzle to ensure proper delivery of fuel that is metered and timed by the injection pump. The nozzle is positioned at the lower end of the nozzle holder.

The nozzle holder is positioned vertically in the cylinder head and centered in the cylinder between the four valves. The nozzle fuel inlet tube is inserted through the side of the cylinder head and the tapered end of the inlet tube seals the area between the tube and the nozzle holder. The tube is secured in position with a sleeve nut.

Special Tool Required

- Injection Nozzle Puller J 37093

Installation

1. Insert a nozzle holder gasket in the bottom of the nozzle holder hole. Refer to Figure 6-61. Make sure the washer-type gasket is lying flat in the bottom of the nozzle holder bore.

N O T E

An alternate method of installing the washer-type gasket is to hold it in place on the bottom of the nozzle with a small dab of grease instead of placing the washer in the hole.

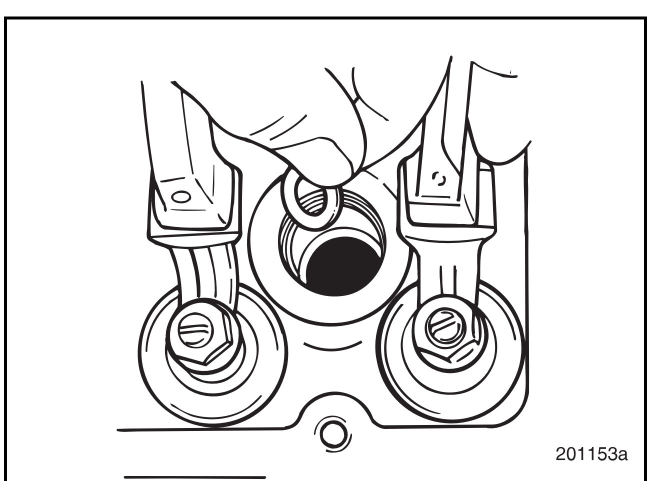


Figure 6-61 — Nozzle Holder Gasket Installation

2. Lubricate the nozzle holder surface and install O-ring on the nozzle holder.
3. Thread injection nozzle puller J 37093 into the top of nozzle holder. Refer to Figure 6-62.

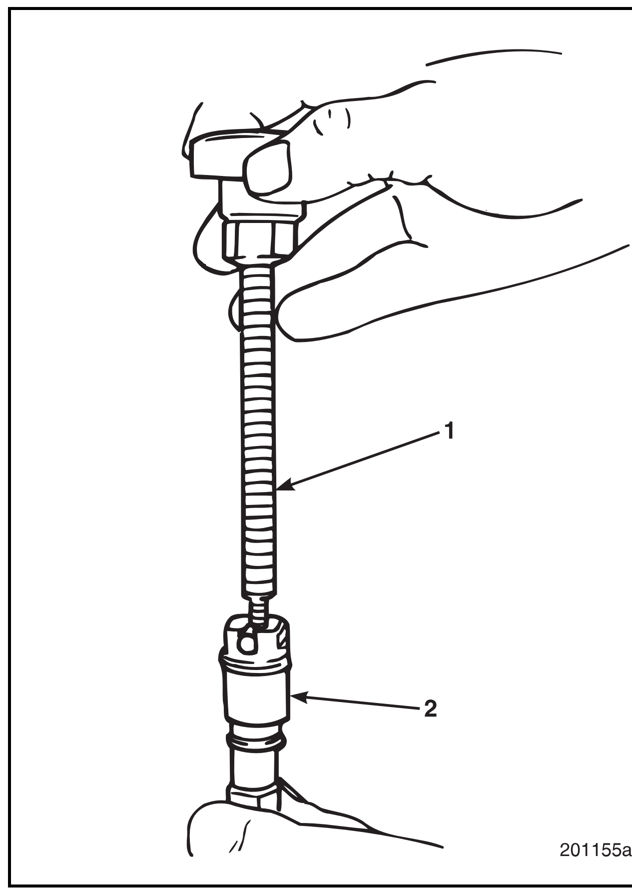


Figure 6-62 — Puller Application

1. Nozzle holder puller J 37093	2. Nozzle holder

4. Insert nozzle holder in the nozzle holder hole. Be sure to align the locator ball in the nozzle holder with the socket in the cylinder head to ensure inlet tube alignment. Refer to Figure 6-63.

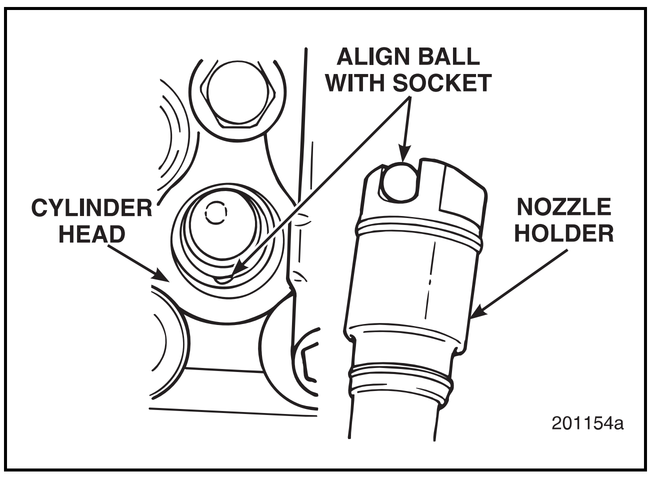


Figure 6-63 — Nozzle Holder Alignment

5. After making sure that the nozzle holder ball is properly aligned with the alignment socket in the cylinder head, push downward on the handle of the installation tool driving the nozzle holder into position. Refer to Figure 6-64.

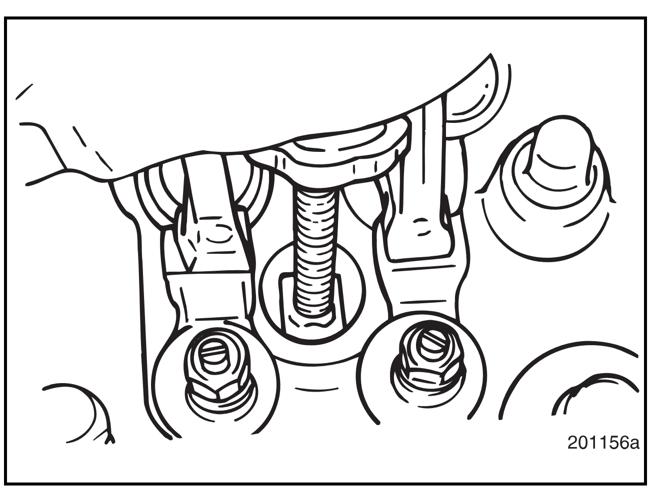


Figure 6-64 — Nozzle Holder Installation

6. Remove the tool from the nozzle holder and insert the gauge block on the end of the tool handle.
7. Insert the gauge block into the nozzle holder hole. The gauge block should be flush with the top of the cylinder head surface. Refer to Figure 6-65.
   - If the gauge block is below level, it may indicate that the gasket was omitted.
   - If the gauge block is too high, it may indicate that there are two gaskets installed under the nozzle holder, or the nozzle holder has not been fully inserted.
   - If a gauge block is not available, measure the distance from the top of the cylinder head to the top of the nozzle holder. The nominal measurement should be 0.564 inch (14.326 mm).

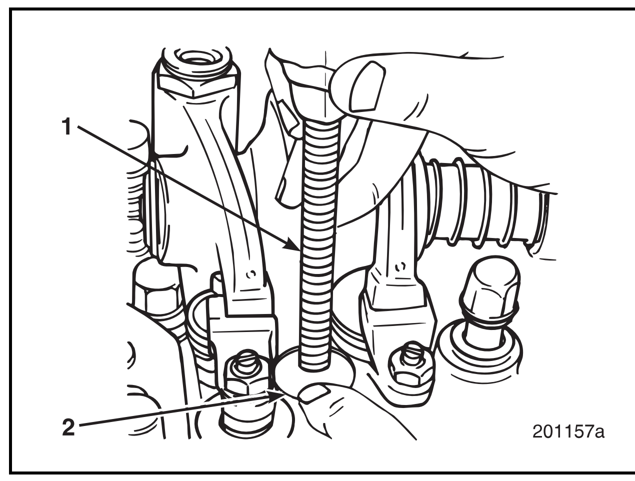


Figure 6-65 — Nozzle Holder Installation Check

1. Nozzle holder puller J 37093	2. Gauge block

8. Lubricate the threads of the retaining plug and install in position. Torque to 45 lb-ft (61 N•m) using torque wrench J 24407 or equivalent. Refer to Figure 6-66.

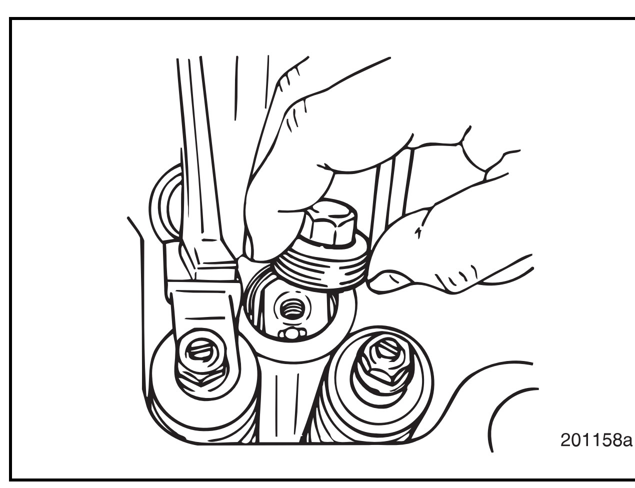


Figure 6-66 — Retaining Plug Installation

[213 LH] VALVE LIFTER PUSH RODS

Inspection

Check the push rods. Replace any push rods that have loose ends, are bent, or show signs of excessive wear.

Identification

Refer to Figure 6-67.

The current E7 valve lifter has no hole in the center of the stem. In conjunction with this change, the E7 inlet and exhaust (nonbrake engine) push rods have a 0.060-inch (1.524 mm) maximum flat or dimple on the ball end. The push rod part number is etched or roll-stamped on the push rod.

The non-current push rod should be used only with the non-current lifter. If the non-current push rod with the wide flat or dimple is used in the current valve lifter which has no center hole, it may create an undesirable wear pattern in the lifter socket.

Mixing current and non-current valve lifters is permissible when using the correct lifter/push rod combination.

- Current push rod can be used with either valve lifter.
- Do not use non-current valve lifter to service current valve lifter.

Only Dynatard exhaust push rods are not affected and can be used with current and non-current valve lifters. Dynatard intake push rods still need to be updated to current push rods when using current valve lifters.

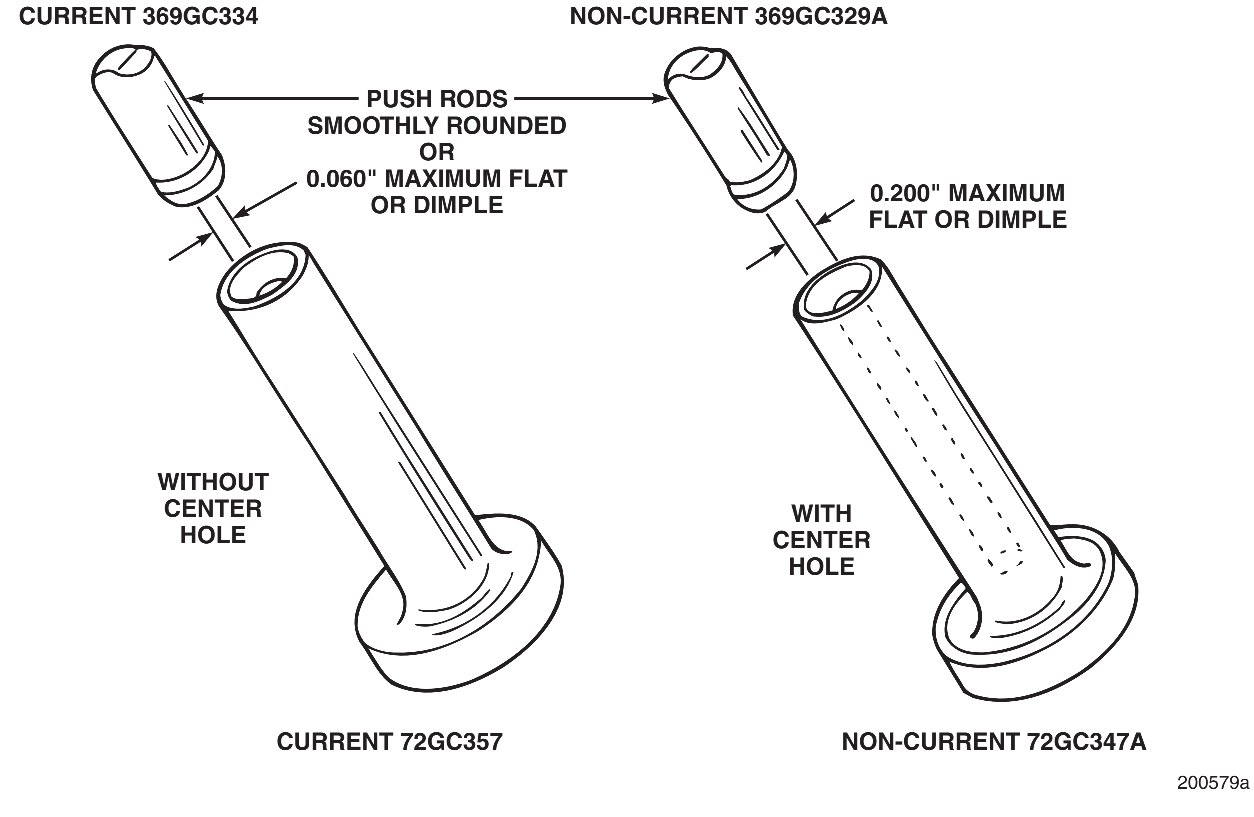


Figure 6-67 — Valve Lifter/Push Rod Identification

All E7 production engines starting with serial No. 2X0000 and above, feature valve lifters with no hole as well as inlet and nonbrake push rods with 0.060 inch (1.524 mm) maximum flat or dimple on the push rod ball end.

Installation

NOTE

Used push rods have established wear patterns. Push rods being returned to service should be installed in the same position from which they were removed.

1. Apply lubricating oil to spherical end of the push rod and insert it into the lifter opening. Ensure that it has engaged the lifter by lifting it slightly. If the lifter has been properly contacted, some resistance will be felt in the rod as the lifter is raised.
2. Repeat step 1 until all 12 push rods are in position.

[213 NV] VALVE YOKES

Description

There are two exhaust valves and two inlet valves for each cylinder. Each rocker arm, in conjunction with the valve yoke, operates both valves together, in a set (exhaust or inlet), per cylinder.

Installation

NOTE

Used yokes have established wear patterns. Yokes being returned to service should be installed in the same position from which they were removed.

Refer to Figure 6-68.

1. Lubricate the yoke guide pins (5) with clean engine oil.

CAUTION

If the engine is equipped with a Jake Brake, the exhaust valve yokes will have a larger rocker arm contact surface. The yokes with the larger surface must be installed on pins corresponding with the Jake Brake actuators.

2. Place the valve yokes (2) on the yoke guide pins from which they were removed. Slightly rock the yokes from side to side to be sure they are seated on the valve stems (4).

NOTE

Engines equipped with Jake Brake: Effective January 1994 (engine serial No. 401269), the E7 Jake Brake yoke was manufactured with metric threads utilizing the Spiralock™ thread form. Refer to Section 7, SETUP AND ADJUSTMENTS, under Valve Yoke, Valve Lash and Slave Piston Adjustments (with Jake Brake) for details regarding correct method to loosen the yoke adjusting screw.

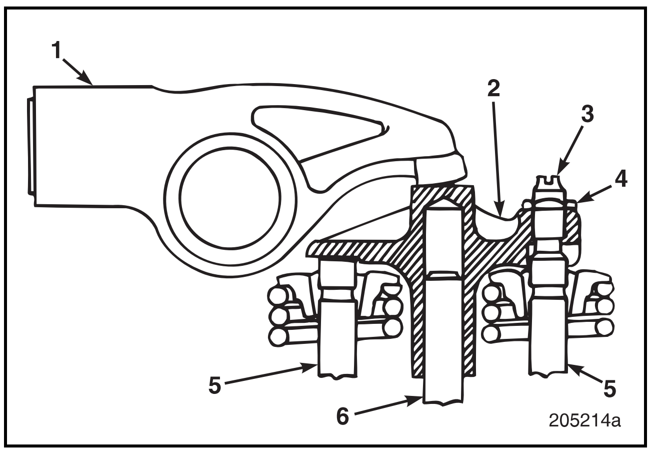


Figure 6-68 — Valve Yoke

1. Rocker arm	4. Jam nut
2. Valve yoke	5. Valve stem
3. Yoke adjusting screw	6. Yoke guide pin

[213 LP] ROCKER ARMS

Description

The valve rockers pivot on a shaft supported by three brackets per cylinder head. Two capscrews secure each bracket to the cylinder head. The rocker arms are operated by a camshaft through valve lifters and push rods extending through the cylinder heads. A coil spring returns each valve to the closed position, holding the rocker arm in contact with the push rod.

Installation (Non-Brake and Dynatard Equipped Engines)

Refer to Figure 6-69.

1. Position the rocker arm assemblies on the cylinder heads.
2. Ensure that the ball end of the rocker arm adjusters are in position in the push rod cups.

CAUTION

Make sure that adjusting screws are retracted upward in the rocker arms. If extended far below rocker arm, the push rods can be bent when tightening the rocker arm assembly brackets.

3. Lubricate the threads of the rocker arm mounting capscrews with clean engine oil. Install the capscrews and torque to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
4. Adjust valve and engine brake slave piston lash settings as applicable. Refer to the SETUP AND ADJUSTMENTS section in this manual for correct specification.

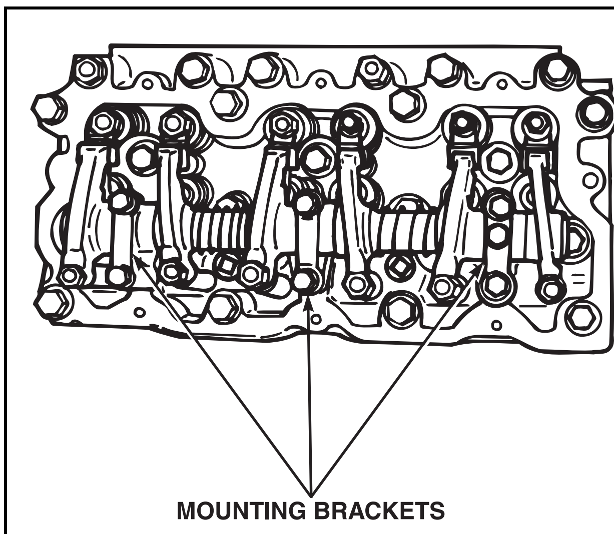


Figure 6-69 — Valve Rocker Arm Installation

Installation (Jake Brake-Equipped Engines)

CAUTION

Use only Jacobs exhaust rocker arm adjusting screws for Jacobs engine brake installation. Using a MACK or any other type of screw will result in severe screw wear and engine damage.

Jacobs exhaust rocker screws have hex heads. MACK screws have a screwdriver slot.

Refer to Figure 6-70.

Verify that Jacobs exhaust rocker arm adjusting screws are installed in the exhaust rocker arms.

Turn the screws all the way into the rocker arms from the underside. Install the MACK locknuts.

1. Install the rocker arm assemblies. Apply clean engine oil to the MACK hold-down capscrews. Install one capscrew with a washer in each bracket next to the push rods. Each rocker assembly has three brackets.

2. Check that all push rods are in their sockets and rocker adjusting screws are backed out to prevent piston damage or bent rods.
3. Start at the center and tighten each bracket hold-down screw in two steps:
   - Torque to 20 lb-ft (27 N•m).
   - Retorque to 40 lb-ft (54 N•m).
4. Lubricate and install O-rings in the groove in the Jacobs oil supply screws. Install the screws into the rocker brackets and tighten to 5 lb-ft (7 N•m).

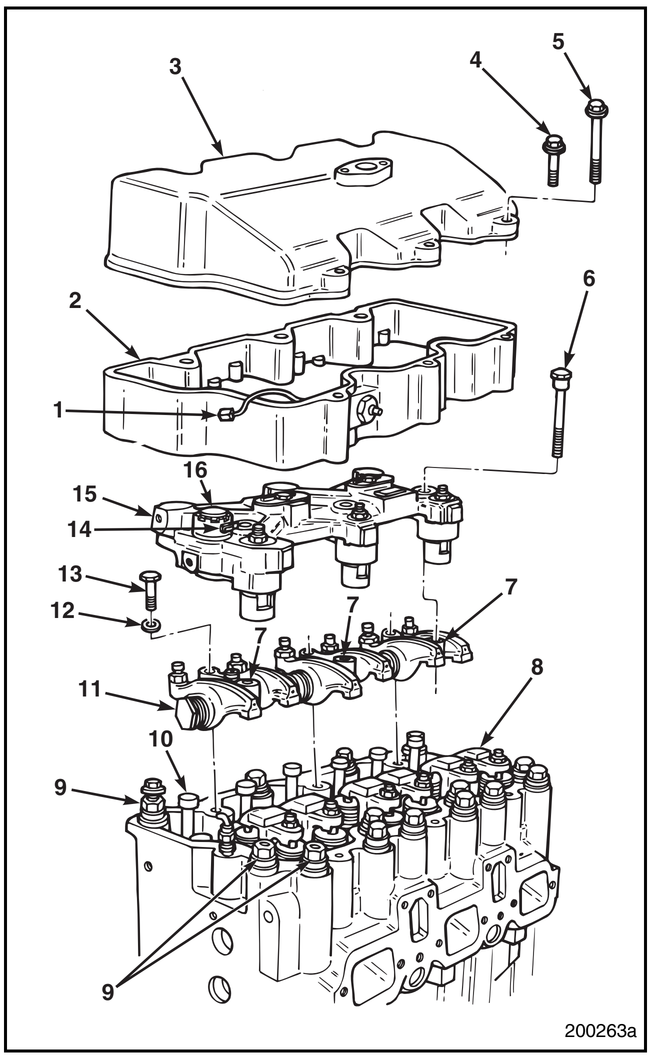


Figure 6-70 — Valve Rocker Arm Installation (with Jake Brake)

1. Wire connector 2. Riser 3. Valve cover 4. Short capscrew 5. Long capscrew 6. Actuator capscrew 7. Rocker arm shaft bracket 8. Valve yoke	9. Head bolt with threaded hole 10. Push rod 11. Rocker arm assembly 12. Washer 13. Capscrew 14. Connector 15. Actuator assembly 16. Actuator solenoid

Brake Housing Installation

Refer back to Figure 6-70.

1. Lubricate the oil supply screw O-rings with clean engine oil.
2. Place the engine brake housing in position on the rocker arm shaft brackets. Be sure the housing marked FRONT is over cylinders 1, 2 and 3, and the housing marked REAR is over cylinders 4, 5 and 6. Position the housings so that the oil supply bores are located over the oil supply screws. Carefully push the housings down until the O-rings enter the bores and the housings rest flat against the rocker-arm shaft brackets.
3. Lubricate all six Jacobs hold-down capscrews with clean engine oil and install them through the housings and into the rocker shaft brackets.
4. Start with the center capscrew on each housing and tighten them to 20 lb-ft (27 N•m). Retorque each, starting with the center capscrew, to 45 lb-ft (61 N•m) using torque wrench J 24407 or equivalent.
5. Check for interference between rocker arm and slave piston by manually moving each rocker arm with the valves closed. Be sure to check all cylinders. If binding occurs, loosen the capscrews and reposition the housing.
6. Connect wiring to Jake actuator solenoid.
7. Adjust yoke, valve and Jake brake slave piston lash as needed. Refer to the SETUP AND ADJUSTMENTS section in this manual for correct specifications and procedures.

[213 JB] VALVE COVER

Description

Valve cover mounting capscrews have undergone a manufacturing change. The existing mounting capscrews require two different sockets for cover installation. The new capscrews require only one socket. Note the capscrews used on your engine and replace with the same capscrews, if required.

Cylinder head cover (No. 337GB494M2) used on E7, CH 4 x 2 models with Jake Brake and air conditioning, contacts the air-conditioning expansion valve (mounted on the cab fire wall) during articulation. To eliminate this engine/cab interference condition, a new rear cylinder head cover (No. 337GB4108M) is available.

NOTE

The valve cover (and riser, if equipped with Jake Brake, Figure 6-73) requires a strip-type seal valve cover gasket, 51 inches (130 cm) in length.

Sealing compounds are not necessary.

Installation

Refer to Figure 6-71.

NOTE

Installation procedures for riser and valve cover seal are identical.

1. Install a seal strip (2) in the seal grooves (3) of the risers.
   a. Thoroughly clean the gasket contact surface.
   b. Install one end of riser gasket into seal groove (inboard side) approximately 1/4 inch (6.4 mm) from the end of the groove.
   c. Guide the seal strip into the groove around the circumference of the riser. Complete installation and overlap at the starting point approximately 1/4 inch (6.4 mm) from the end of the groove.

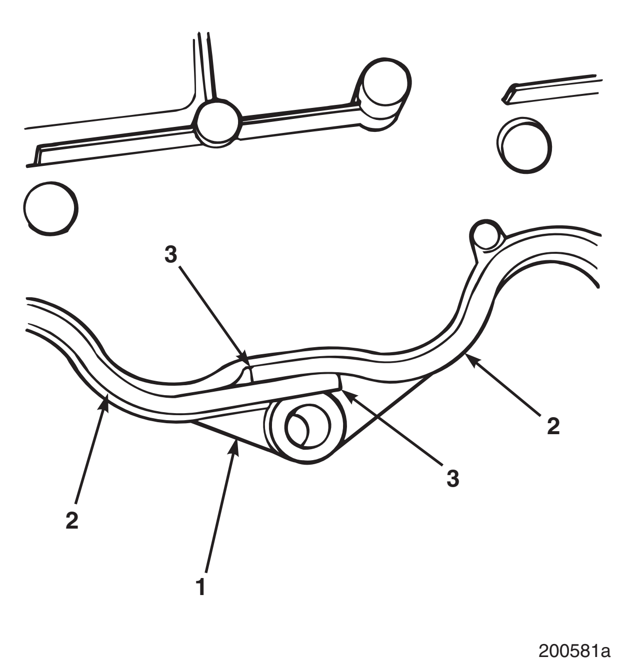


Figure 6-71 — Gasket Installation

1. Valve cover 2. Seal strip	3. Seal groove

Refer to Figure 6-72.

2. Position the riser (4) on the cylinder heads.
3. Connect the actuator wire to the actuator (3).
4. Install a seal strip in the valve cover seal groove of the valve covers.
   a. Thoroughly clean the gasket contact surface.
   b. Install one end of valve cover gasket into seal groove (inboard side) approximately 1/4 inch (6.4 mm) from the end of the groove.
   c. Guide the seal strip into the groove around the circumference of the valve cover. Complete installation and overlap at the starting point approximately 1/4 inch (6.4 mm) from the end of the groove.
5. Position valve covers (1) on the cylinder heads or on the risers (4), if equipped.

6. Lubricate threads of the capscrews (2) and secure the valve covers with the lubricated capscrews. Torque capscrews to 16 lb-ft (22 N•m).

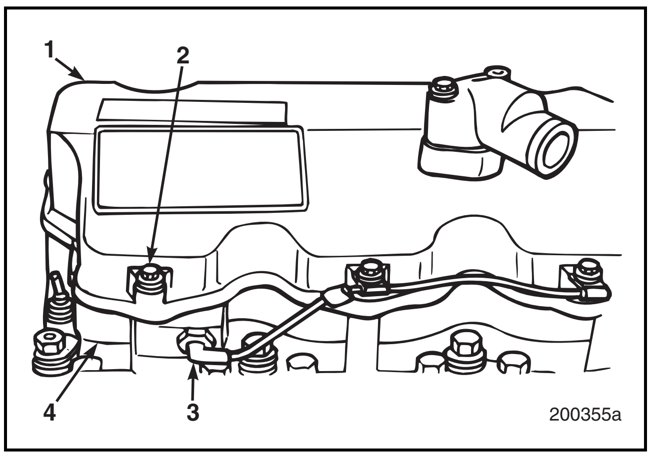


Figure 6-72 — Valve Cover Installation

1. Valve cover 2. Capscrew	3. Actuator 4. Riser

[214 EG] EXHAUST MANIFOLD

Description

In March 1995, a new exhaust manifold with a thicker mounting flange was introduced into production on all E7 engines. The mounting flange on this new “low-boss” exhaust is 3/4 inch (19.1 mm) thick, compared to the 1/2-inch (12.7 mm) thick mounting flange on the previous exhaust manifolds. The new manifolds use mounting studs which are 60 mm (approximately 2-3/8 inches) long, and copper-plated flanged nuts without a locking feature.

E7 engines use a new-style exhaust manifold gasket without the stainless steel insert around the exhaust port opening as on previous gaskets. Engines with the older style exhaust manifolds must continue using the previously used “armored” exhaust manifold gasket.

NOTE

If replacing an existing manifold (on engines manufactured before March 1995) with a low-boss exhaust manifold and reusing the long studs (103 mm long), each stud requires a spacer.

When installing a low-boss exhaust manifold on a pre-1992-1/2 E7 V-MAC engine with injection line brackets fastened to the exhaust manifold, spacer and 113 mm studs are required.

The new manifold fastener arrangements do not require washers or lockplates. When installing new fasteners on an engine that uses washers and lockplates, discard those parts and replace both with the new fasteners.

Installation

Refer to Figure 6-73.

1. Install the 12 studs in position on the cylinder head.
2. Position six manifold gaskets on the studs.

NOTE

Exhaust manifold nuts must be installed dry (no lubrication).

3. Position the exhaust manifold on the mounting studs and secure with nuts. Torque the nuts to:
   - 55 lb-ft (75 N•m) for 10 mm nuts
   - 65 lb-ft (88 N•m) for 12 mm nuts

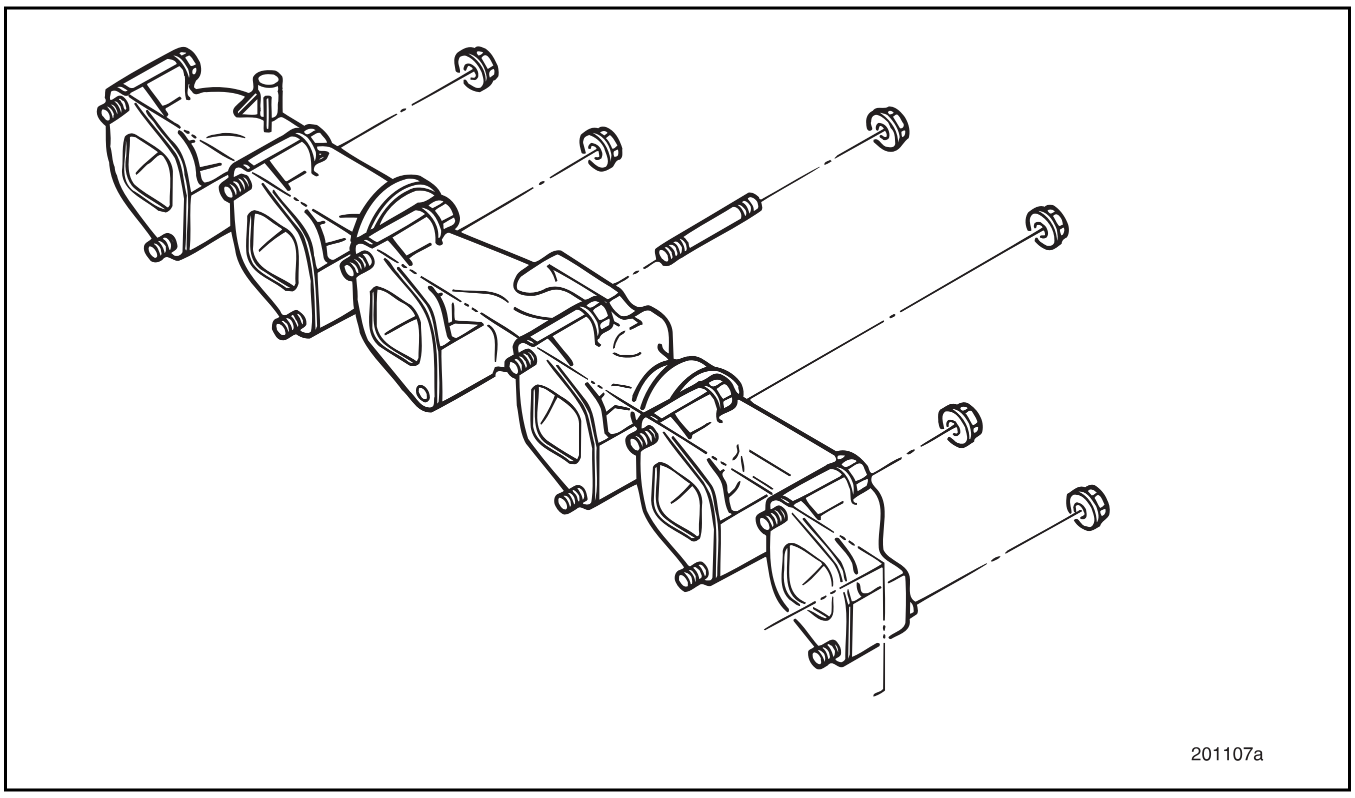


Figure 6-73 — Typical Exhaust Manifold Installation

[215 NK] COOLANT MANIFOLD

Inspection

Check the coolant manifold sections for restrictions, cracks and flange wear. The manifold cannot be repaired. Replace if any signs of damage are present.

Installation

Refer to Figure 6-74.

1. Ensure that the front coolant manifold section (1) is clean. Position a coolant/air inlet manifold gasket on the mounting surface.
2. Lubricate threads of the capscrews (5) with clean engine oil and secure front coolant manifold section with the mounting capscrews.
3. Place couple (2) in position on the couple mounting flange. Place two clamps (3) over the couple.
4. Insert the rear manifold section (4) in the couple.
5. Place a gasket between the mounting surfaces of the rear manifold section and the cylinder head.
6. Lubricate threads of the mounting capscrews (5) and secure the rear manifold section with the mounting capscrews.
7. Torque all mounting capscrews to 25 lb-ft (34 N•m) using torque wrench J 24406 or equivalent.
8. Ensure that the couple is properly installed and secure it in position with the clamps. Tighten the clamps to 38 lb-in (4.3 N•m).

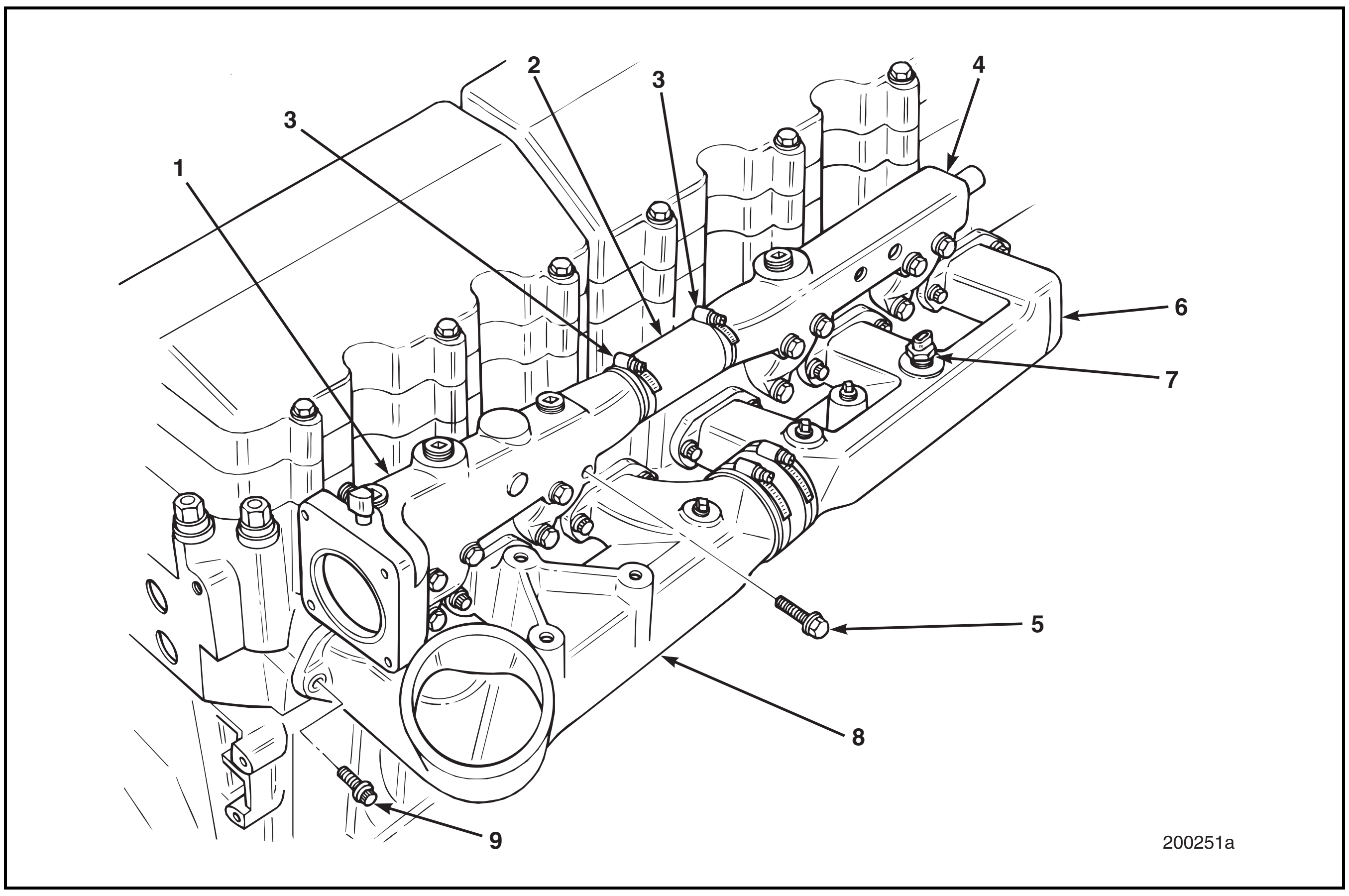


Figure 6-74 — Coolant and Air Inlet Manifold Installation

1. Coolant manifold, front section 2. Couple 3. Clamp 4. Coolant manifold, rear section 5. Capscrew	6. Air inlet manifold, rear section 7. Inlet air temperature sensor (sending unit) 8. Air inlet manifold, front section 9. Capscrew, 12-point

[261 CK] AIR COMPRESSOR

Installation

Refer to Figure 6-75.

1. Install a new gasket on the air compressor mounting flange.
2. Check to ensure that the lubrication oil supply tube (2) is in place and position the air compressor (1) on the mounting flange.

CAUTION

If the oil supply tube is lost, the air compressor will fail from lack of oil.

3. Install the three mounting capscrews (5) and torque to 70 lb-ft (95 N•m) using torque wrench J 24407 or equivalent.
4. Reconnect the coolant lines to the air compressor cylinder head.

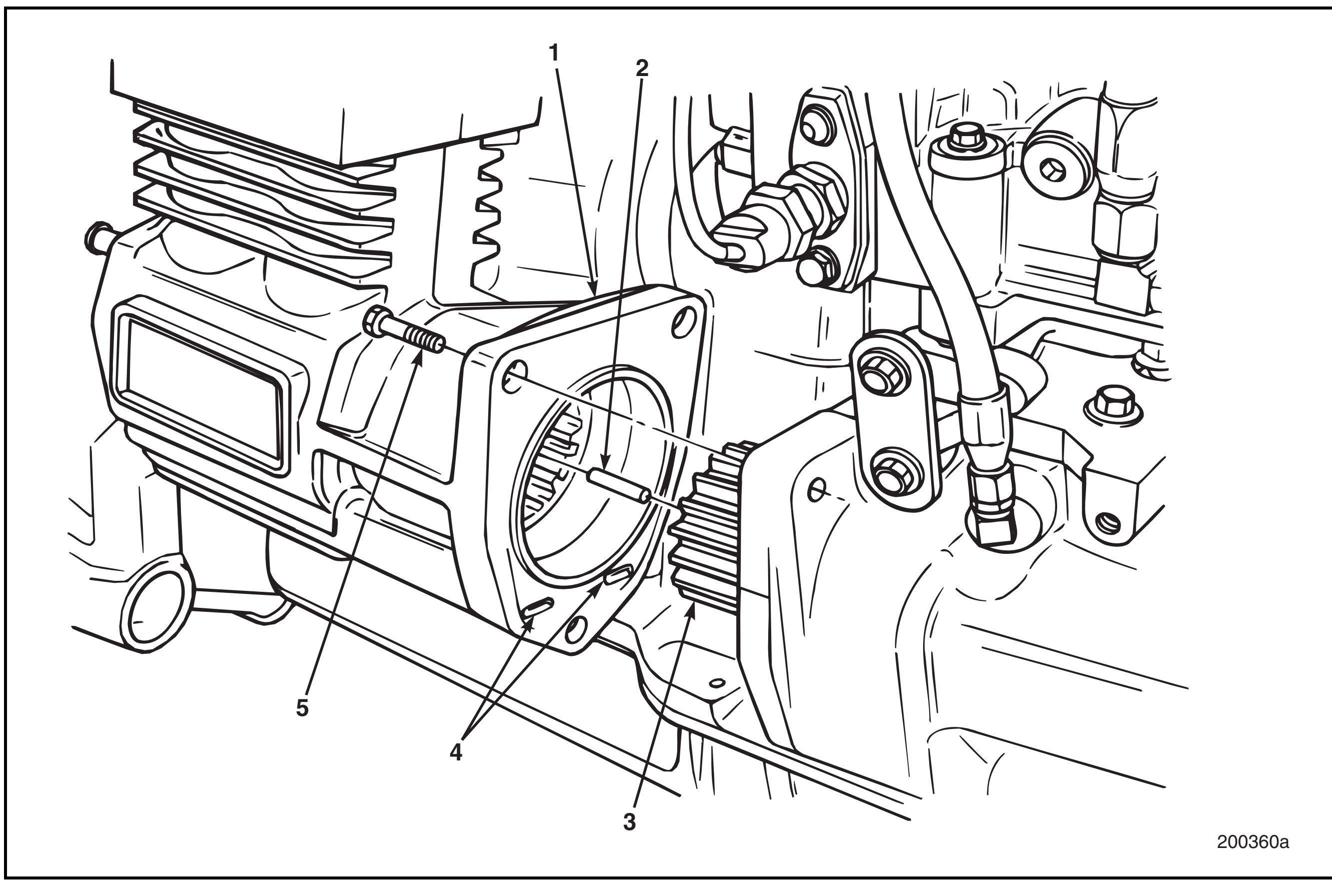


Figure 6-75 — Air Compressor Installation

1. Air compressor 2. Oil supply 3. Auxiliary driveshaft	4. Oil drain openings 5. Capscrew

[221 CD] ECONOVANCE

Installation

Refer to Figure 6-76.

1. Lubricate with clean engine oil and then install O-ring in groove on front of Econovance assembly (5).
2. Position the Econovance assembly (5) on the mounting surface of the engine front flange. You may have to rotate the Econovance shaft to clear the camshaft gear.
3. Install the four capscrews (4) securing the assembly to the front flange. Torque to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent. Check for binding.
4. Slide the drive coupling (3) into the splines (6) of the shaft (pre-1992 style shown).
5. Install the fuel injection pump adapter (2) and gasket (not shown) on the Econovance housing (5). Torque the mounting capscrews (1) to 40 lb-ft (54 N•m).

NOTE

For installation of the fuel injection pump drive gear, refer to Injection Pump Fixed-Timing procedure found in the SETUP AND ADJUSTMENTS section.

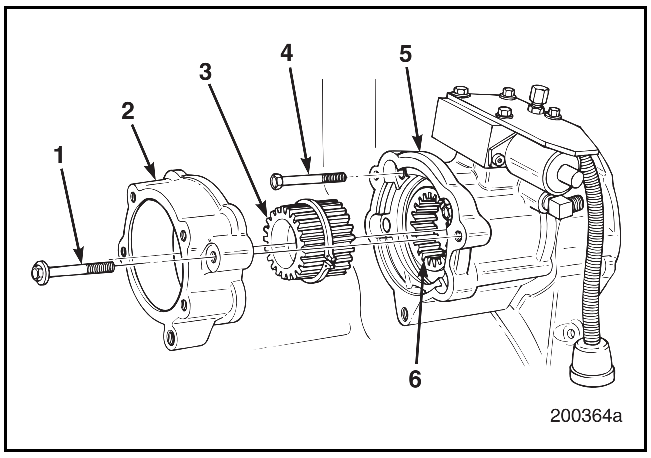


Figure 6-76 — Econovance Housing Installation (Pre-1992 Style Shown)

1. Mounting capscrew 2. Injection pump adapter 3. Drive coupling	4. Capscrew 5. Econovance 6. Splines

[221 GP] FUEL INJECTION PUMP

Installation

This procedure is described and illustrated with pump-to-Econovance adapter installed on pump.

To install the fuel injection pump:

1. Install two J 39732 alignment dowels in the Econovance housing. Install a new injection pump adapter housing to Econovance gasket over the alignment dowels.

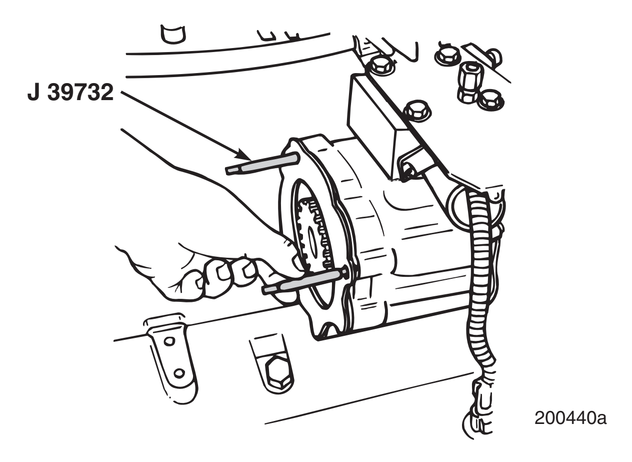


Figure 6-77 — Installing Alignment Dowels

NOTE

Install the outer coupling on the Econovance mating gear prior to fuel injection pump installation. This will prevent the outer coupling from dropping off if installed on the pump prior to installation.

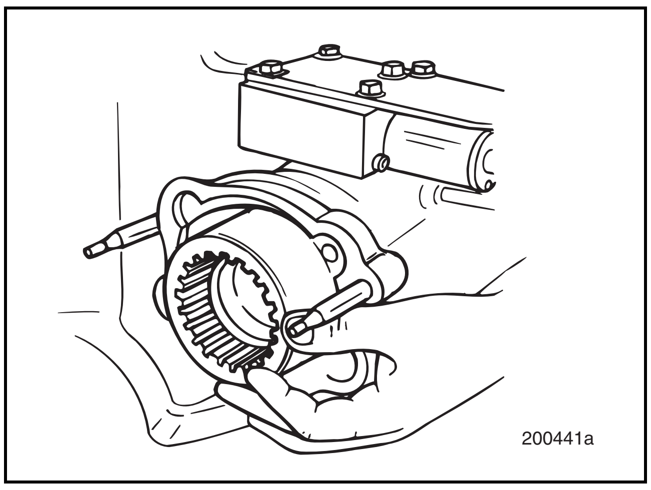


Figure 6-78 — Installing Outer Coupling

2. Loosen the three injection pump rear support bracket-to-cylinder block capscrews. Then hand tighten the capscrews until snug, and loosen 1/4 turn. The lower support bracket should move freely from side to side.

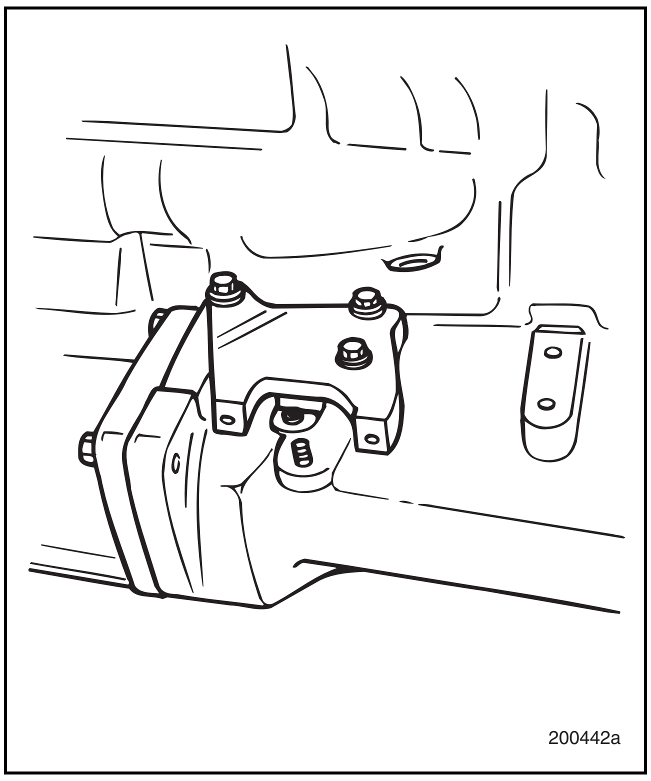


Figure 6-79 — Lower Support Bracket Adjustment

3. Loosen the two upper support bracket-to-fuel injection pump capscrews.

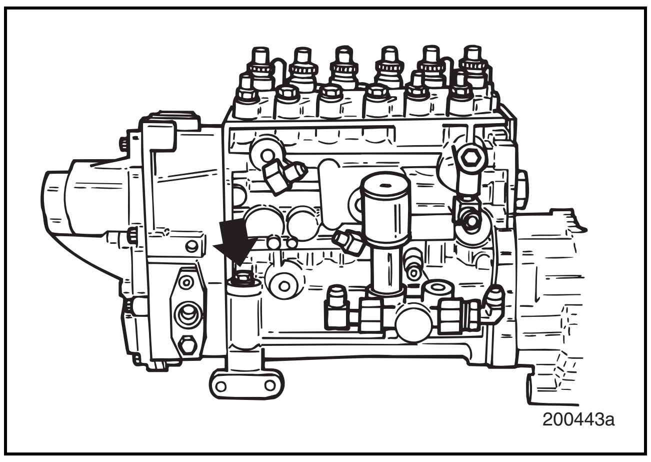


Figure 6-80 — Outer Upper Support Capscrew

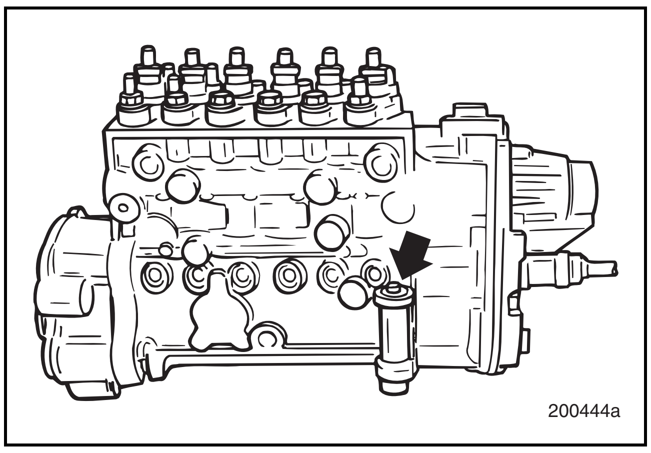


Figure 6-81 — Inner Upper Support Capscrew

4. Align and slide the fuel injection pump and adapter over the two alignment dowels.

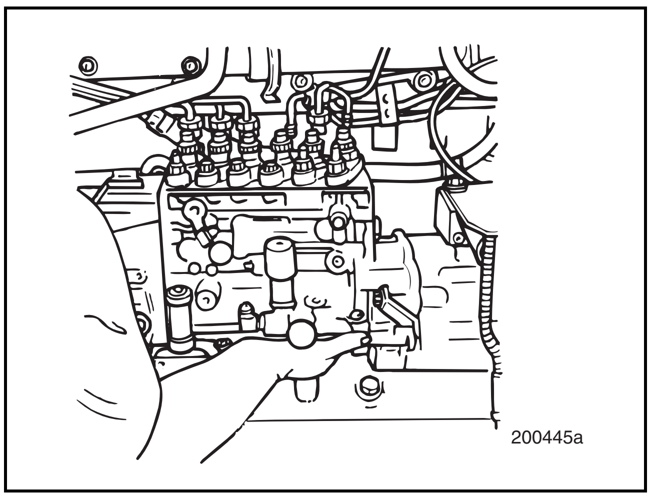


Figure 6-82 — Aligning Pump Over Dowels

5. With the fuel injection pump positioned over the alignment dowels, in one motion, lift the rear of the pump and slightly rotate the Econovance hub. Slide the pump forward into position.

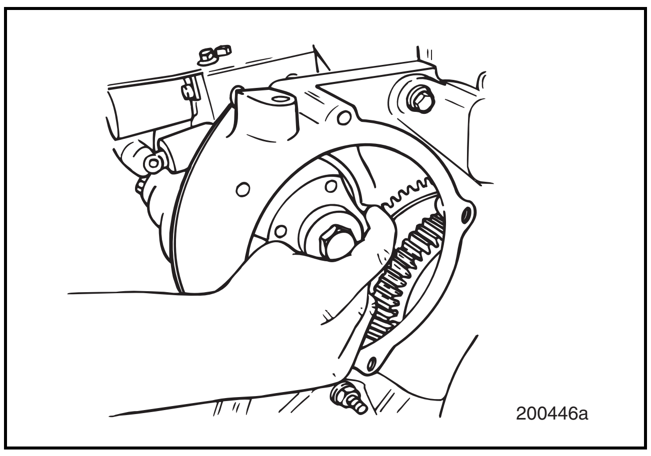


Figure 6-83 — Rotating Hub

6. To secure fuel injection pump, install the lower pump adapter mounting capscrew and then remove the alignment dowels.

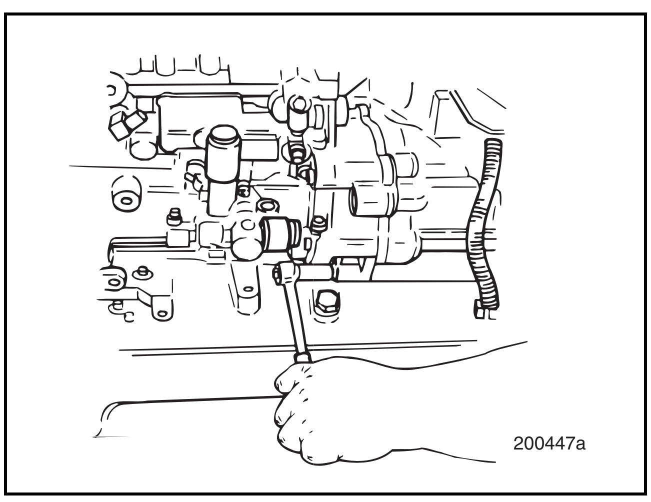


Figure 6-84 — Securing Fuel Injection Pump

7. Install and torque the remaining fuel injection pump adapter mounting capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
8. Install and torque the two link-to-support capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

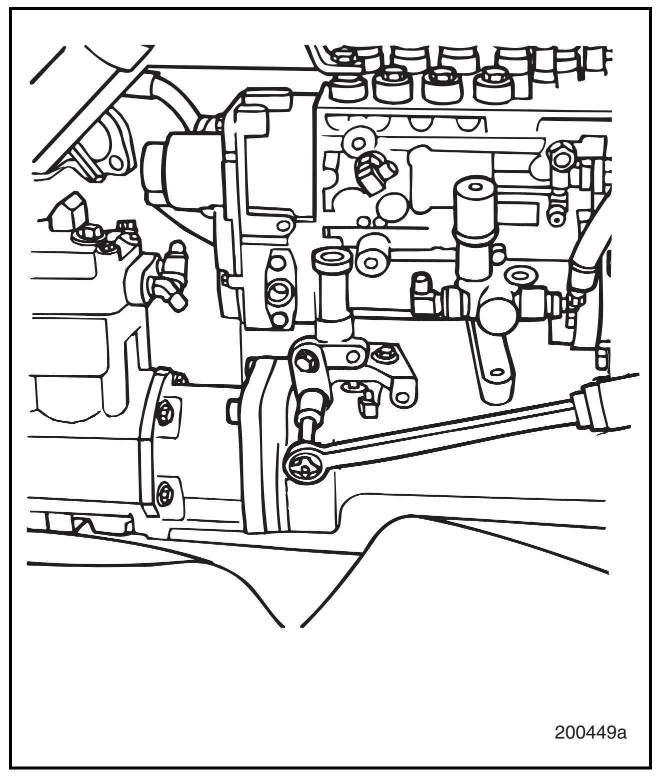


Figure 6-85 — Torquing Link Capscrews

9. Torque the three lower support bracket-to-cylinder block capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

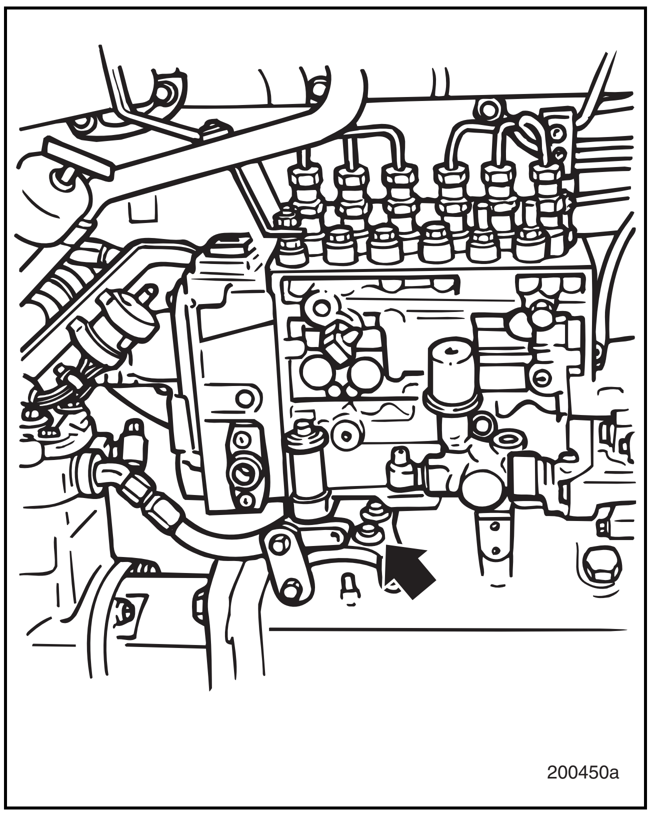


Figure 6-86 — Support Bracket-to-Cylinder Block Capscrews

10. Torque the two upper support bracket-to-fuel injection pump capscrews to 15 lb-ft (20 N•m) using torque wrench J 24407 or equivalent. Loosen and then retorque the capscrews to 40 lb-ft (54 N•m).

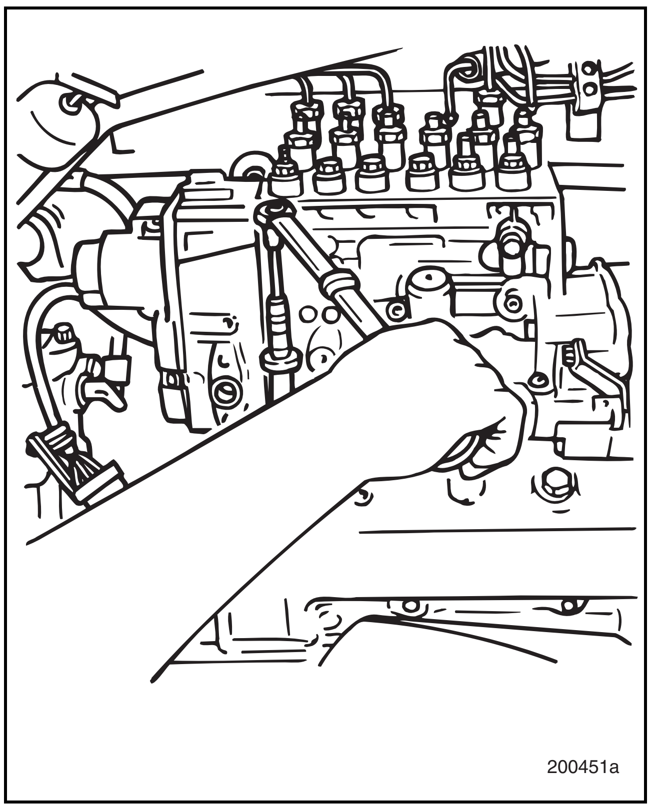


Figure 6-87 — Torquing Upper Support Bracket-to-Fuel Injection Pump Capscrews

11. Loosen the two link-to-support capscrews at least two full turns. Then retorque link-to-support capscrews to specification.

NOTE

Refer to Section 7, SETUP AND ADJUSTMENTS, Fuel Injection Fixed-Timing procedure, for steps to be used in setting fuel injection pump-to-engine timing.

[222 KD] FUEL NOZZLE INLET TUBE ASSEMBLY

Installation

Refer to Figure 6-88.

1. Install the fuel nozzle inlet tube assemblies (1) into the front and rear cylinder heads. Lubricate the nozzle inlet tube clamping screw threads before installing.
2. Install the tube assemblies until light contact is made with the nozzle holders. Lightly tighten the clamping screws and then lightly tighten the fuel inlet tube sleeve nuts (1).
3. Connect the injection pump end of the fuel tubes to the appropriate fuel injection pump outlet ports and lightly tighten the sleeve nuts (6).
4. Install and lightly tighten the fuel inlet tube insulators and clamp plate and brackets (3).

NOTE

These tube insulators and clamp plates and brackets are required to prevent cavitation erosion and vibration failure of the tubes.

5. Tighten all fuel inlet tube assembly clamping screws to 35 lb-ft (48 N•m) torque using torque wrench J 24407 or equivalent.

NOTE

An open-ended “crow’s foot” adapter is required with the torque wrench for installation of nozzle fuel inlet tube assemblies. Avoid twisting the lines when tightening the sleeve nuts.

6. While holding the fuel inlet tube assembly clamping screws, tighten the tube sleeve nuts (1) at the cylinder heads to 25 lb-ft (34 N•m) torque using torque wrench J 24407 or equivalent
7. Tighten all fuel inlet tube sleeve nuts (6) located at the fuel injection pump outlet ports to 25 lb-ft (34 N•m) torque using torque wrench J 24407 or equivalent.
8. Tighten all fuel inlet tube insulators and clamp plates and brackets.

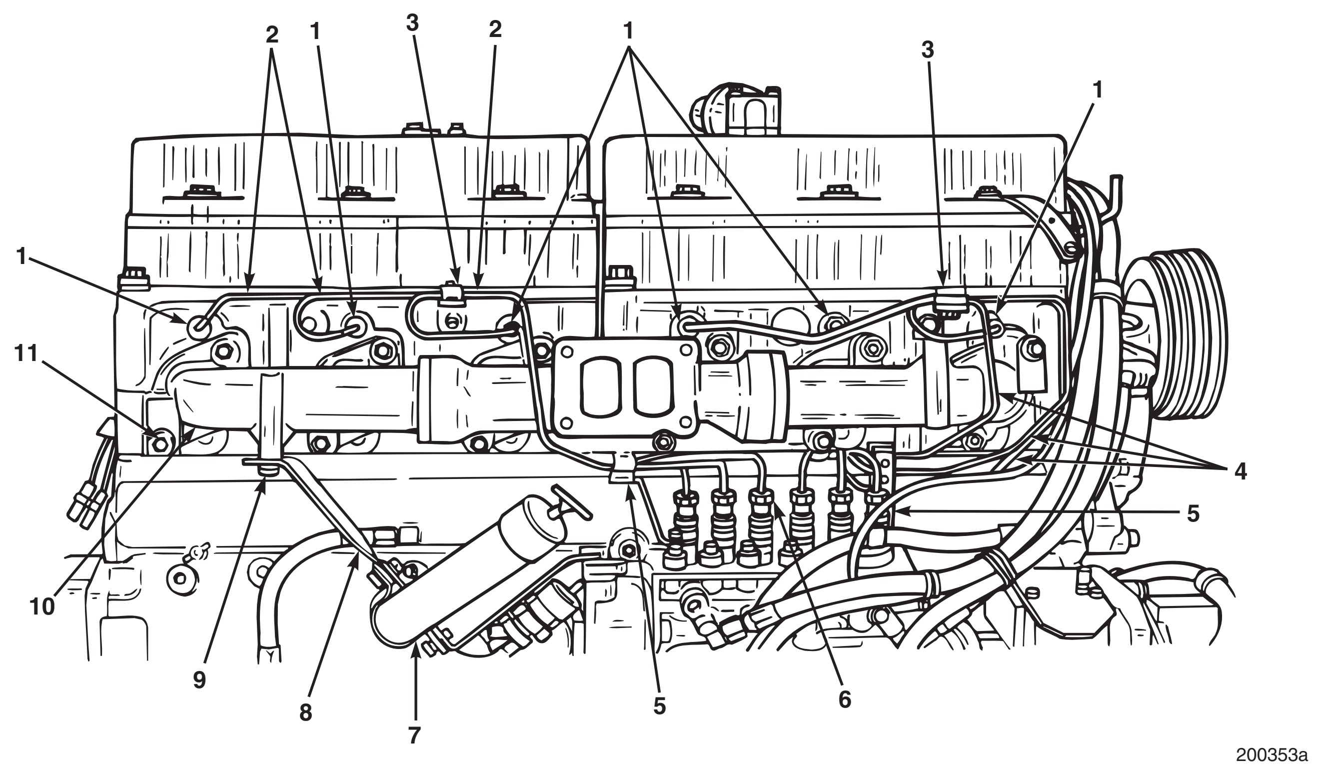


Figure 6-88 — Fuel Nozzle Inlet Tube Assembly Installation

1. Nozzle fuel inlet tube and sleeve nut	7. Oil filler feed tube
2. Rear fuel inlet tube assembly	8. Oil filler feed tube bracket
3. Bracket/insulator (tube clamp)	9. Capscrew
4. Front fuel inlet tube assembly	10. Exhaust manifold
5. Bracket/insulator (tube clamp)	11. Capscrew
6. Sleeve nut	

[214 SC] TURBOCHARGER

Installation (Includes Pre-Lubing Procedures)

Refer to Figure 6-89.

1. Inspect the intake and exhaust systems leading to and from the turbocharger to ensure absence of foreign material, including burrs and loose lining fragments.

NOTE

A thorough inspection is required as even small particles can cause severe rotor damage if inducted during high-speed operation.

2. Use new and approved gaskets at the various air, oil and exhaust connections to the turbocharger. Avoid the use of sealing or jointing compounds at all flanged connections.
3. Use a high-temperature, anti-seize compound (such as Fel Pro C5A) on all threaded fasteners connected to the turbocharger.
4. Position the turbocharger (1) over the mounting studs on the exhaust manifold.
5. Install the four mounting nuts (6) and torque to 40 lb-ft (54 N•m) using torque wrench J 24406 or equivalent.
6. Fill the oil inlet port to overflowing with clean engine oil before connecting the oil feed hose to the turbocharger.
7. Install the lubrication feed hose (2).
8. If the clamp plates or V-bands are loosened for angular orientation of the compressor cover or turbine housing, be certain that the mating flanges are tightly seated and that the fasteners are snug but will still allow cover orientation.

Complete the orientation of the cover and housing before making any rigid connections to the compressor inlet or to the turbine outlet. Torque the clamp plate capscrews (used on Schwitzer model S300 turbocharger only) to 140 lb-in (16 N•m), if equipped, and V-band retaining nuts to 90 lb-in (10 N•m) using torque wrench J 5853-C or equivalent. Then make certain that all ducting aligns closely with the turbocharger. This minimizes the external stresses acting on the unit.

9. Before connecting the drain hose, crank the engine without firing until a steady stream of oil flows from the drain port.
10. Install the lubrication drain tube (4) and torque the capscrews (3) to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.
11. Install the clamp (5) securing the lubrication drain tube to the oil fill tube.
12. Operate the engine at low idle for at least three minutes after completing the installation of the turbocharger.

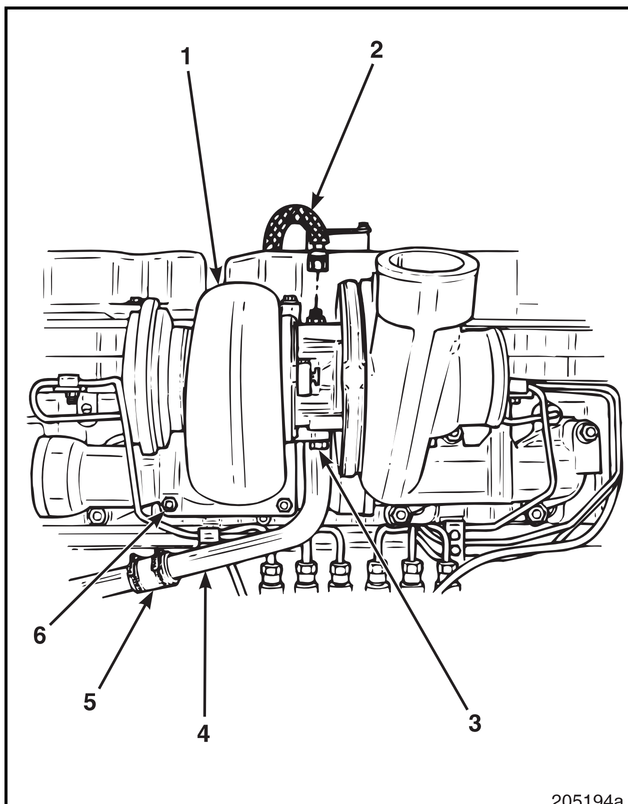


Figure 6-89 — Turbocharger Installation

1. Turbocharger	4. Lubrication drain tube
2. Lubrication feed hose	5. Clamp
3. Capscrew	6. Mounting nut

[215 NU, NG & LD] THERMOSTAT, THERMOSTAT HOUSING, THERMOSTAT SEAL AND COOLANT CONDITIONER

Refer to Figure 6-90.

1. When replacing a seal for any reason, examine the surface of the thermostat sleeve, the bore area and the seal to prevent premature failure of the new seal. A sealing lip that has been turned back, cut or otherwise damaged will leak and must be replaced. The lip faces the front of the engine.
2. Remove any surface nicks, burrs, sharp edges and tool marks from the thermostat sleeve and housing bore area using crocus cloth.
3. Check to see that replacement seals are free from any contaminants such as chips, grit, dust, or any other debris that would prevent the seal from properly seating in the thermostat housing.
4. Press the seal into the housing bore with smooth, uniform pressure using seal installation tool J 26637-A and driver handle J 8092.

NOTE

Tool J 26637-A is designed to regulate thermostat seal installation depth. The shoulder on the tool bottoms on the thermostat bore of the housing to prevent the seal from being installed too far.

NOTE

Wherever possible, an arbor press should be used to apply assembly pressure. Do not apply hammer blows or uneven pressure directly to seal surfaces. Precautions should be taken against cocking of seal throughout the installation operation. Make sure the seal is not cocked when installed.

5. Position thermostat (7) in the housing (5) with jiggle pin or caged ball up.
6. Install a gasket (8) on the housing mounting surface.
7. Position housing assembly on the coolant manifold (9) mounting surface.
8. Secure in position with two lower mounting capscrews (13).
9. Position a check valve assembly (3) in the coolant conditioner head assembly (2). The ball end of the check valve must be inserted first.
10. Position an O-ring (4) in the O-ring recess of the head assembly.
11. Install head assembly (2) on the thermostat housing (5) and secure with capscrews (1).
12. Torque capscrews to 25 lb-ft (34 N•m) using torque wrench J 24406 or equivalent.
13. Apply a light film of oil on the face of the coolant conditioner filter gasket seal.
14. Install the coolant conditioner filter element (14). Turn the coolant conditioner filter one full turn after gasket contacts base. Use tool J 24783 to tighten.

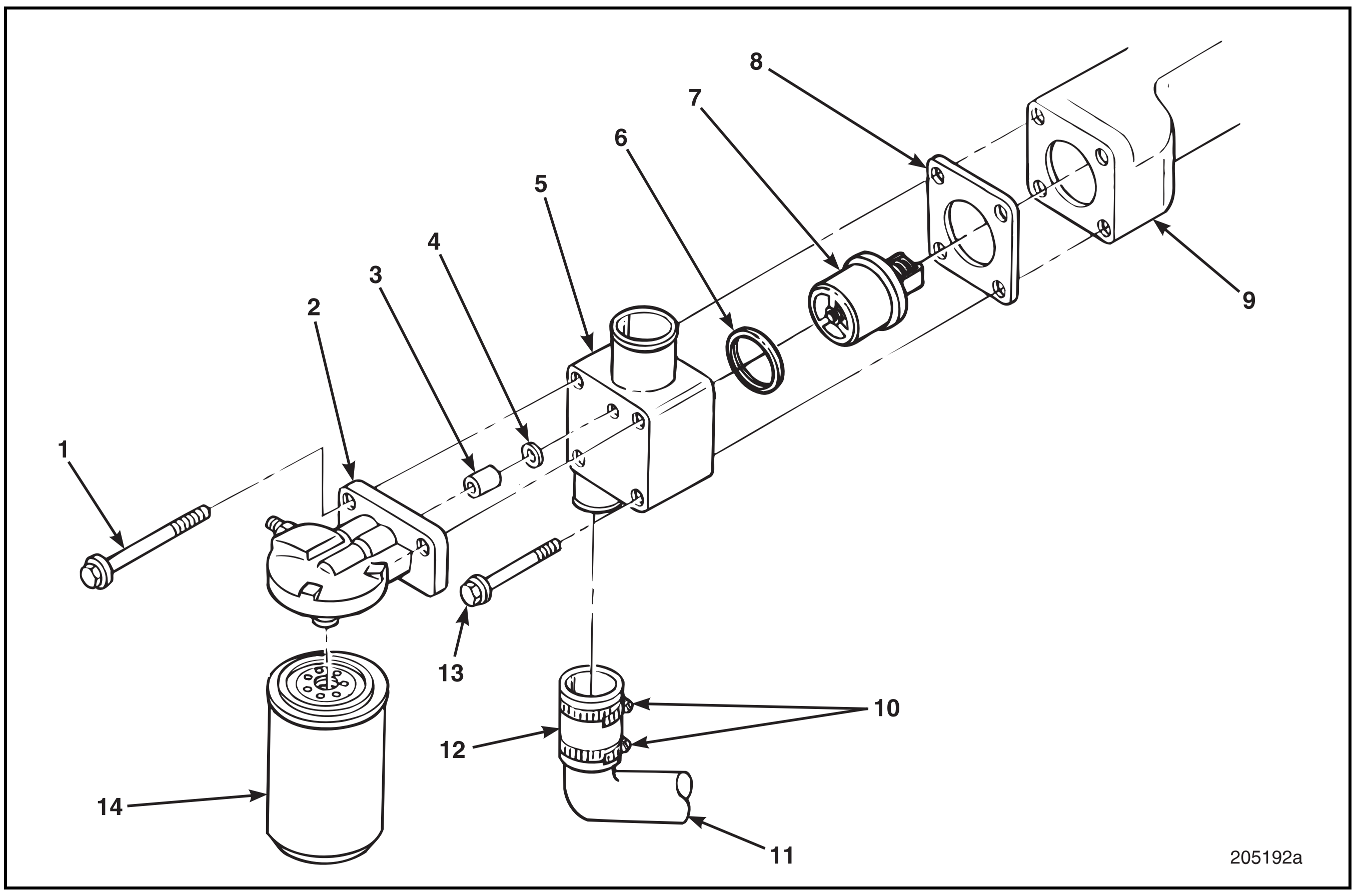


Figure 6-90 — Thermostat Housing Installation

1. Capscrew	8. Gasket
2. Coolant conditioner head assembly	9. Coolant manifold
3. Check valve	10. Clamps
4. O-ring	11. Oil cooler supply tube
5. Thermostat housing	12. Coupling (hose)
6. Thermostat seal	13. Capscrew
7. Thermostat	14. Coolant conditioner filter element

[214 HD] AIR INLET MANIFOLD

Refer back to Figure 6-74.

1. Place the front air inlet manifold section (8) into position on the cylinder head and insert the 12-point capscrews (9) and washers.
2. Torque capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
3. Place the coupling on the rear of the front air inlet section (8). Assemble two clamps on the coupling and install the rear air inlet section (6).
4. Insert the 12-point capscrews and torque to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
5. Tighten the clamps on the coupling and torque to 38 lb-in (4.3 N•m).

[231 PB] FUEL FILTER ADAPTER ASSEMBLY

Installation

Refer to Figure 6-91.

1. Install fuel filter adapter (1) to the air inlet assembly (7).
2. Install the three capscrews (4) and torque to 35 lb-ft (48 N•m).
3. Install the three fuel lines to fittings (2, 3 and 5) and torque to 25 lb-ft (34 N•m).

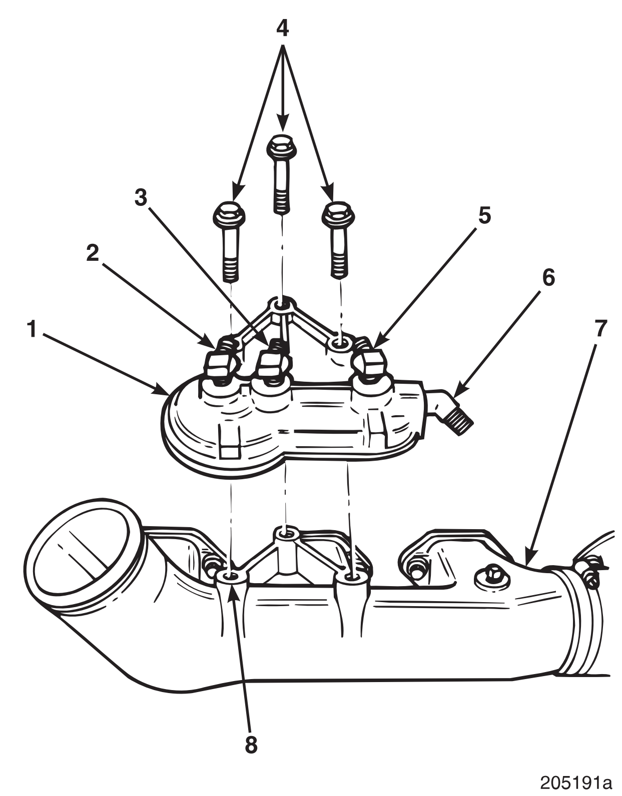


Figure 6-91 — Fuel Filter Adapter Assembly Installation

1. Fuel filter adapter assembly	4. Capscrews
2. Secondary filter fitting (out)	5. Primary filter fitting (out)
3. Secondary filter fitting (in)	6. Primary filter fitting (in)
	7. Air inlet manifold
	8. Mounting flange

[215 SW] WATER PUMP

Installation

Refer to Figure 6-92.

CAUTION

Water pump-to-housing mounting capscrews should not be lubricated before installation. Instead, apply thread sealing compound to all water pump-to-water pump housing capscrews. Also apply thread sealing compound to water pump housing (pump outlet) to block capscrews.

1. Position a gasket on the water pump mounting flange.
2. Secure pump with three mounting capscrews (3).
3. Position refrigerant compressor support bracket, if required, on the front of the cylinder head. (Insert spacer if refrigerant compressor support bracket and fan ring arrangement are not used.) Secure bracket with mounting hardware.

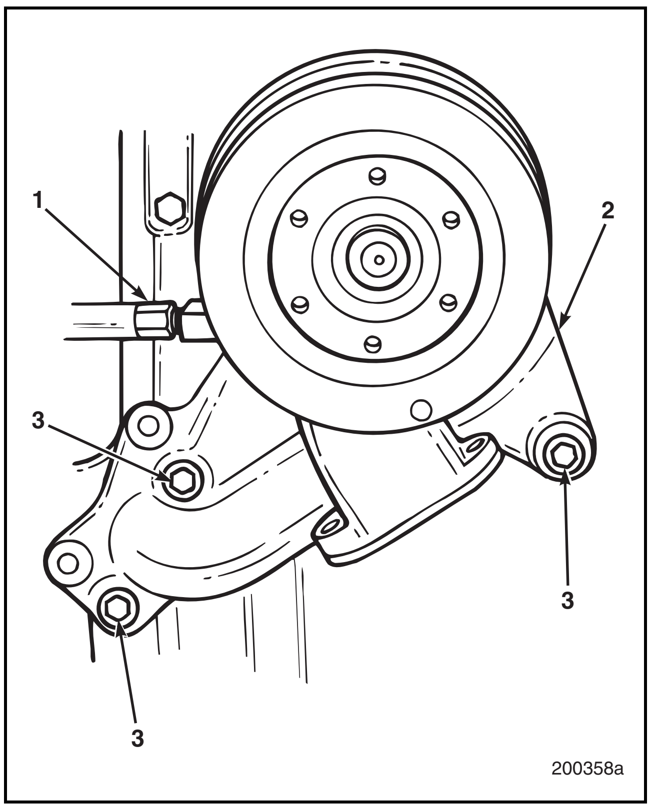


Figure 6-92 — Water Pump Installation

1. Air compressor line 2. Water pump	3. Capscrew

[215 DW & 219 EP] OIL COOLER AND OIL FILTER HEAD

Assembling a New Oil Filter Adapter

The oil filter head does not come as a complete assembly, so the fittings, nipples, spuds, etc., must be installed before installing the filter head onto the engine. Perform the following procedures before installing the threaded spuds into the filter head.

Refer to Figure 6-93.

1. Apply a continuous bead of Loctite 609 around the circumference of the spud, between the second and fifth threads from the upper end.
2. Screw the spuds into the filter adapter until they protrude 0.703 inch (17.856 mm) when measured from the bottom of the spud to the sealing surface of the oil filter head assembly. To ensure that spuds are secure in the adapter housing, they may be "staked" by using a small punch to make a small indentation between the threads of the spud and the adapter.
3. Apply a continuous bead of Loctite 609 around the circumference of the fitting between the second and fifth threads of the upper end of the Centri-Max™ fitting. Install the fitting and torque to 135–165 lb-ft (183–224 N•m) using torque wrench J 24407 or equivalent. Do not stake the Centri-Max™ fitting.

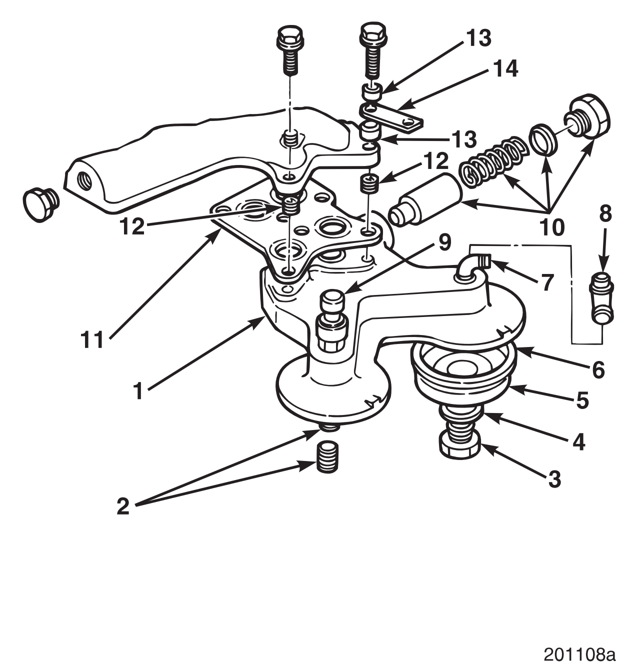


Figure 6-93 — Oil Filter Adapter Assembly

1. Adapter housing	8. Vent hose fitting
2. Filter adapter fitting	9. Oil pressure sensor
3. Filter adapter fitting (Centri-Max™)	10. Oil filter bypass valve plunger assembly
4. Pilot ring washer	11. Adapter gasket
5. Pilot ring	12. Insert
6. Gasket	13. Spacer
7. Gauge connector elbow	14. Wiring harness bracket

SERVICE HINT

The oil cooler and oil filter head assembly can be installed separately, but assembling them together on a bench is easier and reduces the possibility of damaging O-ring seals.

Installation

Refer to Figure 6-94.

1. Lubricate the oil cooler supply tube (5) with Vaseline® or equivalent.
2. Position coupling (4) over the lubricated tube.
3. Place two clamps (3) over the coupling.
4. Place a gasket on the oil supply mounting flange (11).
5. Position the oil cooler and oil filter head assembly on the engine. Slide the coupling (4) over the thermostat housing flange. Lubricate threads of the capscrews (10) and insert into the mounting flange. Do not tighten at this time.
6. Place a gasket on the water pump mounting flange (2).
7. Lubricate threads of capscrews (1) and insert the two mounting capscrews to secure flange (2) to the water pump. Torque capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
8. Tighten oil supply housing capscrews (10). Torque to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
9. Tighten clamps (3). Torque to 38 lb-in (4.3 N•m).
10. Connect Centri-Max™ filter breather hose (6) to the breather hose fitting (7). (For MR chassis Jake Brake applications, install the Centri-Max™ breather filter.)
11. Connect oil hose (8) to the fitting (9).
12. Coat the threads of the oil sending unit (12) with sealing compound and install in the oil filter head assembly (13).

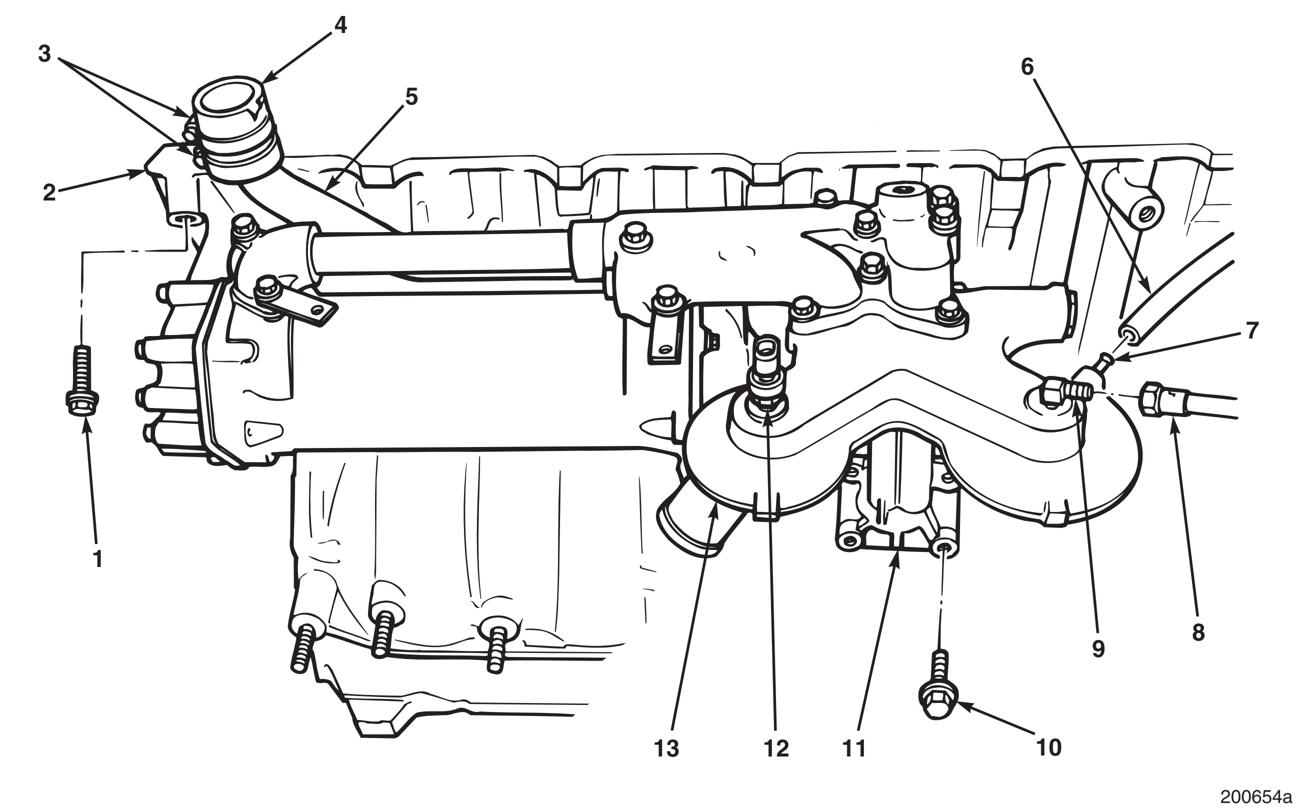


Figure 6-94 — Oil Cooler and Oil Filter Head Installation

1. Capscrew 2. Water pump mounting flange 3. Clamps 4. Coupling 5. Oil cooler supply tube (water bypass tube) 6. Centri-Max™ filter breather hose 7. Breather hose fitting (MR chassis with Jake Brake use breather assembly)	8. Oil hose 9. Fitting 10. Capscrew 11. Oil supply mounting flange 12. Sending unit 13. Oil filter head assembly

[271 CB] ALTERNATOR

Installation

Refer to Figure 6-95.

1. Install the alternator plate (5) and mounting hardware (4).
2. Position the alternator (7) on the plate and install capscrews (3), washers and mounting nuts (6).
3. Connect the electrical wires as tagged during disassembly.
4. Install drive belt(s) (1).
5. Adjust drive belt tension to specification as described in the following Fan Belt(s) Adjustment procedure.

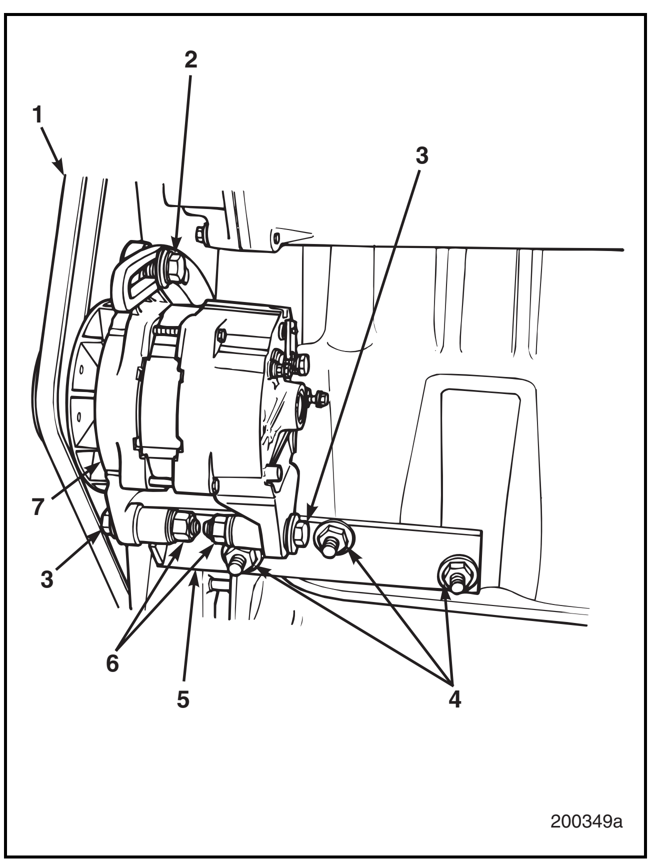


Figure 6-95 — Alternator Installation

1. Drive belt 2. Adjusting capscrew 3. Capscrew 4. Mounting hardware	5. Alternator plate 6. Mounting nuts 7. Alternator

Fan Belt(s)

ADJUSTMENT

1. For consistent measurements, use belt tension gauge tool BT3373-F to check the belt tension.
2. Check tension at the center of the longest span, and chalk-mark the point checked.
3. When installing new belt(s), initially adjust the tension to give a gauge reading of 130–150 lbs. (578–667 N). Chalk-mark the point checked. Run the engine for approximately 5–10 minutes. Allow the belt(s) to cool and recheck at the chalk mark. If the tension is less than 100 lbs. (445 N), readjust the tension to approximately 110–120 lbs. (489–534 N).
4. After adjusting belt tension, tighten alternator mounting bolts as follows:
   a. Tighten upper alternator adjusting capscrew (2) to 60–70 lb-ft (81–95 N•m) using torque wrench J 24407 or equivalent.
   b. Tighten lower alternator mounting fasteners (3 and 6) to 60–70 lb-ft (81–95 N•m) using torque wrench J 24407 or equivalent.

NOTE

With other belt types and configurations, refer to the current Maintenance and Lubrication Manual, TS494, for belt tensioning specifications.

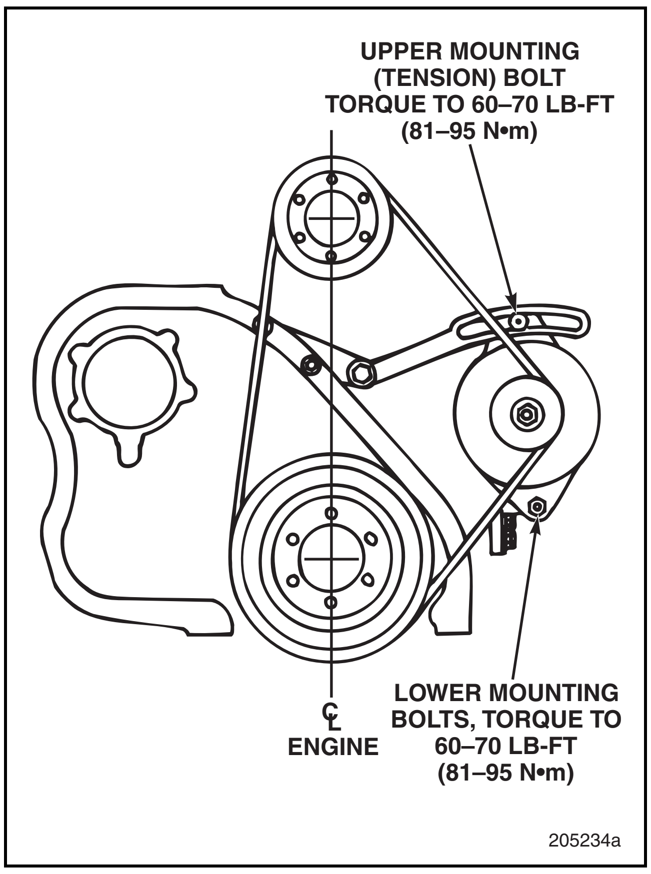


Figure 6-96 — Engine Belt Arrangement

NOTES

SETUP AND ADJUSTMENTS

[213 NB] VALVE YOKE AND VALVE LASH ADJUSTMENTS (NON-JAKE BRAKE ENGINE AND DYNATARD EQUIPPED)

Description

Yoke and valve adjustments are done in two stages on E7 engines. Adjust the yoke clearance first, then adjust the valve lash. Make sure both adjustments are done in firing order sequence. Manually rotate the engine in normal rotation direction until pointer in flywheel housing aligns with valves 1 and 6 mark on the flywheel and the No. 1 piston on the compression stroke.

The flywheel has a stamped timing scale consisting of TC through 45 degrees of engine travel for setting and checking pump-to-engine timing. Also, the flywheel has three stamped locations at 120-degree intervals for valve settings.

Some E7 engines are equipped with a pointer on the timing gear cover and marks on the vibration damper. To adjust the yoke and valves on these engines, bar engine in normal rotation direction until the TC mark on the damper (with the No. 1 piston on the compression stroke) aligns with pointer marked VALVE. This provides the 30-degrees-after-TDC relationship for valve lash adjustment necessary with the E7 camshaft design.

NOTE

Yoke and valve adjustments must be made under static conditions with coolant temperature below 100°F (37°C).

NOTE

E7 engine firing order is 1-5-3-6-2-4.

Special Tool Required

- Engine Barring Socket J 38587-A

Locating and Marking Flywheel Valve Adjustment Markings

NOTE

Some E7 engines built in early 1995 may be equipped with flywheels that have missing or illegible valve adjustment markings. If this problem is encountered, a typical flywheel can be marked while the engine is in the chassis.

TYPICAL FLYWHEELS

On a typical flywheel, the TC markings, and the valve adjustment markings, are directly in line with the clutch mounting bolt/bolt holes. To determine if the engine is equipped with a typical flywheel, view the flywheel through the timing access hole in the flywheel housing. Align the TC markings with the timing pointer. If the flywheel is typical, there should be a clutch mounting bolt/bolt hole directly in line with the TC marking. In this case, the valve adjustment markings should be in line with a clutch mounting bolt at three locations. (Refer to Figure 7-2 Flywheel Marks.)

There are 12 clutch mounting bolt holes in the flywheel, but only 8 of these holes are used to mount the clutch. Every third bolt hole, for a total of four, is not used. These holes are in an open area between the clutch mounting flanges. The unused holes are easy to see through the timing access hole in the flywheel housing. The bolt holes where there is a clutch mounting bolt are more difficult to see because the clutch mounting bolt head is somewhat rearward of the timing access opening. To aid in counting the clutch mounting bolt/bolt holes, keep in mind that there is slightly over four inches between one bolt hole and the next. Locating the clutch mounting bolts may be made easier by removing the bell housing inspection cover and viewing or feeling for the bolts through the bell housing.

After verifying that there is a clutch mounting bolt/bolt hole in line with the TC mark, the next step is to locate the three locations where the valve adjustment marks should be. Put a temporary (chalk, grease pencil, paint, etc.) mark at each of the three locations. Proceed as follows:

1. Beginning with the TC mark aligned with the timing pointer, rotate the engine in the direction of normal rotation (counterclockwise, viewed from rear) to the next clutch mounting bolt/bolt hole. Temporarily mark this location for cylinders 1 and 6.
2. Continue rotating the engine in the normal direction and count the clutch mounting bolt/bolt holes as they pass the timing access opening. At the fourth mounting bolt/bolt hole, make a temporary mark on the flywheel for cylinders 2 and 5.
3. Rotate the engine another four mounting bolt/bolt holes and make a temporary mark on the flywheel for cylinders 3 and 4.
4. Rotate the engine another three clutch mounting bolt/bolt holes and verify that the flywheel is at the TC mark. Then, rotate the engine one more bolt/bolt hole and verify that the flywheel is at the temporary mark made for cylinders 1 and 6.
5. Permanently mark the flywheel at this location for cylinders 1 and 6. To gain access, rotate the engine slightly so that the area to be marked is either to the right or left side of the timing pointer. Place a chisel mark directly in line with the clutch mounting bolt/bolt hole. Then, stamp or electric-etch the cylinder numbers on either side of the chisel mark.
6. Rotate the engine to the remaining locations and make sure to count the clutch mounting bolt/bolt holes to verify the locations of the temporary markings. Once verified, permanently mark each location as described.

NON-TYPICAL FLYWHEELS

If the engine is equipped with a non-typical flywheel, the TC markings will be halfway between two clutch mounting bolts. If this type of flywheel has no valve adjustment markings, it should be replaced. Also, any flywheel which has no markings for injection pump timing should be replaced, even though piston travel method of injection pump timing could be used.

Valve Yoke Adjustment

CAUTION

On mechanically governed engines, before barring engine for any reason, secure injection pump stop lever in stop position.

Make sure that adjusting screws are retracted upward in the rocker arms. If they extend too far below the rocker arm, the push rods can be bent when tightening the rocker arm assembly brackets.

Refer to Figures 7-1, 7-2 and 7-3.

1. Using engine barring socket J 38587-A, manually rotate engine in normal rotation direction until pointer in flywheel housing aligns with valves 1 and 6 mark on the flywheel and the No. 1 piston is on the compression stroke (or until the pointer marked VALVE aligns with the TC mark on the vibration damper, if equipped).

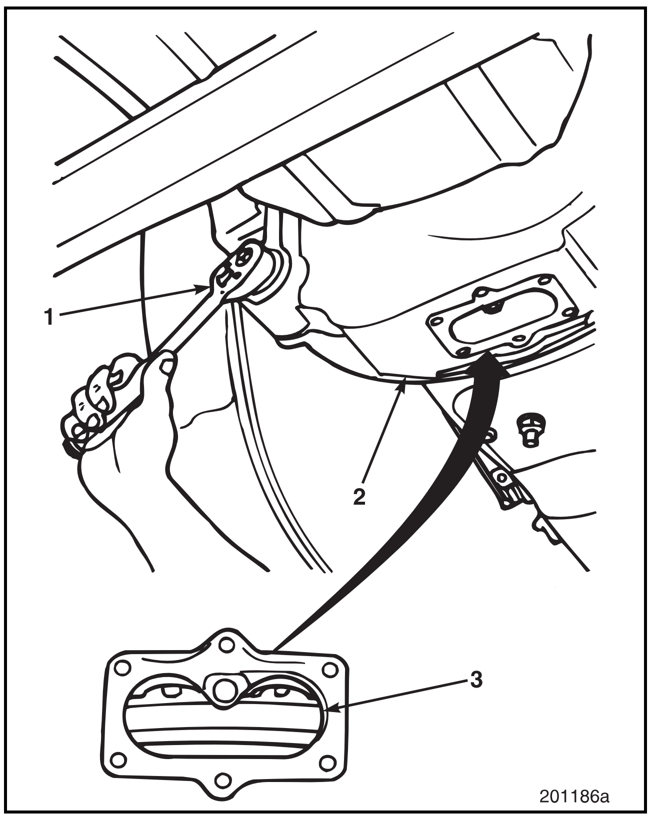


Figure 7-1 — Engine Crankshaft Rotation

1. Barring socket J 38587-A	2. Flywheel housing 3. Flywheel

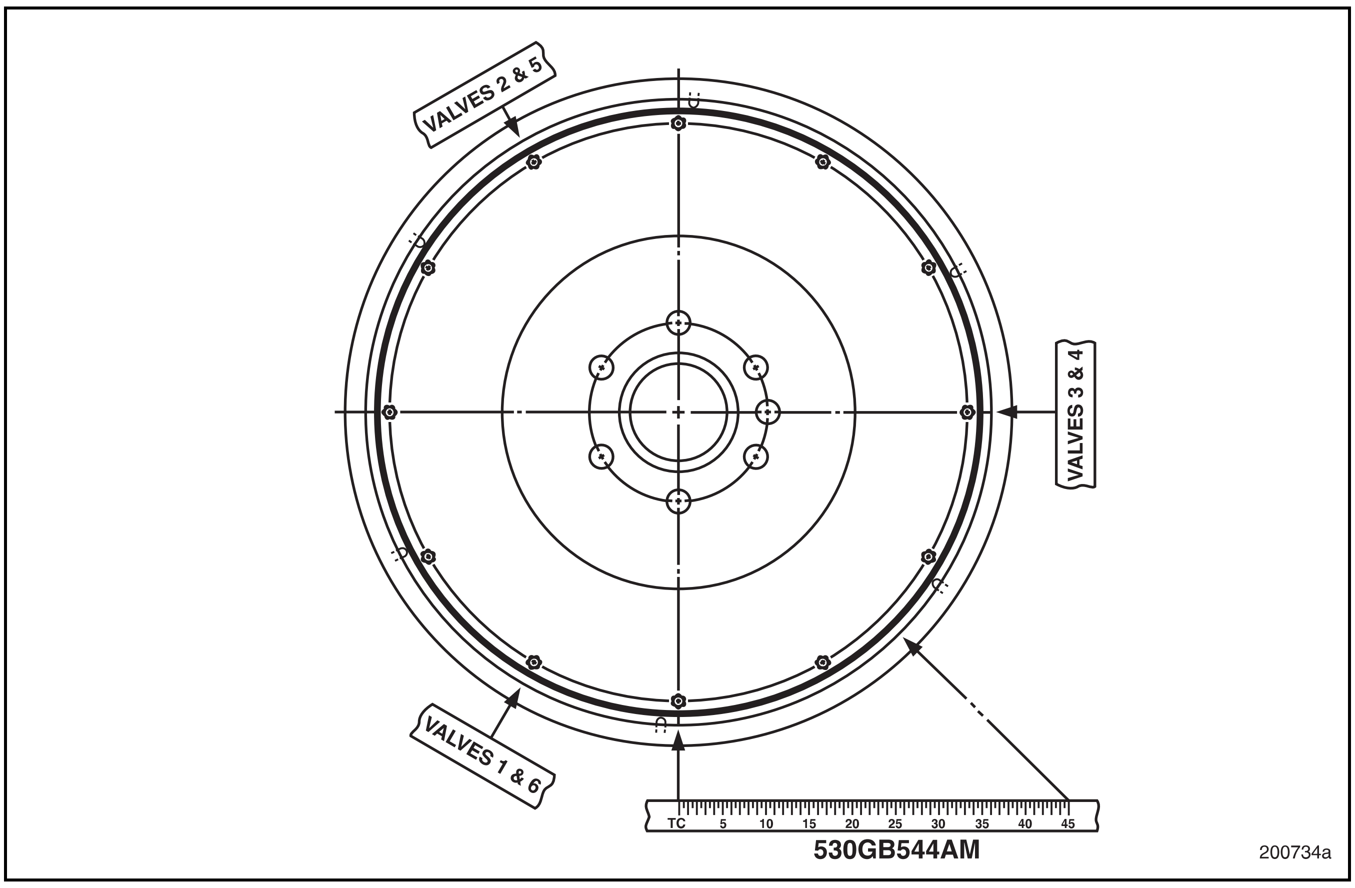


Figure 7-2 — Flywheel Marks

2. Back off the valve rocker adjusting screws.
3. Loosen the No. 1 cylinder yoke adjusting screw locknuts.
4. Exert moderate force on the yoke by pressing on the rocker arm slipper end. Turn down the yoke adjusting screw until it makes solid contact with the outboard valve stem tip, as sensed by a light drag on the adjusting screw.
5. Turn adjusting screw an additional 1/6 turn (60 degrees) clockwise.

S E R V I C E   H I N T

A 1/6 turn is equal to one flat on the adjusting screw locknut.

6. Hold the yoke adjusting screw in this position while tightening the adjusting screw locknut. Torque locknut to 33 lb-ft (45 N•m) using torque wrench J 24407 or equivalent.

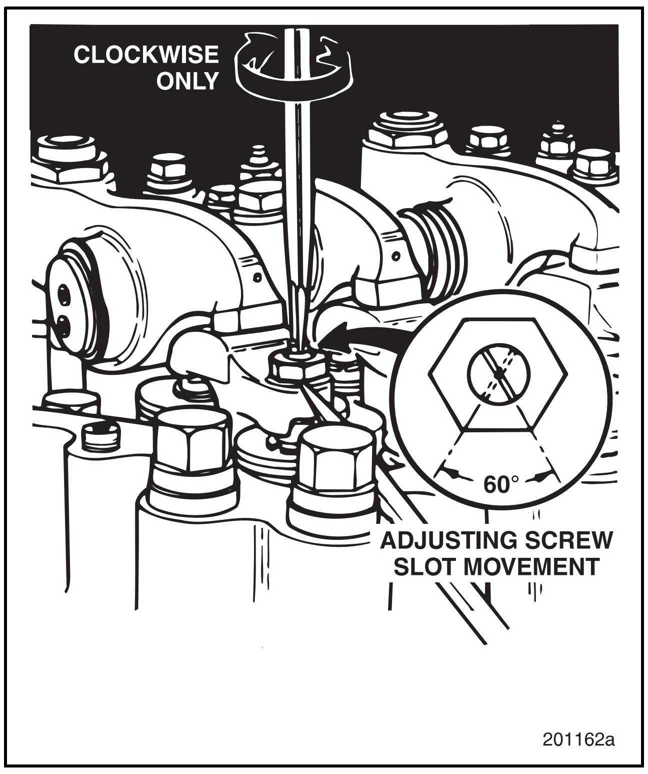


Figure 7-3 — Yoke Adjusting Screw and Locknut

CHECKING YOKE ADJUSTMENT

Refer to Figure 7-4.

1. Insert a 0.010-inch (0.254 mm) thickness gauge between the yoke and valve stem, at both the inboard and outboard locations.
2. Exert moderate force on the yoke by pressing on the rocker arm slipper end. An equal drag should be felt on both thickness gauges. If drag is unequal, readjust the yoke adjusting screw, as required.

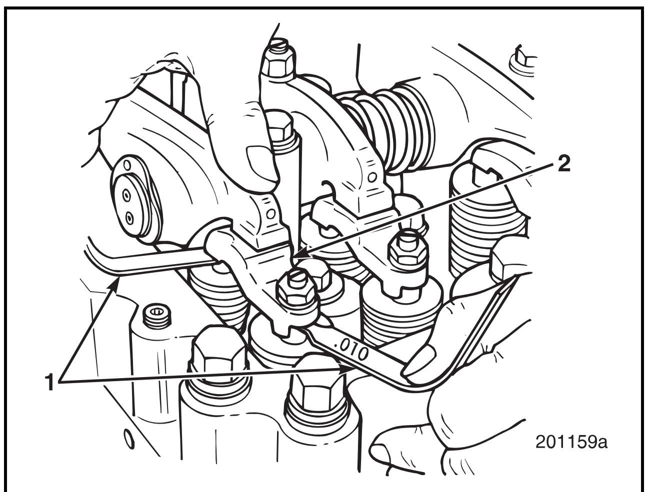


Figure 7-4 — Checking Yoke Adjustment

1. Thickness gauge	2. Yoke

Inlet Valve Adjustment

Refer to Figure 7-5.

Inlet valve lash clearance is 0.016 inch (0.406 mm).

1. Place a 0.016-inch (0.406 mm) thickness gauge between the rocker arm and yoke on the No. 1 cylinder.
2. Turn the adjusting screw until a light drag is felt on the thickness gauge.
3. After setting adjustment screw, tighten locknut. Torque locknut to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

NOTE

Do not allow the adjustment screw to turn.

4. After tightening locknut, recheck valve lash clearance. Readjust as necessary.

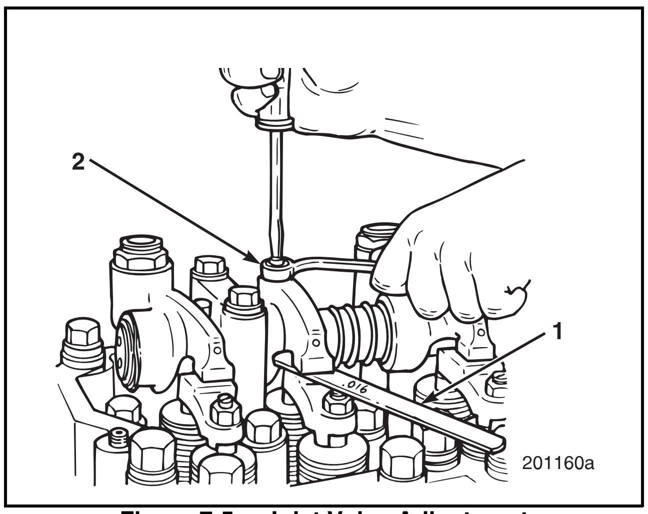


Figure 7-5 — Inlet Valve Adjustment

1. Thickness gauge	2. Adjusting screw and locknut

Exhaust Valve Adjustment

Refer to Figure 7-6.

Exhaust valve clearance is 0.024 inch (0.610 mm) for engines produced through engine serial No. 6F in April 1996 and 0.028 inch (0.711 mm) for engines produced after engine serial No. 6F in April 1996.

1. Place the proper thickness gauge between the rocker arm and yoke on the No. 1 cylinder.
2. Turn the adjusting screw until a light drag is felt on the thickness gauge.
   - If equipped with a Dynatard engine brake, use Dynatard valve-lash adjusting wrench J 37092 to rotate adjusting screw. Press downward with hand on the hydraulic lash adjuster while gauging valve lash. Adjust the lash until a light drag is felt on the thickness gauge.
3. After adjustment is complete, tighten locknut. Torque locknut to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

NOTE

Do not allow the adjustment screw to turn.

4. Recheck valve lash clearance after tightening locknut. Readjust as necessary.

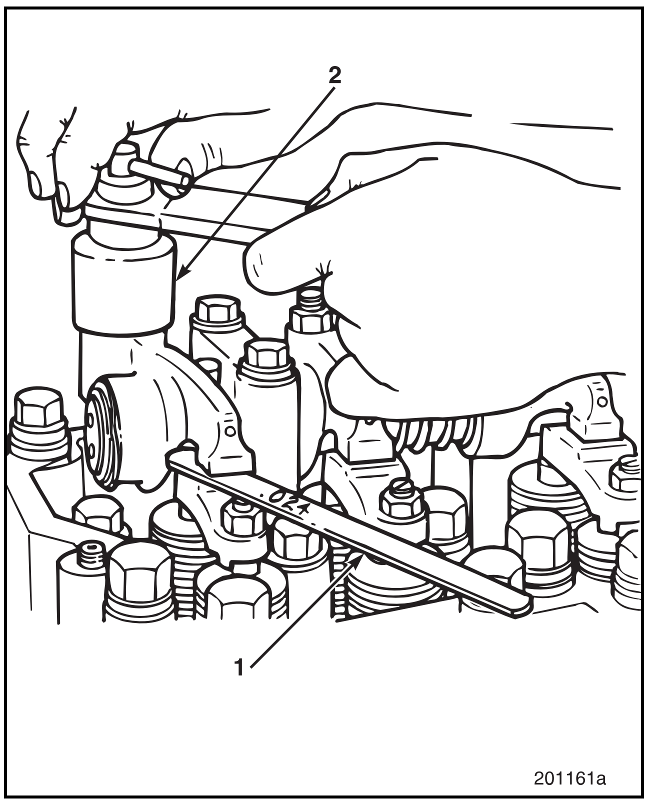


Figure 7-6 — Exhaust Valve Adjustment

1. Thickness gauge	2. Adjusting wrench J 37092

Continuation of Adjustments

Refer to Figure 7-7.

1. Using engine barring socket J 38587-A, manually rotate engine in normal rotation direction 120 degrees until pointer in flywheel housing aligns with the "5" mark on the flywheel. The No. 5 piston will be on the compression stroke. If engine is equipped with a pointer mounted on the timing gear cover and marks on the vibration damper, rotate the engine until the pointer marked VALVE aligns with the "5" mark on the vibration damper.
2. Adjust the yoke and valve lash as previously outlined for the No. 1 cylinder.

NOTE

E7 engine firing order is 1 - 5 - 3 - 6 - 2 - 4.

3. Continue adjusting yoke and valve lash for the remaining cylinders, in firing order. Rotate crankshaft to place each piston 30 degrees past TDC.

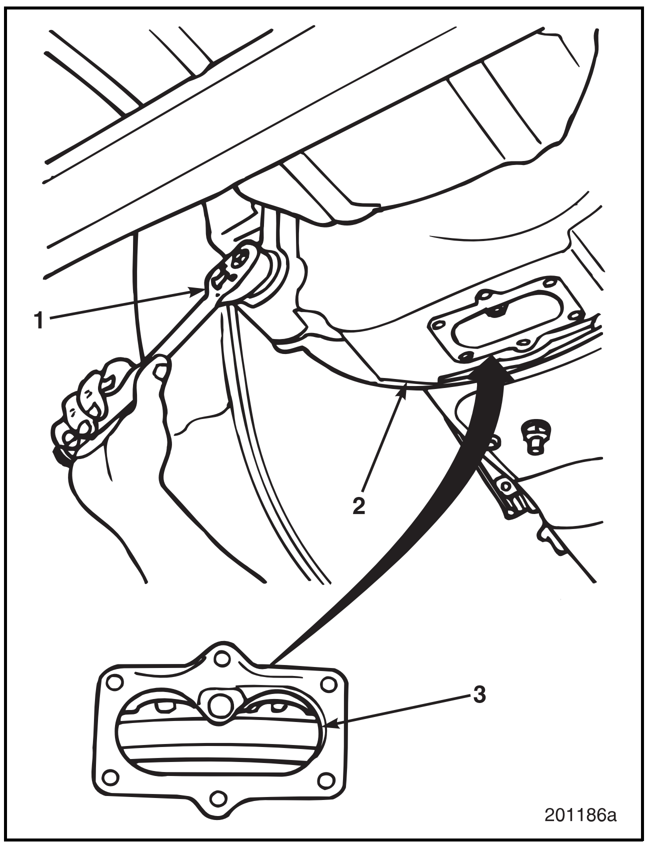


Figure 7-7 — Engine Crankshaft Rotation

[213 NB] VALVE YOKE, VALVE LASH AND SLAVE PISTON ADJUSTMENTS (JACOBS BRAKE ENGINE)

Description

Make yoke and valve lash adjustments for each cylinder in the proper order. Adjust the yoke clearance first, then adjust the valve lash. Adjust the Jake Brake slave piston last. The flywheel has a stamped timing scale TC through 45 degrees of crankshaft rotation for setting and checking pump-to-engine timing. Also, the flywheel has three stamped valve setting locations.

Some E7 engines are equipped with a pointer marked VALVE on the timing gear cover. When aligned with the TC mark on the vibration damper, it provides the 30 degrees after Top Dead Center (TDC) damper relationship for valve lash adjustment. Make all adjustments in firing order sequence.

NOTE

E7 engine firing order is 1 - 5 - 3 - 6 - 2 - 4.

The Jacobs exhaust valve yoke originally used a valve yoke screw with SAE threads. MACK yokes had metric threads. SAE and metric threads are different enough so that mixing threads should not be possible. An incorrect screw can be started into the threads but will lock up after a quarter of a turn to two full turns.

Effective January 1994, on engine serial No. 401269, the E7 Jacobs yoke has metric threads utilizing the Spiralock™ thread form. This special thread form has a wedge ramp at the root of each thread to provide a locking effect. The yoke adjusting screw is free-spinning in the yoke threads until the locknut is tightened. When the locknut is tightened, the crests of yoke adjusting screw threads are pulled tightly against the wedge ramp of screw threads. Because of this feature, when the locknut is loosened, the adjusting screw usually remains locked to the yoke threads and can be difficult to turn with a screwdriver. A light tap squarely on top of the yoke adjusting screw may be required to loosen the locking effect and allow screw to be turned. Refer to Figure 7-8.

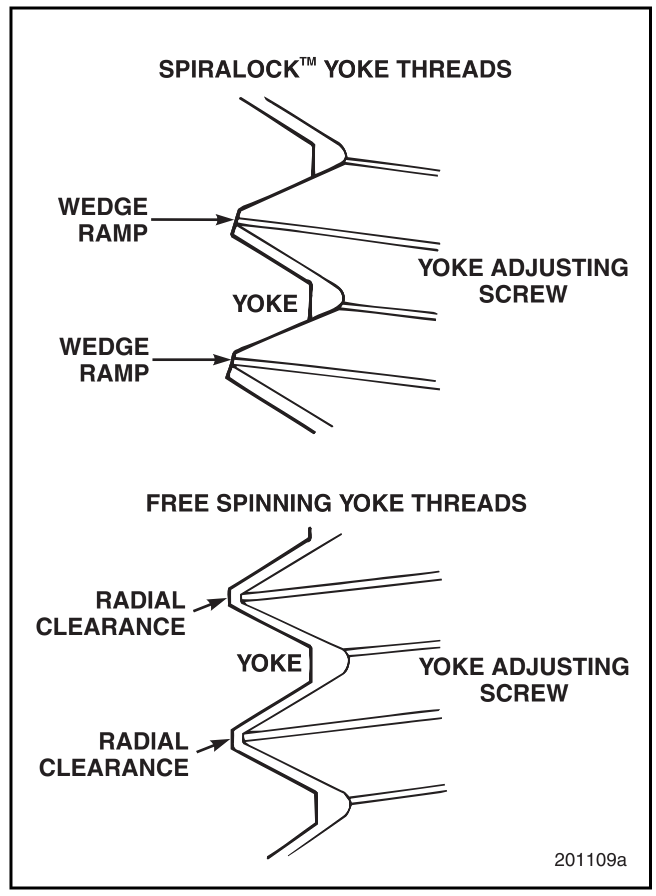


Figure 7-8 — Spiralock™ Thread Ramp

NOTE

Yoke and valve lash adjustment must be made under static conditions with coolant temperature below 100°F (38°C).

Housing Identification

Each engine brake housing assembly has an identification tag showing the model number and is marked FRONT or REAR to show installation location. Make sure to install front to front or rear to rear. Engine brake housing serial numbers are stamped on top of the castings. E7 engines use the Jacobs Model 680B engine brake assembly.

Special Tools Required

Jacobs feeler gauges:

- 0.060 inch (1.52 mm) No. 022001
- 0.080 inch (2.03 mm) No. 018781
- 0.085 inch (2.16 mm) No. 014177
- 0.100 inch (2.54 mm) No. 021327

Valve Yoke

Jacobs yokes must be installed on the exhaust yoke guide pins. Lubricate the guide pin and the pallet of the yoke with engine oil. Install yoke with the adjustment screw outboard (toward the intake manifold side of the engine).

1. Loosen the yoke adjusting screw locknut and back the screw out several turns.
2. Exert a moderate force on the yoke by pressing on the rocker arm slipper end. Turn down yoke adjusting screw until it makes solid contact with outboard valve stem tip as sensed by a light drag on the adjusting screw.
3. Turn adjusting screw an additional 1/6 turn (60 degrees) clockwise.

SERVICE HINT

A 1/6 turn is equal to one flat on the adjusting screw locknut.

4. Hold the yoke adjusting screw in this position while tightening the adjusting screw locknut. Torque locknut to 33 lb-ft (45 N•m) using torque wrench J 24407 or equivalent.

CHECKING YOKE ADJUSTMENT

1. To check the yoke adjustment, insert a 0.010-inch (0.254 mm) thickness gauge between the yoke and valve stem, at both the inboard and outboard locations.

Refer to Figure 7-9.

2. Exert moderate force on the yoke by pressing on the rocker arm slipper end. An equal drag should be felt on both thickness gauges. If drag is unequal, readjust yoke adjusting screw.

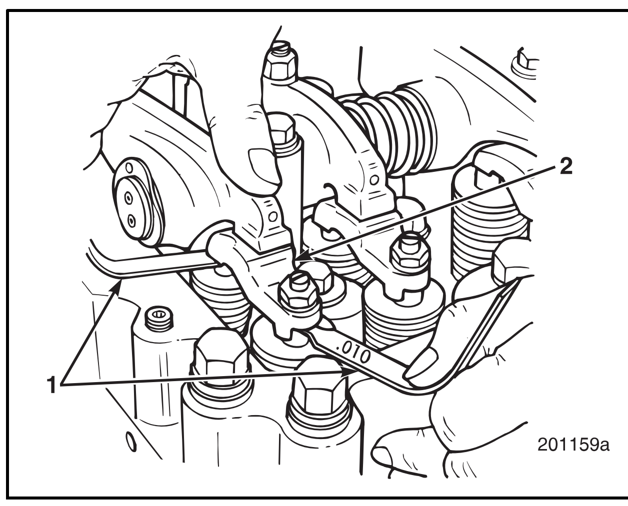


Figure 7-9 — Checking Yoke Adjustment

1. Thickness gauge	2. Yoke

Slave Piston, Inlet Valve and Exhaust Valve Lash Adjustments

Make the following adjustments with the engine shut down. Coolant temperature must be below 100!F (38!C) to ensure proper adjustment.

CAUTION

On mechanically governed engines, before barring engine for any reason, secure injection pump stop lever in STOP position.

NOTE

Do not rotate the engine crankshaft backward when using the hub damper bolt. This might change the torque.

1. Using engine barring socket J 38587, manually rotate engine in normal rotation direction.
2. Rotate until pointer in flywheel housing aligns with the mark for valves 1 and 6 on the flywheel and the No. 1 piston on the compression stroke (or until the pointer marked VALVE aligns with the TC mark on the vibration damper, if equipped). This provides the 30 degrees after TDC relationship for valve lash adjustment necessary with the E7 valve design.

Inlet Valve Adjustment

Inlet valve lash clearance is 0.016 inch (0.406 mm).

1. Place a 0.016-inch (0.406 mm) thickness gauge between the rocker arm and yoke.
2. Turn adjusting screw until a light drag is felt on the thickness gauge.
3. After adjustment is complete, hold screw (to keep from turning) and tighten locknut. Torque locknut to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
4. After tightening locknut, recheck valve lash clearance. Readjust as necessary.

Exhaust Valve Adjustment

Exhaust valve lash clearance is 0.024 inch (0.610 mm) or 0.028 inch (0.711 mm) for V-MAC II or mechanically governed engines equipped with camshafts effective April 1996.

1. Place the appropriate thickness gauge between the rocker arm and yoke.

NOTE

Exhaust valve lash clearance is 0.028 inch (0.711 mm) for V-MAC II or mechanically governed engines equipped with the new cam effective April 1996. Check the engine identification plate for the proper setting. Refer to Figure 7-10.

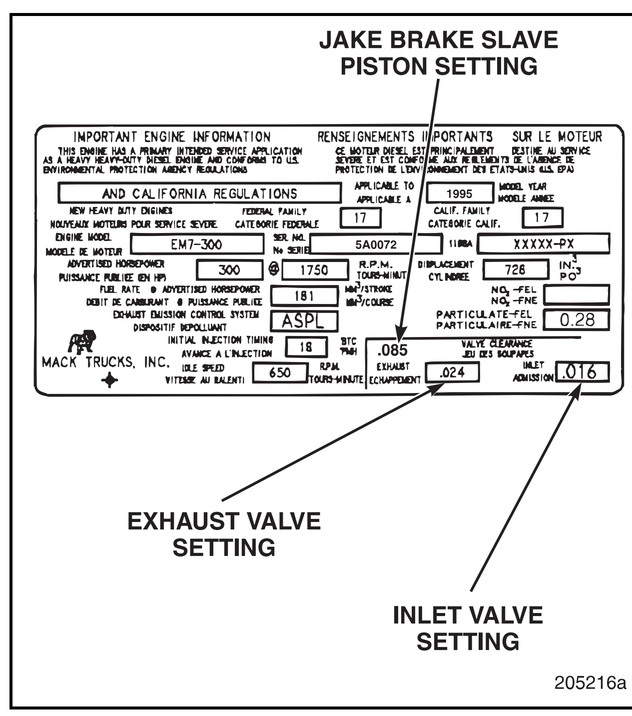


Figure 7-10 — Typical Engine Identification Plate

2. Turn adjusting screw until a light drag is felt on the thickness gauge.
3. After adjustment is complete, hold screw (to keep from turning) and tighten locknut. Torque locknut to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
4. After tightening locknut, recheck valve lash clearance. Readjust as necessary.

Slave Piston Adjustment

Engine and Turbocharger Model, and Camshaft Part No. 454GC —	Engine Brake	Slave Lash	Adjusting Tool Part No.
1996/1997 E7 with 5205 camshaft and S300 or S400 Turbocharger	Jake Brake plus Extarder	0.085"	014177
1996/1997 E7 with 5205 camshaft and S300 or S400 Turbocharger	Jake Brake Only	0.060"	022001
1996 E7 with 583(A), 5142 camshaft and S3B or S4D Turbocharger	Jake Brake Only	0.080"	018781/ 020521
1991–1996 E7 with 583(A), 5142 camshaft and S3B or S4D Turbocharger	Jake Brake plus Extarder	0.100"	021327
1991–1995 E7 with 583(A), 5142 camshaft	Jake Brake Only	0.080"	018781/ 020521
Pre-1991 E7 with 583(A) and 5142 camshaft	Jake Brake Only	0.085"	014177

* Refer to 200 APPENDIX (at the back of this manual) for list of selected 1990 E7 engine serial numbers requiring 0.080-inch (2.05 mm) thickness gauge No. 017099 for slave piston adjustment.

NOTE

To determine the proper Jake brake slave piston lash setting for a particular engine, first determine if the engine has the Jake brake only or Jake brake plus Extarder, then refer to the appropriate chart. The production change from the 5142 camshaft to the 5205 camshaft occurred mid-year 1996. To determine which camshaft a 1996 engine has, determine the turbocharger model from the turbocharger identification plate. A turbocharger model S3B or S4D means the engine was built with a 5142 camshaft. A turbocharger model S300 or S400 means the engine was built with a 5205 camshaft.

NOTE

If an S3B or S4D turbocharger is mistakenly replaced with an S300 or S400 turbocharger on a Jake Brake-equipped engine, slave lash adjustment does not change. Slave lash adjustment is determined by the original engine camshaft, not the turbocharger.

CAUTION

Make this adjustment carefully. After slave piston adjusting screw locknut is properly torqued to 40 lb-ft (54 N•m), recheck the clearance with the Jacobs feeler gauge. Readjust as necessary.

1. Loosen the No. 1 cylinder slave piston adjusting screw until the slave piston is fully retracted in its bore (no drag on screw).
2. Insert the proper Jacobs feeler gauge between slave piston feet and Jacobs yoke. Turn the adjusting screw in until a slight drag is felt on the feeler gauge.
3. Hold adjusting screw (to keep from turning) and tighten locknut. Torque locknut to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent. Refer to the Lash Adjustment chart under Slave Piston Adjustment for correct thickness gauge.

Continuation of Adjustments

1. Using engine barring socket J 38587-A, manually rotate engine in normal rotation direction 120 degrees until pointer in flywheel housing aligns with the “5” mark on the flywheel. The No. 5 piston will be on the compression stroke. If engine is equipped with a pointer on the timing gear cover and marks on the vibration damper, rotate the engine until the pointer marked VALVE aligns with the “5” mark on the vibration damper. Refer to Figure 7-11.

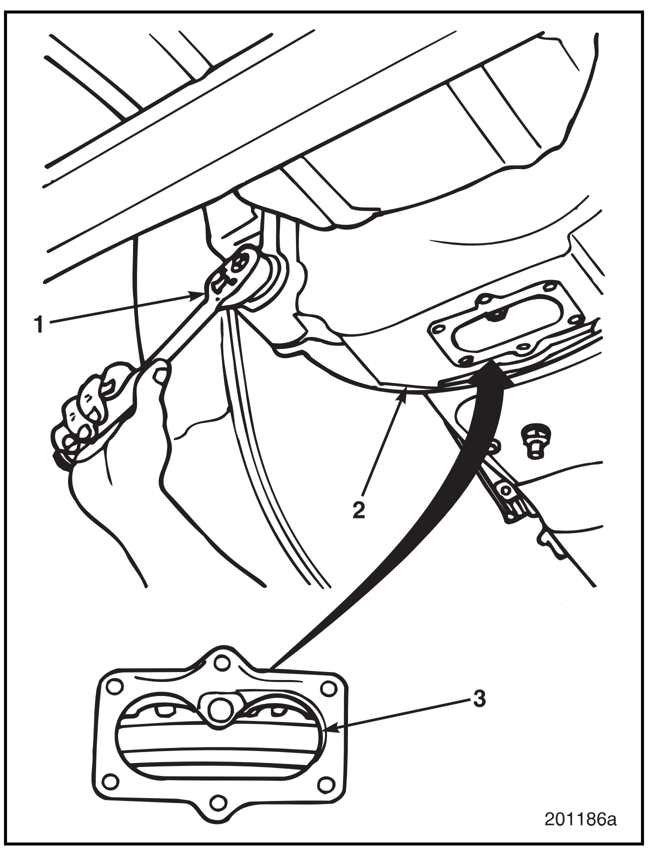


Figure 7-11 — Engine Crankshaft Rotation

2. Adjust the yoke, valves and slave piston lash as previously outlined for the No. 1 cylinder.

NOTE

E7 engine firing order is 1 - 5 - 3 - 6 - 2 - 4.

3. Continue adjusting yokes, valves and slave cylinder lash for the remaining cylinders, in firing order, placing each piston 30 degrees past TDC by rotating the crankshaft and aligning marks on the flywheel with pointer marked VALVE and appropriate mark on vibration damper, if equipped.

[221 GP] INJECTION PUMP FIXED-TIMING PROCEDURES

NOTE

Whenever the injection pump is removed from a MACK E7 engine, it is necessary to set injection pump-to-engine timing using the fixed-timing method. This method uses a portable fixed-timing light which electronically determines port closure to verify precise injection pump-to-engine timing.

Description

The fixed-timing method is a simple, accurate procedure which uses a timing light to set injection-to-engine timing. Using the fixed-timing method ensures optimum fuel economy and engine durability, and maintains engine exhaust within established EPA limits.

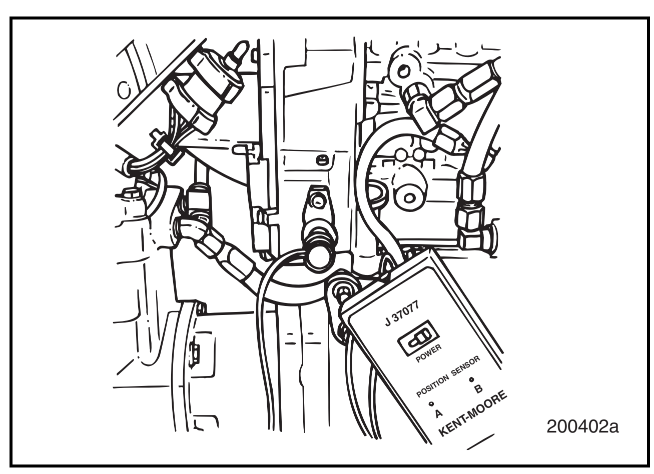


Figure 7-12 — Fixed Timing Method

CAUTION

Make sure key is off.

- On all P7100 non V-MAC mechanically controlled fuel-injection systems, injection timing is referenced to the No. 1 cylinder. The engine must be timed during the compression stroke of cylinder No. 1.
- On all P7100 V-MAC electronically controlled fuel-injection systems, injection timing is referenced to the No. 6 cylinder. The engine must be timed during the compression stroke of cylinder No. 6.
- On all P8500 V-MAC electronically controlled fuel-injection systems, injection timing is referenced to the No. 1 cylinder. The engine must be timed during the compression stroke of cylinder No. 1.

NOTE

The injection pump driven gear capscrews on factory-assembled E7 engines come in three different head sizes (15 mm, 16 mm or 17 mm). All four capscrews on a given engine will be the same and the torque is the same for all three head sizes: 40 lb-ft (54 N•m).

On mechanically governed engines, different head sizes pose no problem. On V-MAC engines, however, different capscrew head sizes can affect the use of V-MAC hub rotation tool J 38740, used to rotate the injection pump when setting injection pump-to-engine timing. J 38740 actually consists of two tools:

- An adapter with two posts that fit into tapped holes in drive hub.
- An adapter with two tubes, one on each end, fit over the heads of two of the timing adjustment capscrews. (This adapter will not fit over the heads of some of the timing adjustment capscrews. If this problem occurs, simply remove two of the adjustment capscrews and washers, and use the tool with posts in the openings.)

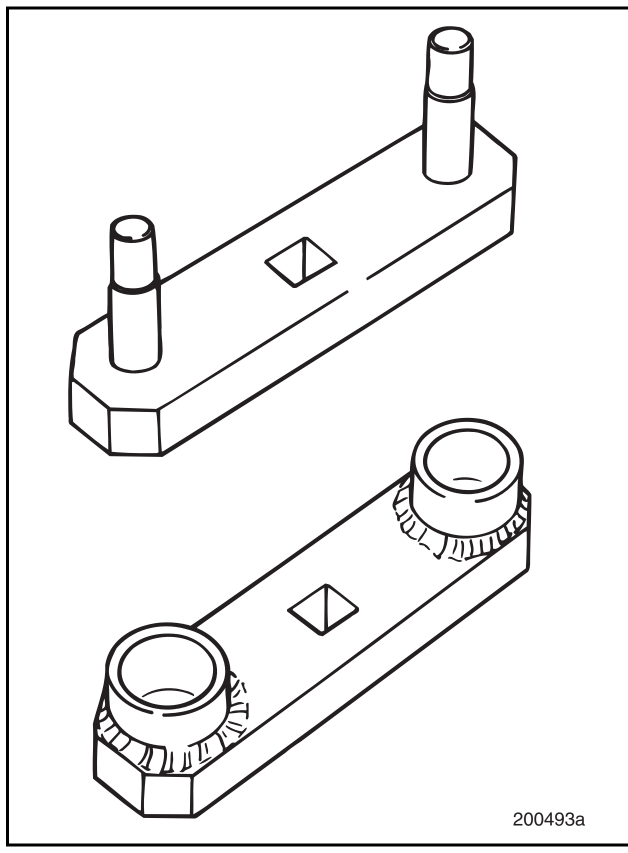


Figure 7-13 — V-MAC Hub Rotation Tool J 38740

CAUTION

When removing capscrews and washers, be extremely careful not to drop a washer into the engine. Removing the washer is difficult and may require some engine disassembly.

Following are procedures for:

- Setting Static Fuel Injection Pump Timing
- Fuel Injection Pump Driven Gear Installation
- Checking Pump-to-Engine Timing
- Fuel Injection Pump Access Cover Installation
- Fuel Injection Pump Pre-Lubrication
- Timing Event Marker (TEM) Installation

SERVICE HINT

Accurately setting the injection pump timing is the best way to ensure optimum fuel economy, engine durability, and maintain engine exhaust within established EPA limits.

Special Tools Required

- Fixed Timing Position Sensor (Light) J 37077
- Alignment Fixture J 37078
- Pump Drive Gear Alignment Dowels J 37085
- Hub Rotation Tool J 38740

Setting Static Fuel Injection Pump Timing

To set the static fuel injection pump timing, prior to pump removal, proceed as follows:

1. Remove the TEM sensor (on mechanically governed engines, remove plug) from the fixed timing port.

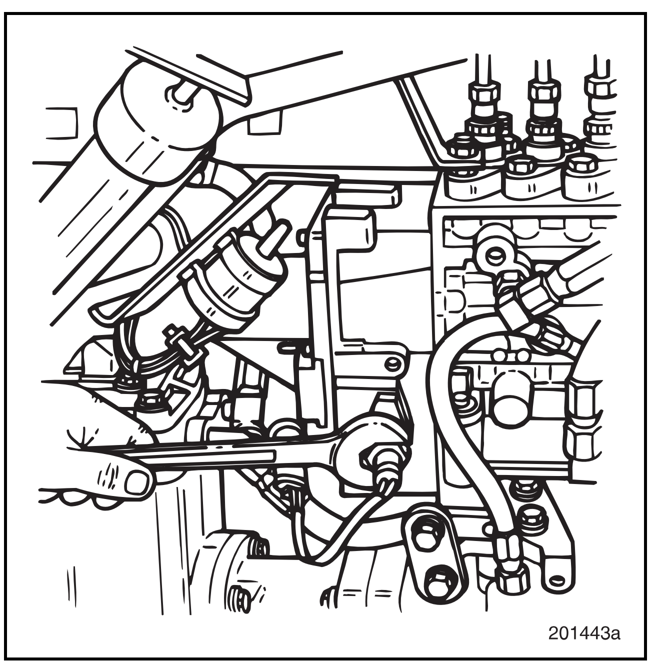


Figure 7-14 — Removing TEM Sensor

CAUTION

Thoroughly clean all residue from the fixed timing port threads (timing access window) before installing tool sensor. This will prevent the possibility of a false reading.

2. Clean all residue from the TEM sensor or plug threads.

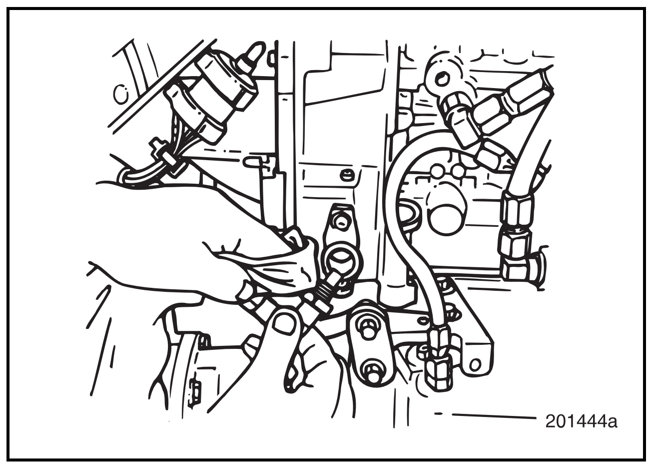


Figure 7-15 — Cleaning TEM Sensor Threads

3. Clean the J 37077 tool sensor probe points with compressed air before using. This helps prevent metallic contamination between the sensor probe points.

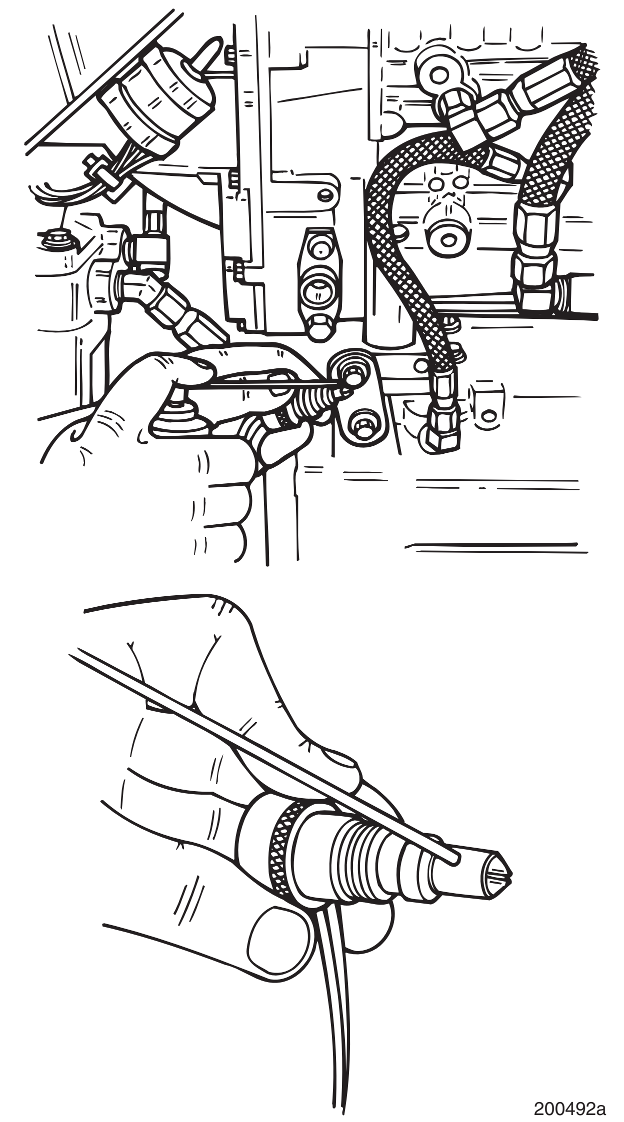


Figure 7-16 — Cleaning Sensor Probe Points

4. Install fixed timing position sensor tool J 37077. Make sure that tool is correctly aligned with the locating groove in the fixed timing port.

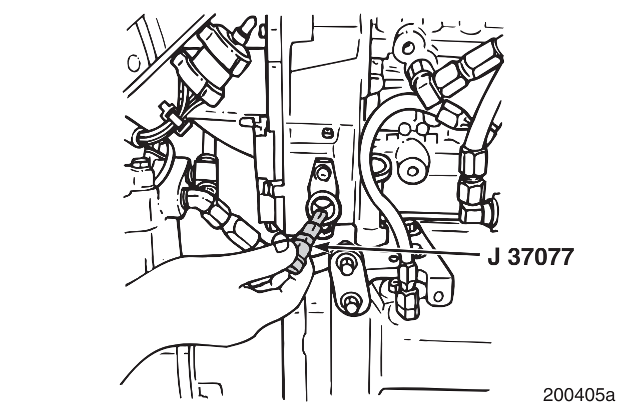


Figure 7-17 — Installing J 37077 Tool

5. Slowly turn the knurled surface clockwise to lock the tool into place. Check to make sure tool is seated by applying pressure to the end of the tool and checking for any movement. If movement is detected, remove and reinstall the tool.

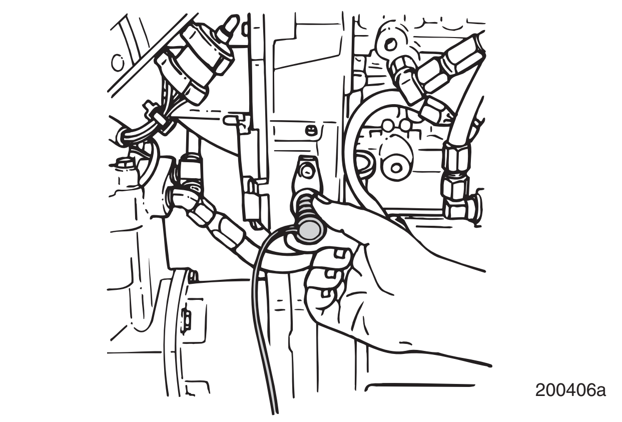


Figure 7-18 — Turning Knurled Surface Clockwise

6. Connect the fixed timing tool ground to the engine and press power switch on.

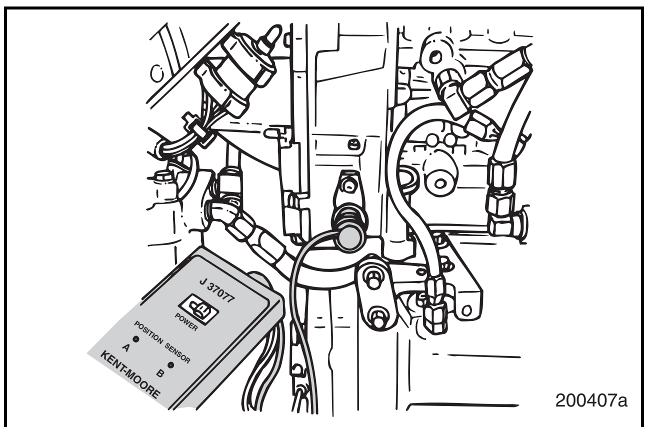


Figure 7-19 — Grounding and Turning Tool On

7. To continue the procedures for setting the timing, refer to the following applications for an engine with front timing indicator or with rear timing indicator.

ENGINE WITH FRONT TIMING INDICATOR

E7 mechanically governed engines with automatic transmissions use the Center Web Vibration Damper with timing marks. The vibration damper timing indicator and engine front turnover bracket are used in this application.

1. Rotate the engine crankshaft counterclockwise (as viewed from the front of the engine) to a minimum of 45 degrees before Top Dead Center (TDC).
2. Rotate the engine crankshaft clockwise until lamps A and B are both lit. Fuel injection pump-to-engine timing is now set and the injection pump can be removed from the engine.

ENGINE WITH REAR TIMING INDICATOR

E7 mechanically governed engines with manual transmissions and all V-MAC engines with manual and automatic transmissions use the flatback vibration damper with no timing marks. They are also equipped with flywheel and flywheel housings that incorporate engine timing and turnover features. With rear timing, the front timing indicator and engine front turnover bracket are not utilized.

1. Remove all six 8-mm capscrews to access the flywheel housing timing window.
2. Remove the plastic plug in the cast-machined opening in the forward face of the housing.
3. Insert engine barring socket tool J 38587 into the opening.
4. Install a 1/2-inch drive ratchet into tool J 38587 to rotate the flywheel.
5. Rotate the flywheel counterclockwise to a minimum of 45 degrees before TDC.
6. Rotate the flywheel clockwise in normal direction (as viewed from the front of the engine), until lamps A and B are both lit. Fuel injection pump-to-engine timing is now set and the injection pump can be removed from the engine. Remove tool J 38587 from the flywheel housing.

Fuel Injection Pump Driven Gear Installation

To install the fuel injection pump gear:

1. Verify crankshaft is set to correct BTDC position for pump timing.
2. Connect timing-light tool J 37077 (refer to beginning of the section, Setting Static Fuel Injection Pump Timing). Using hub rotation tool J 38740, rotate the timing gear hub clockwise until both lights A and B are lit.

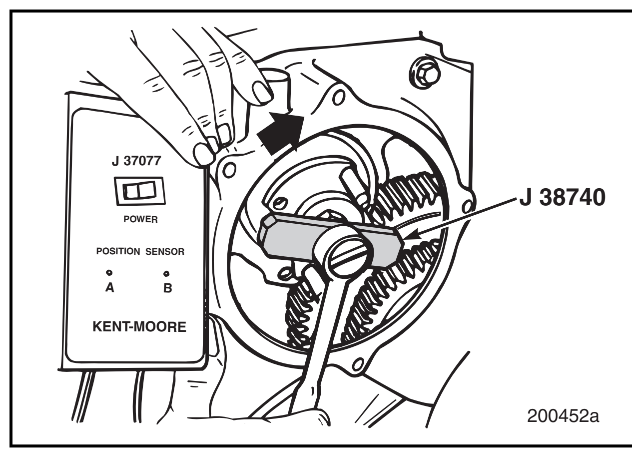


Figure 7-20 — Rotating Timing Gear Hub Clockwise

⚠ CAUTION

- *Use the proper hub rotation tool J 38740 which allows rotation of the hub only.*
- *Do not use the inner shaft nut (25 mm) to rotate the timing gear hub.*
- *If the inner shaft nut is used to rotate the hub, the nut may loosen, resulting in subsequent failure.*

3. Install two pump drive gear alignment dowels, J 37085, to ease alignment of drive gear to timing gear hub.

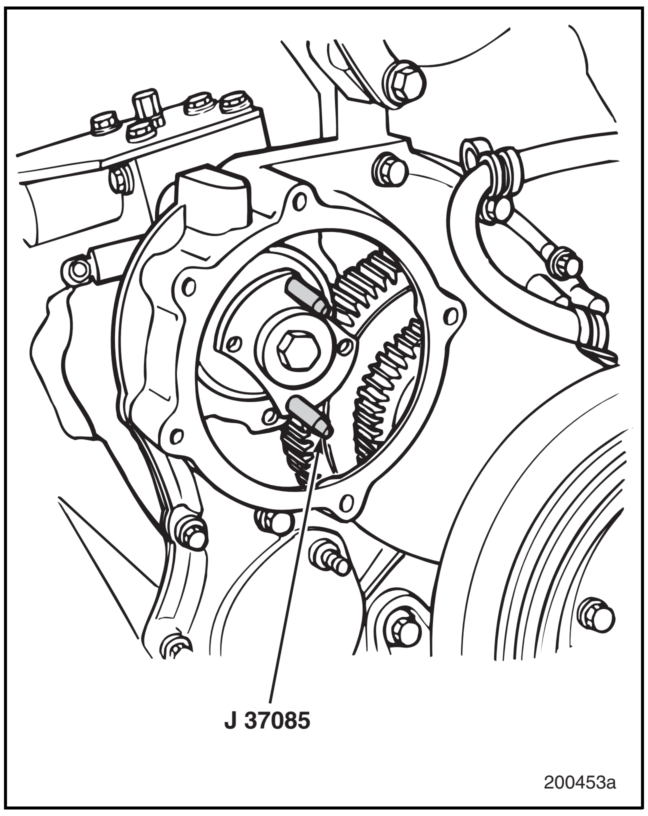


Figure 7-21 — Installing Drive Alignment Dowels

4. Install the fuel injection pump driven gear on the timing gear hub so the screw holes in the hub are centered in the gear slots/alignment dowels.

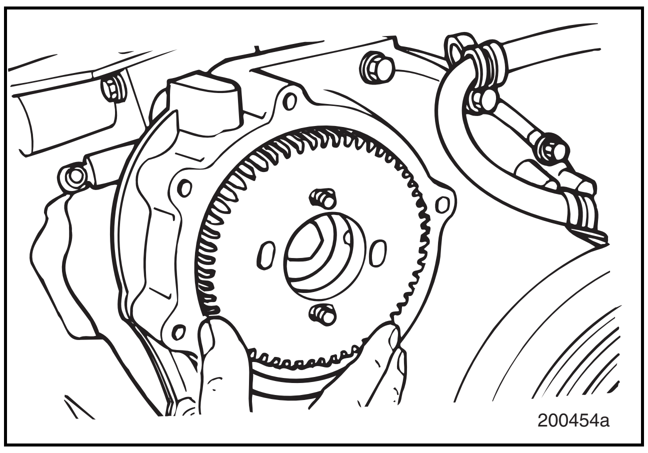


Figure 7-22 — Installing Driven Gear

5. Install two driven gear capscrews in the open holes. Install capscrews snugly to remove clearance but allow relative motion between hub and gear.

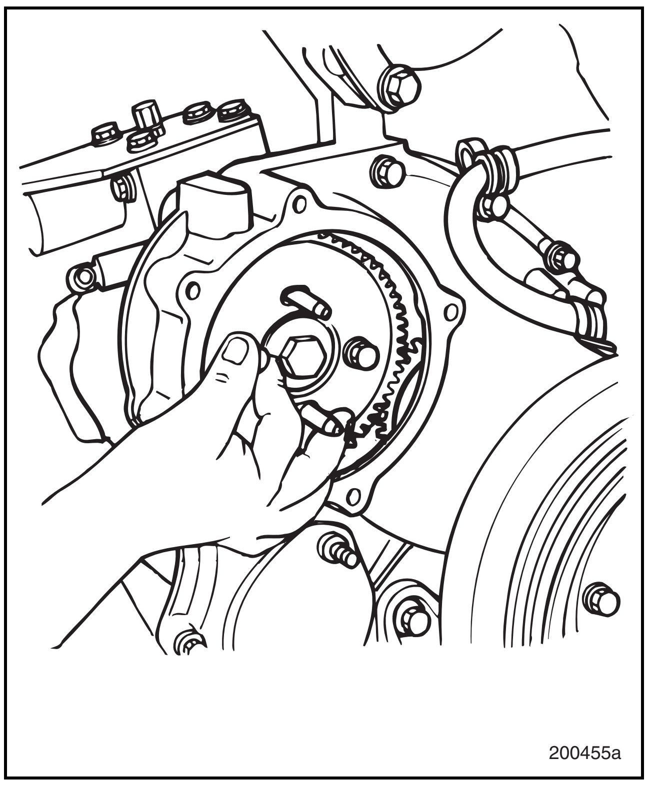


Figure 7-23 — Installing Driven Gear Capscrews

6. Remove the alignment dowels and install remaining capscrews in the same manner.
7. Using hub rotation tool J 38740, rotate the timing gear hub counterclockwise until screws bottom in the ends of the gear slots in the fuel injection pump driven gear. When this happens, both lamps will go out.

NOTE

Three different head sizes have been used for the injection pump timing adjustment capscrews. Refer to Description at the beginning of this procedure for additional information.

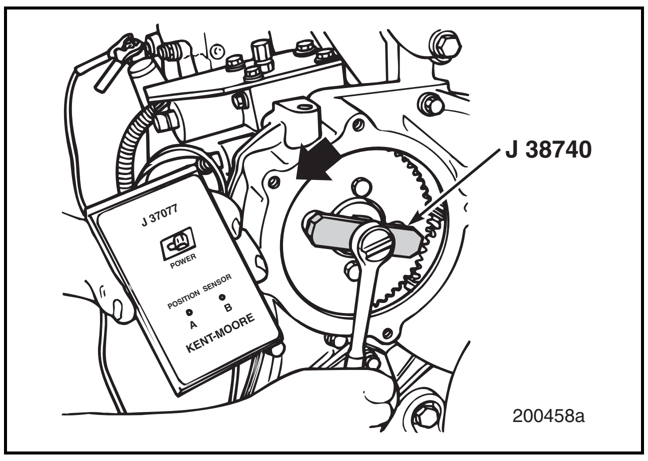


Figure 7-24 — Rotating Timing Gear Hub Counterclockwise

8. Rotate timing gear hub clockwise until both A and B lamps are lit. There is only a very small band of rotation for which both lamps are lit.

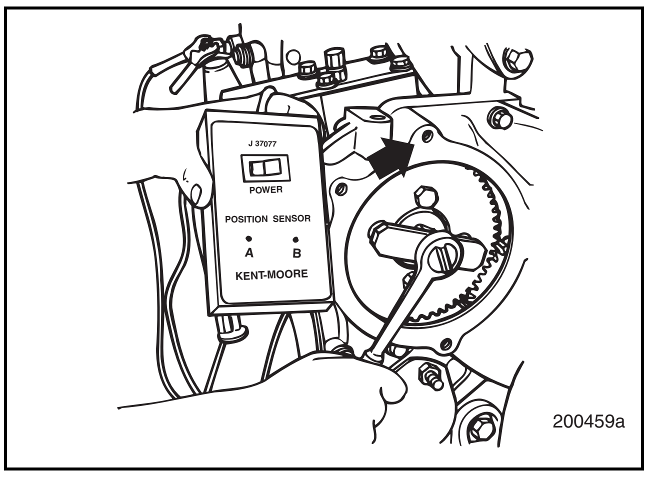


Figure 7-25 — Rotating Timing Gear Hub Clockwise

9. Torque all fuel injection pump driven gear capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

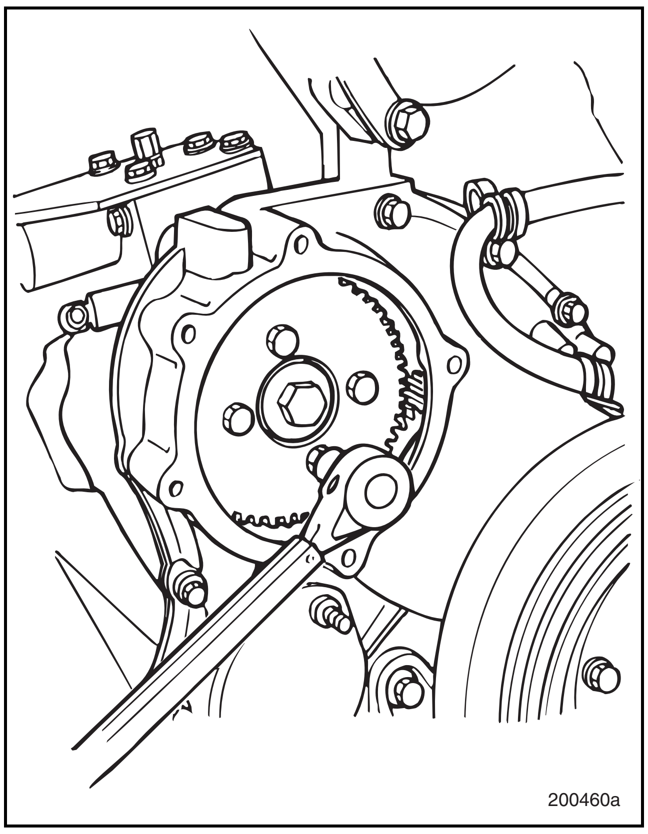


Figure 7-26 — Torquing Driven Gear Capscrews

CAUTION

Lamp A or B may go out during torquing procedure. This is acceptable. Do not attempt to keep lamps lit. Doing so may cause improper pump-to-engine timing.

Checking Pump-to-Engine Timing

CAUTION

Using hub bolt to rotate engine backward may change bolt torque. Check torque of hub bolt after completing timing procedure.

1. Rotate engine crankshaft counterclockwise to a minimum of 45 degrees before TDC. Both A and B lamps will go out.
2. Rotate engine crankshaft clockwise until both A and B lamps are lit. If timing pointer does not cover a value within ± 0.5 (1/2) degree of desired timing, the engine is not timed correctly. Before continuing, check and verify piston is at TDC. Refer to Locating Piston Top Dead Center (TDC) in SETUP AND ADJUSTMENTS.

NOTE

If timing is not within specification, reset and recheck timing.

3. After achieving correct timing, remove timing tools.
   a. Turn tester power off.
   b. Disconnect tester ground.
   c. Remove fixed timing probe.
4. Install fixed timing port plug or TEM sensor.
5. Check torque of hub bolt. The correct torque is 360 lb-ft (488 N•m).

Fuel Injection Pump Access Cover Installation

To install the fuel injection pump access cover:

1. Lubricate the access cover O-ring with Lubrizol® OS-50044 or equivalent.

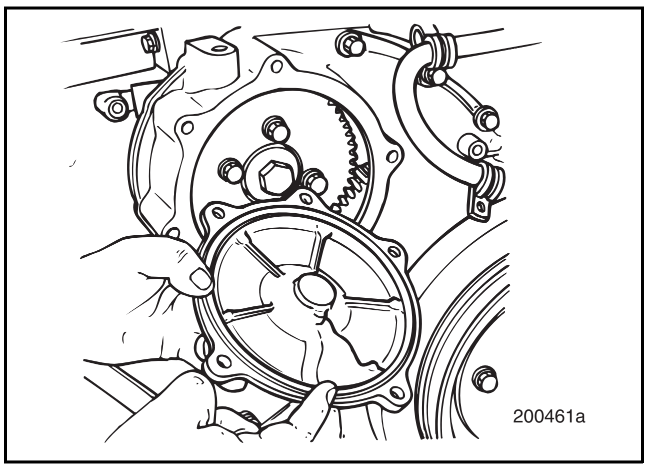


Figure 7-27 — Lubricating Access Cover O-Ring

2. Install clamp and access cover capscrews.
3. Torque access cover capscrews to 30 lb-ft (41 N•m) using torque wrench J 24407 or equivalent.

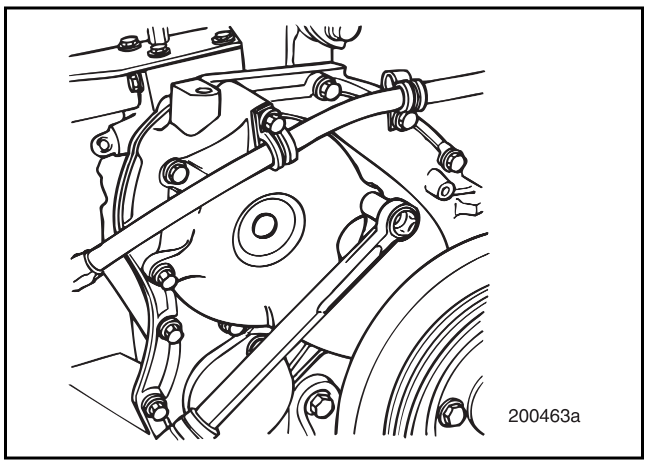


Figure 7-28 — Installing and Torquing Access Cover Capscrews

4. Run wire through both the drilled access cover capscrews and through the center of the lead seal and loop it. Then bring it through again.

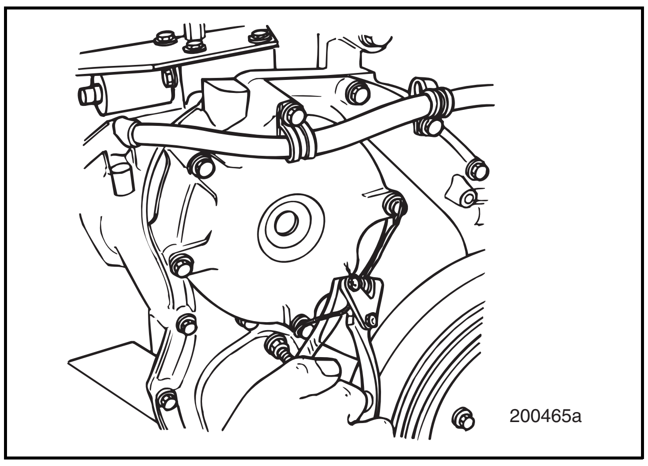


Figure 7-29 — Installing Access Cover Seal

5. Using Midget sealing tool 814 or equivalent, compress the lead seal.
6. Reconnect fuel injection pump oil supply line.

Fuel Injection Pump Pre-Lubrication

To pre-lubricate the P8500/RE30 fuel injection pump and governor, add 12 ounces (0.4 liter) of clean engine oil through the Timing Event Marker (TEM) port located in the RE30 governor housing. Oil will run through the governor into the pump.

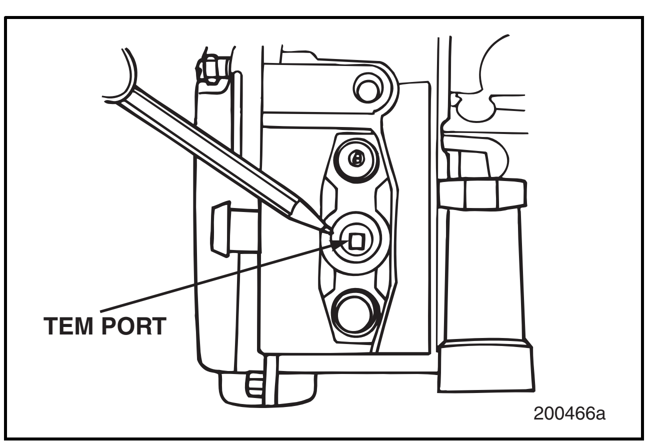


Figure 7-30 — P8500/RE30 Injection Pump Pre-Lubrication

To pre-lubricate the P7100 fuel injection pump with mechanical governor, remove the timing sensor (fixing plate) plug in the governor housing. Add 12 ounces (355 ml) of clean engine oil. This will fill both the governor and fuel injection pump. Reinstall the timing sensor (fixing plate) plug.

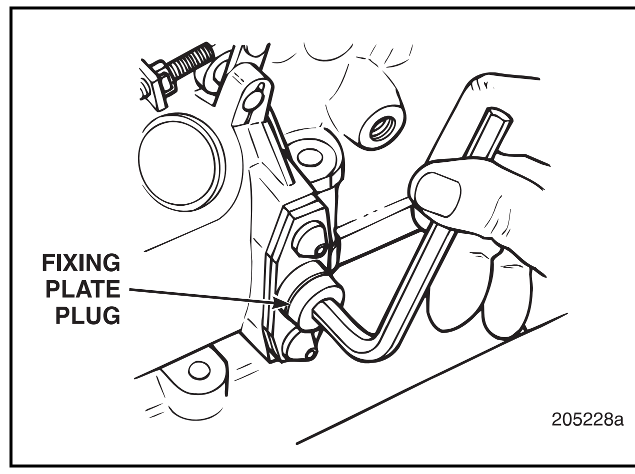


Figure 7-31 — P7100 Injection Pump/Mechanical Governor Pre-Lubrication

To pre-lubricate the P7100 V-MAC fuel injection pump and governor, remove the timing event marker located on the governor and add 3.5 ounces (104 ml) of clean engine oil. Reinstall the timing event marker. To pre-lubricate the V-MAC injection pump, remove the plug in the side of the pump housing and add 11 ounces of clean engine oil. Reinstall the plug.

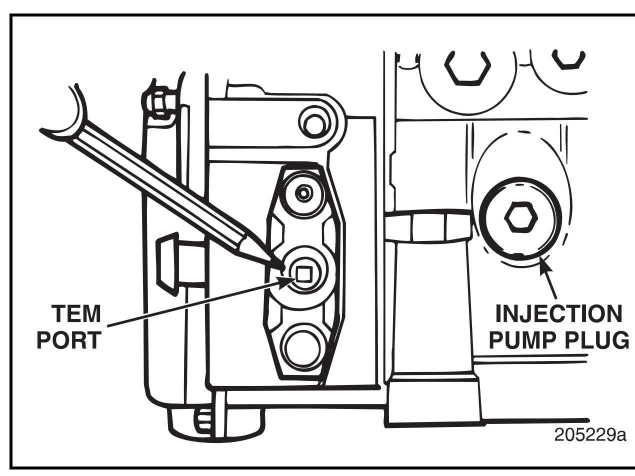


Figure 7-32 — P7100 V-MAC Injection Pump/Governor Pre-Lubrication

NOTE

Pre-lubrication is required anytime a new or used fuel injection pump is removed and then installed on the engine.

Timing Event Marker (TEM) Installation

To install the TEM:

1. Thoroughly clean all oil residue from the TEM and timing access window.
2. Completely back off the TEM jam nut (toward the sensor pigtail).
3. Apply a 1/8- to 1/4-inch bead of Silastic (MACK part No. 342SX32 or equivalent) around the sensor threads at the jam nut.

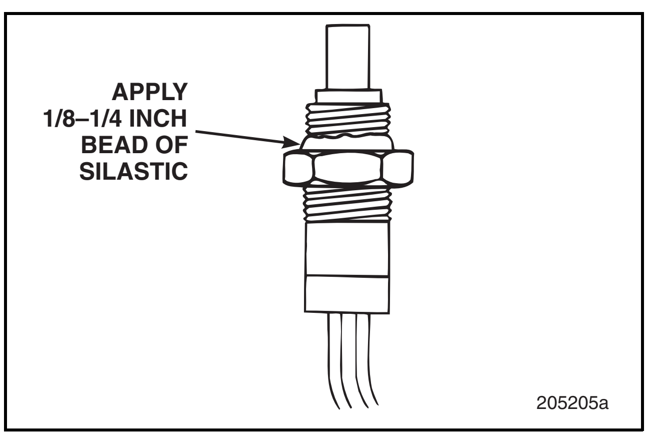


Figure 7-33 — Silastic Application

4. Install the TEM sensor into the timing access window and hand tighten until seated in the timing window.

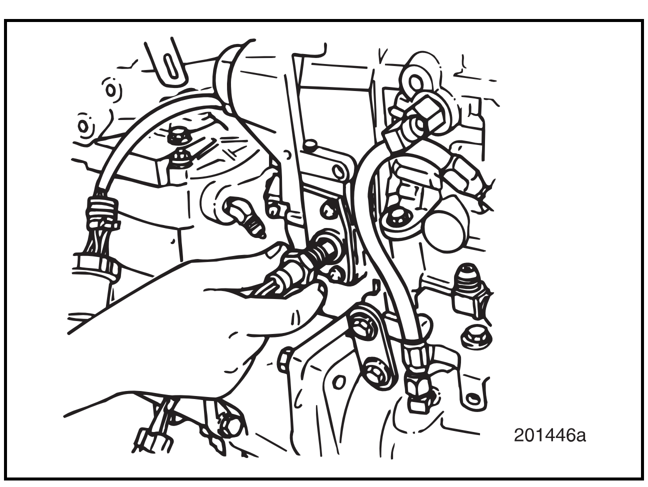


Figure 7-34 — Installing TEM Sensor

5. Tighten the jam nut, running it over the Silastic.
6. Torque the jam nut to 22 lb-ft (30 N•m) using torque wrench J 24406 or equivalent.

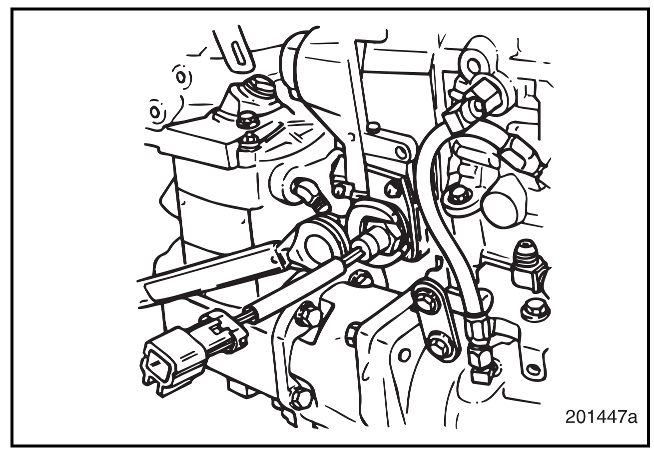


Figure 7-35 — Torquing TEM Sensor Jam Nut

7. Wipe the excess Silastic with a dry cloth.
8. Reconnect all brackets, connections and fuel lines.

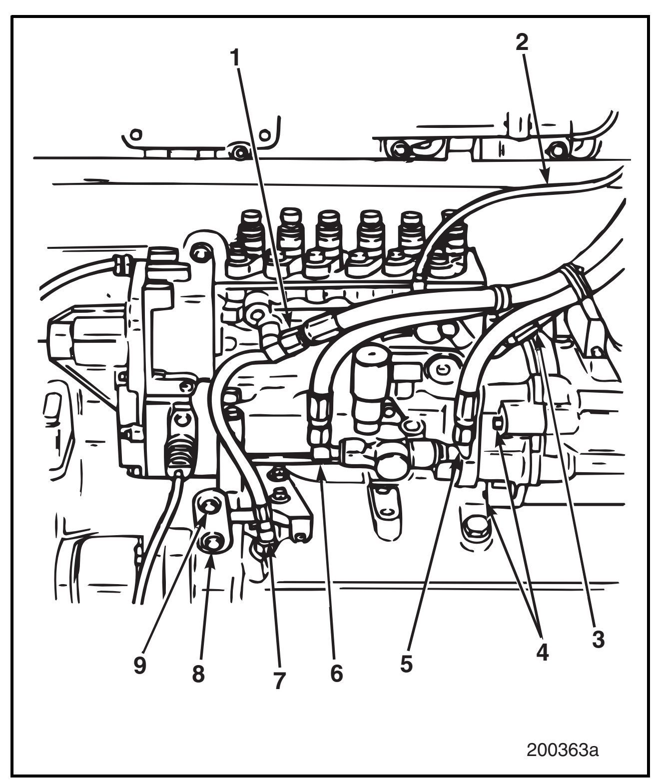


Figure 7-36 — Pump Line Connections

1. Return from secondary filter	5. Return to secondary filter
2. Cylinder head overflow line	6. Return from primary filter
3. Return to tank line	7. Lubrication supply line
4. Capscrew	8. Capscrew
	9. Capscrew

9. Check all connections and clamps for tightness. Check for leaks.

[212 NP] LOCATING PISTON TOP DEAD CENTER (TDC)

E7 Series Engines with Front Timing Indicators

During timing inspection, if timing is found to be incorrect, check piston TDC and retime engine. The following instructions are provided to aid in locating piston TDC in the event the engine front timing pointer is bent or misaligned.

NOTE

On engines with front timing indicators, vibration damper is marked to show TDC location relative to No. 1 piston on compression stroke. After locating piston TDC, front timing indicator may be adjusted slightly until it aligns with the TC or “0” mark stamped on vibration damper.

Special Tool Required

- Top Dead Center Indicator Tool J 29539-A

Locating Piston TDC

CAUTION

If chassis is equipped with an engine stop control, pull control out to prevent accidental starting.

Refer to Figure 7-37.

1. Rotate engine in normal rotation direction until No. 1 piston is approximately at TDC on compression stroke.
2. Remove injection nozzle holder assembly from the No. 1 cylinder (front cylinder on E6 and E7 engines).
3. Install TDC indicator tool J 29539-A in nozzle holder opening.
4. Rotate engine in normal rotation direction until the highest reading is obtained on the dial indicator. At this point, zero dial indicator.
5. Center a 5-inch (127 mm) length of masking tape below the pump timing pointer and on the vibration damper.
6. Rotate engine in direction opposite to normal rotation until a reading of 0.060 inch (1.524 mm) is obtained on the dial indicator.
7. Rotate engine in normal rotation direction until dial indicator reads exactly 0.035 inch (0.889 mm).
8. Place a mark on the masking tape on the vibration damper to align with pump timing indicator pointer.
9. Rotate engine in normal rotation direction past zero on dial indicator until a reading of 0.060 inch (1.524 mm) is obtained.

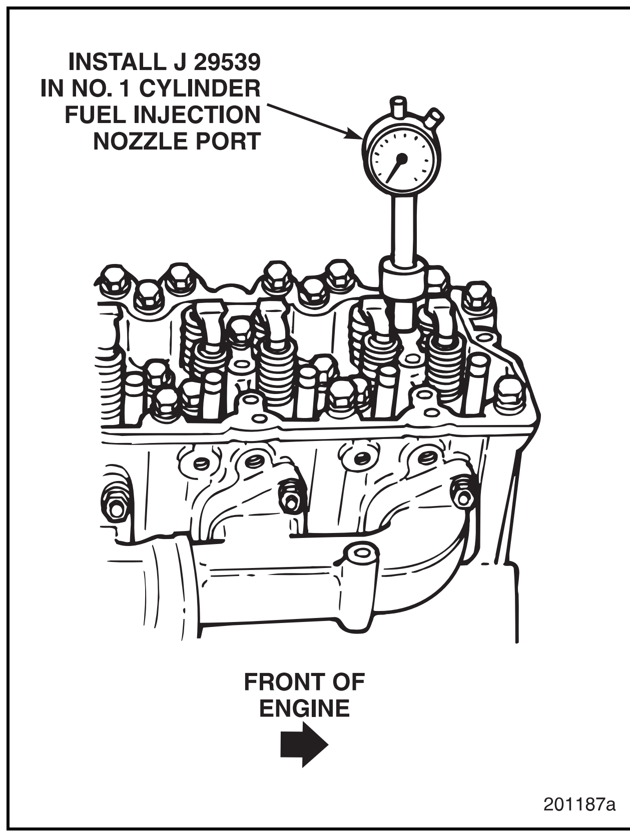


Figure 7-37 — Locating Piston TDC

10. Rotate engine in direction opposite to normal rotation until a reading of exactly 0.035 inch (0.889 mm) is indicated on dial indicator.
11. Place a mark on the masking tape on the vibration damper to align with pump timing pointer.
12. Measure distance between the two marks just made on the masking tape and place a third mark exactly at the midpoint between the first two marks.
13. Rotate engine in direction opposite to normal rotation until engine timing pointer aligns with the middle mark just made on vibration damper. Remove masking tape.
14. If necessary, without rotating the engine, realign pump timing pointer until it aligns with the TC or “0” mark stamped on the vibration damper.

ENGINE INSTALLATION & TESTING

INSTALLATION

Description

Engine installation details vary from vehicle to vehicle. The following procedure provides general installation guidelines for MACK E7 engines.

It is good practice to steam-clean road grime, grease, and oil from the engine before service. Steam-cleaning the engine and engine compartment permits more detailed inspection and improved workmanship.

Before beginning, make sure all equipment has been inspected for safety and is available for use. Place vehicle on a flat, level surface. Make sure area has ample work space.

NOTE

Newly designed torsional idler-gear assemblies are now available for servicing both 1:1 and 0.7:1 ratio Flywheel Power Take-Off (FWPTO) units in E7 engines equipped with a T200 series transmission and FWPTO. New assemblies feature a two-piece idler gear and torsion spring.

The new torsional idler-gear assembly reduces spline wear on the FWPTO input (drive) gear. If the unit is removed for any reason:

- Inspect input gear splines for excessive wear.
- If splines show excessive wear, disassemble the FWPTO far enough to gain access to idler-gear assembly. Refer to MACK Service Manual 10-901, Flywheel Power Take-Off.

Removing Engine from Engine Stand

1. Attach a suitable lifting device to lifting points on engine.
2. Position and attach an engine hoist to lifting device; place tension on the device by operating hoist.
3. With lifting device supporting the engine weight, remove mounting capscrews from engine stand.

Engine Installation into Vehicle

NOTE

Obtain assistance when installing the engine. Be sure to watch for obstructions such as engine or chassis components, brackets, clamps or other components that may interfere with engine installation.

1. Align engine with torque converter or clutch (as applicable) and install transmission bell housing to the flywheel housing capscrews. Torque to specification.
2. Install engine mount capscrews to secure engine mounts to engine. Torque to specification.
3. Remove transmission jack from under transmission.
4. Install clutch linkage and bracket-retaining capscrews.
5. Install power-steering hoses and reservoir, if applicable.
6. Install hood rest crossmember(s), if applicable.
7. Install exhaust bracket to flywheel housing and exhaust clamp at turbocharger.
8. Install starter. Connect wiring and cables.
9. Install air cleaner housing, if required.
10. Install all coolant tubes, ground straps, air lines, fuel lines, hydraulic hoses or tubes, throttle linkage and electrical wiring harnesses that were removed from engine during removal.

NOTE

On some E7 models, the machined V-band was replaced with a 3.5-inch push-on turbocharger discharge connection that is angled forward. The remaining models use a 3-inch push-on connection directed 90 degrees outward from the center line of turbocharger.

NOTE

A new S3B turbocharger with a 3.5-inch push-on compressor discharge has replaced the earlier S3B turbocharger with cast elbow required for V-band connection. You will need to know which type turbocharger is used on your engine when ordering replacement parts.

11. Connect tube to turbocharger and air cleaner assembly.
12. Connect heater hoses and A/C refrigerant lines, if applicable, where attached at lower dash panel behind engine.
13. Install fan and fan clutch assembly.

NOTE

Belts used on the same drive must be installed in matched sets. Refer to the Maintenance and Lubrication manual, TS494, for procedures and specifications.

14. Install and adjust belts per specifications.
15. Install radiator using a lifting device and an assistant, if required.
16. Install retaining capscrews to radiator support mounts.
17. Install retaining capscrews to radiator support rods at radiator support.
18. Install fastener to bracket that secures radiator fan air clutch solenoid valve to radiator support.
19. Locate engine coolant temperature sensor and connect electrical connector. Install sensor harness to radiator support.
20. Connect Chassis-Mounted Charge Air Cooler (CMCAC) outlet hose at cooler.
21. Connect CMCAC inlet hose at cooler.
22. Install clamps that retain coolant overflow tank and install tank.
23. Connect lower radiator hose to coolant inlet of oil cooler assembly.
24. Connect upper radiator hose to engine coolant outlet fitting.
25. If vehicle is equipped with air conditioning:
    a. Connect electrical connector to low-pressure cutout switch in A/C refrigerant line.
    b. Connect electrical connector to binary (cycling clutch) pressure switch on receiver/dryer.
    c. Connect A/C line at receiver/dryer.
    d. Connect A/C compressor discharge hose at connection near radiator support.
    e. Obtain A/C refrigerant recovery and recycling equipment (J 38750-A for R12 or J 39500-B for R134A), and recover A/C system refrigerant.
26. Tighten clamps securing air intake tube to turbocharger and air filter. Install intake tube.
27. Install hood. Refer to Hood Installation procedures in the appropriate vehicle manual.

Filter Element Installation

⚠ CAUTION

All filters and coolant conditioners must meet MACK specifications. Prime oil filters before installation using the correct specification engine oil.

1. Install a new air filter in air filter housing.
2. Install Centri-Max™ assembly. Be sure to use a new element and O-rings.
3. Using an appropriate filter wrench such as J 29927, install oil filter elements and coolant conditioner element.

NOTE

Prime fuel filter elements before installation. Use only clean, MACK-specified, Grade 2D diesel fuel.

4. Prime the PRIMARY fuel filter element (red) by filling with clean No. 2 fuel oil. Do not fill filter through center hole; it must be filled using outer holes. Lubricate gasket with oil and install filter.

5. Prime the SECONDARY fuel filter element (green) by filling with clean No. 2 fuel oil. Do not fill filter through center hole; it must be filled using outer holes. Lubricate gasket with oil and install filter.

FINAL PREPARATION

Lubrication

A lubricating oil film coats rotating parts and bearings of an overhauled engine, but this may not provide sufficient lubrication when engine is started for the first time. The following briefly describes the recommended procedure for ensuring proper lubrication.

CAUTION

Do not mix brands or types of lubricants. Chemical additives may be incompatible and may contribute to the formation of sludge, acid or hardening.

SERVICE HINT

Usually there are various points on the engine where a pressure line may be tapped into, but if no other is apparent, the oil gauge line may be disconnected and pressure tank applied at that point.

ENGINE LUBRICATION SYSTEM (PRIMING)

1. Fill engine crankcase with EO-L engine oil.

NOTE

MACK-specified EO-L engine lubricant is recommended. E7 series engine capacity is 33.5 quarts (32 liters).

2. Fill a pressure prelubricator (J 39258-A) with the recommended oil and connect pressure prelubricator to main oil gallery. Prime engine lubrication system with sufficient oil.
3. Remove oil level dipstick and check crankcase level. Add sufficient oil, if necessary, to bring it to the FULL mark on dipstick. Do not overfill.

TURBOCHARGER

1. Disconnect turbocharger oil inlet line and pour approximately one pint (473 ml) of clean engine oil into line. This ensures that bearings are properly lubricated for initial start-up.
2. Reconnect oil line.

AIR INLET SYSTEM

1. Check the integrity of air inlet system.
2. Inspect all piping, connections and the air cleaner element. Replace components as required.

COOLING SYSTEM

1. Check cooling system. Make sure all plugs are installed and tight. Make sure thermostat is installed.
2. Fill system with recommended coolant.

NOTE

To ensure that all air is purged from cooling system, remove a plug from top (or end) of coolant manifold during filling. This will eliminate any air that was trapped as a result of rapid filling.

3. Install a new coolant conditioner and fill with the recommended coolant mixture.
4. Check that all plugs and thermostat(s) are installed.

FUEL INJECTION PUMP (MECHANICALLY GOVERNED AND V-MAC ENGINES)

1. Remove the TEM sensor or the 12-mm plug in the governor housing.
2. Fill pump housing with 12 ounces (355 ml) of EO-L engine lubricant.
3. Reinstall TEM sensor or 12-mm plug.

NOTE

Prelubing should be performed after new and used injection pumps are installed on the engine.

FUEL SYSTEM

1. Check fuel system to ensure that all connections are tight.
2. Remove any trapped air by operating manual priming pump, if equipped, located on the side of injection pump (V-MAC only).

NOTE

Prime the fuel system with clean, Grade 2D diesel fuel (DF-A).

3. Check injection pump timing. Injection pump-to-engine timing must be set for the specific engine. See Engine Identification Plate or Tune-Up manual for specifications.

Engine Operational Check

1. Remove all tools from the engine compartment.
2. Connect battery cables (negative cable last).
3. Clear work area of debris and personnel.
4. Start the engine. Check for leaks and monitor gauges for satisfactory oil pressure, etc.
5. After several minutes, shut the engine down. Check fluid levels and fill to capacity before restarting engine.
6. Refer to the following Rebuilt Engine Run-In Procedures for testing procedures.

REBUILT ENGINE RUN-IN PROCEDURES

Description

The durability and service life of a rebuilt engine is directly related to its initial run-in following overhaul. After a complete overhaul or any major repair job involving installation of piston rings, pistons, cylinder sleeves or bearings, the engine must be run-in prior to release for service.

Run-in procedures vary depending on method used (i.e., engine dynamometer, chassis dynamometer or highway run-in). Regardless of method, however, always properly prepare engine before starting it for the first time.

Run-In Check

NOTE

Install any additional instrumentation needed for run-in method selected.

The operator should be familiar with correct, established procedure for checking chassis power *before* using chassis dynamometer method for run-in (refer to applicable chassis dynamometer operation procedures).

The operator must be observant throughout the entire run-in procedure, in order to detect any problems that develop. Constantly monitor the instrumentation displaying functions of the engine and support systems, and record all readings.

If, during run-in, the engine develops any of the following abnormal running characteristics, shut it down immediately. Investigate and correct the problem before continuing run-in procedure.

Always investigate the following conditions:

- Unusual noises such as knocking, scraping, etc.
- A significant drop in engine oil pressure.
- A significant rise in coolant temperature, exceeding 240°F (116°C).
- A significant rise in oil temperature that exceeds 240°F (116°C).
- An exhaust temperature that exceeds maximum acceptable limit for the specific engine involved, as measured by a pyrometer (if applicable).
- Any oil, coolant or air inlet system leaks.

[233 FA] CHASSIS-MOUNTED CHARGE AIR COOLING

Description

The Chassis-Mounted Charge Air Cooling (CMCAC) system cools hot turbocharged air before it enters the engine intake manifold. The CMCAC system uses ambient air as a cooling medium by allowing it to pass through a core equipped with heat-exchanging fins.

Hot turbocharged air, varying in pressure from 0.0–25 psi (0.0–172 kPa), passes through core tubes where heat is transferred to the ambient air by heat-exchanging fins.

Front-section core construction consists of a series of cold bars, cold fins and tube plates. Side-section core construction consists of a series of hot bars and hot fins.

Special Tool Required

- Charge Air Cooler Pressure Fixture J 41473

CMCAC Troubleshooting

Symptom	Probable Cause	Remedy
Normal Boost — High Pyrometer	1. Core fin obstructions.	1. Clean core fins.
Low Boost — High Pyrometer	1. Restriction in ducting between air cleaner and turbo. 2. Dirty turbocharger. 3. Leaks in the pressurized side of the induction system. 4. Inlet manifold leak. 5. Open petcock (if equipped). 6. Core leakage.	1. Check for blockage and clean. 2. Clean turbocharger. 3. Check for and repair leaks. 4. Check for loose or missing fittings, plugs, and/or damaged manifold-to-cylinder head gaskets. Replace missing parts, and repair loose connections. 5. Close petcock. 6. Pressure test core. Remove, repair or replace core if test results are not satisfactory.
Low Power	1. Restrictions in cooler. 2. Restrictions in cooler inlet and outlet tubes.	1. Perform restriction pressure test. Clean out restriction. 2. Disconnect and clean obstructions.

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CMCAC Pressure Test

1. Remove air ducting from core.
2. Plug core inlet opening.
3. Insert a plug with an air-line adapter in core outlet opening.
4. Connect a safety chain to both plugs. Use air charge cooler pressure fixture J 41473 on coolers with flange connections.

WARNING

Stand clear of plug area when system is pressurized.

5. When plugs are secured, attach an air line (fitted to a pressure regulator and gauge) to air-line adapter in core outlet opening.
6. Pressurize system to 30 psi (207 kPa).
7. Shut off air source. Pressure should not drop more than 5 psi (35 kPa) within 15 seconds. Repair or replace core if pressure drop exceeds specification.
8. Carefully release pressure in system.
9. After repairing or replacing core, reconnect ducting. Torque clamp nuts until clamp spring is fully compressed.

NOTE

When the spring is fully compressed, torque on the nut is generally between 40–55 lb-in (4.5–6.2 N•m).

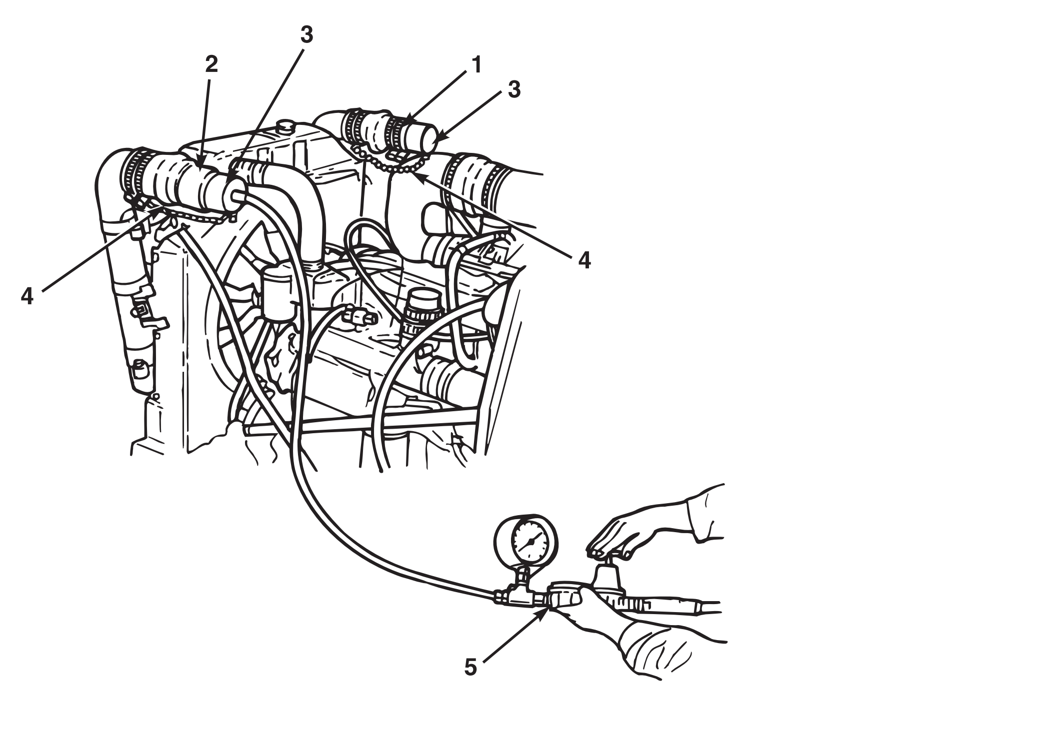

Figure 8-1 — CMCAC Pressure Test

1. Core inlet 2. Core outlet 3. Plug (part of J 41473)	4. Safety chain 5. Air pressure regulator and gauge (J 41473)

Restriction Pressure Test

SERVICE HINT

Perform restriction pressure test at maximum, full-load condition.

A restriction in the internal portion of cooler may interfere with proper airflow, and can result in excessively high pyrometer readings. To perform a restriction pressure test, use the following procedure:

1. Units are equipped with connections on the inward sides of inlet and outlet charge cooler tubes. Remove plugs and install pressure gauge lines to begin test.
2. Install the appropriate pressure gauge to inlet and outlet charge air cooler tubes. The maximum allowable pressure drop across cooler is 2 psi (13.79 kPa) at full-load condition.

NOTE

If using manometers for this test, the difference between readings should not exceed 4 in-Hg (13.5 kPa).

3. If pressure drop is higher than specified amount, remove CMCAC. Flush the inside to remove any deposits that may be present. Do not use caustic cleaners. Be extremely careful when handling cooler so as not to damage core.

CAUTION

The clamp springs must always be located on underside of tube to avoid damaging hood when closed.

4. Reinstall cooler if removed to flush and then pressure-test CMCAC system.
5. If cooler passes restriction and pressure tests, remove test equipment, reinstall inlet and outlet tubes, hoses and clamps or reinstall plugs, if equipped. Tighten clamps to 38 lb-in (4.3 N•m).

Core Repair

Certain types of CMCAC core foreign object impact damage can be field-repaired (depending on extent of damage). Other types, or more extensive damage, cannot be field-repaired and require core replacement.

Determining whether or not core damage is repairable is a critical first step. Proper diagnosis can eliminate costly man hours and keep vehicle downtime to a minimum.

REPAIR PROCEDURES

The following guidelines will help you determine which areas are repairable or nonrepairable.

To ensure the CMCAC system will function properly after repair or replacement, a pressure/leak test is recommended.

Damage	Core Failures	Recommended Repair Procedure	System Check
Repairable	All header tank-to-core separations	Tungsten-Inert (TIG) weld method	Perform pressure/leak test
	All header tank cracks	Tungsten-Inert (TIG) weld method	Perform pressure/leak test
	Bent cold fins	Straighten with small screwdriver or pair of small needlenose pliers	Perform pressure/leak test
	Tube plate cracks or welds not exceeding 0.25 inch (6.35 mm) in length	RTV method or Tungsten-Inert (TIG) weld method	Perform pressure/leak test
	Tube cracks or weld separations exceeding 0.25 inch (6.35 mm) in length	Tungsten-Inert (TIG) weld method	Perform pressure/leak test
Nonrepairable	Internal fins damaged and separated from tube plate	No repair procedure is recommended — replace unit	Perform pressure/leak test
	Tube blockage	No repair procedure is recommended — replace unit	Perform pressure/leak test
	Cold bar separations or openings exceeding 0.25 inch (6.35 mm) in length	No repair procedure is recommended — replace unit	Perform pressure/leak test
	Excessive cold fin damage (original shape of fins distorted beyond repair)	No repair procedure is recommended — replace unit	Perform pressure/leak test

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INSPECTION

1. Carefully inspect entire system to determine exact location and extent of damage.
2. Inspect cold fins and cold bars that run horizontally in cooler.
3. Inspect all brazed or welded joints in header tank.
4. Make sure area to be repaired is free of surface oxide and foreign materials such as oil, grease, dirt, etc. Prior to repair, prepare surface with a clean stainless-steel brush.

TUNGSTEN-INERT (TIG) WELD METHOD

TIG-weld using 1/16–5/32 inch diameter AWS ER 4043 filler rod. Welds should exhibit complete fusion without excessive overlap or undercut.

NOTE

MACK recommends pressure-testing the CMCAC system after repairs are complete.

CMCAC Preventive Maintenance

In case of engine and/or turbocharger failure, perform the following steps to make sure CMCAC system is free from debris:

1. Remove chassis-mounted cooler and flush inside with a safety solvent to remove oil and other foreign debris.
2. Shake cooler to remove large pieces.
3. Wash with hot soapy water. Rinse with clean water and blow dry with compressed air in reverse direction of flow.
4. Carefully inspect cooler to ensure cleanliness. Do not use caustic cleaners.

NOTES

TROUBLESHOOTING

ENGINE WILL NOT CRANK

Possible Cause	Correction
1. Batteries have low output.	1. Check the batteries. Charge or replace as required.
2. Loose or corroded battery connections.	2. Clean and tighten battery connections.
3. Broken or corroded wires.	3. Check voltage at the following connections: — Switch to starter — Battery to starter Replace as required.
4. Faulty starter or starter solenoid.	4. Check operation of starter and solenoid. Repair as required.
5. Faulty key switch.	5. Replace key switch.
6. Internal seizure.	6. Bar the engine over one complete revolution. If the engine cannot be turned, internal damage to the clutch is indicated. Disassemble clutch or engine and repair as required.

200766a

ENGINE CRANKS — WILL NOT START

Possible Cause	Correction
1. Slow cranking speed.	1. Check corrections listed in preceding section, ENGINE WILL NOT CRANK.
2. Emergency shut-off valve closed or partially closed.	2. Check emergency shut-off system. Make necessary repairs.
3. No fuel to engine.	3. Check for fuel in the fuel tank. Also check for plugged fuel tank connections, restricted or kinked fuel suction lines, fuel transfer pump failure, or clogged fuel filters.
4. Governor throttle shaft linkage binding/improper setting of accelerator linkage.	4. Check throttle shaft and accelerator linkage. Repair as necessary.
5. Defective fuel transfer pump.	5. Check transfer pump for minimum output pressure. Change fuel filters if low. Look for air leaks and recheck pressure. If still below minimum, replace transfer pump.
6. Poor quality fuel or water in fuel.	6. Drain fuel from tank. Replace fuel filters and fill fuel tank with MACK-specified diesel fuel.
7. Incorrect engine oil viscosity.	7. Drain oil. Replace oil filters and fill crankcase with recommended grade oil.
8. Low compression.	8. Check cylinder compression. If low, refer to LOW COMPRESSION in this section.
9. Injection pump-to-engine timing incorrect.	9. Check injection pump-to-engine timing. Setting is protected by seals, and must be checked by an authorized MACK Fuel Injection System Repair facility.

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ENGINE MISFIRES

Possible Cause	Correction
1. Poor quality fuel, or water or dirt in the fuel.	1. Drain fuel from tanks. Replace fuel filters and fill tank with MACK-specified diesel fuel.
2. Air in fuel system.	2. Check fuel system for air leaks. Repair as necessary. (Air generally gets into the fuel system on the suction side of the fuel pump.)
3. Broken or leaking high-pressure fuel lines.	3. Check for fuel leaks. Repair as necessary.
4. Restricted fuel lines or drain lines.	4. Check for proper fuel flow. If no flow, replace lines.
5. Low fuel-supply pressure.	5. Check to be sure there is fuel in the fuel tank. Check for sharp bends or kinks in the fuel line between the fuel tank and the fuel transfer pump. Also check for clogged suction pipe (in the fuel tank) or a plugged fuel suction hose. Check for air in the fuel system, and check the fuel pressure. If the pressure is lower than specified, replace the fuel filters. If still low, replace the transfer pump.
6. Improper valve lash adjustment.	6. Check adjustment. Correct as necessary.
7. Defective fuel injection nozzles or fuel pump.	7. Run engine at speed which gives maximum misfiring or rough running. Cut the fuel flow to each cylinder, one at a time, by loosening the fuel line nut on the injection pump. If engine rpm does not change when the fuel is cut to a cylinder, it indicates that the cylinder is not firing. Remove the injection nozzle and check. Repair or replace as necessary. If nozzle is OK, check cylinder for low compression. If no fuel is present when line is loosened, pump may be defective. Repair or replace as required.
8. Improper timing.	8. Check fuel injection pump to engine timing.
9. Cylinder head gasket leakage.	9. Check for visible signs of leakage, coolant in the oil, or traces of oil in the coolant. Use a compression tester to check each cylinder. Replace cylinder head gasket if necessary.
10. Worn camshaft lobe.	10. With valve lash properly adjusted, check rocker arm movement. If not within specifications, replace worn parts.

200768a

ENGINE STALLS AT LOW SPEEDS

Possible Cause	Correction
1. Idle speed set too low.	1. Check idle setting. Adjust as necessary.
2. Fuel tank vent clogged or partially clogged.	2. Check fuel tank vents. Repair as necessary.
3. Low fuel supply.	3. Check for sufficient fuel in the fuel tank. Check for fuel leaks. Check for kinks or sharp bends in the fuel lines. Check fuel pressure; it must be within specifications. If not, replace fuel filters. If still low, repair or replace transfer pump.
4. Injection pump overflow valve leaking, or stuck open or closed.	4. Repair or replace valve.
5. Defective fuel injection nozzle.	5. Isolate defective nozzle and replace. Refer to item 7 in preceding ENGINE MISFIRES section.
6. Defective fuel injection pump.	6. Remove, repair, and reinstall pump.
7. High parasitic load.	7. Check for excessive loading due to engaged auxiliary attachments.

200769a

ERRATIC ENGINE SPEED

Possible Cause	Correction
1. Air leaks in fuel suction line.	1. Check for air leaks. Repair as necessary.
2. Throttle linkage loose or out of adjustment.	2. Check throttle linkage. Repair or adjust as necessary.
3. Injection pump governor failure.	3. Remove injection pump and have it checked as follows by an authorized MACK Fuel Injection System Repair facility: — Check for damaged or broken springs or other components. — Check for free travel of the fuel rack. — Make sure the correct governor springs are installed. — Repair or replace damaged parts as necessary. — Recalibrate the injection pump and reinstall.

200770a

NOTE

When diagnosing low-power complaints, it is possible to trace the trouble to chassis components rather than the engine. Make sure the chassis rolls freely when the brakes are released.

LOW POWER

Possible Cause	Correction
1. Restrictions in the air-intake system such as a clogged air filter(s).	1. Check the air pressure in the air-intake manifold. Replace the air filter and make necessary repairs to the air system.
2. Poor quality fuel.	2. Drain fuel tank(s), clean system and replace fuel filters. Fill tank with MACK-specified diesel fuel. Bleed system.
3. Damage or restrictions in the accelerator/shut-off cable linkage.	3. Check linkage and adjust to achieve full travel. Replace if damaged or bent.
4. Low fuel pressure.	4. Check fuel supply lines for kinks or restrictions. Check for air in system. Check fuel pressure. If low, replace fuel filters. If still low, replace or repair fuel transfer pump. Also check for sticking, binding or defective fuel overflow valve. Repair or replace.
5. Improper valve lash adjustment.	5. Adjust valve lash to specified clearance.
6. Incorrect fuel injection timing.	6. Adjust fuel injection pump timing.
7. Plugged fuel tank vents.	7. Clean the fuel tank vents.
8. Fuel injection nozzle failure.	8. Isolate defective nozzle. Repair or replace.
9. Carbon or other friction-causing deposits in turbocharger.	9. Inspect turbocharger. Clean, repair or replace as required.
10. Internal fuel injection pump wear which prevents full rack travel.	10. Remove injection pump. Send the pump to an authorized MACK Fuel Injection System Repair facility for repair and recalibration. Then reinstall the pump.
11. High-altitude operation.	11. Engines lose horsepower with increases in altitude. The percentage of power loss is governed by the altitude at which the engine is operated. Make necessary adjustments.
12. Low boost pressure.	12. Check for restrictions in the air-intake system.
13. Exhaust restriction.	13. Check for restrictions in the exhaust system.
14. Low compression.	14. Check items listed for low compression.
15. Restrictions in cooler.	15. Perform restriction pressure test. Clean any restrictions.
16. Restrictions in cooler inlet or outlet tubes.	16. Disconnect tubing and clean restrictions.
17. Leaking cooler.	17. Repair or replace leaking cooler.

200771a

ENGINE WILL NOT ACHIEVE NO-LOAD GOVERNED RPM

Possible Cause	Correction
1. Air in fuel system.	1. Check system for air leaks and correct as required. Air will generally enter the fuel system on the suction side of the fuel transfer pump.
2. Accelerator linkage loose or out of adjustment.	2. Check linkage. Make necessary adjustments.
3. Restricted fuel lines or stuck overflow valve.	3. Check flow in fuel lines. Check overflow valve for defects, improper setting, sticking, or defective spring.
4. High idle adjustment set too high.	4. Check high idle adjustments. Adjust as required.
5. Chassis equipped with MACK Maxi-Miser: Air leaks in the air supply line or defective control valve.	5. Leaks in the air supply line to the transmission, or from the transmission to the fuel injection pump governor, will restrict maximum engine rpm in all gears. Check all lines and connections for leaks and repair as required. Replace control valve if necessary.
6. Fuel injection pump calibration incorrect.	6. Remove injection pump and nozzle assemblies from the engine. Send the pump to an authorized MACK Fuel Injection System Repair facility for repair and recalibration. Then reinstall the pump.
7. Internal fuel pump governor wear.	7. Remove the injection pump. Send the pump to an authorized MACK Fuel Injection System Repair facility for repair and recalibration. Then reinstall the pump.

200773a

EXCESSIVE ENGINE VIBRATION

Possible Cause	Correction
1. Loose vibration damper hub nut bolt.	1. Check condition of mounting. Make necessary repairs and retorque.
2. Defective or damaged vibration damper.	2. Replace damper if it is verified as damaged or defective.
3. Fan blade not balanced.	3. Loosen or remove fan belts. Run the engine for a short period of time at the rpm where the vibration was most noticeable. If the vibration disappears, replace the fan assembly.
4. Engine supports loose, worn or defective.	4. Tighten all mounting bolts, or replace components as required.
5. Engine misfiring or running rough.	5. Check items listed in ENGINE MISFIRES in this section.

200774a

EXCESSIVE BLACK OR GRAY SMOKE

Possible Cause	Correction
1. Insufficient air for combustion.	1. Check air cleaner for restrictions. Check inlet manifold pressure, and inspect the turbocharger for proper operation. Repair or replace as required.
2. Excessive exhaust back pressure.	2. Check for faulty exhaust piping or restrictions in the muffler. Repair or replace as required.
3. Improper grade of fuel.	3. Drain fuel from tank(s). Replace fuel filters and fill tank(s) with MACK-specified diesel fuel.
4. Faulty fuel injection nozzle.	4. Isolate faulty nozzle and replace. Refer to item 7 in ENGINE MISFIRES in this section.
5. Improper injection pump-to-engine timing.	5. Check timing and adjust as required.

200775a

EXCESSIVE BLUE OR WHITE SMOKE

Possible Cause	Correction
1. Engine lubricating oil level too high.	1. Drain excess lubricating oil. If the oil is contaminated with either fuel or coolant, completely drain the oil pan. Change the oil filters. Locate the source of the leak and correct. Fill with MACK-specified engine oil. Check the oil level with the dipstick. DO NOT overfill.
2. Turbocharger oil seal failure.	2. Check for oil in the inlet manifold. Install remanufactured turbocharger.
3. Worn piston rings.	3. Check cylinder walls for scuffing. Clean or replace sleeves as required. Install new piston rings.
4. Engine misfiring or running rough.	4. Check items as outlined in ENGINE MISFIRES in this section.
5. Incorrect fuel injection pump-to-engine timing.	5. Check and reset timing as required.

200776a

EXCESSIVE FUEL CONSUMPTION

Possible Cause	Correction
1. Restrictions in the air induction system.	1. Inspect system. Remove restrictions and replace defective parts as required.
2. External fuel system leakage.	2. Check external piping on fuel system for signs of fuel leakage. Repair as required.
3. Incorrect fuel injection pump-to-engine timing.	3. Check fuel injection pump-to-engine timing. Reset as required.
4. Defective injection nozzle assembly.	4. Isolate defective nozzle assembly. Repair or replace as required.
5. Incorrect fuel injection pump calibration.	5. Remove injection pump and nozzle assemblies from the engine. Send the pump to an authorized MACK Fuel Injection System Repair facility for recalibration. Then reinstall the pump and nozzle assemblies.
6. Internal engine wear.	6. Overhaul engine.

200777a

EXCESSIVE OIL CONSUMPTION

Possible Cause	Correction
1. External oil leaks.	1. Check engine for visible signs of oil leakage. Look for loose or stripped oil drain plugs, broken gaskets (cylinder head cover, etc.) and front and rear oil seal leakage.
2. Clogged crankcase breather pipe.	2. Remove obstructions.
3. Excessive exhaust back pressure.	3. Check exhaust pressure. Repair as required.
4. Worn valve guides.	4. Replace valve guides.
5. Air compressor passing oil.	5. Repair or replace air compressor.
6. Turbocharger sealing rings failure.	6. Check for oil in the inlet manifold. Install remanufactured turbocharger.
7. Internal engine wear.	7. Overhaul engine.

200778a

ENGINE OVERHEATS

Possible Cause	Correction
1. Coolant level low.	1. Locate cause. Look for leaking gaskets or loose or leaking hoses. Repair, replace or tighten as required. Replenish coolant.
2. Loose or worn fan belts.	2. Adjust belt tension or replace belts as required.
3. Restricted airflow through radiator.	3. Remove any restrictions from the outer surface of the radiator.
4. Defective radiator pressure cap.	4. Test pressure of the radiator cap. Replace cap, if required.
5. Defective coolant thermostat or temperature gauge.	5. Check opening temperature of thermostat. Check for correct installation. Check temperature gauge. Replace if defective.
6. Fan improperly positioned or viscous drive fan not operating properly.	6. Check fan operation. Repair as required.
7. Shutters not opening properly (for chassis equipped with shutters).	7. Check shutter operation. Repair as required.
8. Combustion gases in coolant.	8. Determine point where gases are entering the cooling system. Repair or replace parts as required.
9. Plugged oil cooler.	9. Remove oil cooler. Disassemble, remove restrictions/replace parts as required. Reinstall.
10. Defective water pump.	10. Remove, repair or reinstall water pump as required.
11. Incorrect fuel injection pump-to-engine timing.	11. Check fuel injection pump to engine timing. Reset timing as required.
12. Improper valve lash adjustment.	12. Adjust valve lash to specified clearance.

200779a

HIGH EXHAUST TEMPERATURE

Possible Cause	Correction
1. Operating chassis in wrong gear ratio for load, grade and/or altitude.	1. Instruct operator on correct gear selection for load and grade conditions.
2. Restrictions in the air induction system.	2. Inspect air induction system. Remove restrictions and/or replace defective parts.
3. Air leaks in the air induction system.	3. Check pressure in the air intake manifold. Look for leaking piping, and/or loose clamps. Make necessary repairs.
4. Leaks in the exhaust system (before the turbocharger).	4. Check exhaust system for leaks. Make necessary repairs.
5. Incorrect fuel injection pump-to-engine timing.	5. Check fuel injection pump-to-engine timing. Adjust as required.
6. Restrictions in the exhaust system.	6. Inspect system. Make necessary repairs.
7. Improper valve lash adjustment.	7. Adjust valve lash setting to specified clearance.
8. Defective fuel injection nozzle assembly.	8. Isolate defective nozzle assembly. Remove, repair and/or replace and reinstall.
9. Incorrect fuel injection pump calibration.	9. Remove injection pump and nozzle assemblies. Send fuel injection pump to an authorized MACK Fuel Injection System Repair facility for recalibration. Then reinstall the pump and nozzle assemblies.
High Pyrometer — Normal Boost	
10. Loose ducting.	10. Repair loose connections.
11. Core fin obstructions.	11. Clean core fins.
High Pyrometer — Low Boost	
12. Blockage in ducting between the air cleaner and the turbocharger.	12. Check for blockage and repair.
13. Dirty turbocharger.	13. Remove turbocharger and clean.
14. Leaks in the pressurized side of the air induction system.	14. Check for leaks. Repair as required.
15. Core leak or inlet manifold leak.	15. Check for damaged core gaskets.
16. Open petcock.	16. Close petcock.
17. Core leakage.	17. Pressure test core. Remove, repair or replace core if test results are unsatisfactory.

200780a

LOW ENGINE OIL PRESSURE

Possible Cause	Correction
1. Oil level insufficient. Oil leaking from oil line, gasket, etc.	1. Check engine oil level. Add oil if necessary. Check for oil leaks. Repair as required.
2. Incorrect oil viscosity.	2. Drain oil, change oil filters, and fill with the proper grade oil meeting MACK specifications.
3. Defective oil pressure gauge.	3. Check the operation of the oil pressure gauge. If defective, replace.
4. Clogged oil filter(s).	4. Replace oil filters. Clean or replace oil cooler. Drain oil and refill with oil meeting MACK specifications.
5. Engine oil diluted with diesel fuel.	5. Check fuel system for leaks. Make necessary repairs. Drain diluted oil, change oil filters, and refill with oil meeting MACK specifications.
6. Defective oil pump relief valve.	6. Remove oil pressure relief valve and check condition of seat. Check that relief valve spring is not sticking, and check for proper spring tension. Check cap. Check assembly parts. Using the incorrect parts will result in incorrect oil pressure. Make any necessary repairs or install a new relief valve.
7. Oil pump gears not meshing properly.	7. Check mounting arrangement. If the engine has been rebuilt, check that the gear ratio of the oil pump drive and driven gears are correct. Incorrect gear combinations will result in immediate gear failure and possible engine damage. Check for correct oil pad gasket.
8. Excessive clearance between crankshaft and bearings.	8. Overhaul the engine. Replace any worn/defective parts.

200781a

OIL IN THE COOLING SYSTEM

Possible Cause	Correction
1. Defective oil cooler core.	1. Disassemble and repair or replace oil cooler core.
2. Blown head gasket.	2. Replace head gasket.

COOLANT IN ENGINE OIL

Possible Cause	Correction
Cylinder sleeve seat seal failure.	Repair cylinder sleeve seat seals.

LOW COMPRESSION

Possible Cause	Correction
1. Improper valve lash adjustment.	1. Adjust valve lash to specified clearance.
2. Blown head gasket.	2. Replace head gasket.
3. Broken or weak valve springs.	3. Check and replace defective parts.
4. Burned valves, seats or parts.	4. Remove, recondition, and reinstall heads.
5. Piston rings stuck, worn, broken or improperly seated.	5. Overhaul engine.
6. Camshaft or valve lifters worn.	6. Replace camshaft and/or valve lifters. Overhaul engine if required.

200782a

CAMSHAFT TIMING CHECK

Correct camshaft timing is essential for proper engine performance. Incorrect camshaft timing may be suspected if soon after engine overhaul, lack of performance, unusual noise or excessive smoke are reported.

NOTE

Camshaft timing can be checked using either cylinder No. 3 or No. 4 inlet valve. For example purposes, No. 3 cylinder will be used in the steps below.

1. Remove cylinder head cover over cylinder No. 3.
2. Locate inlet valve(s) for the No. 3 cylinder (the sixth valve from front of the engine). Position No. 3 piston at Top Dead Center (TDC) (compression stroke).
3. Loosen (back off) the inlet valve rocker adjusting screw. Ensure valve yoke is correctly adjusted. Adjust inlet valve to zero lash.
4. Position dial indicator (magnetic-base type) probe on valve spring retainer. Preload indicator to 1/2 indicator plunger travel.
5. Bar the engine in direction of normal rotation and carefully observe direction in which needle of indicator travels. Use dial indicator to determine when the inlet valve is fully open.
6. Stop rotating engine when travel of dial indicator needle stops. If dial indicator needle reverses direction, full-open position is passed. Repeat procedure.
7. Check timing indicator. Pointer should be within three degrees (retard or advance) of timing indicator specification given in table that follows. A difference of approximately 10 degrees indicates crankshaft to camshaft timing gears may be mismatched one tooth.
8. If the engine has a front timing indicator, the pointer marked **PUMP** must be used for the camshaft timing check. The pointer marked **VALVE** is used only for valve adjustment.

CAMSHAFT AND TIMING INDICATOR RELATIONSHIP

Camshaft Part No.	Timing Indicator
583, 583A	20 degrees BTDC
5142	26 degrees BTDC
5205	27 degrees BTDC

CAMSHAFT LOBE LIFT CHECK

When diagnosing potential lifter or camshaft failures, 0.030 inch (0.76 mm) less than the lift of a new camshaft is considered the minimum acceptable camshaft lobe lift for used components. Intake lobe lift differs depending on the camshaft part number. Camshaft lobe lift is measured by using a dial indicator at the push rod with the rocker arm adjusted to zero lash. Refer to the chart below for the minimum acceptable camshaft lobe lift for the different part number E7 camshafts.

MINIMUM ACCEPTABLE CAMSHAFT LOBE LIFT

Camshaft Part No.	Exhaust Lobe	Intake Lobe
454GC583, 454GC583A	0.300"	0.300"
454GC5142	0.300"	0.270"
454GC5205	0.300"	0.280"

PROPER FIRE RING/CYLINDER SLEEVE-TOP COMBINATIONS

General Information

Two types of cylinder head gasket/fire ring kits are available for E7 engines: a flat fire-ring kit and a stepped fire-ring kit. Both kits include instructions.

Two sleeve-top configurations are also available. Use the correct fire ring and cylinder sleeve combination to ensure full contact support and improved combustion sealing. MACK recommends using the latest cylinder sleeve configuration when replacing all six sleeves. The hardware selections for single cylinder sleeve replacement and complete overhauls are sometimes different. Either of the two correct sleeve/fire ring configurations provide equal combustion sealing.

CAUTION

Failure to use the correct fire ring can result in insufficient sealing and damage to the engine.

NOTE

To identify the fire ring/sleeve-top configuration, look at the sleeve top outboard of the coining bead. If the surface between the coining bead and the sleeve OD is flat, it is an older sleeve and requires a stepped fire ring. If the surface has a step, use a flat fire ring. Refer to Figures 9-1 and 9-2.

Engines Built Prior to 1993

Refer to Figure 9-1.

All pre-1991 E7 engines were manufactured with the type of cylinder sleeve shown in Figure 9-1, and originally used flat fire rings. MACK no longer recommends this combination. Replace the fire rings on both heads with the stepped fire ring.

E7 engines built between January 1991 and June 1993 (before 3L serial number) require stepped fire rings. The sleeve and piston ring sets for these engines are different from earlier engines, but the sleeve-top design is the same.

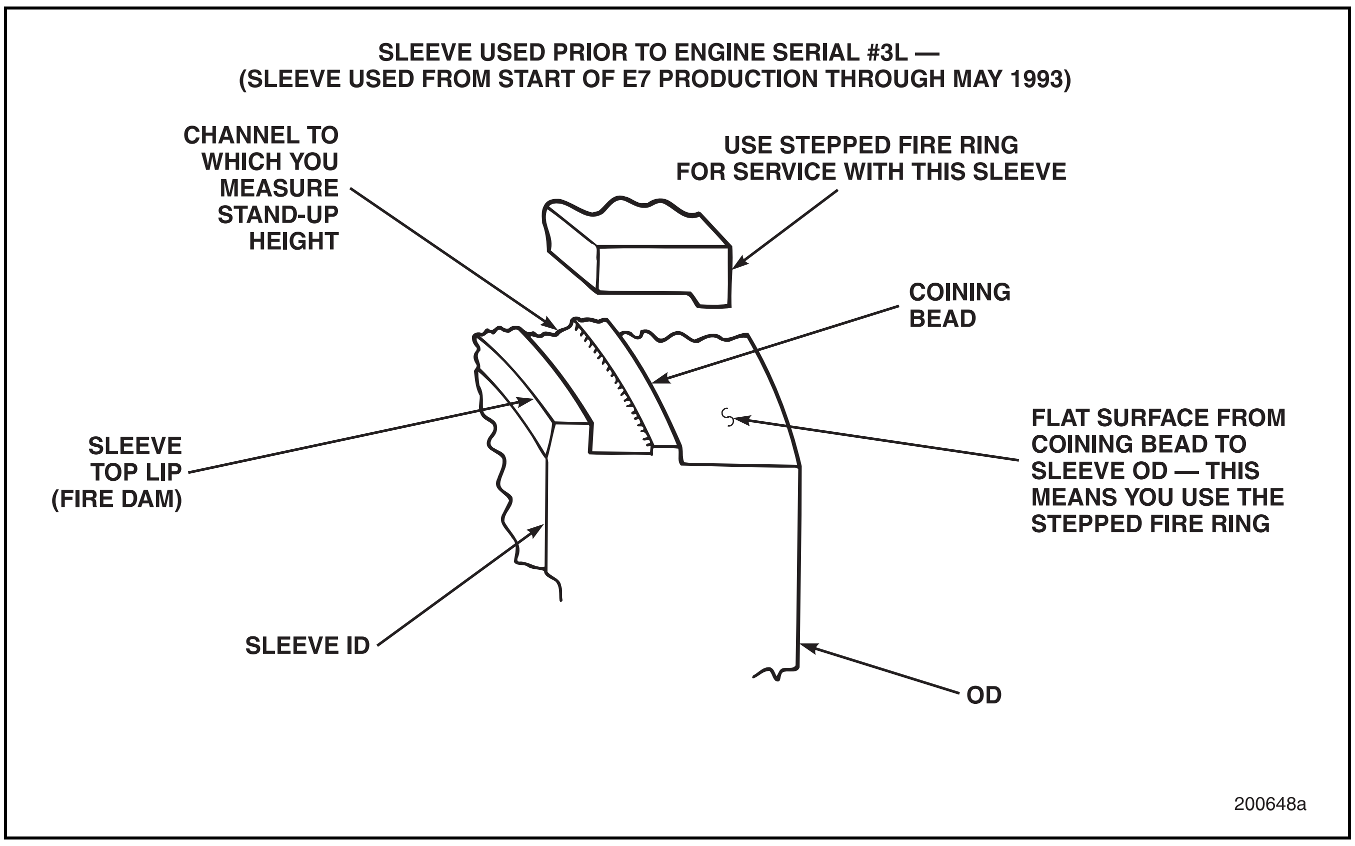


Figure 9-1— Cylinder Sleeve/Fire Ring Configuration (Through May 1993)

If replacing less than a full set of six sleeves, use the same original production sleeve. For each sleeve replaced, use a new crevice seal and apply Silastic at the cylinder block sleeve seat. Depending on their condition, new piston ring sets may also be needed. O-rings are no longer used in the cylinder block groove below the sleeve seats.

When it is necessary to replace all the sleeves, use the new full-contact type sleeves with flat fire rings. Also use new crevice seals, Silastic and new piston ring sets. O-rings are no longer used in a groove in the cylinder block below the sleeve seats.

NOTE

Some engines built before June 1993 may be fitted with sleeves which use flat fire rings. Always visually examine all six sleeves to determine which sleeve-top configuration applies.

If replacing head gaskets with original parts, use the sleeve-top configuration shown in Figure 9-1 and the cylinder gasket kit with the stepped fire ring.

Engines Built from June 1993 to Present (3L Serial Number and Later)

Refer to Figure 9-2.

E7 engines built since June 1993 use the full-contact type of cylinder sleeve. This sleeve provides full-contact support for the flat fire ring.

If replacing sleeves, either a full or partial set, use the same type sleeve. For each sleeve replaced, use a new crevice seal and apply Silastic to each cylinder block sleeve seat. Depending on their condition, new piston ring sets may also be needed for each sleeve replaced. O-rings are no longer used in the cylinder block groove below the sleeve seats.

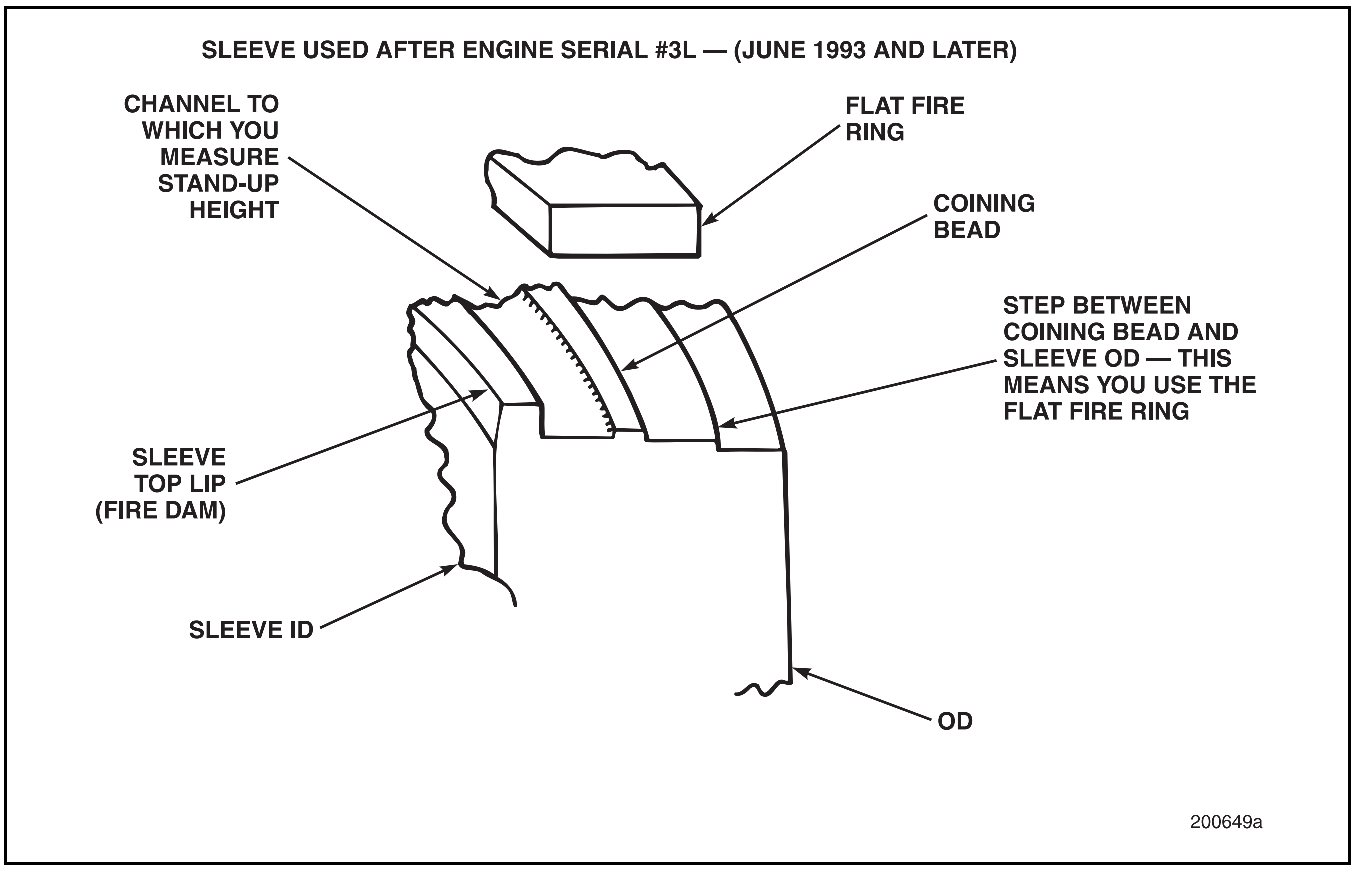


Figure 9-2— Cylinder Sleeve/Fire Ring Configuration (June 1993 and Later)

Cylinder Head and Cylinder Block Leak Test Procedure

Verify suspected leaks in the cylinder heads or cylinder block by pressure testing before deciding to replace the cylinder head or block. Do not use magnaflux inspections alone as replacement criteria.

Before proceeding with the following tests, make sure leakage is not from the oil cooler or air compressor. Watch for small bubbles indicating minor leaks that can develop into more severe leaks during engine operation.

NOTE

To prevent unnecessary engine disassembly, perform the simpler checks first.

CYLINDER HEAD AND HEAD GASKET CHECK — IN CHASSIS

1. Look for coolant stains around the 3/4-inch NPT pipe plugs on top of the cylinder heads. Check plug torque. Plug torque specification is 28 lb-ft (38 N•m). Refer to Figure 9-3.

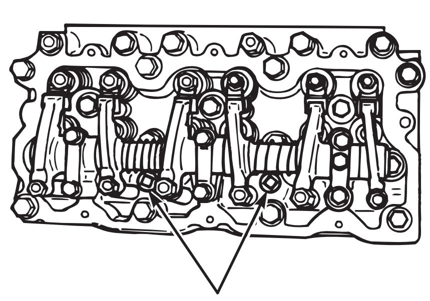


Figure 9-3 — Cylinder Head Pipe Plugs (3/4-Inch NPT)

2. Before removing thermostat, drain coolant from the cooling system until coolant level is below the thermostat housing.
3. Remove the thermostat and leave the thermostat housing open. Install a short section of hose, approximately 6–8 inches (152–203 mm) long, on thermostat housing. Add enough coolant to fill the thermostat housing.
4. Remove fan belts from the water pump.
5. Start engine and run at 1000 rpm.
6. Observe coolant in the thermostat housing for air bubbles. This indicates combustion pressurization of the cooling system and possible cylinder head gasket failure. Air bubbles may also indicate leakage from the cylinder head or oil passage.
7. Apply a soap-and-water solution between two cylinder heads to check for external combustion leakage.

CYLINDER HEAD FUEL PASSAGES LEAK CHECK — IN CHASSIS

NOTE

The symptoms of coolant-in-fuel are a loss of coolant with no apparent external leak, together with one or more of the following: coolant in fuel tank, coolant in fuel filter or yellow fuel out of fuel return line.

1. Disconnect the return fuel inter-connecting tube between the front and rear cylinder heads. Run a line from each cylinder head into a container.
2. Pressurize the cooling system with a maximum of 15 psi (103 kPa) air pressure and look for coolant coming out of a fuel return line.
3. An alternative method is to disconnect the fuel return line at the front of the front cylinder head. Introduce a maximum air pressure of 25 psi (172 kPa) to the fitting in the cylinder head. Then look for air bubbles in the coolant.
4. After determining which cylinder head is suspected of leaking, remove the nozzles from that cylinder head and pressurize the cooling system with a maximum of 15 psi (103 kPa). Look into each nozzle sleeve bore for signs of coolant leakage.
5. A cracked or leaking nozzle sleeve should be replaced as an on-engine repair using the procedures described in the ENGINE DISASSEMBLY section. If replacing the nozzle sleeve(s) and the re-pressure test shows that the problem still exists, the cylinder head(s) should be replaced.

CYLINDER BLOCK/CYLINDER HEAD COOLANT PASSAGES LEAK CHECK — IN CHASSIS

Refer to Figure 9-4.

1. Drain coolant from the engine.
2. Remove the engine oil pan and valve lifter covers.
3. Remove the water pump assembly and use a suitable plate and gasket to seal opening.
4. Remove the upper and lower hoses from the thermostat housing. Remove the thermostat housing and thermostat.
5. Secure a suitable plate and gasket over the thermostat housing opening.
6. Install an air fitting into one of the pipe plug holes in the coolant manifold.
7. Reinforce the hose connecting the coolant manifold sections by installing a hose clamp around the center of the hose to prevent the hose from rupturing during testing.
8. Remove one of the large pipe plugs from the water manifold and add hot water to fill the cooling system. Increase cylinder block temperature to 150°F (66°C). Loosen one of the pipe plugs near the top of the cylinder block to bleed air from the water jacket while filling. Also open the block drain to allow water to flow out. This will help warm the cylinder block.
9. After cylinder block is sufficiently heated, close block drain and apply approximately 50 psi (345 kPa) air pressure to the air connection.

CAUTION

Do not exceed 50 psi (345 kPa) air pressure. Damage to seals or cup plugs may result.

10. Check for coolant leaks at the bottom of each cylinder bore.
    - Coolant leaking between the cylinder sleeve outside diameter and cylinder block indicates a leaking cylinder sleeve seat.
    - Coolant leaking down the inside diameter of the cylinder sleeve indicates a leaking head gasket.

NOTE

Water leaking from the No. 2 or No. 5 cam bushings or from the No. 2 or No. 5 main bearings can indicate a breakthrough between the rocker arm feed passage and the water jacket.

Refer to the repair procedures in this manual to correct leaks.

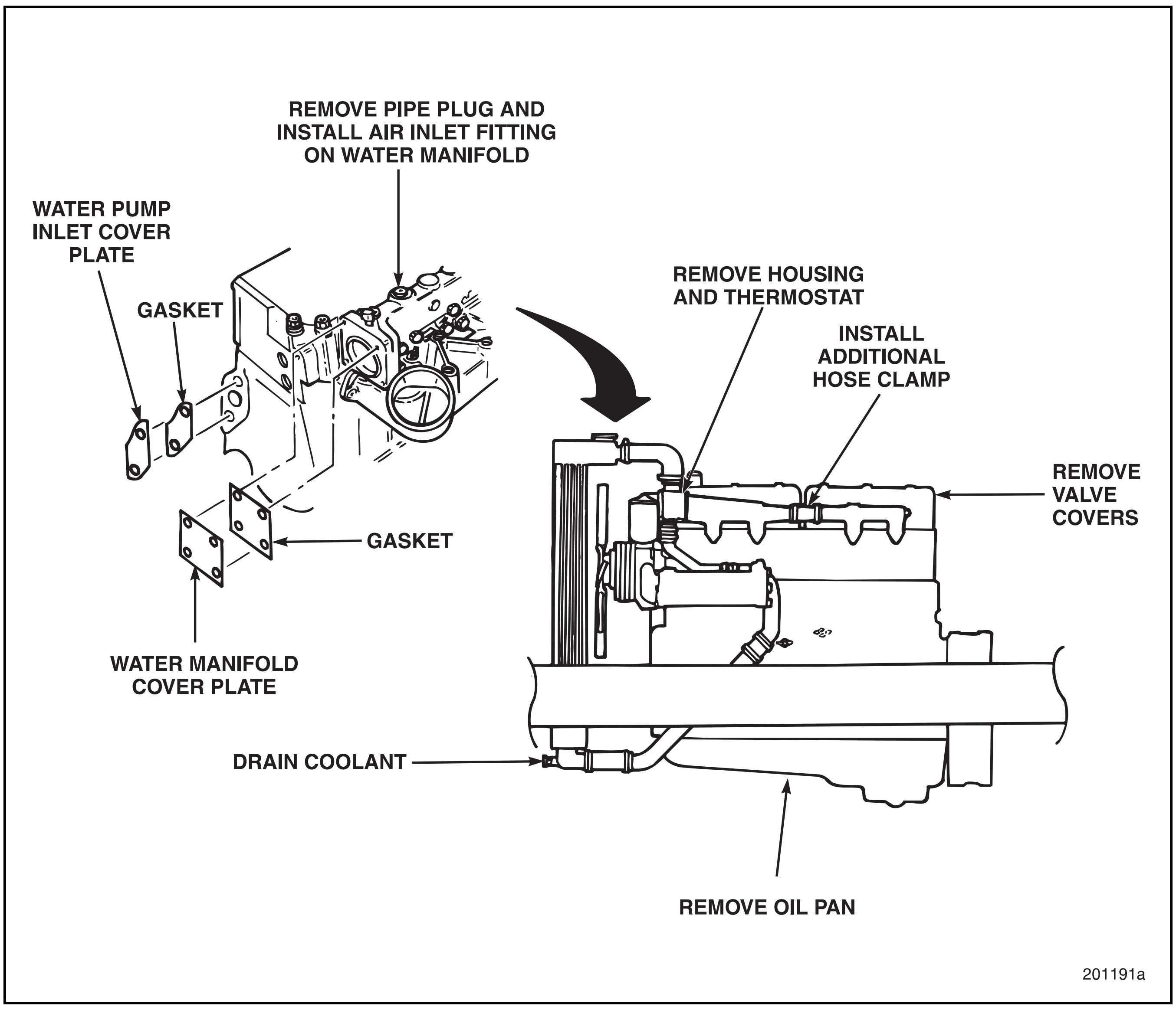


Figure 9-4 — Cylinder Block/Cylinder Head Leak Check (In Chassis)

CYLINDER HEAD OIL PASSAGE LEAK CHECK — OUT OF CHASSIS

Refer to Figure 9-5.

1. Remove cylinder head from the engine.
2. Install a suitable plug to seal the rocker arm oil passage at deck side of head. There are two ways to plug the hole:
   - Drill and tap the oil passage to accept a pipe plug.
   - Insert a suitable rubber plug and clamp the plug in position with a C-clamp.
3. Install an air fitting in the rocker arm passage in the top of the head. Use a discarded rocker arm bracket, preferably with an oil feed passage. Cut the bracket through the rocker arm shaft bore parallel to the mounting surface. Drill and tap the oil supply passage to accept an air fitting.
4. Bolt the modified bracket, with air fitting, to the cylinder head over the oil supply passage.
5. Immerse cylinder head in water and heat to 150°F (66°C).
6. Apply up to 50 psi (345 kPa) air pressure to air fitting adapter installed in rocker arm oil passage. Check for air bubbles. The formation of air bubbles indicates internal leakage in cylinder head oil passage.

CAUTION

Do not exceed 50 psi (345 kPa). Damage to seals or cup plugs may result.

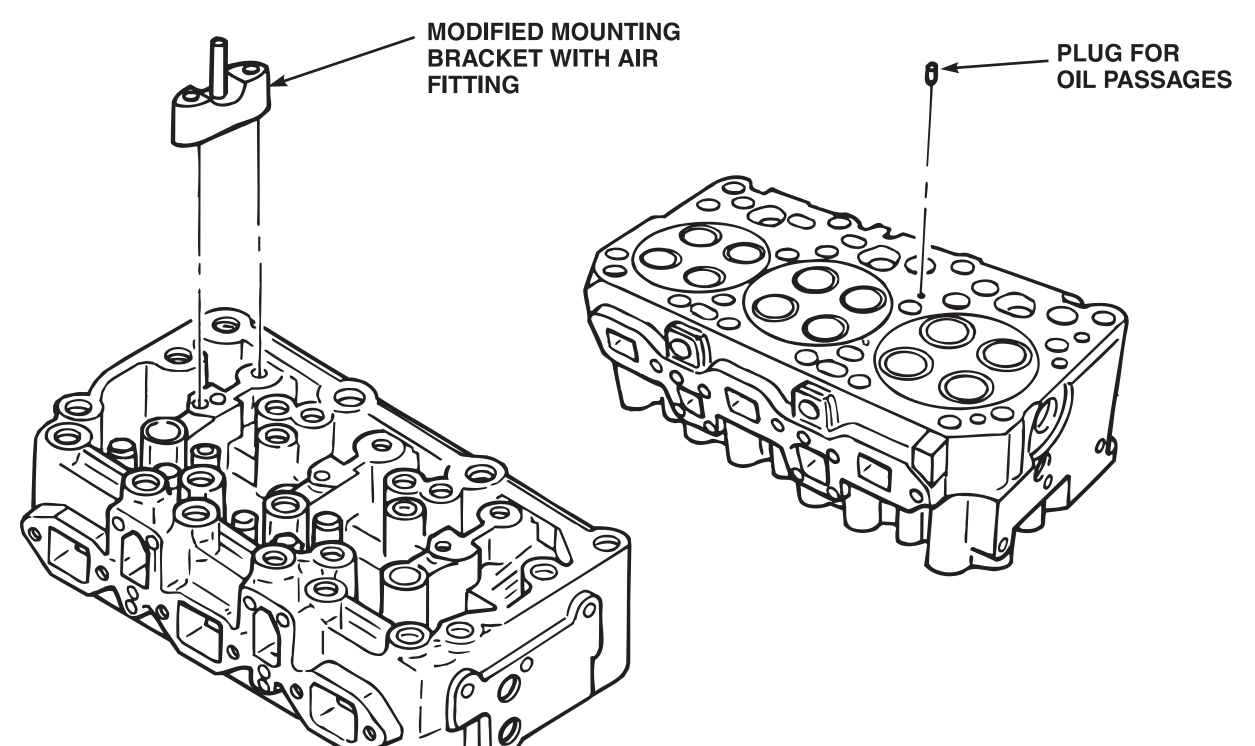


Figure 9-5 — Cylinder Head Oil Passage Leak Check (Out of Chassis)

CYLINDER HEAD COOLANT PASSAGE LEAK CHECK — OUT OF CHASSIS

Refer to Figure 9-6.

1. Remove cylinder head from engine.
2. Fabricate a suitable 3/4-inch-thick (19.1 mm) steel plate and a 1/4-inch (6.4 mm) rubber gasket. The plate must have cutouts for the entire combustion chamber. Position plate and gasket assembly on underside of head and secure with C-clamps.
3. Use suitable plate and gasket to seal water manifold openings. Install an air fitting onto the plate.
4. Immerse cylinder head in water. Heat water and head to 150°F (66°C).
5. Apply up to 50 psi (345 kPa) air pressure to the fitting installed in the plate covering the water manifold opening. Check for air bubbles. The formation of air bubbles indicates that cylinder head coolant passages may be leaking.

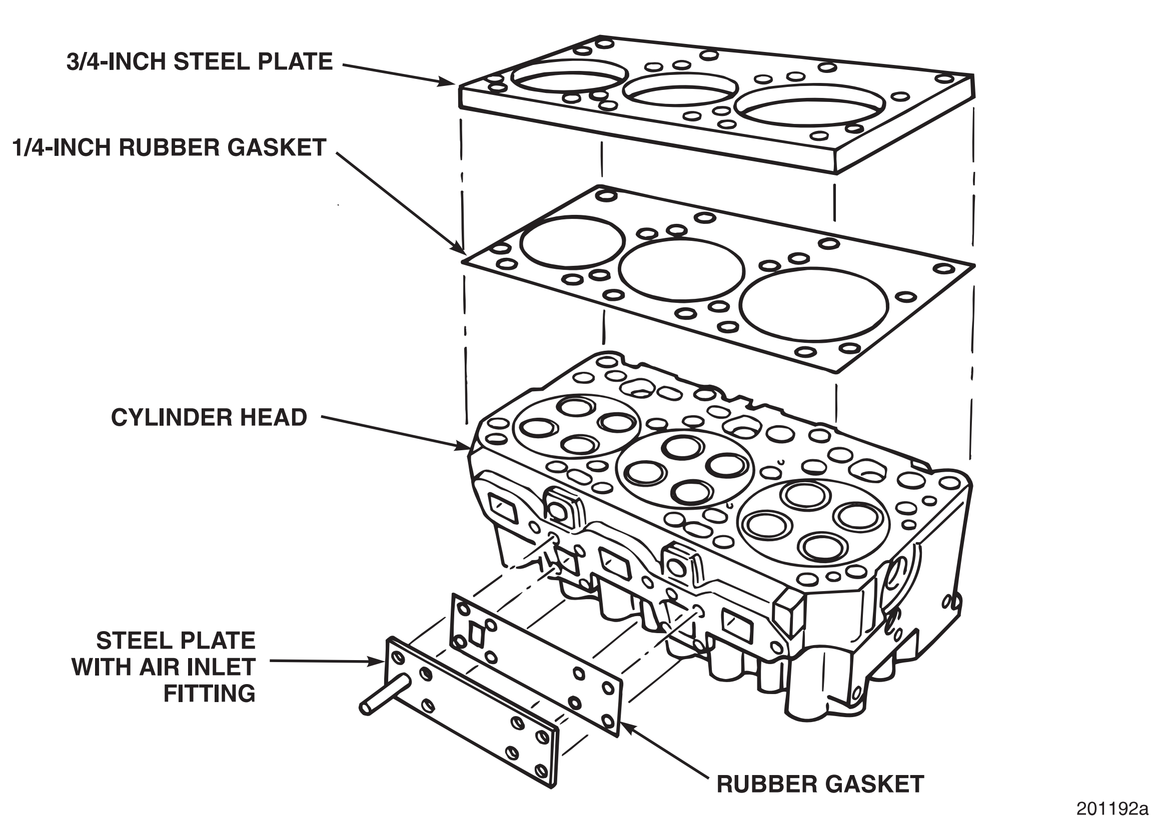


Figure 9-6 — Cylinder Head Coolant Passage Leak Check (Out of Chassis)

CYLINDER BLOCK COOLANT PASSAGE LEAK CHECK — OUT OF CHASSIS

Refer to Figure 9-7.

1. Fabricate two 3/4-inch thick (19.1 mm) steel plates to simulate cylinder heads. The plates must have cutouts for the head capscrews and liners. Use a 1/4-inch (6.4 mm) rubber gasket as a seal. Install the plates onto the cylinder head.

NOTE

As an alternative to step 1, conduct the test using two known leak-free cylinder heads complete with gaskets and fire rings in place of the steel plates. With this alternative, a water manifold (with the outlet end sealed) can be used to seal off the cylinder head coolant ports. Fittings can be installed on the water manifold to introduce the heated water and air pressure needed for the test.

2. Remove water pump assembly and seal opening with a suitable plate and rubber gasket. The plate must be fabricated so that water heated to 150°F (66°C) and pressurized to 50 psi (345 kPa) can be introduced into the system.
3. Apply approximately 50 psi (345 kPa) air pressure into the cooling system. Visually inspect the cylinder block for signs of air and water leaks.

CAUTION

Do not exceed 50 psi (345 kPa). Damage to seals or cup plugs may result.

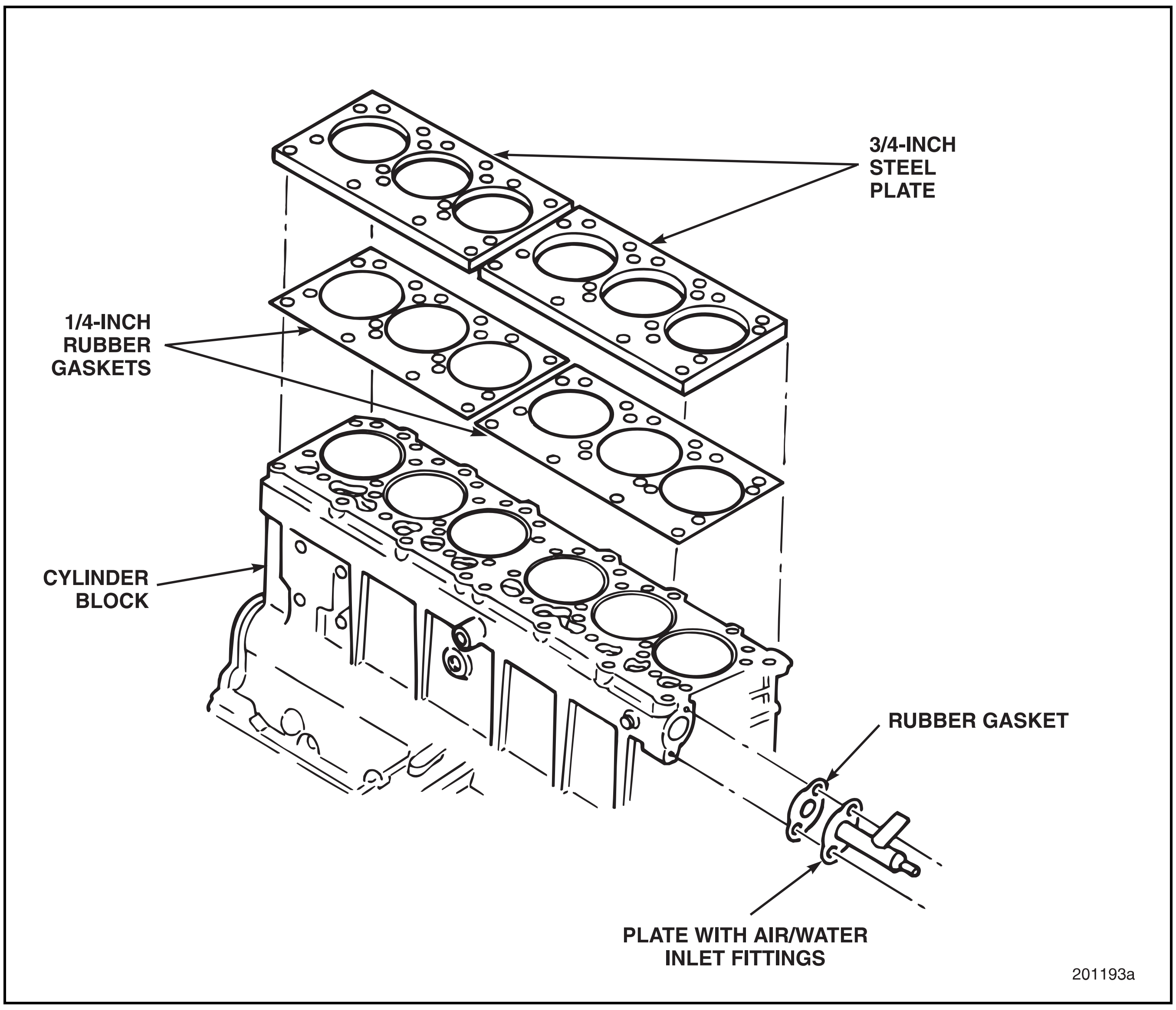


Figure 9-7 — Cylinder Block Coolant Passage Leak Check (Out of Chassis)

NOTES

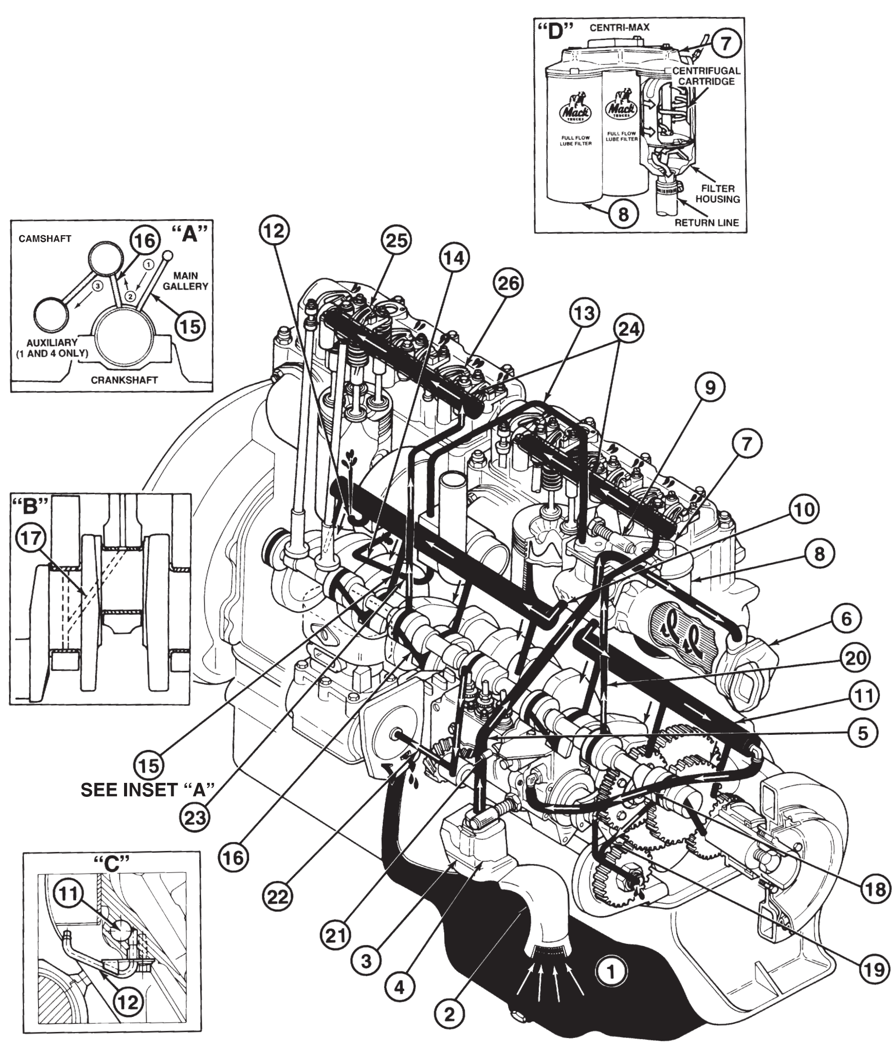
APPENDIX

E7 ENGINE SERIAL NUMBERS, JACOBS BRAKE APPLICATION

The following is a list of selected 1990 E7 engine serial numbers requiring 0.080-inch (2.03 mm) Jacobs thickness gauge 017099 for Jacobs Brake slave piston adjustment. Refer to the Slave Piston Adjustment procedure in the SETUP AND ADJUSTMENTS section of this manual.

OW1577	OX0114	OX0115	OX0116	OX0169	OX0170	OX0234	OX0235
OX0258	OX0306	OX0307	OX0334	OX0417	OX0468	OX0481	OX0482
OX0483	OX0512	OX0549	OX0594	OX0595	OX0602	OX0603	OX0604
OX0605	OX0637	OX0638	OX0639	OX0640	OX0646	OX0647	OX0720
OX1134	OX1157	OX1158	OX1159	OX1168	OX1169	OX1273	OX1274
OZ0009	OZ0028	OZ0029	OZ0030	OZ0031	OZ0056	OZ0064	OZ0089
OZ0090	OZ0092	OZ0093	OZ0094	OZ0148	OZ0163	OZ0164	OZ0166
OZ0167	OZ0192	OZ0193	OZ0194	OZ0205	OZ0206	OZ0207	OZ0208
OZ0227	OZ0228	OZ0229	OZ0230	OZ0231	OZ0244	OZ0284	OZ0286
OZ0351	OZ0352	OZ0353	OZ0357	OZ0358	OZ0359	OZ0360	OZ0361
OZ0391	OZ0392	OZ0393	OZ0405	OZ0406	OZ0426	OZ0427	OZ0428
OZ0429	OZ0430	OZ0483	OZ0484	OZ0485	OZ0486	OZ0487	OZ0488
OZ0497	OZ0498	OZ0553	OZ0554	OZ0564	OZ0579	OZ0580	OZ0581
OZ0582	OZ0586	OZ0597	OZ0604	OZ0624	OZ0655	OZ0663	OZ0674
OZ0675	OZ0690	OZ0745	OZ0746	OZ0747	OZ0748	OZ0749	OZ0750
OZ0751	OZ0752	OZ0753	OZ0754	OZ0755	OZ0756	OZ0757	OZ0758
OZ0759	OZ0760	OZ0761	OZ0762	OZ0763	OZ0765	OZ0766	OZ0768
OZ0843	OZ0848	OZ0882	OZ0899	OZ0900	OZ0928	OZ0929	OZ0930
OZ0931	OZ0939	OZ0940	OZ0983	OZ0984	OZ0985	OZ0986	OZ0987
OZ0989	OZ0992	OZ0993	OZ0995	OZO996	OZ0997	OZ0998	OZ1003
OZ1035	OZ1036	OZ1037	OZ1038	OZ1039	OZ1040	OZ1041	OZ1043
OZ1044	OZ1045	OZ1046	OZ1047	OZ1048	OZ1049	OZ1050	OZ1051
OZ1052	OZ1053	OZ1054					

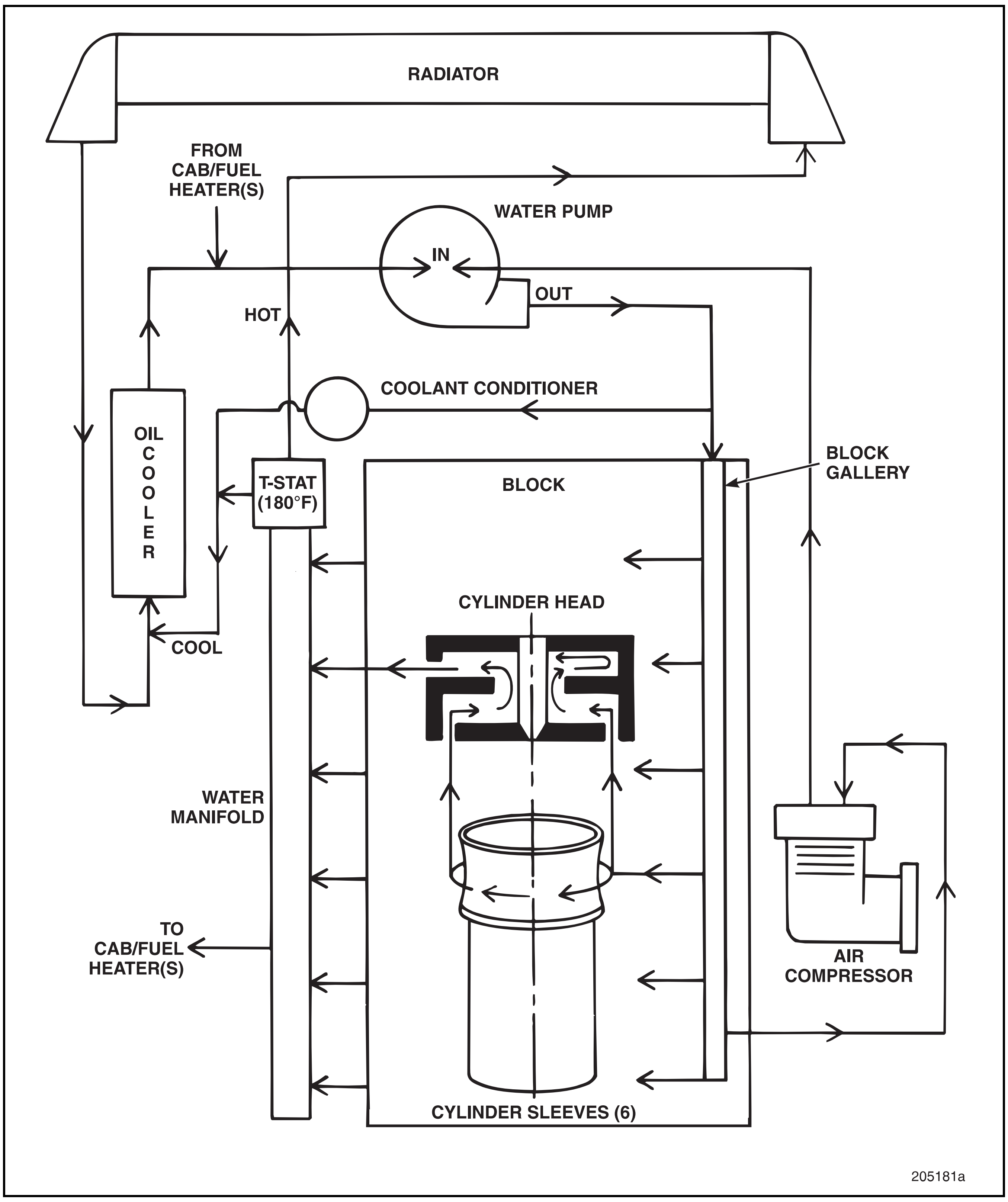
E7 LUBRICATION SYSTEM



1. OIL SUMP
2. OIL PUMP INLET TUBE
3. OIL PUMP
4. OIL PRESSURE RELIEF VALVE (LOCATED IN PUMP)
5. OIL PUMP DISCHARGE SUPPLY TO OIL COOLER
6. OIL COOLER
7. OIL FILTER MOUNTING ADAPTER (SEE INSET "D")
8. OIL FILTER(S) (SEE INSET "D")
9. OIL FILTER BYPASS VALVE
10. OIL SUPPLY ENTERING MAIN OIL GALLERY
11. MAIN OIL GALLERY (SEE INSET "C")
12. PISTON COOLING OIL SPRAY NOZZLE (SEE INSET "C")
13. TURBOCHARGER OIL SUPPLY LINE (EXTERNAL)
14. TURBOCHARGER OIL RETURN LINE (EXTERNAL)
15. OIL SUPPLY FROM MAIN OIL GALLERY TO CRANKSHAFT MAIN BEARINGS (SEE INSET "A")
16. OIL FLOW FROM MAIN BEARINGS TO CAMSHAFT BEARINGS (SEE INSET "A")
17. MAIN BEARING AND CONNECTING ROD BEARING LUBE OIL PASSAGES (SEE INSET "B")
18. ECONOVANCE OIL SUPPLY LINE (V-MAC ENGINES)
19. LINE TO AUXILIARY SHAFT FRONT BUSHING FROM CAMSHAFT BUSHING NO. 1
20. OIL SUPPLY FROM CAMSHAFT BUSHING NO. 2 TO ROCKER ARM SHAFT
21. LINE TO INJECTION PUMP (EXTERNAL) AND GOVERNOR FROM CAMSHAFT BUSHING NO. 4
22. LINE TO AUXILIARY SHAFT REAR BUSHING AND COMPRESSOR FROM CAMSHAFT BUSHING NO. 4
23. OIL SUPPLY FROM CAMSHAFT BUSHING NO. 5 TO ROCKER ARM SHAFT
24. ROCKER ARM SHAFTS
25. VALVE ROCKER ARM
26. OIL SUPPLY FROM ROCKER ARM SHAFT TO ROCKER ARM TIP

205220a

E7 COOLING SYSTEM



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