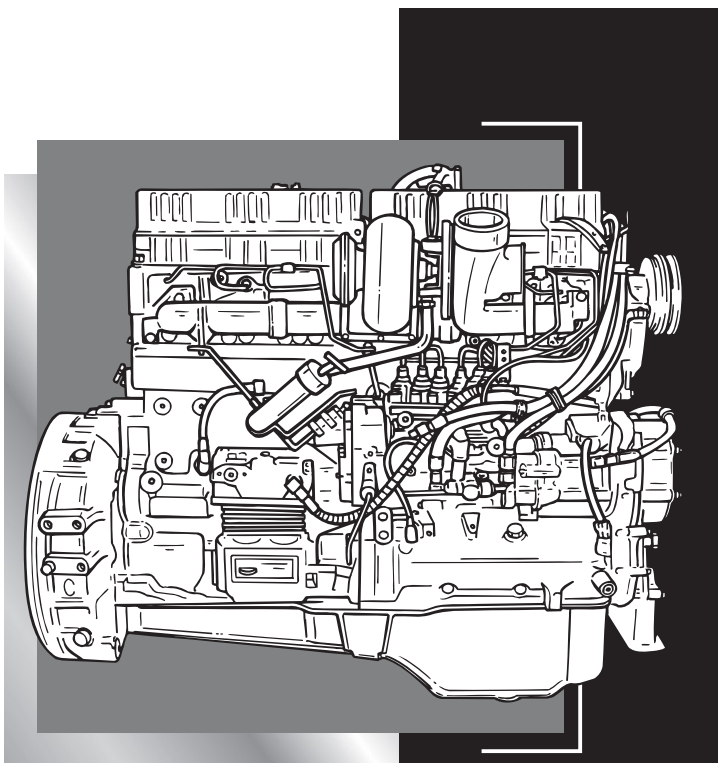
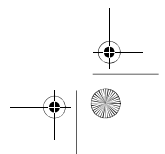
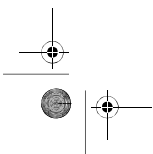
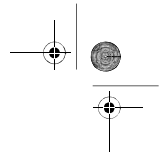
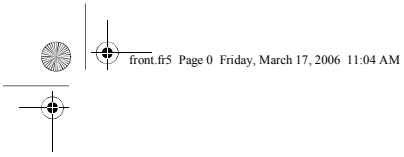




E7 ENGINE OVERHAUL



AUGUST 1997
ENGINE 5-101





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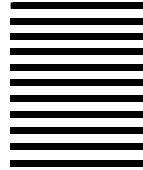
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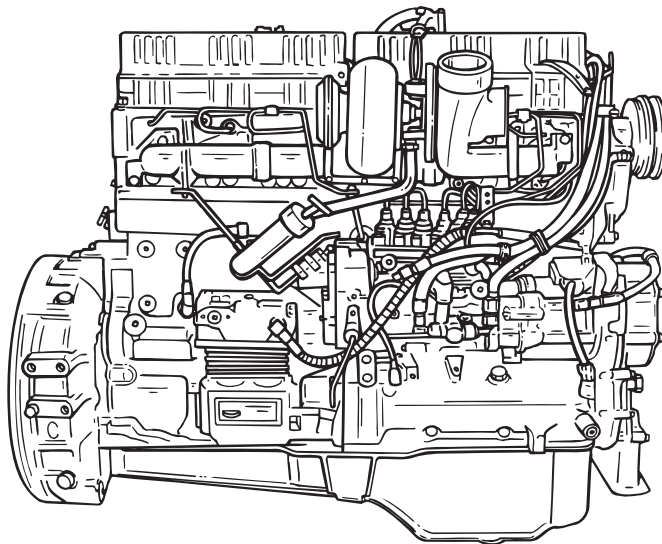
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ATTENTION

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.

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SAFETY INFORMATION

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 NUMERICAL CODE



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 000 — INSPECTIONS
 GROUP 100 — CHASSIS
 GROUP 200 — ENGINE
 GROUP 300 — CLUTCH, TRANSMISSION,
 TRANSFER CASE AND PTO

GROUP 400 — STEERING, AXLES, WHEELS
 AND TIRES, DRIVELINE

GROUP 500 — BRAKES, AUXILIARY
 SYSTEMS

GROUP 600 — CAB, TRUCK BODY

GROUP 700 — 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:

Base Operation

Cylinder Block Moving Parts

Rings, Piston

MACK E7

Replace (one piston)

212

NV

2J

53

200976a



ABOUT THIS MANUAL



ABOUT THIS MANUAL





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





200 GENERAL INFORMATION

GENERAL INFORMATION



200 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.

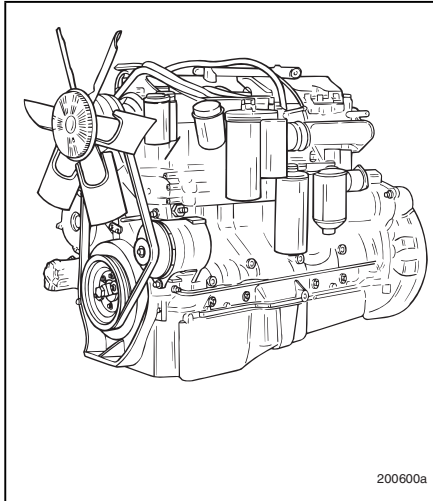


Figure 1 — 3/4 View E7, Front, Left

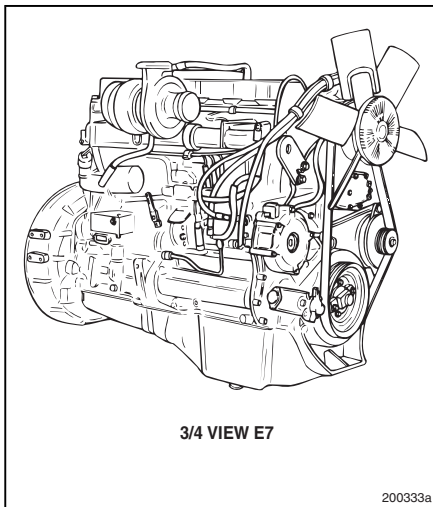


Figure 2 — 3/4 View E7, Front, Right



200 GENERAL INFORMATION

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.



200 GENERAL INFORMATION

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.

IMPORTANT ENGINE INFORMATION THIS ENGINE HAS A PRIMARY INTENDED SERVICE APPLICATION AS A HEAVY DUTY DIESEL ENGINE. IS CERTIFIED TO OPERATE ON DIESEL FUEL AND CONFORMS TO:		RENSEIGNEMENTS IMPORTANTS SUR LE MOTEUR CE MOTEUR DIESEL EST PRINCIPALEMENT DESTINE AU SERVICE SEVERE. EST CERTIFIE POUR FONCTIONNER AVEC DU CARBURANT DIESEL ET EST CONFORME AUX REGLEMENTS	
1 U.S. E.P.A. REGULATIONS DE L'AGENCE DE PROTECTION DE L'ENVIRONNEMENT DES ETATS-UNIS	2 AND CALIFORNIA REGULATIONS NEW HEAVY DUTY ENGINES NOUVEAUX MOTEURS POUR SERVICE SEVERE	3 ADR 30/00 AND ADR 70/00 REGULATIONS	4 MODEL YEAR MODELE ANNEE
ENGINE MODEL MODELE DE MOTEUR	SER. NO. NO. SERIE	FEDERAL FAMILY CATEGORIE FEDERALE	5 CALIF. FAMILY CATEGORIE CALIF.
ADVERTISED HORSEPOWER PUISSANCE PUBLIEE (CV/HP)	R.P.M. TOURS-MINUTE	DISPLACEMENT CYLINDRAGE	6
FUEL RATE @ ADVERTISED HORSEPOWER DEBIT DE CARBURANT @ PUISSANCE PUBLIEE	IN ³ /STROKE CM ³ /COURSE	PARTICULATE-FEL PARTICULAT-FNE	IN ³ PO ³
EXHAUST EMISSION CONTROL SYSTEM DISPOSITIF DE POLLUANT	7 B7C "PMH	VALVE CLEARANCE JEU DES SOUPAPES	NO-FEL NO-FNE
INITIAL INJECTION TIMING AVANCEE A L'INJECTION	8 R.P.M. TOURS-MINUTE	EXHAUST EQUIPPEMENT	ENGINE BRAKE 4M03317
IDLE SPEED VITESSE AU RALENTI		INLET ADMISSION	

205187a

Figure 4 — Engine Information Plate



200 GENERAL INFORMATION

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



200 GENERAL INFORMATION

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.



200 SPECIFICATIONS

SPECIFICATIONS



200 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



200 SPECIFICATIONS

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
— 240GB5240M4	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



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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.



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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.

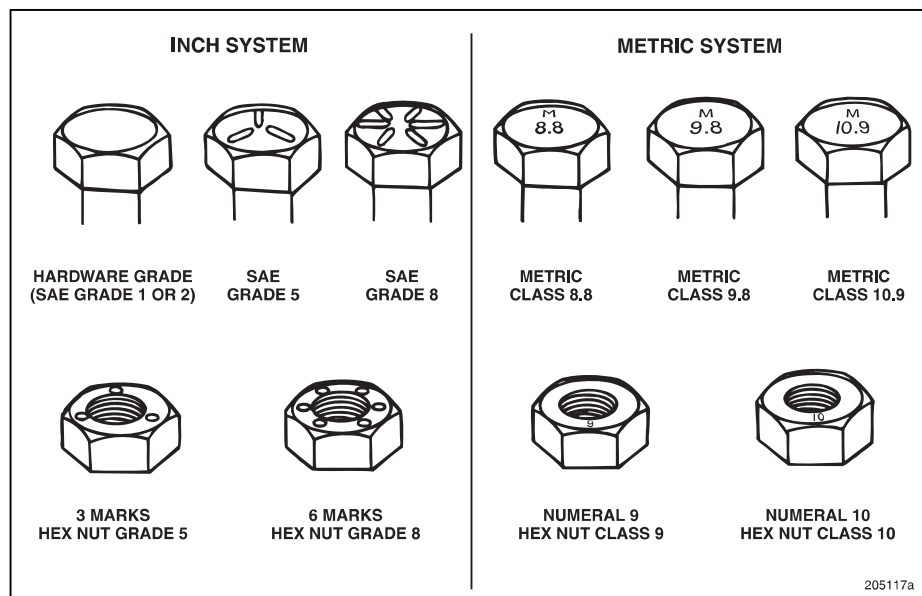


Figure 2-1 — Fastener Grading System



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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).

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.

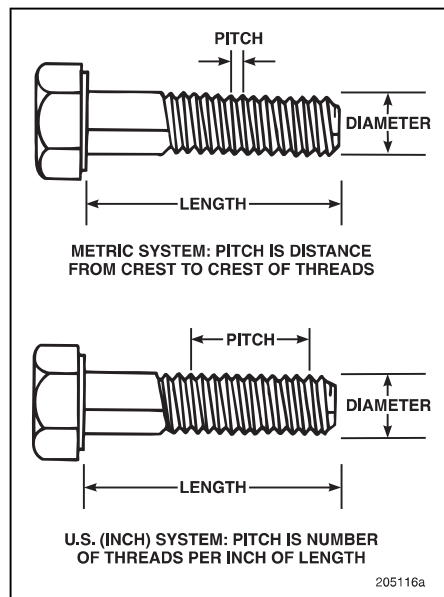


Figure 2-2 — Fastener Dimensions

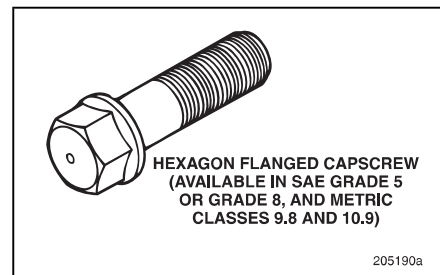


Figure 2-3 — Flanged Capscrew



200 SPECIFICATIONS

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-in ②	20②
Econovance diagnostic port cap	125 lb-in ②	14②
Econovance thrust washer retaining screw	150②	203②

① English threads.

② V-MAC applications.



200 SPECIFICATIONS

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-adaptor 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.



200 SPECIFICATIONS

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.



200 SPECIFICATIONS

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.



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

Fits and Limits (Cont.)

Component	Standard Size or Fit	
	English	Metric
CYLINDER HEAD (CONT.)		
Injection nozzle holder insert to bore fit — upper and intermediate — lower	0.001–0.003 in. tight 0.0015–.004 in. tight	0.0254–0.0762 mm 0.0381–0.1016 mm
Injection nozzle holder insert bore — upper and intermediate bore — bottom bore	0.9360–0.9375 in. 0.904–0.906 in.	23.7744–23.8125 mm 22.962–23.012 mm
Injection nozzle holder insert OD — upper and intermediate — lower 1/2 inch (12.7 mm)	0.9390–0.9385 in. 0.9080–0.9075 in.	23.8506–23.8379 mm 23.0632–23.0505 mm
Fire ring groove — width — depth — ID	0.030–0.036 in. 0.005–0.013 in. 5.137–5.139 in.	0.762–0.914 mm 0.127–0.330 mm 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 — inlet	0.051–0.081 in. 1/16 ± 1/64 in. 0.051–0.081 in. 1/16 ± 1/64 in.	1.295–2.057 mm or 1.588 ± 0.397 mm 1.295–2.057 mm or 1.588 ± 0.397 mm
Valve seat insert face angle Before November 1996 — inlet and exhaust November 1996 and later — inlet — exhaust	30° – 0' / +30' 20° 30' ± 15' 30° – 0' / +30'	
Valve seat width runout	0.001 in. F.I.M.	0.0254 mm
Valve seat insert counterbore diameter — exhaust — inlet	1.6875–1.6885 in. 1.8285–1.8295 in.	42.8625–42.8879 mm 46.4439–46.4693 mm
Valve seat OD — exhaust — inlet	1.692–1.693 in. 1.831–1.832 in.	42.977–43.002 mm 46.507–46.533 mm
Valve seat insert press fit in head — exhaust — inlet	0.0035–0.0055 in. 0.0015–0.0035 in.	0.0889–0.1397 mm 0.0381–0.0889 mm
Valve seat counterbore depth — exhaust — inlet	0.372–0.376 in. 0.360–0.364 in.	9.449–9.550 mm 9.144–9.246 mm



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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. (0.018–0.025) in	0.4572–0.7620 mm (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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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)



200 SPECIFICATIONS

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



200 SPECIFICATIONS

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