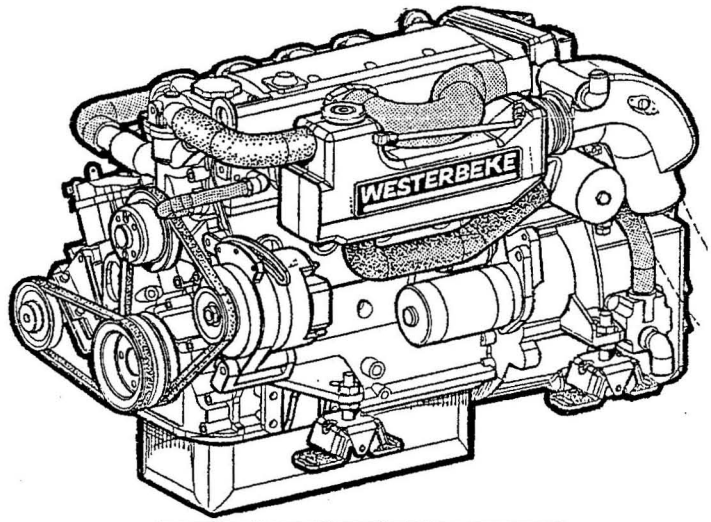
SERVICE MANUAL

55B-FOUR and 55C-FOUR MARINE DIESEL ENGINE



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WESTERBEKE

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CALIFORNIA PROPOSITION 65 WARNING

Exhaust gas from diesel and gasoline engines (and some of its constituents) are known to the State of California to cause cancer, birth defects, and other reproductive harm.

⚠ WARNING:

Exhaust gasses contain Carbon Monoxide, an odorless and colorless gas. Carbon Monoxide is poisonous and can cause unconsciousness and death. Symptoms of Carbon Monoxide exposure can include:

- ***Dizziness***
- ***Nausea***
- ***Headache***
- ***Weakness and Sleepiness***
- ***Throbbing in Temples***
- ***Muscular Twitching***
- ***Vomiting***
- ***Inability to Think Coherently***

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not restart until it has been inspected and repaired.

A WARNING DECAL is provided by WESTERBEKE and should be fixed to a bulkhead near your engine or generator.

WESTERBEKE also recommends installing CARBON MONOXIDE DETECTORS in the living/sleeping quarters of your vessel. They are inexpensive and easily obtainable at your local marine store.

WESTERBEKE
Engines & Generators

SAFETY INSTRUCTIONS

INTRODUCTION

Read this safety manual carefully. Most accidents are caused by failure to follow fundamental rules and precautions. Know when dangerous conditions exist and take the necessary precautions to protect yourself, your personnel, and your machinery.
The following safety instructions are in compliance with the American Boat and Yacht Council (ABYC) standards.

PREVENT ELECTRIC SHOCK

⚠ WARNING: ***Do not touch AC electrical connections while engine is running, or when connected to shore power. Lethal voltage is present at these connections!***

- Do not operate this machinery without electrical enclosures and covers in place.
- Shut off electrical power before accessing electrical equipment.
- Use insulated mats whenever working on electrical equipment.
- Make sure your clothing and skin are dry, not damp (particularly shoes) when handling electrical equipment.
- Remove wristwatch and all jewelry when working on electrical equipment.
- Do not connect utility shore power to vessels AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessels AC generator may result if this procedure is not followed.
- Electrical shock results from handling a charged capacitor. Discharge capacitor by shorting terminals together.

PREVENT BURNS — HOT ENGINE

⚠ WARNING: ***Do not touch hot engine parts or exhaust system components. A running engine gets very hot!***

- Always check the engine coolant level at the coolant recovery tank.

⚠ WARNING: ***Steam can cause injury or death!***

- In case of an engine overheat, allow the engine to cool before touching the engine or checking the coolant.

PREVENT BURNS — FIRE

⚠ WARNING: ***Fire can cause injury or death!***

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the carburetor, fuel line, filter, fuel pump, or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line, carburetor, or fuel filters.
- Do not operate with a Coast Guard Approved flame arrester removed. Backfire can cause severe injury or death.
- Do not operate with the air cleaner/silencer removed. Backfire can cause severe injury or death.
- Do not smoke or permit flames or sparks to occur near the fuel system. Keep the compartment and the engine/generator clean and free of debris to minimize the chances of fire. Wipe up all spilled fuel and engine oil.
- Be aware — diesel fuel will burn.

PREVENT BURNS — EXPLOSION

⚠ WARNING: ***Explosions from fuel vapors can cause injury or death!***

- Follow re-fueling safety instructions. Keep the vessels hatches closed when fueling. Open and ventilate cabin after fueling. Check below for fumes/vapor before running the blower. Run the blower for four minutes before starting your engine.
- All fuel vapors are highly explosive. Use extreme care when handling and storing fuels. Store fuel in a well-ventilated area away from spark-producing equipment and out of the reach of children.
- Do not fill the fuel tank(s) while the engine is running.
- Shut off the fuel service valve at the engine when servicing the fuel system. Take care in catching any fuel that might spill. DO NOT allow any smoking, open flames, or other sources of fire near the fuel system or engine when servicing. Ensure proper ventilation exists when servicing the fuel system.
- Do not alter or modify the fuel system.
- Be sure all fuel supplies have a positive shutoff valve.
- Be certain fuel line fittings are adequately tightened and free of leaks.
- Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

⚠ WARNING: ***Accidental starting can cause injury or death!***

- Disconnect the battery cables before servicing the engine/generator. Remove the negative lead first and reconnect it last.
- Make certain all personnel are clear of the engine before starting.
- Make certain all covers, guards, and hatches are re-installed before starting the engine.

BATTERY EXPLOSION

⚠ WARNING: ***Battery explosion can cause injury or death!***

- Do not smoke or allow an open flame near the battery being serviced. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or by lit tobacco products. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.
- Never connect the negative (–) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together. Sparks could ignite battery gases or fuel vapors. Ventilate any compartment containing batteries to prevent accumulation of explosive gases. To avoid sparks, do not disturb the battery charger connections while the battery is being charged.
- Avoid contacting the terminals with tools, etc., to prevent burns or sparks that could cause an explosion. Remove wristwatch, rings, and any other jewelry before handling the battery.
- Always turn the battery charger off before disconnecting the battery connections. Remove the negative lead first and reconnect it last when disconnecting the battery.

BATTERY ACID

⚠ WARNING: ***Sulfuric acid in batteries can cause severe injury or death!***

- When servicing the battery or checking the electrolyte level, wear rubber gloves, a rubber apron, and eye protection. Batteries contain sulfuric acid which is destructive. If it comes in contact with your skin, wash it off at once with water. Acid may splash on the skin or into the eyes inadvertently when removing electrolyte caps.

TOXIC EXHAUST GASES

⚠ WARNING: ***Carbon monoxide (CO) is a deadly gas!***

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifolds/water-injected elbow is securely attached.
- Be sure the unit and its surroundings are well ventilated. Run blowers when running the generator set or engine.
- Do not run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYCA-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC T-22 (educational information on Carbon Monoxide).

⚠ WARNING: ***Carbon monoxide (CO) is an invisible odorless gas. Inhalation produces flu-like symptoms, nausea or death!***

- Do not use copper tubing in diesel exhaust systems. Diesel fumes can rapidly destroy copper tubing in exhaust systems. Exhaust sulfur causes rapid deterioration of copper tubing resulting in exhaust/water leakage.
- Do not install exhaust outlet where exhaust can be drawn through portholes, vents, or air conditioners. If the engine exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Avoid overloading the craft.
- Although diesel engine exhaust gases are not as toxic as exhaust fumes from gasoline engines, carbon monoxide gas is present in diesel exhaust fumes. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:

Vomiting	Inability to think coherently
Dizziness	Throbbing in temples
Headache	Muscular twitching
Nausea	Weakness and sleepiness

AVOID MOVING PARTS

⚠ WARNING: ***Rotating parts can cause injury or death!***

- Do not service the engine while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid touching moving parts and hot exhaust system components.

- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belts tension while the engine is operating.
- Stay clear of the drive shaft and the transmission coupling when the engine is running; hair and clothing can easily be caught in these rotating parts.

HAZARDOUS NOISE

⚠ WARNING: ***High noise levels can cause hearing loss!***

- Never operate an engine without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.
- Do not run engines for long periods with their enclosures open.

⚠ WARNING: ***Do not work on machinery when you are mentally or physically incapacitated by fatigue!***

OPERATORS MANUAL

Many of the preceding safety tips and warnings are repeated in your Operators Manual along with other cautions and notes to highlight critical information. Read your manual carefully, maintain your equipment, and follow all safety procedures.

GASOLINE ENGINE AND GENERATOR INSTALLATIONS

Preparations to install an engine should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

H-2 Ventilation
P-1 Exhaust Systems
P-4 Inboard Engines
E-9 DC Electrical Systems

All installations must comply with the Federal Code of Regulations (FCR).

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

Read the following ABYC, NFPA and USCG publications for safety codes and standards. Follow their recommendations when installing your engine.

ABYC (American Boat and Yacht Council)
"Safety Standards for Small Craft"

Order from:

ABYC
3069 Solomon's Island Rd.
Edgewater, MD 21037

NFPA (National Fire Protection Association)
"Fire Protection Standard for Motor Craft"

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

USCG (United States Coast Guard)
"USCG 33CFR183"

Order from:

U.S. Government Printing Office
Washington, D.C. 20404

INSTALLATION

When installing WESTERBEKE engines and generators it is important that strict attention be paid to the following information:

CODES AND REGULATIONS

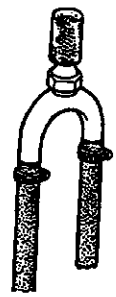
Strict federal regulations, ABYC guidelines, and safety codes must be complied with when installing engines and generators in a marine environment.

SIPHON-BREAK

For installations where the exhaust manifold/water injected exhaust elbow is close to or will be below the vessel's waterline, provisions must be made to install a siphon-break in the raw water supply hose to the exhaust elbow. This hose must be looped a minimum of 20" above the vessel's waterline. ***Failure to use a siphon-break when the exhaust manifold injection port is at or below the load waterline will result in raw water damage to the engine and possible flooding of the boat.***

If you have any doubt about the position of the water-injected exhaust elbow relative to the vessel's waterline under the vessel's various operating conditions, ***install a siphon-break.***

NOTE: *A siphon-break requires periodic inspection and cleaning to ensure proper operation. Failure to properly maintain a siphon-break can result in catastrophic engine damage. Consult the siphon-break manufacturer for proper maintenance.*



AVAILABLE FROM YOUR WESTERBEKE DEALER

EXHAUST SYSTEM

The exhaust hose must be certified for marine use. The system must be designed to prevent water from entering the exhaust under any sea conditions and at any angle of the vessels hull.

A detailed 40 page Marine Installation Manual covering gasoline and diesel, engines and generators, is available from your WESTERBEKE dealer.

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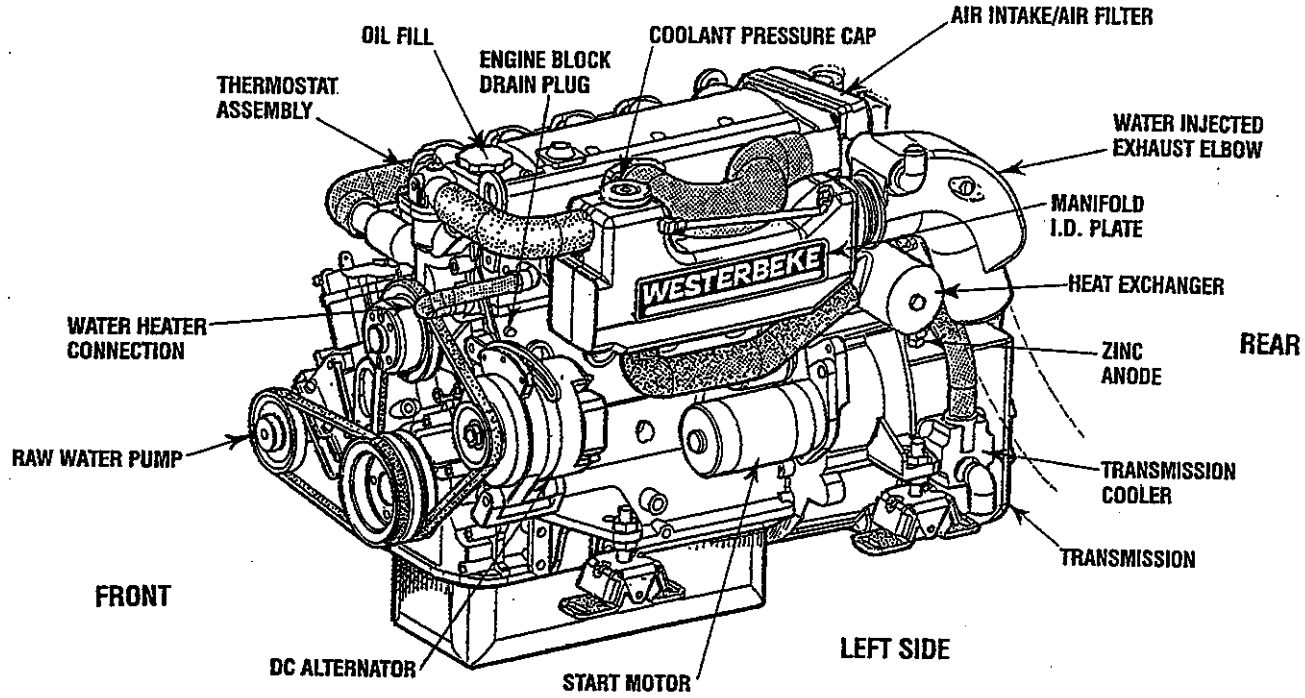
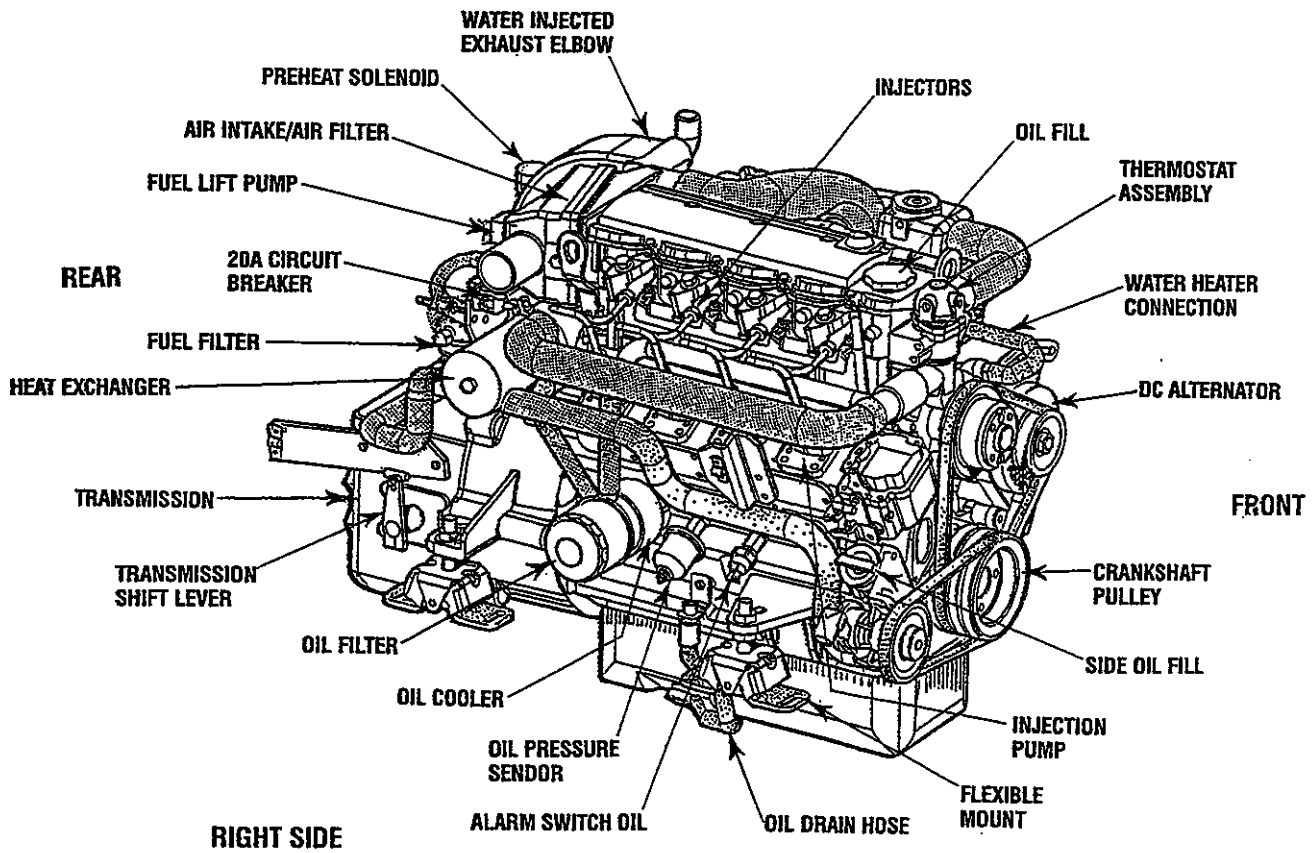
PARTS IDENTIFICATION





INTRODUCTION

PRODUCT SOFTWARE

Product software, (technical data, parts lists, manuals, brochures and catalogs), provided from sources other than WESTERBEKE are not within WESTERBEKE'S control.

WESTERBEKE CANNOT BE RESPONSIBLE FOR THE CONTENT OF SUCH SOFTWARE, MAKES NO WARRANTIES OR REPRESENTATIONS WITH RESPECT THERETO, INCLUDING ACCURACY, TIMELINESS OR COMPLETENESS THEREOF AND WILL IN NO EVENT BE LIABLE FOR ANY TYPE OF DAMAGE OR INJURY INCURRED IN CONNECTION WITH OR ARISING OUT OF THE FURNISHING OR USE OF SUCH SOFTWARE.

WESTERBEKE customers should keep in mind the time span between printings of WESTERBEKE product software and the unavoidable existence of earlier WESTERBEKE product software. The product software provided with WESTERBEKE products, whether from WESTERBEKE or other suppliers, must not and cannot be relied upon exclusively as the definitive authority on the respective product. It not only makes good sense but is imperative that appropriate representatives of WESTERBEKE or the supplier in question be consulted to determine the accuracy and currentness of the product software being consulted by the customer.

SERIAL NUMBER LOCATION

The engine's model number and serial number are located on a nameplate mounted on the side of the engine's manifold. The engine's serial number can also be found stamped into the engine block on the flat surface of the block just forward of the number one cylinders injection pump. Take the time to enter this information on the illustration of the nameplate shown below, as this will provide a quick reference when seeking technical information and/or ordering repair parts.

ORDERING PARTS

Whenever replacement parts are needed, always provide the engine model number and serial number as they appear on the silver and black nameplate located on the manifold. You must provide us with this information so we may properly identify your engine. In addition, include a complete part description and part number for each part needed (see the separately furnished Parts List). Insist upon WESTERBEKE packaged parts because *will fit* or generic parts are frequently not made to the same specifications as original equipment.

RAW WATER COOLING SYSTEM

Siphon-Break

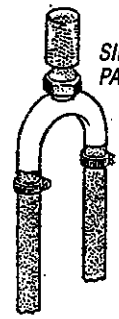
For installations where the water injected exhaust elbow is close to or will be below the vessels waterline, provisions **must** be made to install a siphon-break in the raw water supply hose to the water injected exhaust elbow. The siphon-break provides an air vent in the raw water cooling system to prevent raw water from filling the exhaust system and the engine's cylinders when the engine is shutdown.

> ⚠ **CAUTION:** ***Failure to use a siphon-break when the exhaust manifold injection port is at or below the load waterline will result in raw water damage to the engine and possible flooding of the boat.***

If you have any doubt about the position of the water-injected exhaust elbow relative to the vessels waterline under the vessels various operating conditions, ***install a siphon-break.*** This precaution is necessary to protect your engine.

The siphon-break must be installed in the highest point of a hose that is looped a minimum of 20 inches (51cm) above the vessels waterline. This siphon-break **must always** be above the waterline during all angles of vessel operation to prevent siphoning.

NOTE: *A siphon-break requires periodic inspection and cleaning to ensure proper operation. Failure to properly maintain a siphon-break can result in catastrophic engine damage. Consult the siphon-break manufacturer for proper maintenance.*



SIPHON-BREAK
PART NO. 033327

SIPHON-BREAK WITH STAINLESS LOOP FOR 3/4" HOSE
PART NO.045368

SPECIFICATIONS 55B ENGINE

SPECIFICATIONS

Engine Type	Diesel, water cooled, four cycle, four cylinder, in-line overhead valve type
Displacement	133 cubic inches (2.179 liter)
Combustion Type	In-direct injection
Combustion System	Swirl chamber
Bore & Stroke	3.35 x 3.78 inches (85 x 96 mm)
Max. Angle of Installation	Not to exceed 14°
Max. Angle of Rotation	Not to exceed 30° for 30 minutes
Firing Order	1 - 3 - 4 - 2
Direction of Rotation	Counterclockwise, when viewed from flywheel
Propeller Shaft	Right hand direction of rotation
Compression Ratio	21:5:1
Aspiration	Naturally Aspirated
Engine Speed	Idle speed: 850-1000 RPM Cruising Speed: 2000-2500 RPM No load speed: 3200 RPM (neutral)
Fuel Consumption	1.5 U.S. gph running at 2500 RPM (approx.) when the propeller used allows the engine to turn at 3000 RPM at full open throttle underway in forward
Dimensions - inches (mm) Engine Only	Height: 23.3 inches (592 mm) Width: 18.6 inches (472 mm) Length: 27.0 inches (687 mm)
Weight	448 lbs (203.2 kgs)
Air Flow	Engine Combustion: 116 cfm (3.3 cmn) Engine Cooling: 200 cfm (5.6cmm)

TUNE-UP SPECIFICATIONS

Compression Pressure	441 psi (3.04 MPa)
Valve Timing Intake Opens Intake Closes	 Open at 15° BTDC - Close 29° ABDC Open at 40° BTDC - Close 16° ATDC
Injection Timing	16° BTDC
Nozzle Injector Pressure	1920 psi (13.2 MPa)
Valve Clearance (engine cold)	0.0157 inches (0.4 mm)

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	400 - 600 CCA (min.)
DC Charging Alternator	50 Amp rated, belt-driven - 12V
Starting Aid	Glow plugs, 12V sheathed
Starter	12 Volt, 1.8 KW with solenoid
Cold Cranking Amps	175 - 200 Amps
Alternator Regulator	Internal regulator, built into alternator

EXHAUST SYSTEM

Exhaust Elbow	45° elbow
Exhaust Hose Size	3.0" I.D. hose
Exhaust Gas Flow	265 cfm at 3000 RPM
Muffler Size (min.)	14" x 14"

FUEL SYSTEM

General	Self bleeding
Fuel	Diesel fuel #2 (cetane rating of 45 or higher).
Fuel Injection Pump	BOSCH, PFR type
Injectors	Throttle type
Fuel Filter	Primary, full flow, spin-on element
Air cleaner	Replaceable paper cartridge.
Fuel Lift Pump	Solid state with external filter

COOLING SYSTEM

General	Fresh water-cooled with tube and shell type heat exchanger.
Operating Temperature	170 – 190° F (77 – 88° C)
Fresh Water Pump	Centrifugal metal impeller type belt-driven.
Raw Water Pump	Positive displacement, rubber impeller, belt-driven.
System Capacity	7.25 US qts (6.86 liters)
Sea Water Flow at 3000 rpm	8.0 - 8.5 gpm (30.2 - 32.1 lpm) (measured before discharging into water injected exhaust elbow)

LUBRICATION SYSTEM

General	Forced lubrication by Trochoid type pump
Oil Filter	Full flow spin-on
Sump Capacity (not including filter)	8 U.S. qts (7.6 liters)
Operating Oil Pressure (engine hot)	43 – 85 psi (290 – 590 KPa)
Oil Grade	API Specification CF or CG-4, SAE 30, 15W-30
Oil Cooler	Fresh water cooled

TRANSMISSION

General	ZF Marine Transmission, case hardened, helical gears, with a servo-operated multiple disc clutch
Gear Ratio (standard)	1:88:1 (ZF25M)
Propeller Recommendations	18 x 13P-2blade (RH) or 18 x 11P 3 blade (RH) (Propeller used should allow the engine to reach its full rated RPM (3000 + 000 -100) at full open throttle while underway in forward gear)
Lubricating Fluid	Automatic transmission fluid, type Dexron II or III
Transmission Sump Capacity	0.75 U.S. qts. (0.79 liters)

TESTING FOR OVERHAUL

HOW TO DETERMINE ENGINE OVERHAUL PERIOD

Cause of Low Compression

Generally, the time at which an engine should be overhauled is determined by various conditions such as lowered engine power output, decreased compression pressure, and increased fuel and oil consumption. The lowered engine power output is not necessarily due to trouble with the engine itself, but is sometimes caused by injector nozzle wear or injection pump wear. The decrease in compression pressure is caused by many factors. It is, therefore, necessary to determine a cause or causes on the basis of data produced by periodic inspection and maintenance. Oil analysis on a seasonal basis is a good means of monitoring engine internal wear. When caused by worn cylinders or piston rings, the following symptoms will occur:

1 **Low engine power output**
2 **Increased fuel consumption**
3 **Increased oil consumption**
4 **Hard engine starting**
5 **Noisy engine operation**

These symptoms often appear together. Symptoms 2 and 4 can result also from excessive fuel injection, improper injection timing, and wear of the injectors. They are caused also by defective electrical devices such as the battery, alternator, starter and glow plugs. Therefore it is desirable to judge the optimum engine overhaul time by the lowered compression pressure caused by worn cylinders and pistons plus increased oil consumption. Satisfactory combustion is obtained only under sufficient compression pressure. If an engine lacks compression pressure, incomplete combustion of fuel will take place even if other parts of the engine are operating properly. To determine the period of engine overhaul, it is important to measure the engine compression pressure regularly. At the same time, the engine speed at which the measurement of compression pressure is made should be checked because the compression pressure varies with engine rpm. The engine rpm can be measured at the front end of the crankshaft.

NOTE: To test engine compression see the *ENGINE ADJUSTMENT* section of this manual.

ASSEMBLY

1. Wash all parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.
2. Always use tools that are in good condition and be sure you understand how to use them before performing any job.
3. Use only good quality lubricants. Be sure to apply a coat of oil, grease or sealant to parts as specified..
4. Be sure to use a torque wrench to tighten parts for which torques are specified.
5. Ant time the engine is assembled, new gaskets and O-rings must be installed.

OVERHAUL CONDITIONS

Compression pressure tends to increase a little in a new engine until piston rings and valve seats have been broken in. Thereafter, it decreases gradually with the progress of wear of these parts.

When decrease of compression pressure reaches the repair limit, the engine must be overhauled.

The engine requires overhaul when oil consumption is high, blowby evident, and compression values are at minimum or below.

55B FOUR COMPRESSION PRESSURE
441 PSI (3.04 MPa) NORMAL AT CRANKING SPEED OF 250 RPM.
44.1 PSI BETWEEN CYLINDERS

DISASSEMBLY

1. Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
2. Drain water, fuel and oil before disassembly.
3. Clean or wash the engine exterior.
4. Do not remove or disassemble the parts that require no disassembly.
5. Perform disassembly in a proper order using proper tools. Keep disassembled parts in order. Apply oil when necessary. Take special care to keep the fuel system parts from intrusion of dust and dirt.
6. Parts must be restored to their respective components from which they were removed at disassembly. This means that all parts must be set aside separately in groups, each marked for its component, so that the same combination or set can be reproduced at assembly.
7. Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly..
8. Carefully check each part or component fore any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

ALTERNATOR INSPECTION

When rebuilding the engine, the alternator should be cleaned and inspected. The housing can be wiped off with a solvent and the alternator terminal studs should be cleaned with a wire brush. Make certain the studs are tight and clean the wiring connections that connect to the wiring harness.

Turn the rotor pulley by hand. It should turn smoothly.

Depending on when the alternator was last serviced, the brushes may need replacing. If the alternator is at all suspect, send it to a service shop for testing and overhaul.

For additional information on alternators refer to the *ALTERNATOR TROUBLESHOOTING* and *MANDO SERVICE* in this manual.

ENGINE TROUBLESHOOTING

The following troubleshooting chart describes certain problems relating to engine service, the probable causes of these problems, and the recommendations to overcome these problems.This chart may be of assistance in determining the need for an engine overhaul.

NOTE: *The engine's electrical system is protected by a 20-ampere manual reset circuit breaker. The preheat solenoid is mounted on the same bracket.*

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
HARD STARTING	**LOW CRANKING SPEED**	
	1. Engine oil viscosity too high.	1. Replace engine oil with less viscous oil.
	2. Run-down battery.	2. Recharge battery.
	3. Worn battery.	3. Replace battery.
	4. Battery terminals loosely connected.	4. Clean terminals and correct cables.
	5. Defective starter.	5. Repair or replace starter.
	DEFECTIVE INJECTION SYSTEM	
	1. Air trapped in fuel passage.	1. Bleed air from fuel system.
	2. Clogged fuel filter.	2. Clean or replace filter.
	3. Low injection pressure.	3. Adjust injection pressure.
	4. Inadequate spray.	4. Clean or replace nozzle.
	5. Injection pump delivering insufficient fuel.	5. Repair or replace injection pump.
	6. Injection too early.	6. Adjust injection timing.
	MAIN ENGINE TROUBLES	
	1. Low compression.	
	a. Incorrect valve clearance.	a. Adjust valve clearance.
	b. Inadequate contact of valve seat.	b. Lap valve.
	c. Valve stem seized.	c. Replace valve and valve guide.
	d. Broken valve spring.	d. Replace valve spring.
	e. Compression leaks through cylinder head gasket.	e. Replace gasket.
	f. Piston ring seized.	f. Replace piston and piston ring.
	g. Worn piston ring and cylinder.	g. Overhaul engine.
	2. Burnt glow plug.	2. Replace glow plug.
	3. Faulty glow plug operation.	3. Correct lead wire connection.
	4. Incorrect governor lever position.	4. Set lever to starting position.
LOW OUTPUT	**LOW COMPRESSION**	See ***HARD STARTING***
	INJECTION SYSTEM OUT OF ADJUSTMENT	
	1. Incorrect injection timing.	1. Adjust injection timing.
	2. Insufficient injection.	2. Repair or replace injection pump.
	3. Low injection pressure.	3. Check injection nozzle and adjust pressure.
	INSUFFICIENT FUEL	
	1. Air trapped in fuel system.	1. Check and retighten connector.
	2. Clogged filter.	2. Clean or replace filter.
	3. Contaminated fuel tank.	3. Clean tank.
	INSUFFICIENT INTAKE AIR	
	1. Clogged air cleaner.	1. Clean or replace air cleaner.

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
LOW OUTPUT *(cont.)*	**OVERHEATING**	
	1. Low coolant level.	1. Add coolant.
	2. Loose V-belt.	2. Adjust or replace V-belt.
	3. Incorrect injection timing.	3. Adjust injection timing.
	4. Low engine oil level.	6. Add engine oil.
EXCESSIVE OIL CONSUMPTION	**OIL LEAKAGE**	
	1. Defective oil seals.	1. Replace oil seals.
	2. Broken gear case gasket.	2. Replace gasket.
	3. Loose gear case attaching bolts.	3. Retighten bolts.
	4. Loose drain hose.	4. Retighten hose.
	5. Loose oil pipe connector.	5. Retighten oil connections.
	6. Broken rocker cover gasket.	6. Replace gasket.
	7. Loose rocker cover attaching bolts.	7. Retighten attaching bolts.
	OIL LEVEL RISING	
	1. Incorrectly positioned piston ring gaps.	1. Correct ring gap positions.
	2. Displaced or twisted connecting rod.	2. Replace connecting rod.
	3. Worn piston ring.	3. Replace ring.
	4. Worn piston or cylinder.	4. Replace piston and rebore cylinder.
	OIL LEVEL FALLING	
	1. Defective stem seal.	1. Replace stem seal.
	2. Worn valve and valve guide.	4. Replace a valve and valve guide.
EXCESSIVE FUEL CONSUMPTION	**ENGINE BODY TROUBLES**	
	1. Noisy knocking.	1. See *KNOCKING.*
	2. Smoky exhaust.	2. See *SMOKY EXHAUST.*
	3. Moving parts nearly seized or excessively worn.	3. Repair or replace.
	4. Poor compression.	4. See *LOW COMPRESSION; HARD STARTING.*
	5. Improper valve timing.	5. Adjust.
	6. Improper valve clearance.	6. Adjust.
	INSUFFICIENT INTAKE AIR	
	1. Air intake obstructed.	1. Remove obstruction.
	NOZZLE TROUBLES	
	1. Seized nozzle.	1. Replace.
	2. Worn nozzle.	2. Replace.
	IMPROPER FUEL	Replace with proper fuel.
	FUEL LEAKS	Find fuel leaks.
SMOKY EXHAUST	**WHITISH OR PURPLISH**	
	1. Excessive engine oil.	1. Correct oil level.
	2. Excessive rise of oil into combustion chamber.	
	a. Poor piston contact.	a. Check.
	b. Seized piston ring.	b. Replace or clean.
	c. Excessive piston-to-cylinder clearance.	c. Replace or correct.

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
SMOKY EXHAUST *(cont.)*	**WHITISH OR PURPLISH *(cont..)***	
	d. Worn valve stem and valve guide.	**d.** Replace.
	e. Low engine oil viscosity.	**e.** Replace.
	f. Excessive oil pressure.	**f.** Correct.
	3. Injection timing is too late.	**3.** Adjust.
	4. Insufficient compression.	**4.** See *LOW COMPRESSION; HARD STARTING.*
	BLACKISH OR DARK GRAYISH	
	1. Engine body troubles.	
	a. Poor compression.	**a.** See *LOW COMPRESSION; HARD STARTING.*
	b. Improper valve clearance.	**b.** Adjust.
	2. Insufficient intake air (air cleaner clogged).	**2.** Clean air cleaner.
	3. Improper fuel.	**3.** Replace with proper fuel.
ABNORMAL SOUND OR NOISE	**CRANKSHAFT AND MAIN BEARING**	
	1. Badly worn bearing.	**1.** Replace bearing and grind crankshaft.
	2. Badly worn crankshaft.	**2.** Grind crankshaft.
	3. Melted bearing.	**3.** Replace bearing and check lubrication system.
	CONNECTING ROD AND CONNECTING ROD BEARING	
	1. Worn connecting rod big end bearing.	**1.** Replace bearing.
	2. Worn crankpin.	**2.** Grind crankshaft.
	3. Bent connecting rod.	**3.** Correct bend or replace.
	PISTON, PISTON PIN, AND PISTON RING	
	1. Worn cylinder.	**1.** Rebore cylinder to oversize and replace piston.
	2. Worn piston pin.	**2.** Replace piston.
	3. Piston seized.	**3.** Replace piston and rebore cylinder.
	4. Piston seized and ring worn or damaged.	**4.** Replace piston and rings.
	VALVE MECHANISM	
	1. Worn camshaft.	**1.** Replace.
	2. Excessive valve clearance.	**2.** Adjust.
	3. Worn timing gear.	**3.** Replace.
	4. Worn fan pulley bearing.	**4.** Replace.
ROUGH OPERATION	**INJECTION PUMP SYSTEM**	
	1. Uneven injection.	**1.** Adjust injection or replace parts.
	2. Control rack malfunctioning.	**2.** Disassemble, check and correct injection pump.
	3. Worn delivery valve.	**3.** Replace.
	4. Inadequate injection nozzle spray.	**4.** Replace injection nozzle.
	GOVERNING SYSTEM	
	1. Governor lever malfunctioning.	**1.** Check governor shaft and correct operation.
	2. Fatigued governor spring.	**2.** Replace.

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
KNOCKING	**ENGINE KNOCKS WITHOUT MUCH SMOKE**	
	1. Main engine troubles.	
	a. Overheated cylinder.	a. See *OVERHEATING; LOW OUTPUT.*
	b. Carbon deposits in cylinder.	b. Clean.
	2. Too early injection timing.	2. Correct.
	3. Too high injection pressure.	3. Correct.
	4. Improper fuel.	4. Replace with proper fuel.
	KNOCKING WITH DARK SMOKE	
	1. Poor compression.	1. See *LOW COMPRESSION; HARD STARTING.*
	2. Injection pump malfunctioning.	2. Adjust/Repair
	3. Improper nozzle.	
	a. Poor spray.	a. Clean or replace nozzle.
	b. Poor chattering.	b. Repair or replace nozzle.
	c. After-injection drip.	c. Repair or replace nozzle.
	d. Nozzle needle valve seized.	d. Replace.
INTERMITTENT EXHAUST SOUND	1. Fuel filter clogged.	1. Clean or replace.
	2. Water mixed in fuel	2. Replace fuel.
OVERHEATING	1. V-belt slackening or slippery with oil.	1. Adjust, replace or clean.
	2. Damaged water pump.	2. Replace.
	3. Lack of coolant.	3. Add.
	4. Low oil level or poor oil quality.	4. Add or change.
	5. Knocking.	5. See *KNOCKING.*
	6. Moving parts seized or damaged.	6. Replace.
	7. Defective thermostat.	7. Replace.
LOW OIL PRESSURE	1. Worn Bearings.	1. Engine overhaul replace bearings.
	2. Relief valve malfunction.	2. Overhaul oil pump.
	3. Clogged oil cooler.	3. Repair.
	4. Diesel dilution of the oil.	4. Injection pump repair.

ENGINE DISASSEMBLY

PROPULSION ENGINE

Switch off the batteries and disconnect the battery cables from the engine and tape over the terminals.

Drain or pump out all the engine oil and drain the coolant from the engine and engine hoses.

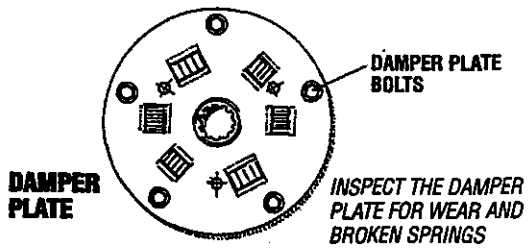
Unplug the instrument panel wiring harness. Drain the transmission fluid and the transmission oil cooler hoses, Detach the oil cooler hoses and unbolt the transmission from the engine.

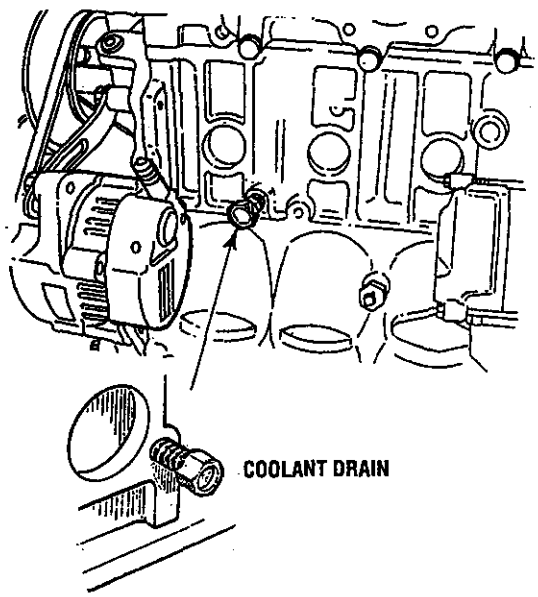
NOTE: *Label any lines, hoses or cables as you separate them.*

TRANSMISSION

If the transmission is not being rebuilt it should be visually inspected. Flush out and pressure test the oil cooler and replace the coolant hoses. Inspect and lubricate the gear shift linkage and the propeller shaft coupling. Clean and repaint the transmission and change the transmission fluid.

For transmission service and maintenance refer to your transmission manual. To rebuild a transmission contact your WESTERBEKE dealer or an authorized transmission service center.





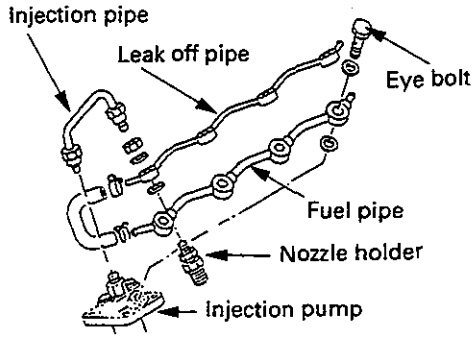
ENGINE DISASSEMBLY

Take the following precautions:

- **Clean the exterior of the engine of any deposits of dirt and oil.**
- **Be careful not to damage the disassembled parts.**
- **Arrange parts in the order of disassembly. Mark or label parts as needed to insure proper mating and reassembly. Keep parts clean.**
- **Mount the engine on a suitable engine stand for disassembly.**

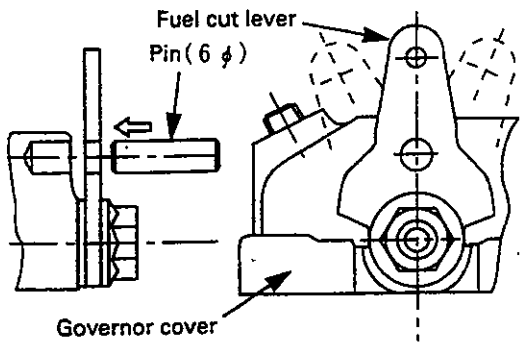
With the transmission separated from the engine, begin the following step by step procedure to disassemble the engine.

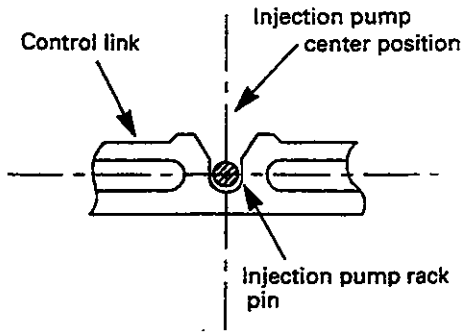
1. **Remove the transmission damper plate from the engine flywheel.**
2. **Remove the engine oil cooler and oil hoses.** Note oil hose connections from the oil cooler to the engine.
3. **Remove the engine heat exchanger.** If possible, leave one end of each hose connected to the part being removed.
4. **Remove the bell housing and the circuit breaker/ preheat solenoid mounting bracket.**
5. **Remove the engine back plate.**
6. **Remove the start motor, drive belt and the alternator.** Label the wires and cables.
7. **Remove the engine mounted raw water pump, complete with its adapter mounting plate.** See *RAW WATER PUMP* for parts breakdown.
8. **With the hoses disconnected, remove the thermostat housing and housing gasket,** leaving the temperature sender in place.
9. **Remove the coolant circulating pump.** Refer to *COOLANT CIRCULATING PUMP ASSEMBLY.*
10. **Remove the air intake silencer and the intake manifold.**
11. **Remove the oil filter and the mounting bracket from the engine block.**
12. **Unbolt the elbows and remove the exhaust manifold in its entirety.**
13. **Remove the fuel injection pumps.** Disconnect the fuel injection pipes and fuel leak-off pipe from the fuel injection pumps and nozzles.
14. **Fuel pipe, injection pipe, and leak off pipe.**
    a. Loosen the sleeve nuts on the nozzle holder side and on the injection pump side, and then disconnect the injection pipes.
    b. Disconnect the leak off pipe together with gaskets.
    c. Remove the eye bolt, and then disconnect the fuel pipe.



Injection pump

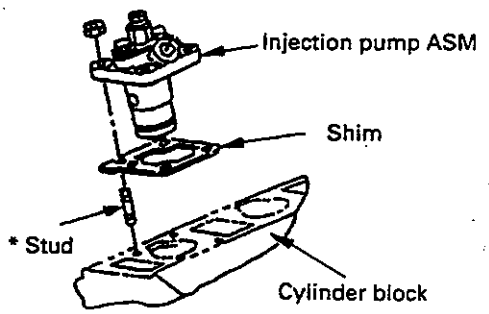
1. Align the hole of the fuel cut lever with the hole of the governor cover, and then insert a pin (6ø) into this hole to hold the fuel cut lever.
2. Check to see if the pin groove of the control link is at the center of the injection pump.
3. Remove the injection pump, and then take out the shim.





NOTE:

1. **Mark each injection pump as to which cylinder it was removed from.**
2. **Do not reuse the shim, replace it with the same thickness that was removed.**



MEASUREMENTS

PRIOR TO MAIN ENGINE DISASSEMBLY

Backlash of timing gear

mm (in.)

	STANDARD	LIMIT
CRANK GEAR/ IDLER GEAR	0.04 (0.0017)	0.2 (0.0079)
CAM GEAR/ IDLER GEAR	0.03 (0.0012)	0.2 (0.0079)

IDLER GEAR END PLAY

mm (in.)

STANDARD	LIMIT
0.058 – 0.115 (0.0023 – 0.0045)	0.2 (0.0079)

CRANKSHAFT END PLAY

mm (in.)

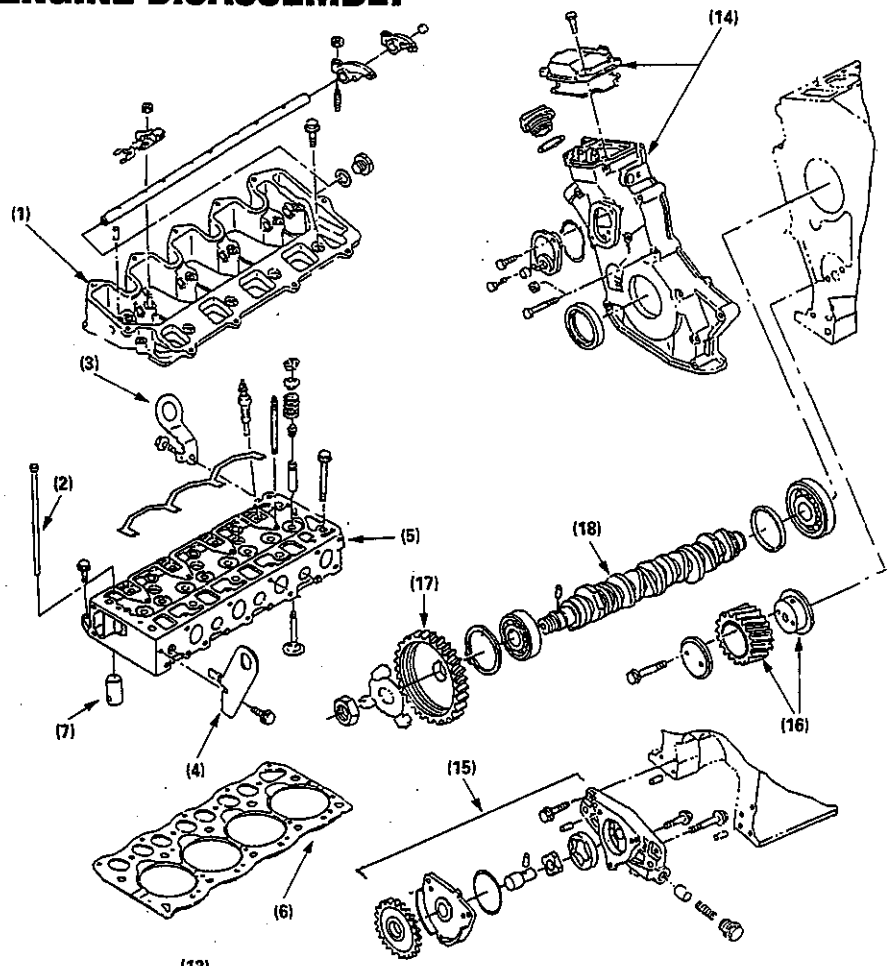
STANDARD	LIMIT
0.058 – 0.208 (0.0023 – 0.0082)	0.3 (0.0118)

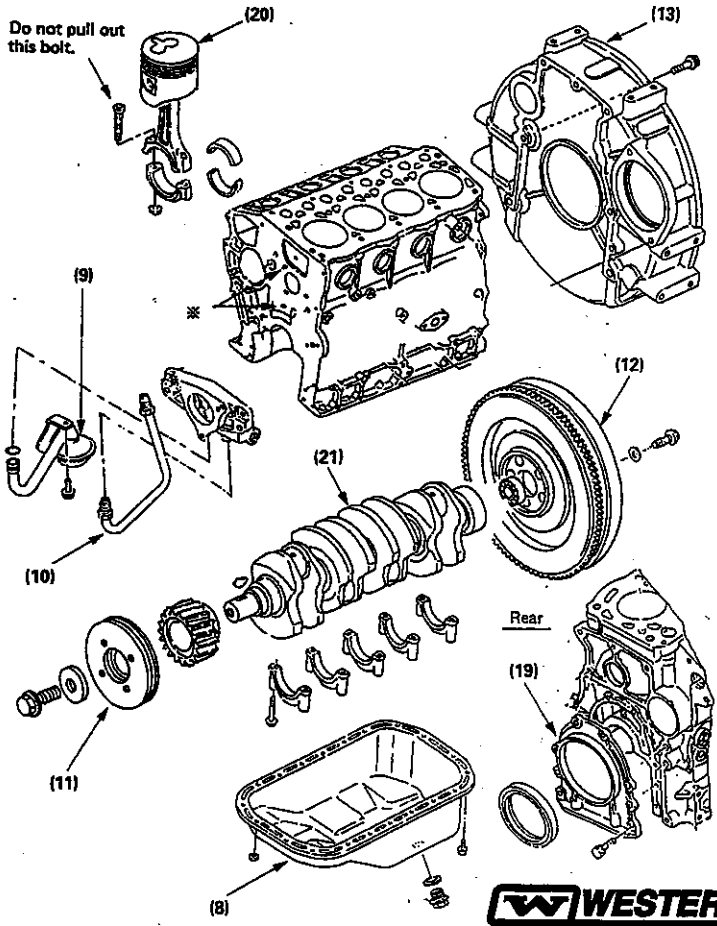
ENGINE DISASSEMBLY

INTERNAL PARTS

Disassembly Steps

(1) Rocker Bracket Assembly
(2) Push Rods
(3) Rear Hanger
(4) Front Hanger
(5) Cylinder Head Assembly
(6) Cylinder Head Gasket
(7) Tappets
(8) Oil Pan
(9) Oil Strainer
(10) Oil Pipe
(11) Crank Pulley
(12) Flywheel
(13) Flywheel Housing
(14) Timing Gear Case
(15) Oil Pump Assembly
(16) Idler Gear and Shaft
(17) Cam Gear
(18) Camshaft
(19) Rear Seal Retainer
(20) Piston Assemblies
(21) Crankshaft

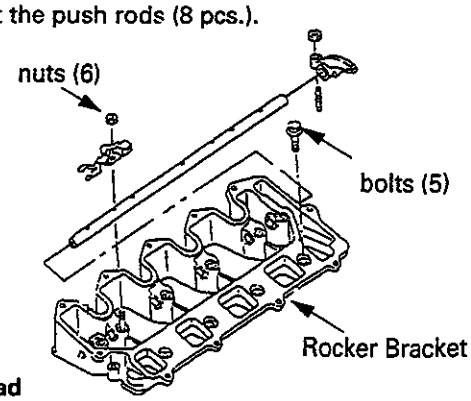




Rocker bracket

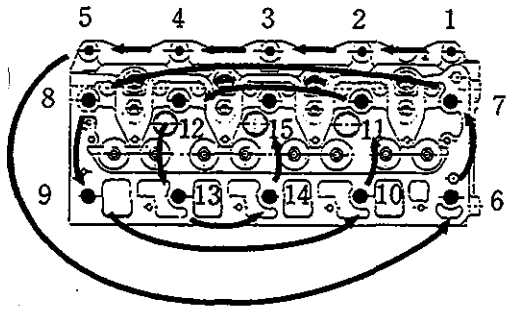
Push rod

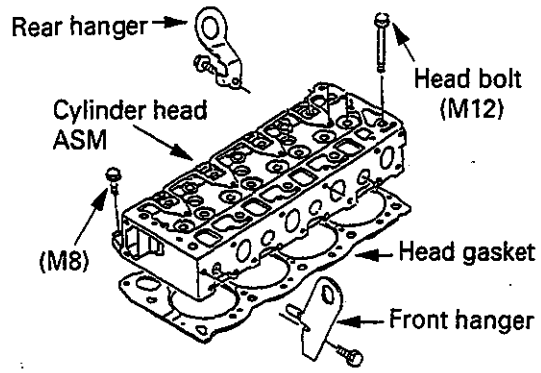
1. Remove the rocker bracket assembly. (M6 × 1 . . . . . 5 bolts and 6 nuts)
2. Pull out the push rods (8 pcs.).



Cylinder head

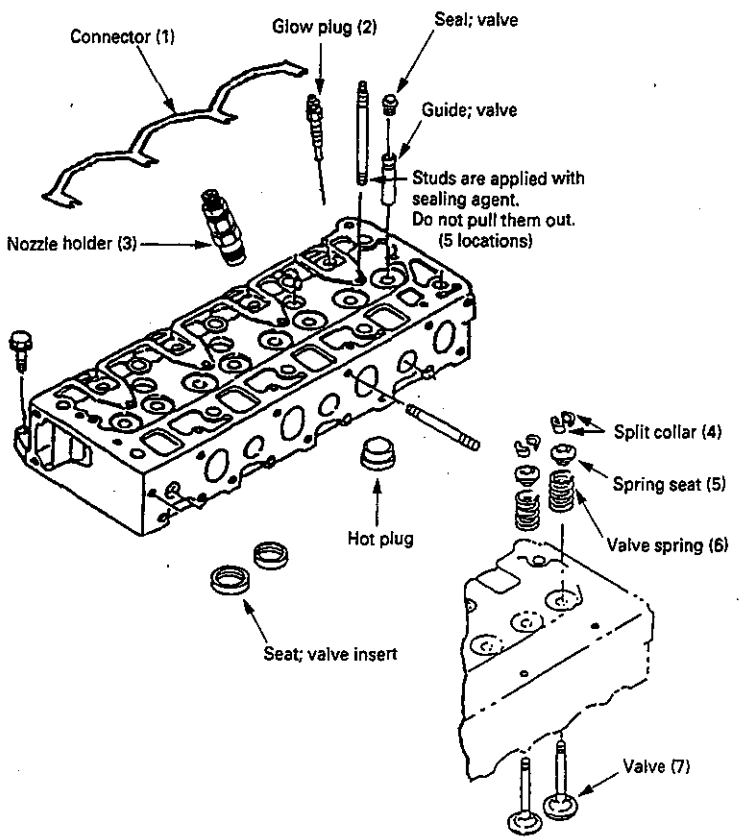
1. Remove the rear and front hangers.
2. When removing the cylinder head bolts, loosen them slowly, a little at a time, starting with the outside, working in a circular pattern inward.
3. Remove the cylinder head assembly and the head gasket.
4. Pull out the tappet from the cylinder body.





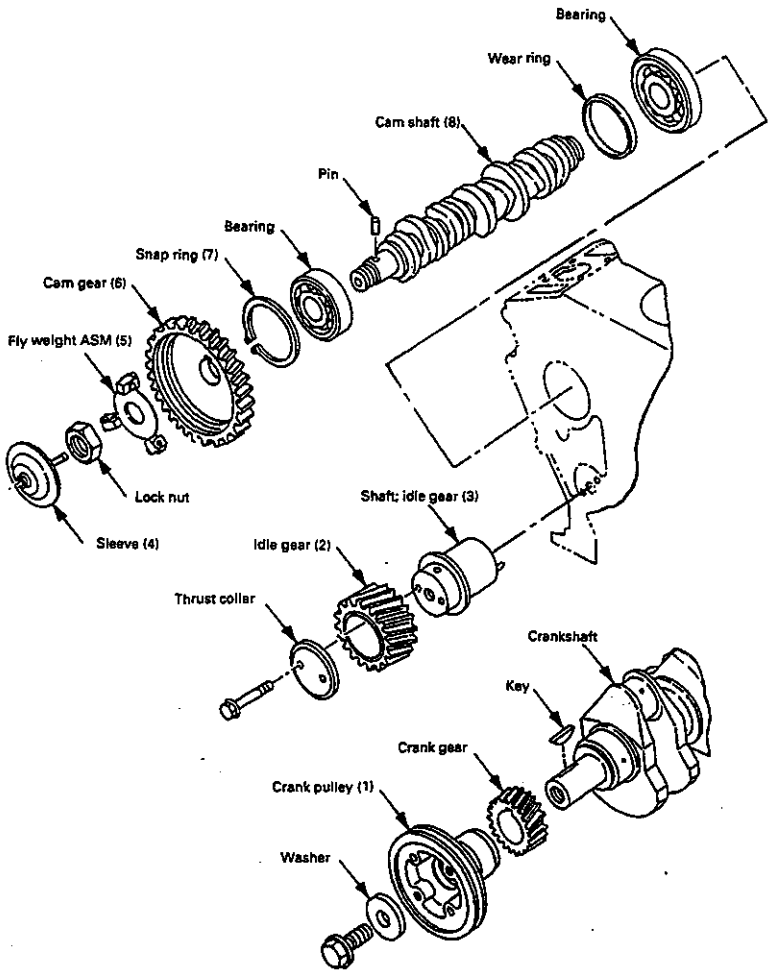
Valve mechanism

1. Before disassembling the valve mechanism, remove the connector, glow plug and nozzle holder assembly.
2. Compressing the valve spring, remove the split collar, spring seat, valve spring and valve.



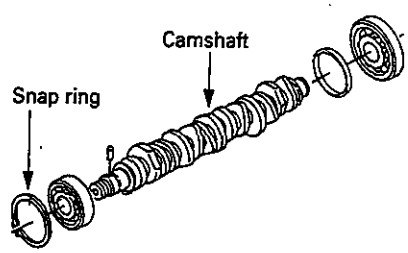
Timing gear

1. Remove the idle gear and the idle gear shaft.
2. Pull out the sleeve from the tip end of the cam shaft.
3. Remove the lock nut of the cam shaft gear, and then remove the flyweight assembly and the cam gear.

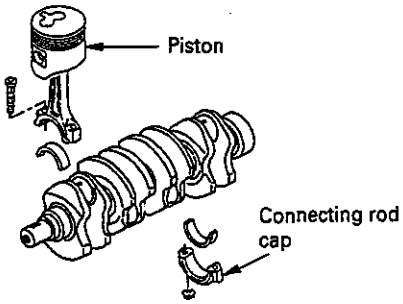


Camshaft

1. Remove the snap ring which holds down the front bearing of the cam shaft from the ring groove of the cylinder block.
2. Pull out the cam shaft from the cylinder block, together with the bearing.



Piston and Connecting Rod



Piston and connecting rod

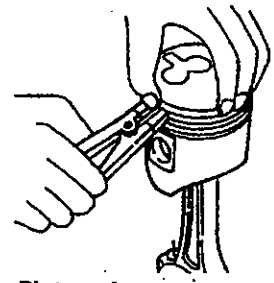
1. Turning the crankshaft, position the piston to be removed at the bottom dead center.
2. Loosen the cap nut of the connecting rod, and then remove it.
3. Give another rotation to the crankshaft to position the piston at the top dead center.
4. With the handle of a hammer placed at the bottom of the connecting rod, push the piston assembly upward out of the cylinder block.

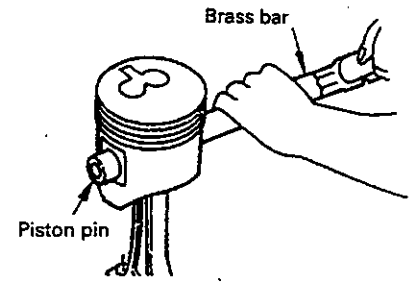
Notes:

1. **Before removing the piston, scrape the carbon deposit off the cylinder wall.**
2. **When pushing out the piston assembly, care should be taken not to damage the cylinder wall.**
3. **Attach a tag with a cylinder number to the removed caps and bearings to keep them in order.**

Piston ring

Remove the piston ring with a ring pliers.



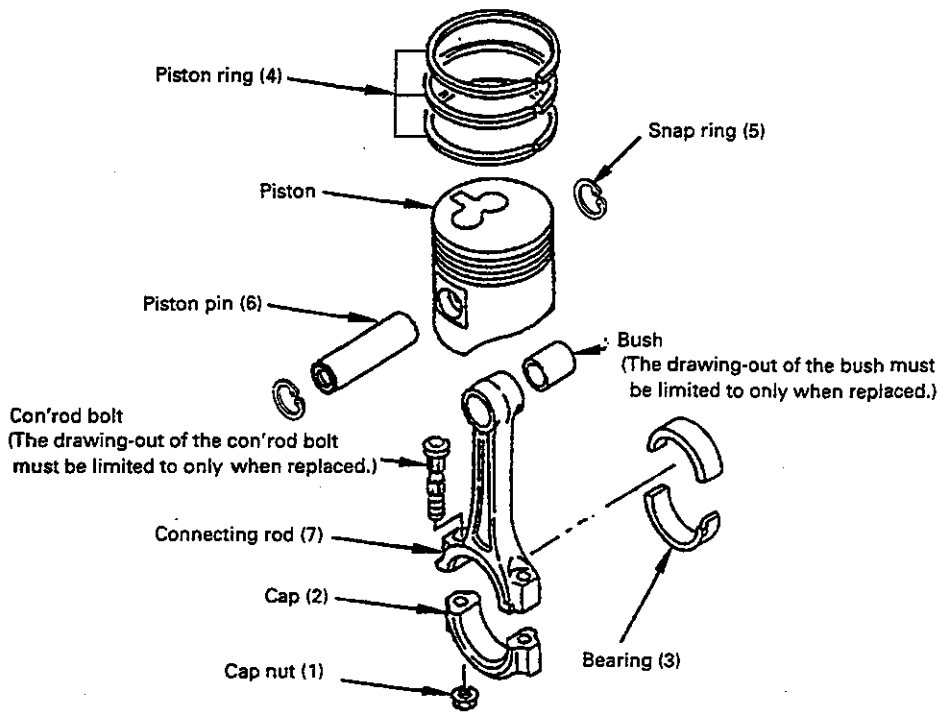


Piston pin

1. Remove the snap rings with a commercially available tool.
2. With a brass bar attached to the piston pin, push it out by hammering it lightly.

Note:

Keep the pistons, piston pins and connecting rods in order for each cylinder.

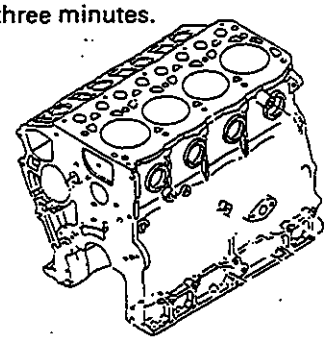


Cylinder block

Check the cylinder block for wear, damage or any other defects.

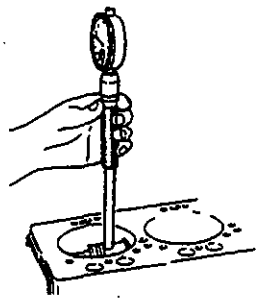
Use the hydraulic gauge to check the water jacket water pressure.

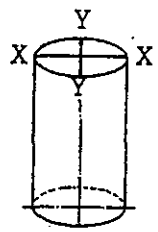
Apply water pressure to the water jacket at 5 kg/cm² (71.1 psi) for three minutes.



Cylinder bore

Measurement position: 13mm below the top
(Measure in X-X and Y-Y directions.)
(Near the No. 1 compression ring)



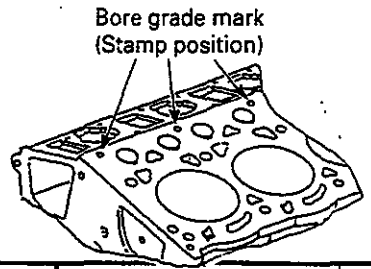


mm (in.)

Engine	Limit	Repair method
	0.2 (0.0079)	Perform boring and honing of the inner diameter.

Cylinder bore diameter and grade mark

The grade mark is stamped on the top surface of the cylinder block (on the mating face with the cylinder head).



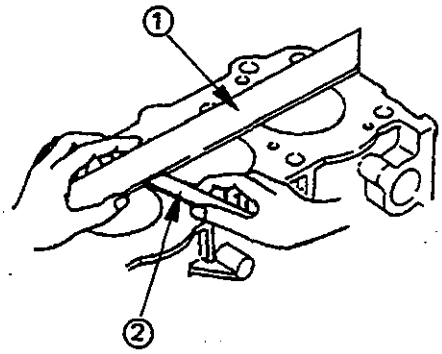
mm (in.)

Engine	Bore Diameter	Grade
	85.000 – 85.010 (3.3464 – 3.3468)	A
	85.011 – 85.020 (3.3468 – 3.3472)	B
	85.021 – 85.030 (3.3472 – 3.3476)	C

Cylinder Body Upper Face Warpage

Use a straight edge ① and a feeler gauge ② to measure the four sides and the two diagonals of the cylinder body upper face.

Regrind the cylinder body upper face if the measured values are greater than the specified limit but less than the maximum grinding allowance.

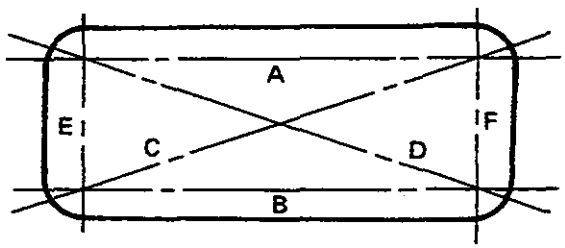


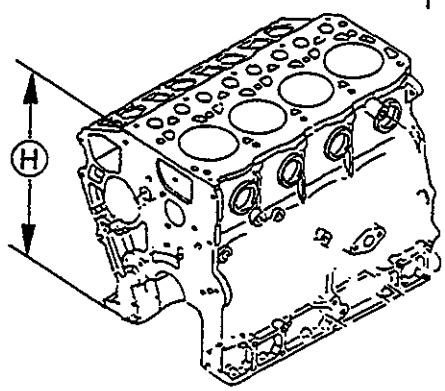
If the measured values exceed the maximum grinding allowance, the cylinder body must be replaced.

Cylinder Body Upper Face Warpage mm (in.)

Standard	Limit	Maximum Grinding Allowance
0.075 (0.0029)	0.15 (0.0059)	0.3 (0.0118)

If the measured value is less than the limit, the cylinder body may be reground.





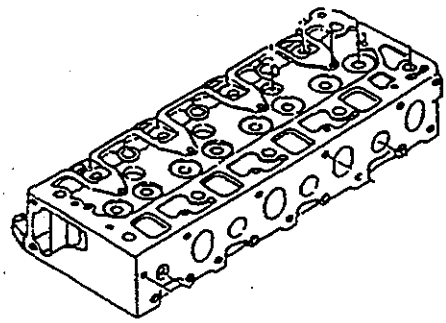
Cylinder Body Height Ⓗ (Reference) mm (in.)

Engine	Standard
	307.94 – 308.06 (12.123 – 12.128)

Cylinder head inspection

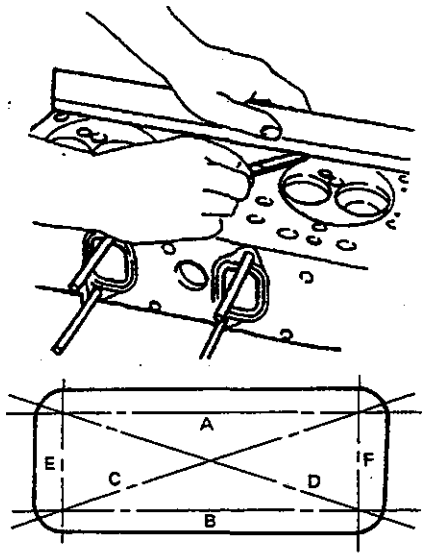
Remove carbon deposit on the bottom surface of the head with care not to damage the valve seat.

Leakage: Water pressure test 5kg/cm² (for 3 minutes)



Cylinder Head Lower Face Warpage

1. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head lower face.
2. Regrind the cylinder head lower face if the measured values are greater than the specified limit but less than the maximum grinding allowance.



If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Cylinder Head Lower Face Warpage mm (in.)

Standard	Limit	Maximum Grinding Allwance
0.075 (0.0029)	0.15 (0.0059)	0.3 (0.0118)

Cylinder Head Height Ⓗ (Reference) mm (in.)

Engine	Standard
	63.90 – 64.10 (2.515 – 2.523)

If the cylinder head lower face is reground, valve depression must be checked.

HOT PLUG

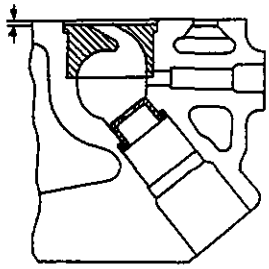
Hot Plug Depression

1. Clean the cylinder head lower face, taking care not to damage the hot plug surfaces.
2. Use a straight edge and a feeler gauge to measure the hot plug depression in a straight line from the No. 1 hot plug to the No. 3 hot plug.

   If the measured value exceeds the specified limit, the hot plugs must be replaced.

Hot Plug Depression mm (in.)

Limit
0.05 (0.002)



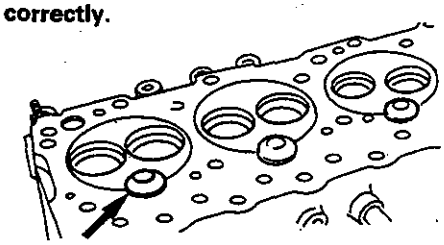
Combustion Chamber Inspection

1. Remove the carbon adhering to the inside of the combustion chamber. Take care not to damage the hot plug fitting positions.
2. Inspect the combustion chamber, the hot plug hole, and the hot plug machined faces for cracking and other damage.

   If cracking or damage is present, the cylinder head must be replaced.

Note:

Be absolutely certain that there are no scratches or protuberances on the combustion chamber surfaces which will be in contact with the hot plug after it is installed. These flaws will prevent the hot plug from seating correctly.



Hot Plug Replacement

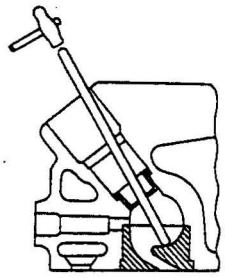
Hot Plug Removal

1. Insert a 3.0 – 5.0 mm (0.12 – 0.20 in) diameter brass bar into the nozzle holder fitting hole until it makes contact with the hot plug.
2. Lightly tap the bar with a hammer to drive the hot plug free.

ENGINE INSPECTION AND REPAIR

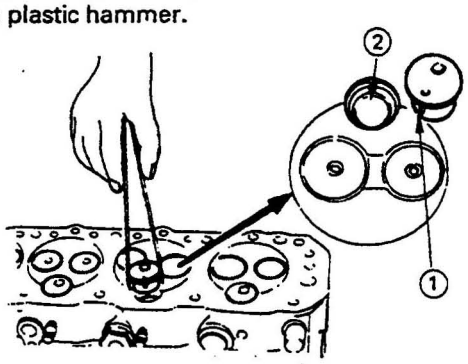
Hot Plug Inspection

Inspect the hot plugs for excessive wear and other damage. Replace the hot plugs if either of these conditions are discovered.

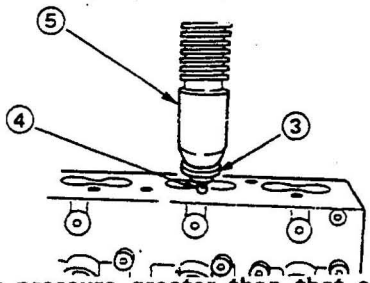


Hot Plug Installation

1. Align the hot plug knock ball ① with the cylinder head groove ② and tap it temporarily into position with a plastic hammer.



2. Place a metal plate ③ approximately 25 mm (1 in) thick over the hot plug upper surface ④.
3. Use a bench press ⑤ to exert a pressure of 4,000 – 5,000 kg (8,819 – 11,023 lb/39,227 – 49,033 N) on the metal plate covering the hot plug upper surface. This will drive the hot plug into position.
4. Lightly tap the hot plug head to make sure that it is firmly seated.
5. Repeat the procedure (Steps 1 – 4) for the remaining hot plugs.



Do not apply pressure greater than that specified. Damage to the cylinder head will result.

6. Use a surface grinder to grind off any hot plug surface protuberances.

   The hot plug surfaces must be perfectly flush with the cylinder head lower face.

7. After grinding, make sure that the hot plug surfaces are completely free of protuberances.

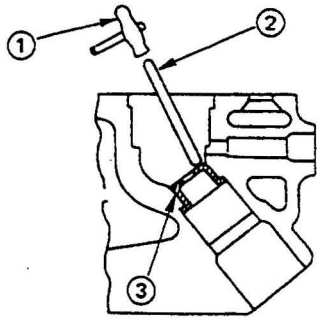
   The hot plug surfaces must also be free of depressions.

   Once again, lightly tap the hot plug heads to make sure that they are firmly seated.

Heat Shield Replacement

Heat Shield Removal

After removing the hot plugs, use a hammer ① and a brass bar ② to lightly tap the lower side of the heat shield ③ and drive it free.



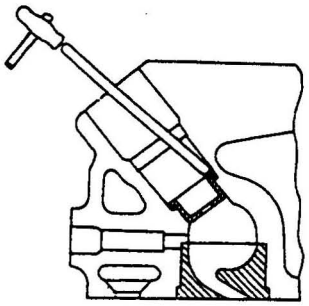
Heat Shield Installation

Install the heat shield to the cylinder head from the nozzle holder installation hole side. Lightly tap the heat shield flange into place with a hammer and a brass bar.

The heat shield flange side must be facing up.

Note:

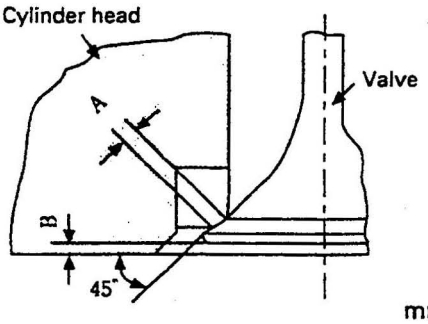
Always install a new heat shield. Never reuse the old heat shield.



VALVE, VALVE SEAT INSERT AND VALVE SEAL

Inspection of valve seat

1. A – Contact width
2. B – Valve depression

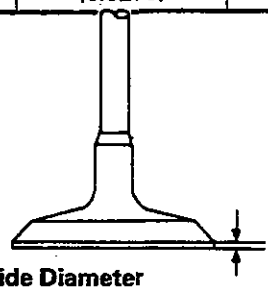


mm (in.)

	Standard	Limit
Contact width	2.0 (0.0787)	2.5 (0.0984)
Valve depression	0.7 (0.0276)	1.2 (0.0427)

Valve thickness

Nominal	Limit	Repair method
1.0 (0.03937)	0.7 (0.0276)	Replace



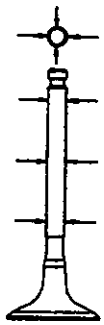
Valve Stem Outside Diameter

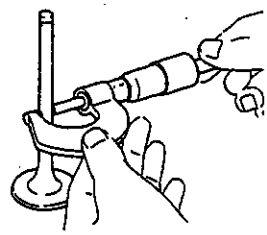
Measure the valve stem diameter at three points.

If the measured value is less than the specified limit, the valve must be replaced.

Valve Stem Outside Diameter mm (in.)

	Standard	Limit
Intake Valve	7.0 (0.2756)	6.85 (0.2697)
Exhaust Valve	7.0 (0.2756)	6.80 (0.2677)





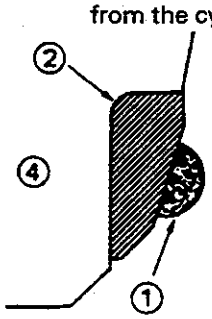
Valve Seat Insert Replacement

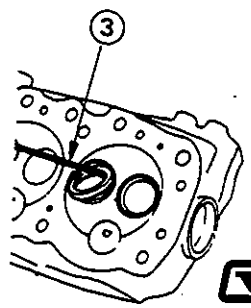
Valve Seat Insert Removal

1. Arc weld the entire inside circumference ① of the valve seat insert ②.
2. Allow the valve seat insert to cool for a few minutes.

   This will invite contraction and make removal of the valve seat insert easier.
3. Use a screwdriver ③ to pry the valve seat insert free.

   Take care not to damage the cylinder head ④.
4. Carefully remove carbon and other foreign material from the cylinder head insert bore.





Valve Seat Insert Installation

1. Carefully place the attachment ① (having a small outside diameter than the valve seat insert) on t valve seat insert ②.

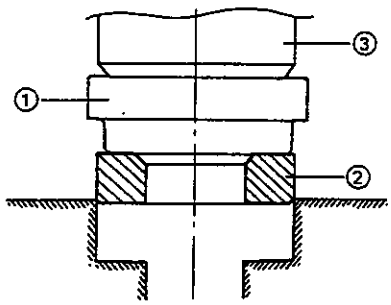
Note:

The smooth side of the attachment must contact the valve seat insert.

2. Use a bench press ③ to gradually apply pressure to the attachment and press the valve seat insert into place. 4,000 kg (8,819 lbs.)

Note:

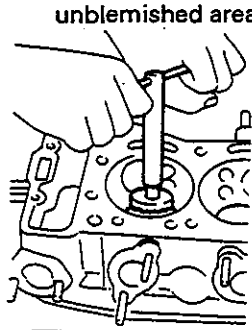
Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.

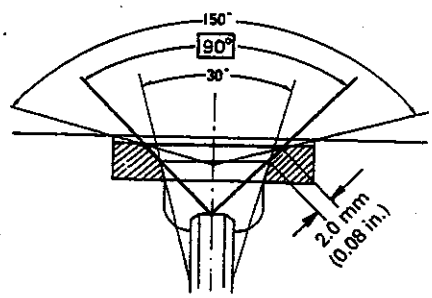


Valve Seat Insert Correction

1. Remove the carbon from the valve seat insert surface.
2. Use a valve cutter (15°, 45°, and 75° blades) to minimize scratches and other rough areas. This wi bring the contact width back to the standard value.

   Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surface.





Valve Seat Angle degree

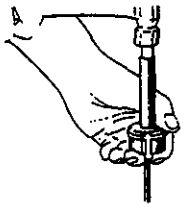
45

Note:

Use an adjustable valve cutter pilot.

Do not allow the valve cutter pilot to wobble inside the valve guide.

3. Apply abrasive compound to the valve seat insert surface.
4. Insert the valve into the valve guide.



5. Apply light pressure to the valve while turning it to fit the valve seat insert.
6. Check that the valve contact width is correct.
7. Check that the valve seat insert surface is in contact with the entire circumference of the valve.
8. Clean the head and valves to remove the abrasive compound and metal particles.

VALVE SPRING

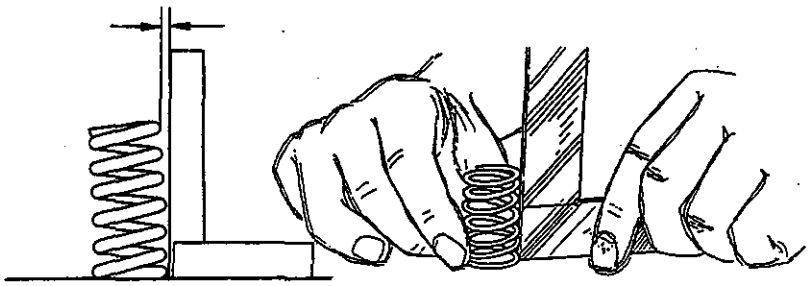
Valve Spring Inclination

Use a surface plate and a square to measure the valve spring inclination.

If the measured value exceeds the specified limit, the valve spring must be replaced.

mm (in.)

	Standard	Limit
Valve Spring Inclination	1.8 (0.0709)	2.5 (0.0984)



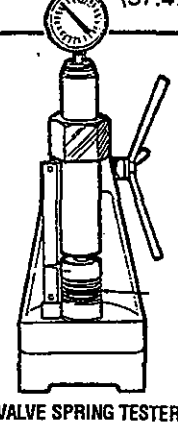
Valve Spring Tension

Use a spring tester to measure the valve spring tension.

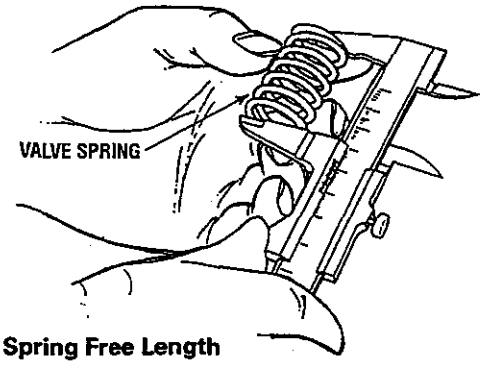
If the measured value is less than the specified limit, the valve spring must be replaced.

mm (in.)

	Standard	Limit
Valve Spring Tension at 29.9 mm Set Length	17.0 (37.479)	15.0 (33.069)



VALVE SPRING TESTER



Valve Spring Free Length

Use a vernier caliper to measure the valve spring free length.

If the measured value is less than the specified limit, the valve spring must be replaced.

mm (in.)

	Standard	Limit
Exhaust and Intake Valve Spring Free Length	42.1 (1.6575)	40.0 (1.5748)

TAPPET (Cam Follower or Valve Lifter) AND PUSH ROD

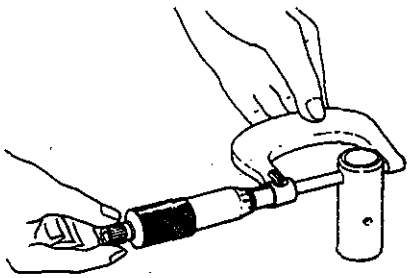
TAPPET

Inspect the tappets for excessive wear, damage and any abnormalities.

Use a micrometer to measure the tappet diameter.

mm (in.)

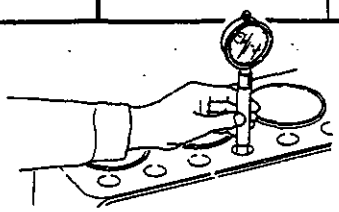
	Standard
Tappet Diameter	20.967 – 20.980 (0.82547 – 0.82598)



Use a dial indicator to measure the clearance between the tappet and cylinder body tappet travelling bore.

mm (in.)

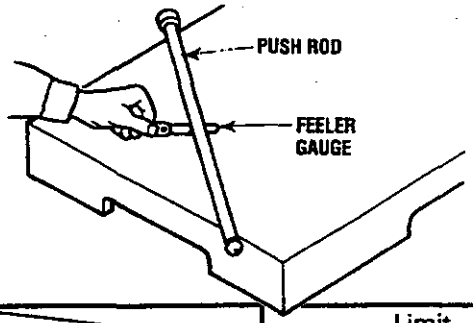
	Standard	Limit
Tappet and Tappet Travelling Bore Clearance	0.020 – 0.054 (0.00079 – 0.00213)	0.08 (0.00315)



PUSH ROD

Use a filler gauge to measure the valve push rod runout.

Roll the push rod along a smooth flat surface (illustration).



mm (in.)

	Limit
Push Rod Run-Out	0.3 (0.0118)

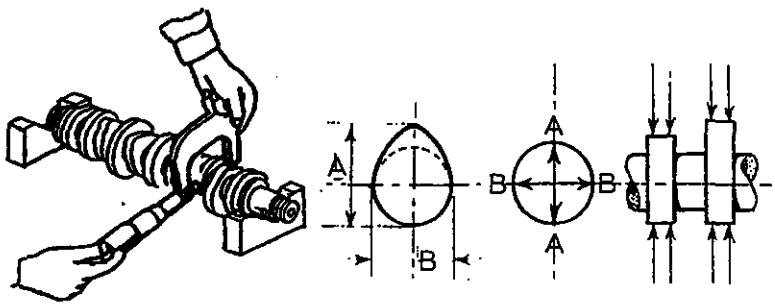
CAM SHAFT

Inspection of cam shaft

Check the journal and the cam for evidence of wear, damage or any other defect.

Note:

With the front and rear parts of camshaft pressed in with ball bearings, and with the cylinder block pressed in with roller bearings as the center bearing, check to see if the camshaft rotates smoothly with no play at each bearing.



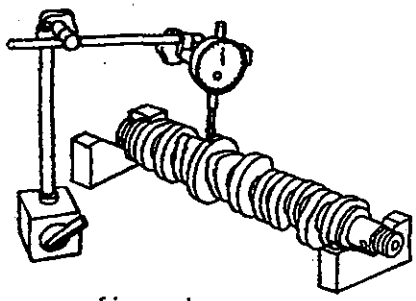
Measurement of journal and cam

1. Cam height (A – B) mm (in.)

	Standard	Limit	Repair method
Intake	6.13 (0.2413)	5.83 (0.2295)	Replace
Exhaust	6.43 (0.2531)	6.13 (0.2413)	Replace

2. Center journal diameter mm (in.)

Nominal	Limit	Repair method
52 ø (2.0472)	51.92 ø (2.0441)	Replace



3. Uneven wear of journal mm (in.)

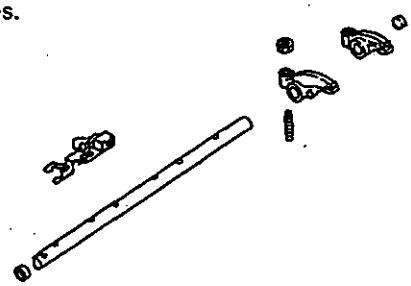
Nominal	Limit	Repair method
52 ø (2.0472)	0.05 (0.002)	Replace

4. Runout of cam shaft mm (in.)

Nominal	Limit	Repair method
0.02 (0.008)	0.1 (0.004)	Replace

ROCKER ARM SHAFT AND ROCKER ARM

Inspect all disassembled parts for wear, damage and any abnormalities.



Rocker Arm Shaft Outside Diameter

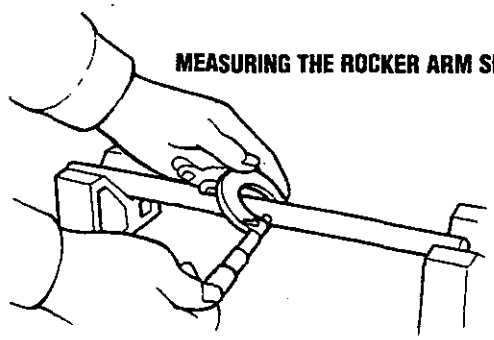
Use a micrometer to measure the rocker arm outside diameter.

If the measured value is less than the specified limit, the shaft must be replaced.

mm (in.)

	Standard
Rocker Arm Shaft Diameter	11.935 – 11.955 (0.4699 – 0.4707)

MEASURING THE ROCKER ARM SHAFT



Rocker Arm Shaft and Rocker Arm Clearance

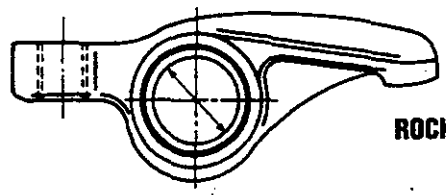
1. Use a vernier caliper to measure the rocker arm bushing inside diameter.

mm (in.)

	Standard
Rocker Arm Bushing Inside Diameter	11.960 – 11.980 (0.4709 – 0.4717)

2. Measure the rocker arm shaft outside diameter.

   Replace either the rocker arm or the rocker arm shaft if the clearance exceeds the specified limit.



ROCKER ARM

mm (in.)

	Standard	Limit
Rocker Arm Bushing and Rocker Arm Shaft Clearance	0.005 – 0.045 (0.0002 – 0.0018)	0.2 (0.0079)

3. Check that the rocker arm oil port is free of obstructions.

   If necessary, use compressed air to clean the rocker arm oil port.

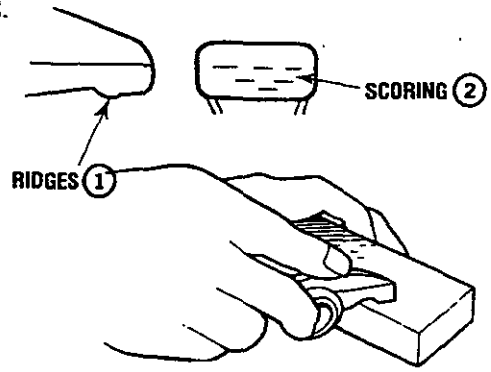
ROCKER ARM SHAFT

Rocker Arm Correction

Inspect the rocker arm valve stem contact surfaces for ridges(1) and scoring(2)

If the surfaces have light ridge or scoring, they may be honed with an oil stone.

If the ridge or scoring is severe, the rocker arm must be replaced.



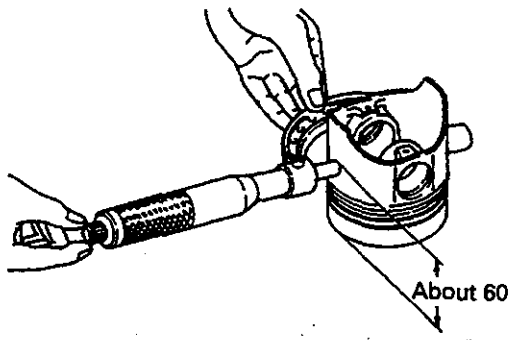
PISTON, PISTON PIN AND PISTON RING

Clearance between piston and cylinder bore

1. Measure the outside diameter of the piston at about 60 mm from the top in a right angle to the piston pin (in the unit of 1/1,000 mm).
2. Calculate the clearance based on the measurements of the cylinder bore and the outside diameter of the piston.

mm (in.)

Clearance	0.015 – 0.035 (0.0006 – 0.0014)

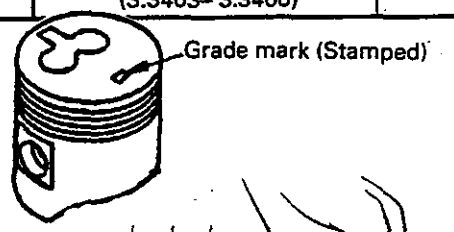


Outside diameter of piston and grade mark

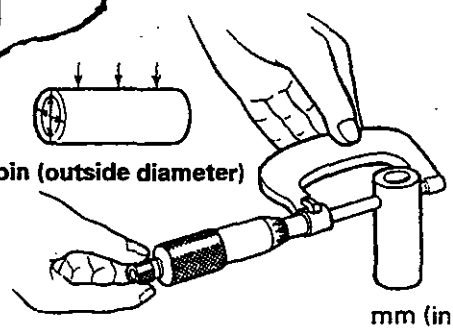
The grade mark is stamped on the top surface of the piston.

mm (in.)

Model	Outside diameter of piston	Grade
	84.975 – 84.985 (3.3454 – 3.3458)	A
	84.986 – 84.995 (3.3459 – 3.3462)	B
	84.996 – 85.005 (3.3463– 3.3466)	C



Wear of piston pin (outside diameter)



mm (in.)

Model	Nominal	Limit	Remarks
	25.0 (0.9843)	24.97 (0.9831)	Replace if worn beyond limit

Clearance between piston pin and piston pin hole

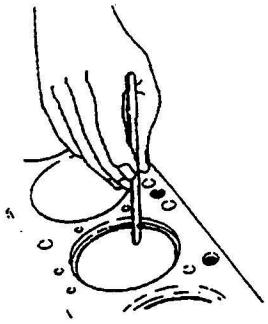
mm (in.)

	Standard
	0.002 – 0.012 (0.00008 – 0.00047)

Piston ring gap

With the ring inserted into the cylinder bore, push it in with the piston head so that it becomes a right angle to the cylinder, and then measure the gap of the piston ring.

If worn beyond the limit, replace the rings.



mm (in.)

	Standard	Limit
1st compression ring	0.2 – 0.35 (0.0079 – 0.0138)	1.5 (0.0590)
2nd compression ring	0.35 – 0.5 (0.0138 – 0.0197)	
Oil ring	0.2 – 0.4 (0.0079 – 0.0157)	1.0 (0.03937)

Clearance between piston ring groove and ring

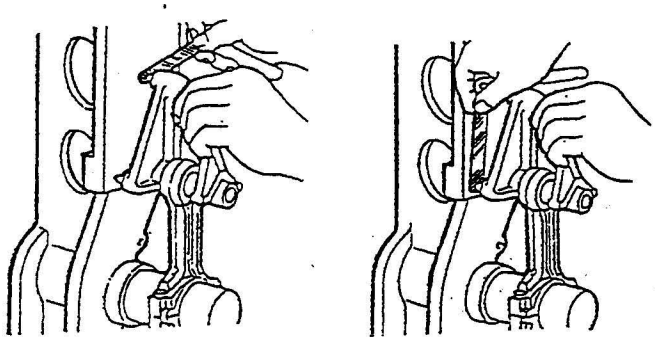
Measure clearance at several places on the circumference.

If worn beyond the limit, replace the rings or piston.

mm (in.)

	Standard	Limit
1st compression ring	0.085 – 0.105 (0.0033 – 0.0041)	0.2 (0.0078)
2nd compression ring	0.050 – 0.085 (0.0020 – 0.0033)	0.15 (0.0059)
Oil ring	0.030 – 0.070 (0.0011 – 0.0027)	

CONNECTING ROD AND CONNECTING ROD BEARING



Torsion and parallelism of connecting rod

If worn beyond the limit-repair or replace.

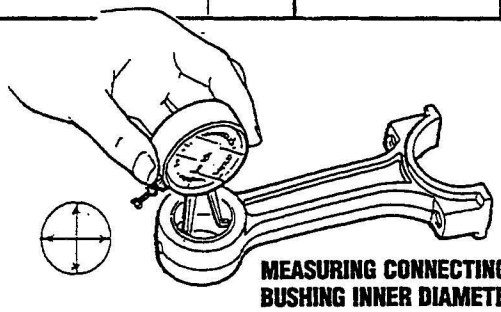
mm (in.)

Per 100 mm (3.94)	Standard	Limit
Torsion	0.05 (0.002)	0.2 (0.0079)
Parallelism	0.05 (0.002)	0.15 (0.0059)

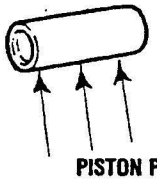
Clearance between small end pin hole of connecting rod and piston pin, inside diameter of bushing

mm (in.)

	Standard	Limit
Clearance	0.008 – 0.020 (0.0003 – 0.0008)	0.05 (0.0020)
Inside diameter	25 (0.9843)	



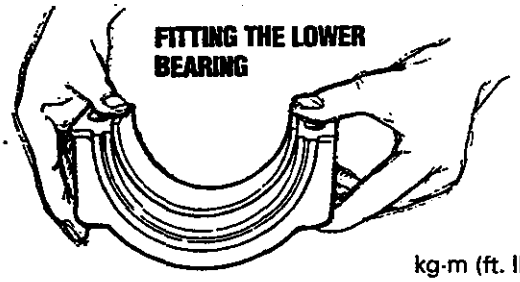
MEASURING CONNECTING ROD BUSHING INNER DIAMETER



PISTON PIN

Connecting Rod Bearing Inspection

1. Fit the connecting rod bearing lower half into the connecting rod bearing cap.
2. Check the connecting rod bearing lower half tension.
   If the tension is insufficient, the bearing must be replaced.
3. Tighten the connecting rod and the bearing cap to the specified torque.



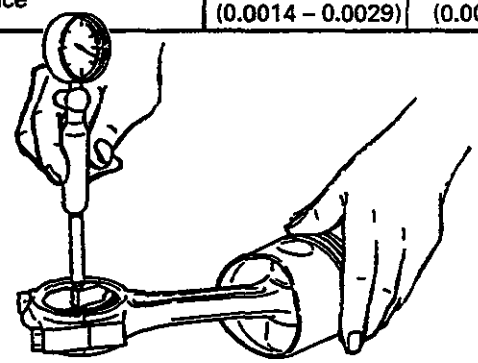
kg-m (ft. lbs.)

Tightening torque	.	7.5 – 8.5 (54 – 61)

Clearance between bearing and crank pin, inside diameter with bearing installed and without.

mm (in.)

	Standard	Limit
Clearance	0.035 – 0.073 (0.0014 – 0.0029)	0.10 (0.0039)



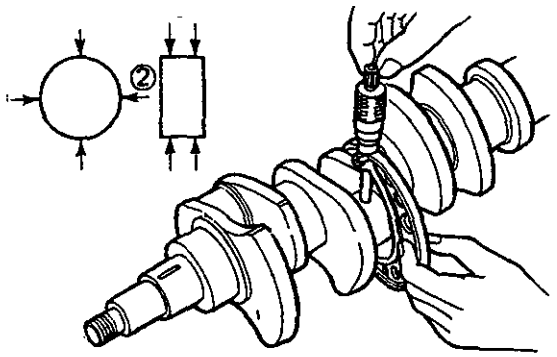
CRANKSHAFT AND CRANKSHAFT BEARING

Outside diameters of journal and pin

If worn beyond the limits-replace

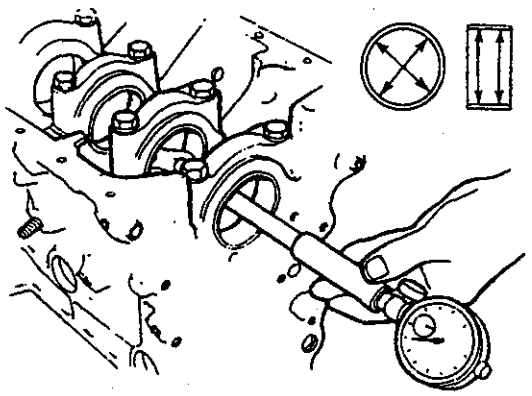
Crank journal mm (in.)

	Standard	Limit
	60.0 (2.3622)	59.86 (2.3567)



Crank pin mm (in.)

	Standard	Limit
	49.0 (1.9291)	48.87 (1.9240)

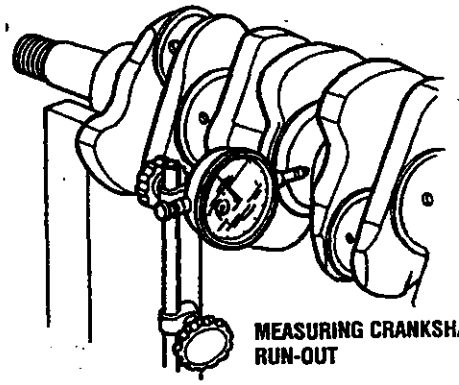


When there occurs an uneven wear to the crankshaft, replace it with a new one without grinding it for reuse.

Clearance between journal and bearing inside diameter with bearing installed and without

mm (in.)

	Standard	Limit
Clearance	0.029 – 0.072 (0.0011 – 0.0028)	0.11 (0.0043)



MEASURING CRANKSHAFT RUN-OUT

Runout of crankshaft

Replace if beyond limit

mm (in.)

Standard	Limit
0.025 (0.001)	0.05 (0.002)

Crankshaft gear

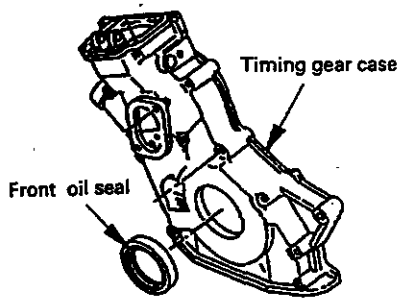
Check the crankshaft gear visually for damage and any other defects.

Oil seal

When the lip of an oil seal is found defective, replace it with a new one.

Installation

Use the crankshaft front oil seal installer to install the crankshaft front oil seal.



FLYWHEEL AND RING GEAR

Ring Gear Replacement

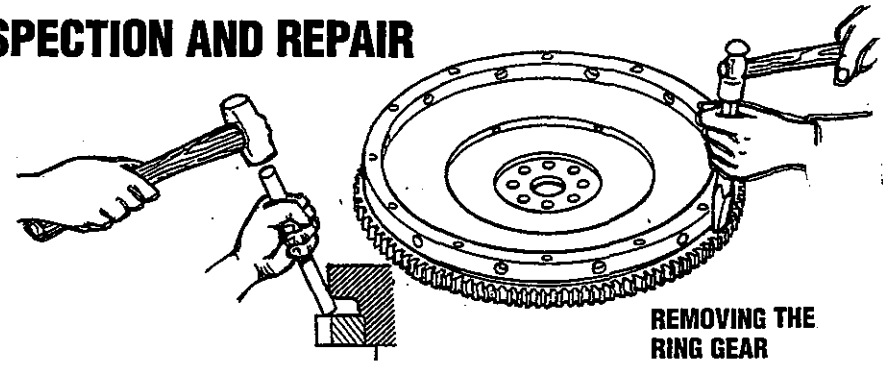
Ring Gear

Inspect the ring gear.

If the ring gear teeth are broken or excessively worn, the ring gear must be replaced.

Ring Gear Removal

Strike around the edges of the ring gear with a hammer and chisel to remove it.



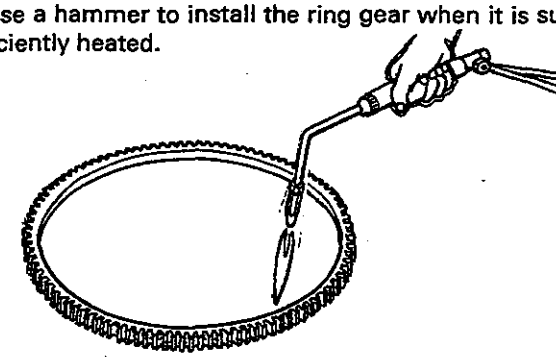
REMOVING THE RING GEAR

Ring Gear Installation

1. Heat the ring gear evenly with a gas burner to invite thermal expansion.

   Do not allow the temperature of the gas burner to exceed 200°C (390°F).

2. Use a hammer to install the ring gear when it is sufficiently heated.

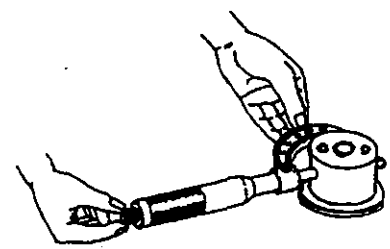


TIMING GEAR

Uneven wear of idle gear shaft

mm (in.)

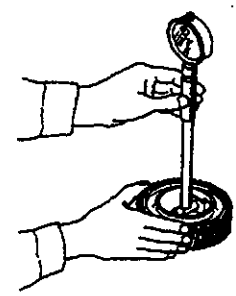
Nominal	Limit
45.0 (1.7717)	0.1 (0.0039)



Clearance between idle gear bushing and shaft

mm (in.)

Standard	Limit
0.025 – 0.085 (0.001 – 0.0033)	0.2 (0.0079)



ENGINE ASSEMBLY

GENERAL INFORMATION

- Be careful not to mix bolts and nuts. Metric and S.A.E. bolts are used on various engine assemblies.
- During assembly, recheck clearances and insure that parts are being assembled in their proper order and facing in the correct direction in relation to the engine block, such as, pistons, piston rings, bearings and bearing caps.
- Apply lubricating oil to moving parts during assembly. Insure that moving parts, when assembled on the engine, rotate or slide and are not subject to binding or excessive tension.
- If there are mating marks scribed during disassembly, reference them correctly for assembly.
- Use new gaskets, lockwashers, O-rings, packings and seals.
- Tighten the bolts and nuts on important parts of the engine to specified torques using a reliable torque wrench.
- When required, use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.
- Most gaskets and many bolt washers are asymmetrical, make certain they are positioned properly.

Torquing Hardware

Prevent mechanical damage by running fasteners down in three steps-1/2, 2/3, and 1/1 torque. Exceptions are torque-to-yield bolts and rocker arm shaft fasteners. The former are torqued as indicated. The latter-rocker shaft fasteners-should be brought down in very small increments, working from the center bolts out. Gaskets, especially head gaskets, might be damaged during assembly, they should be positioned with great care. See *TORQUE SPECIFICATIONS* thru out this manual.

Sealants and Lubricants

Oil based PERMATEX #2 and its HIGH TACK equivalent are excellent all purpose sealers. They are effective in just about any joint in contact with coolant, raw water, oil, or fuel. A light coating of oil or LIQUID TEFLON can be used on rubber gaskets and o-rings.

LOCTITE hydraulic red sealant should be used on oil adapter hoses and the oil filter assembly.

Coat both surfaces of the oil pan gasket with high temp RED SILICONE SEALER.

When installing gaskets that seal around water (coolant) passages, coat both sides with WHITE SILICONE GREASE.

Do not use sealant when installing a new gasket.

HIGH-COPPER ADHESIVE SPRAYS are useful for holding a gasket in position during assembly.

Specialized gasket sealers such as HYLOMAR work well in applications requiring non-hardening properties. HYLOMAR is particularly effective on copper cylinder-head gaskets and resists fuel, oil , and water.

NOTE: *TAPE SEALANTS should be used on pipe plugs and fitting that connect water coolant passages.*

Bolts and Fasteners

Lightly oil head bolts and other fasteners as you assemble them. Bolts and other plugs that penetrate the water jacket should be sealed with PERMATEX #2 or HIGH TACK.

When assembling the flywheel, coat the bolt threads with LOCTITE blue.

LITHIUM based grease is waterproof, ideal for water pump bearings and stuffing boxes.

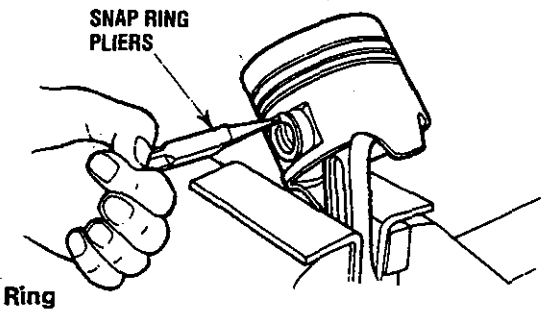
Antiseize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allow them to come apart when necessary. LOCTITE offers levels of locking according to the job.

Heavily oil all sliding and reciprocating components, always use clean engine oil.

PISTON AND CONNECTING ROD

Piston Pin Snap Ring

1. Use a pair of snap ring pliers to install the piston pin snap ring.
2. Check that the piston moves smoothly on the piston pin.



Piston Ring

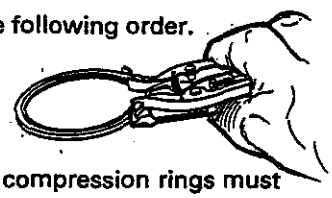
1. Use a piston ring installer to install the three piston rings.

   Install the piston rings in the following order.

   (1) Oil ring

   (2) 2nd compression ring

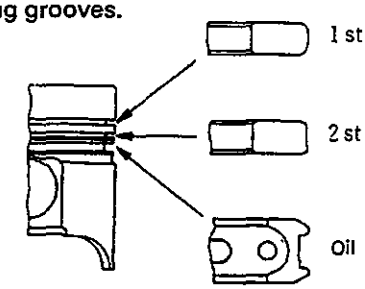
   (3) 1st compression ring



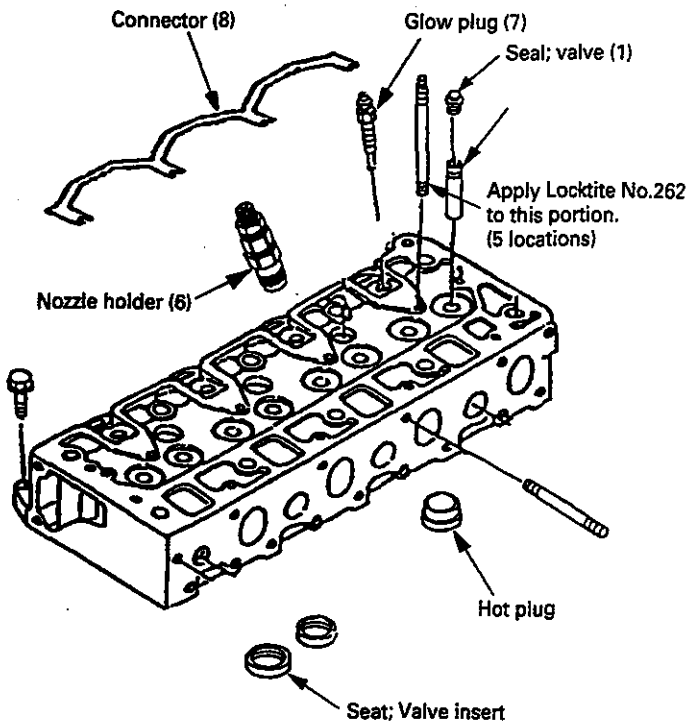
   The marked side of the two compression rings must be facing up.

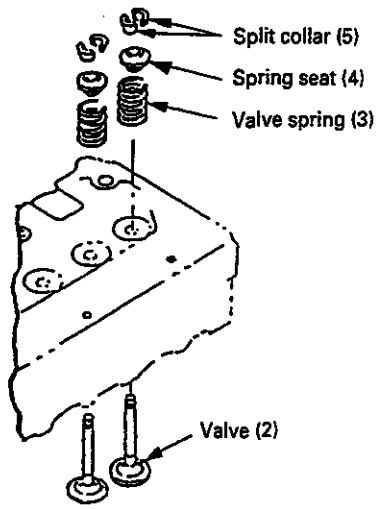
   The undercut side of the second compression ring will be facing down.

   As the oil ring has no any facing mark, it may face in either direction.
2. Lubricate the piston ring surfaces with engine oil.
3. Check that the piston rings rotate smoothly in the piston ring grooves.



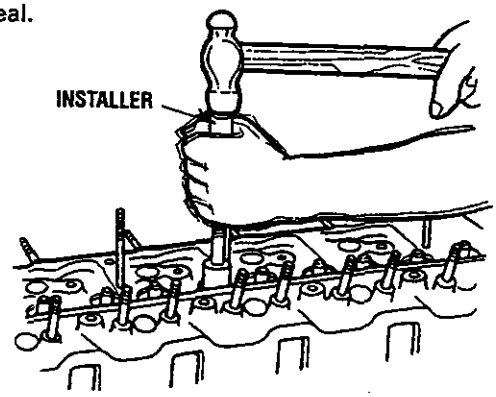
CYLINDER HEAD ASSEMBLY





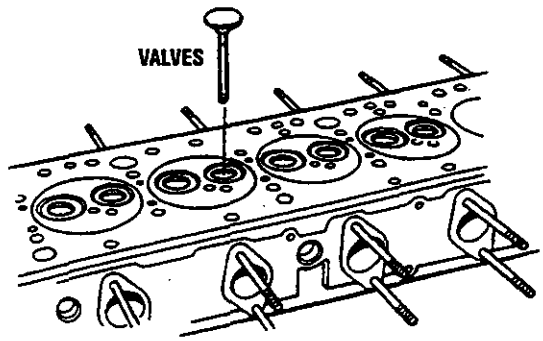
Valve Stem Oil Seal

1. Lubricate the oil seals and valve stem sealing are with engine oil.
2. Use a valve stem oil seal installer to install the oil seal.



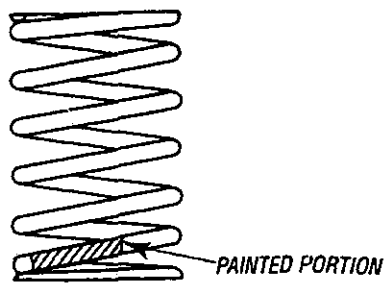
Intake and Exhaust Valves

1. Place the cylinder head on a flat wooden surface.
2. Lubricate valve stems with engine oil.
3. Install the valves to the intake or exhaust guides.
   Install the valves to their original lapped valve seats.



Intake and Exhaust Valve Springs

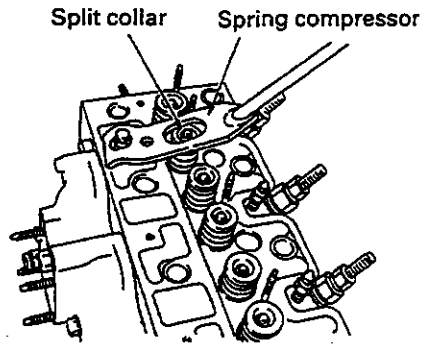
Install the valve springs with their painted end (the close pitched end) facing down.



Spring Seat Split Collar

1. Use a spring compressor to push the valve spring into position.
2. Install the spring seat split collar.
3. Set the spring seat split collar by tapping lightly around the head of the collar with a rubber hammer.

Spring Compressor:



Nozzle holder assembly

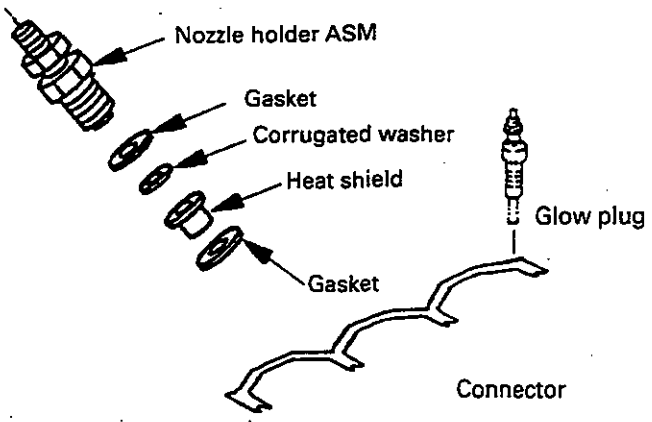
Before assembling the nozzle holder assembly, check to see if the spray condition and the spray pressure of the injection nozzle are appropriate, (Refer to "INSPECTION AND SERVICE.")

Assemble to the cylinder head the gasket (heat shield), heat shield, corrugated washer and gasket (nozzle holder) in this order.

Install the nozzle holder assembly, and then tighten it to the specified torque.

kg-m (ft. lbs.)

Tightening torque	4.0 – 5.0 (29.0 – 36.0)



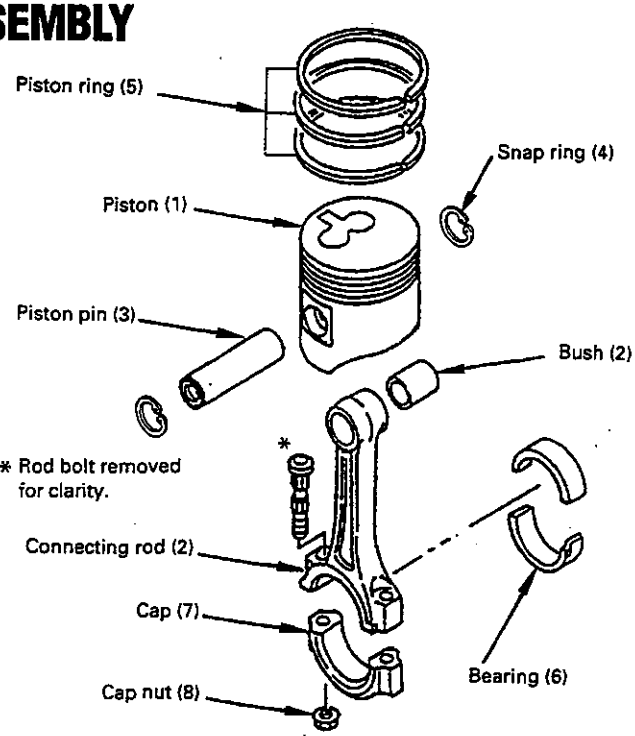
Glow plug and connector

Assemble the glow plug to the cylinder head, and then tighten it to the specified torque.

Install the connector to the glow plug, and then tighten until snug.

kg-m (ft. lbs.)

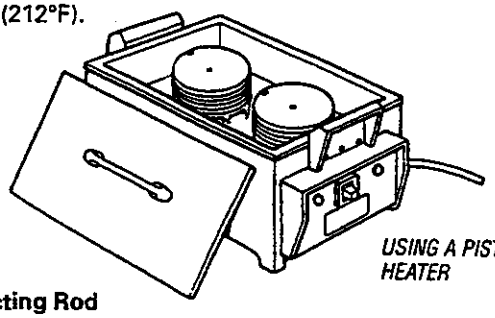
Parts	Tightening torque
Glow plug	1.5 – 2.0 (11.0 – 14.0)



PISTON AND CONNECTING ROD

Piston

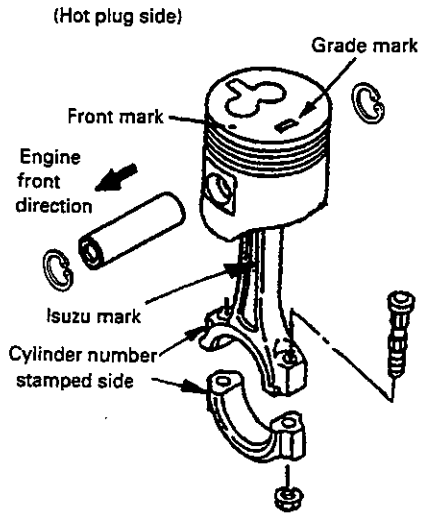
Use a piston heater to heat the pistons to approximately 100°C (212°F).



USING A PISTON HEATER

Connecting Rod

1. Install the connecting rod to the piston with setting the marks as illustrated.
2. Install the piston pin into the piston and the connecting rod bushing.

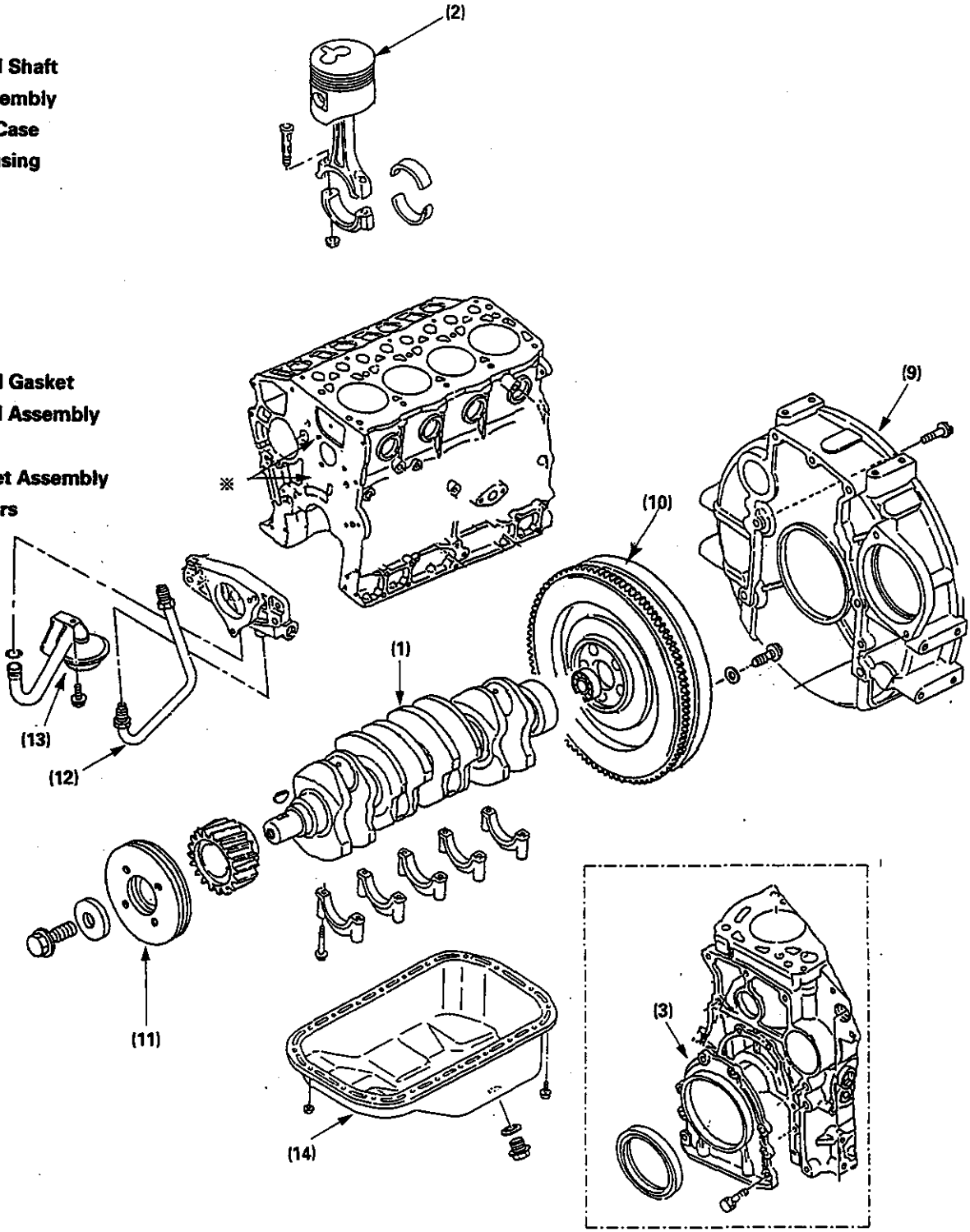


ENGINE ASSEMBLY

INTERNAL PARTS

Reassembly Steps

(1) Crankshaft
(2) Piston Assembly
(3) Rear Seal Retainer
(4) Camshaft
(5) Cam Gear
(6) Idler gear and Shaft
(7) Oil Pump Assembly
(8) Timing Gear Case
(9) Flywheel Housing
(10) Flywheel
(11) Crank Pulley
(12) Oil Pipe
(13) Oil Strainer
(14) Oil Pan
(15) Tappets
(16) Cylinder Head Gasket
(17) Cylinder Head Assembly
(18) Push Rods
(19) Rocker Bracket Assembly
(20) Engine Hangers



ENGINE ASSEMBLY

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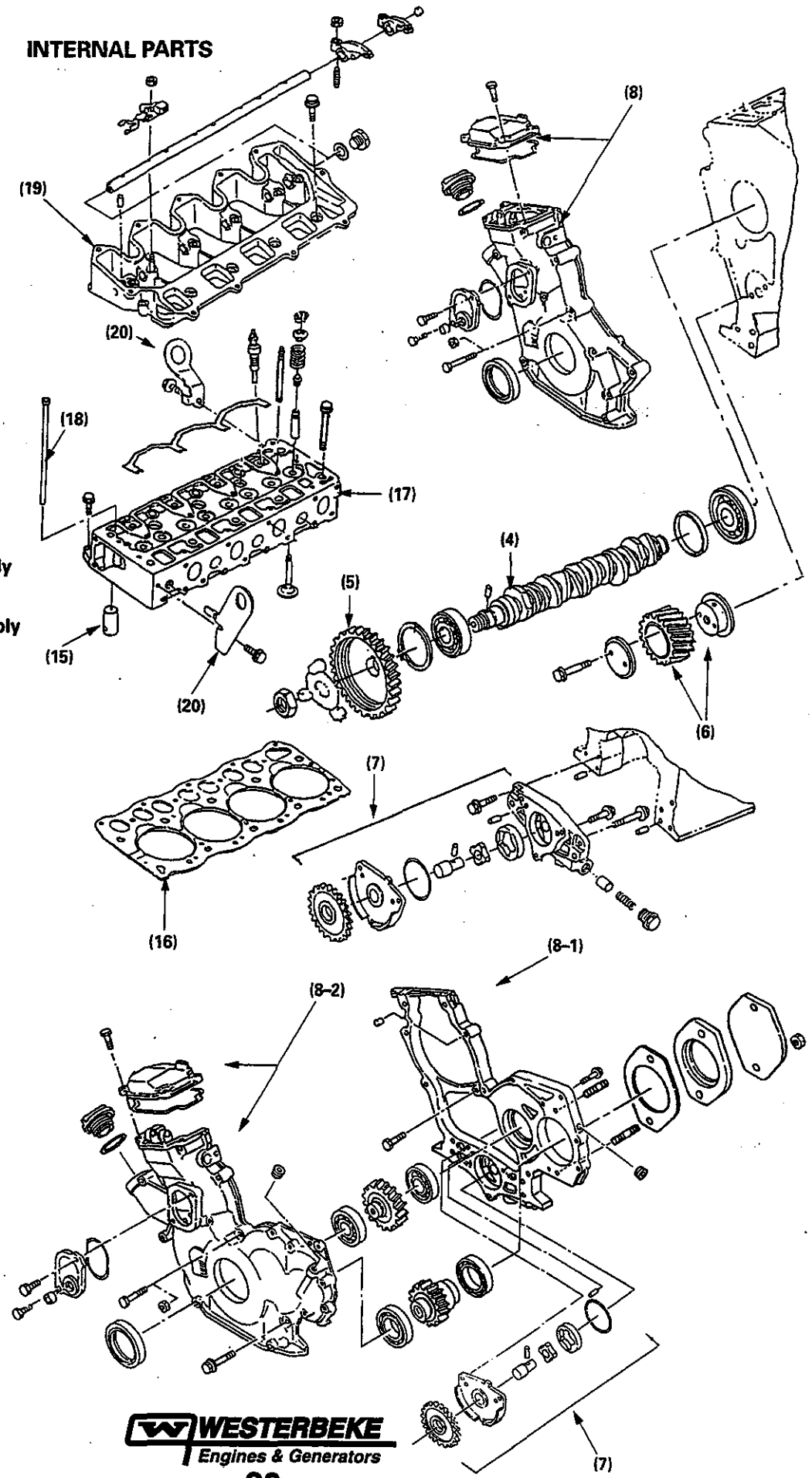
INTERNAL PARTS



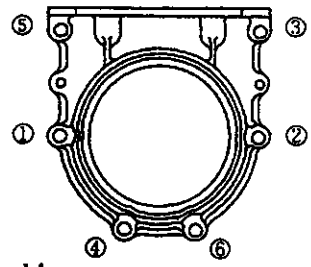
Installation of retainer

After applying engine oil to the lip of the oil seal, install the retainer. Apply sealant.

Tighten bolts on the retainer to the specified torque in the order as shown in the figure left.

kg·m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)



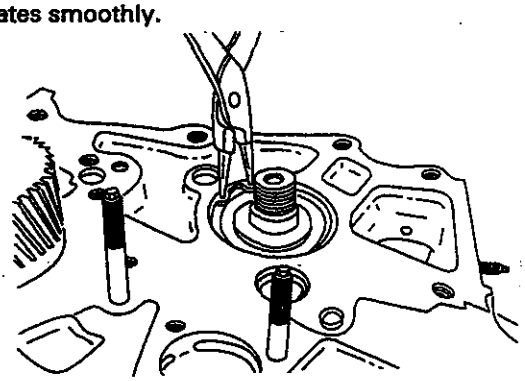
Camshaft assembly

1. Apply engine oil to the inside of the bearing of the cylinder block, and then install the camshaft assembly.

Note:

When installing the assembly, care should be taken not to damage the bearing.

2. After installation of the snap ring to the outside of the front bearing, check to see if the camshaft rotates smoothly.

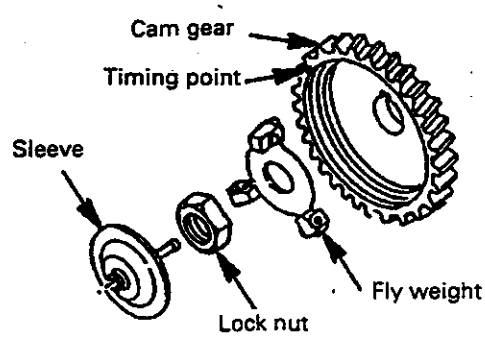


Cam gear and sleeve

1. Install the cam gear to the camshaft so that the timing point (a dot mark "•") comes to the front side.
2. With the flyweight installed, tighten the cam gear with a lock nut.

kg·m (ft. lbs.),

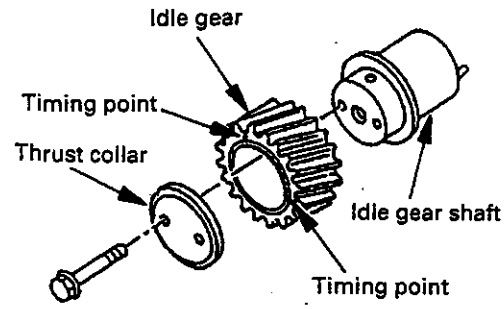
Tightening torque	7.0 – 9.0 (51.0 – 65.0)



3. Apply engine oil to the shaft of the sleeve and the slide of the flyweight.
4. With the lip of the sleeve placed in the cavity of t flyweight, insert the shaft of the sleeve into the ti end of the camshaft.

Note:

Check to see if the sleeve moves smoothly.



Idle Gear

Install the idler gear shaft with the oil hole facing upward.

Lubricate the shaft with oil.

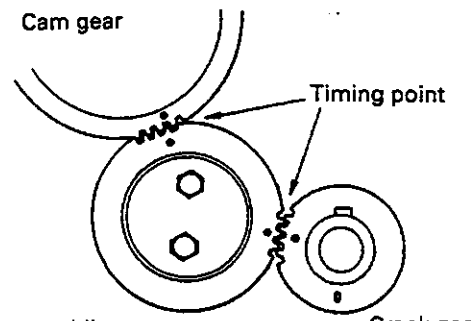
Install the idler gear.

Align the timing marks as shown in the illustration.

Install the thrust collar and tighten the bolts to the specified torque.

kg·m (ft. lb

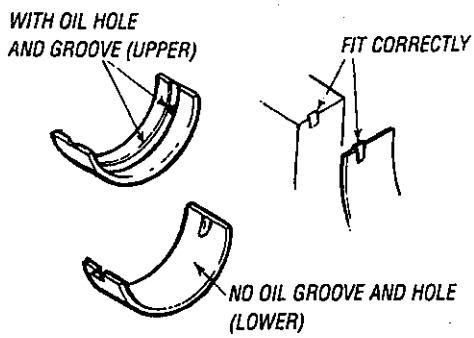
Tightening torque	2.1 – 3.1 (15.2 – 22.4)



Crankshaft bearing

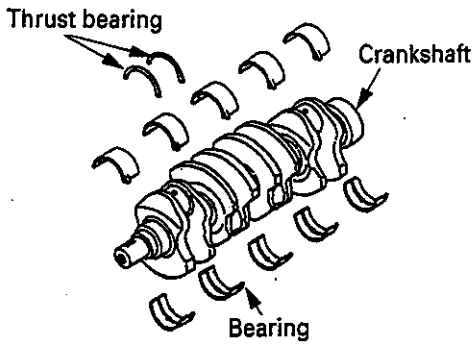
Note that there is an oil hole and an oil groove in the upper bearing (on the block side), but not in the lower bearing (on the bearing cap side).

Fit the bearing tang firmly into the slot machined on the cylinder body bearing arches.



Crankshaft and bearing

Lubricate the bearings with engine oil, install the crankshaft, install the thrust bearings with the groove facing the crankshaft.



Crankshaft Bearing Cap

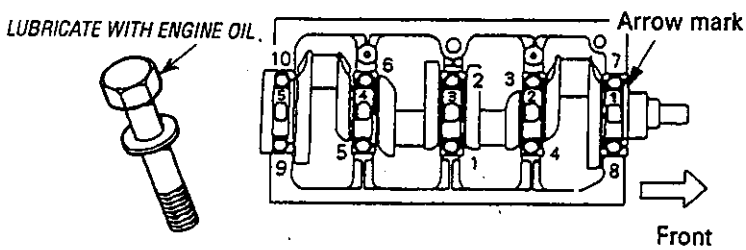
1. Lubricate the bearing cap bolts with engine oil.
2. Install the bearing caps to the crankshaft.

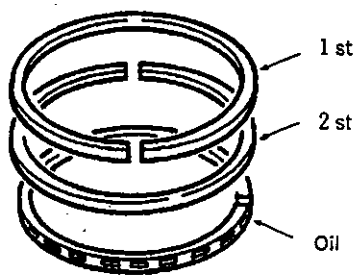
   The arrow mark must be pointing to the front of the engine.
3. Tighten the bearing cap bolts to the specified torque a little at a time in the numerical order shown in the illustration.

kg·m (ft. lbs.)

Crankshaft Bearing Cap Bolt Torque	8.5 – 9.5 (61.0 – 69.0)

4. Check that the crankshaft turns smoothly by manually rotating it.





Position the rings as shown making sure the ring gaps are away from the thrust side.

Piston and Connecting Rod

Lubricate the piston, the piston rings, and the connecting rod bearings with engine oil.

Position the piston front mark towards the front of the engine.

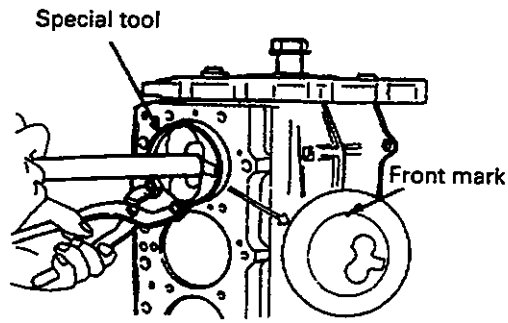
Use the piston ring compressor to compress the piston rings.

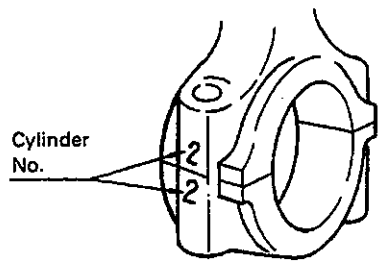
Use a hammer grip to push the piston in until it makes contact with the crank pin.

At the same time, rotate the crankshaft until the crankpin reaches its highest point.

Set the bearing cap cylinder number marks and the connecting rod cylinder number marks.

The marks must be facing the injection pump side.





kg·m (ft. lbs.)

Tightening torque	4LE1	7.5 – 8.5 (54 – 61)

Note:

After installation, confirm that the crankshaft rotates smoothly.

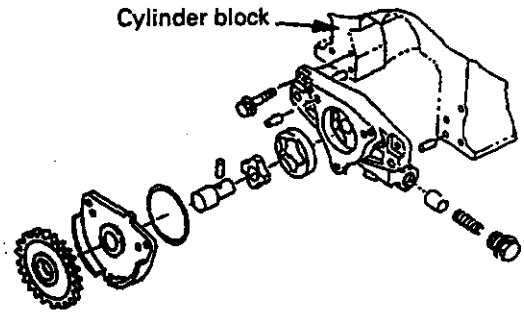
Oil pump assembly

Install the oil pump assembly to the cylinder block.

PTO not provided

kg·m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)



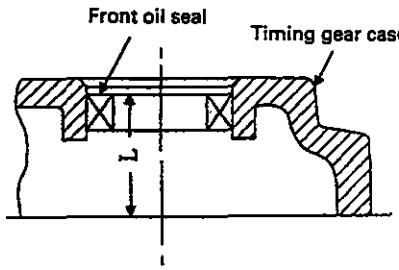
Front oil seal

Install the front oil seal to the timing gear case.

Installation is made according to the "L" dimension shown in the figure.

mm (in.)

	L dimension
	60.2 – 60.8 (2.370 – 2.384)



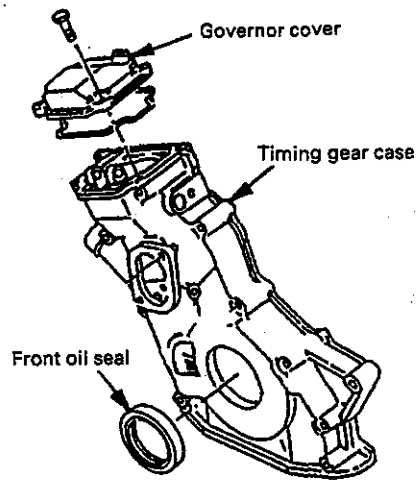
Timing gear case (with governor)

Install the timing gear case to the cylinder block.

1. Put the link plate of the governor incorporated in the gear case through the connecting hole of the injection pump in advance.
2. Apply engine oil to the bushes provided on both ends of the main spring lever of the governor.
3. Apply sealant to the gear case, and then install it to the cylinder block or the front plate.

kg·m (ft. lbs.)

Case tightening torque	1.9 – 2.9 (14.0 – 21.0)



4. Assemble the gasket and the governor cover to the top of the gear case, and then tighten them to the specified torque.

kg·m (ft. lbs.)

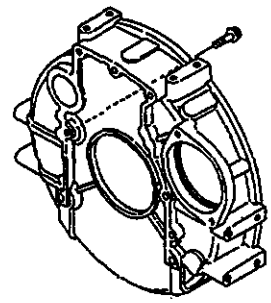
Cover tightening torque	0.8 – 1.2 (6.0 – 9.0)

Flywheel housing

Install the flywheel housing to the cylinder body.

kg·m (ft. lbs.)

Tightening torque	4.2 – 5.6 (30.0 – 40.0)



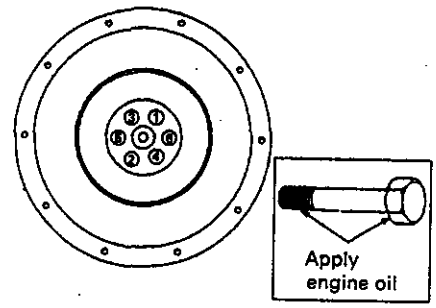
Flywheel

Lubricate bolts with engine oil.

Tighten a little at a time in the sequence shown in the illustration.

kg·m (ft. lbs.)

Tightening torque	9.0 – 11.0 (65.0 – 80.0)



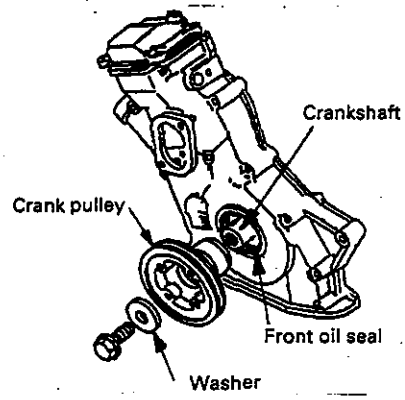
Crank pulley

Lubricate the lip of the front, seal with oil

Install the crank pulley, lock the crankshaft and tighten the front bolt.

kg·m (ft. lbs.)

Tightening torque	17.0 – 19.0 (123.0 – 137.0)

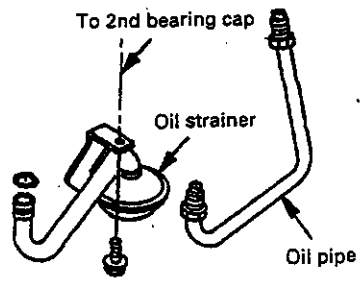


Oil pipe and oil strainer

1. Install the oil pipe from the oil pump assembly to the cylinder block and tighten the sleeve nuts.
2. Install the oil strainer to the oil pump, and then tighten the bracket of the strainer to the No. 2 bearing cap.

kg·m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)

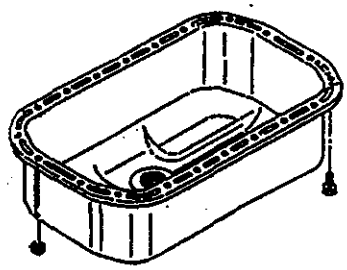


Oil pan

1. Apply sealant to the oil pan.
2. Install the oil pan to the cylinder block and tighten fixing bolts evenly.

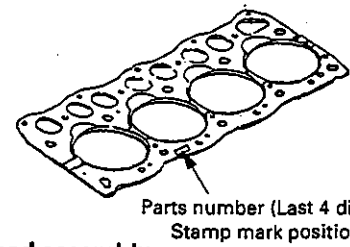
kg·m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)



Tappet and head gasket

1. Install the tappet to the cylinder block.
2. When installing the head gasket, turn up the stamp mark of the parts number (last 4 digits) which is between the No. 2 and No. 3 cylinders of the gasket.



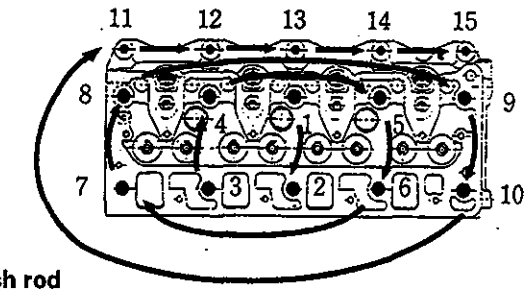
Cylinder head assembly

Lubricate the bolts with oil.

Tighten the bolts in the sequence shown in the illustration to the specified torque.

kg·m (ft. lbs.)

Bolt size	Tightening torque
M12 × 1.5 (8 each)	8.5 – 9.5 (61 – 69) ➡ 60°~90°
M8 × 1.25 (4 each)	2.5 – 3.5 (18 – 25)



Push rod

Install the push rods.

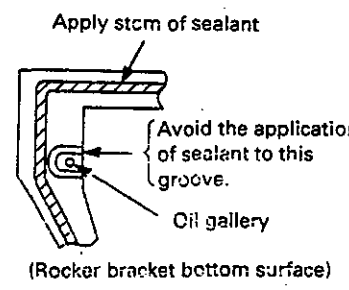
Rocker arm bracket assembly

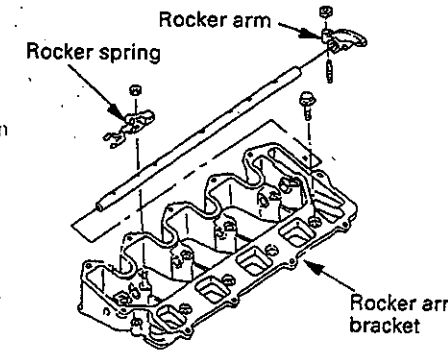
Apply liquid gasket to the the bottom of the rocker arm bracket assembly, being careful not to get any in the groove around the oil galley as shown in the illustration.

Install the rocker arm bracket assembly making sure the push rods align with the rocker arms and tighten to the specified torque.

kg·m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)



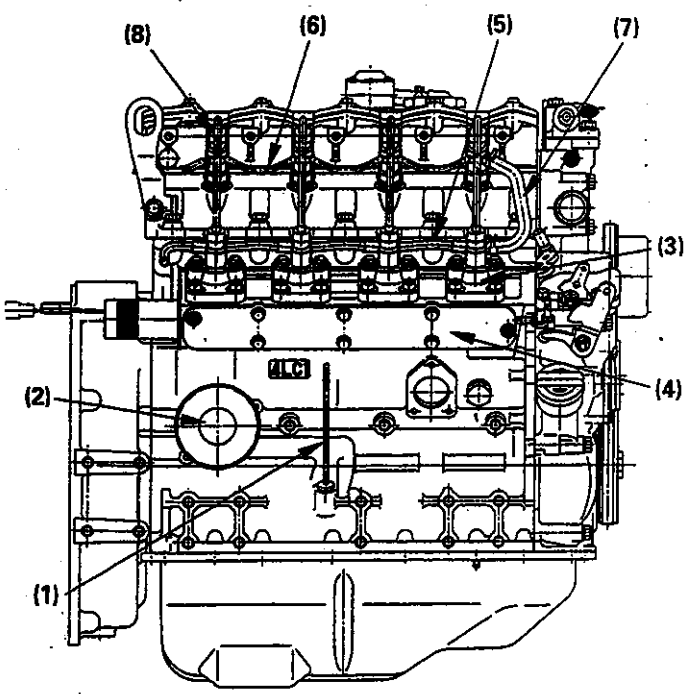


ADJUST THE VALVE CLEARANCE

Refer to the ENGINE ADJUSTMENTS section in this manual.

EXTERNAL PARTS (Right-hand Side)

(1) Dipstick
(2) Oil Filter
(3) Injection Pump
(4) Injection Pump Housing Cover
(5) Fuel Pipe
(6) Leak Off Pipe
(7) Fuel Hose
(8) Injection Pipe

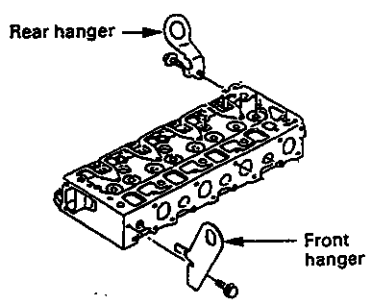


Front hanger and rear hanger

Tighten them to the specified torque shown below.

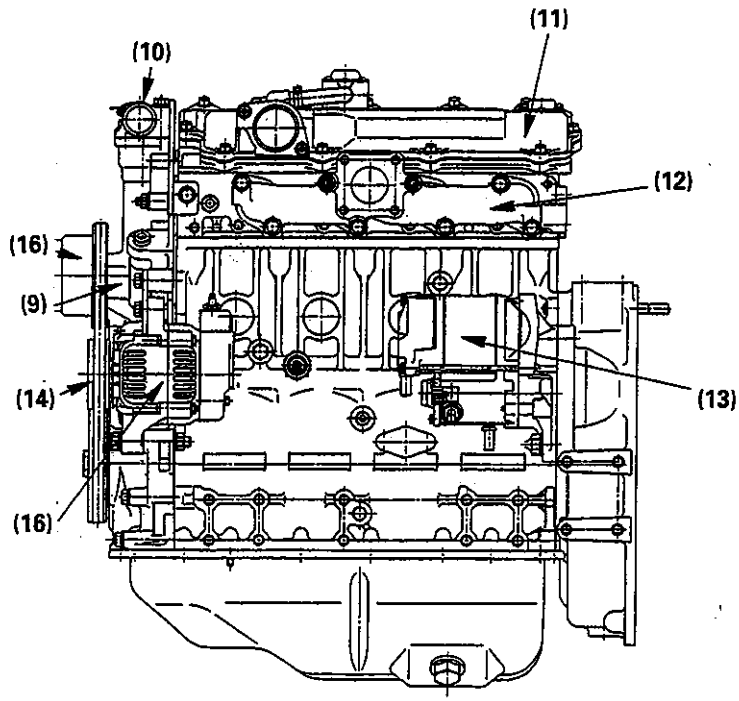
kg-m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)



EXTERNAL PARTS (Left-hand Side)

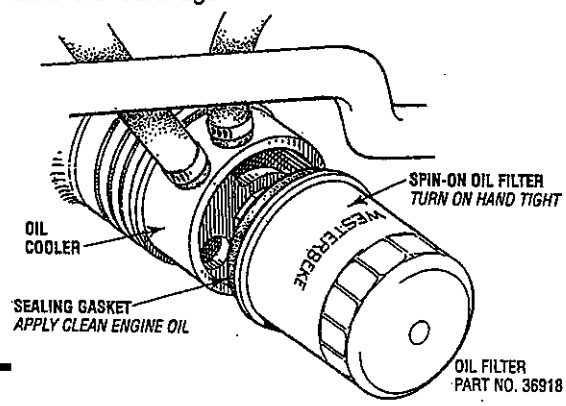
(9) Water Pump
(10) Thermostat and Water Outlet Pipe
(11) Cylinder Head Cover
(12) Exhaust Manifold
(13) Starter
(14) Generator
(15) Pulley
(16) Belt



Dipstick

Oil filter (cartridge)

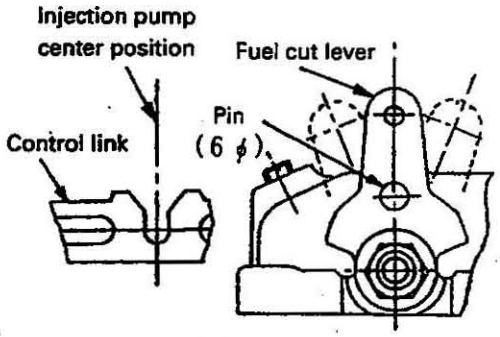
1. Insert the dipstick.
2. Install the cartridge



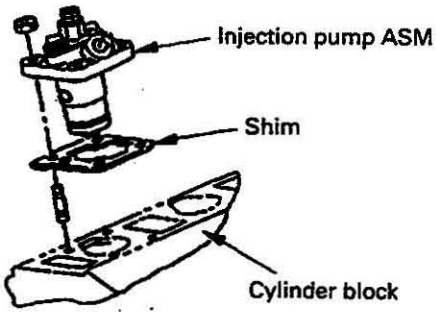
Injection pump

Align the two (2) holes in the fuel cut lever and the governor and lock into place with a pin.

This will center and hold the control link for the installation of the injection pumps.



Install a new shim with the same thickness as the one that was removed. (Refer to the maintenance section on shim selection).

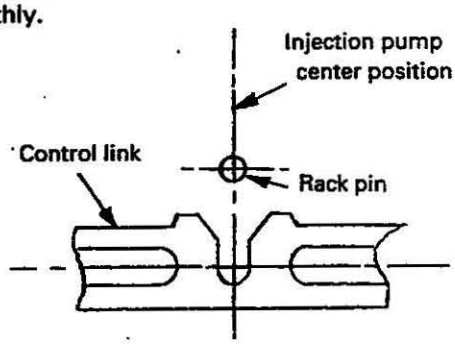


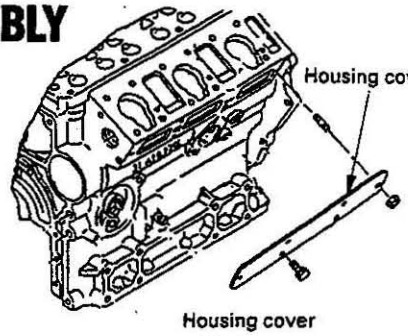
Install the injection pump making sure the rack pin is in the groove of the control rack before tightening the injection pump to the specified torque.

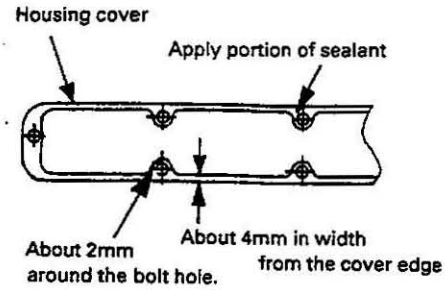
kg-m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)

Remove the rack pin (6ø) which is inserted into the fuel cut lever, and then confirm that the fuel cut lever moves smoothly.







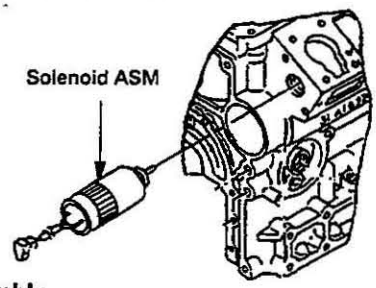
Injection pump housing cover

After applying sealant (TB1207C) to the housing cover, install it to the cylinder block by the side of the injection pump.

kg-m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)

The areas of the housing cover to which liquid gasket is applied are about 4 mm in width from the cover edge and about 2 mm around the bolts.



Solenoid assembly

1. Apply sealant (TB1207C) to the surface (bite groove) in which the solenoid is installed.

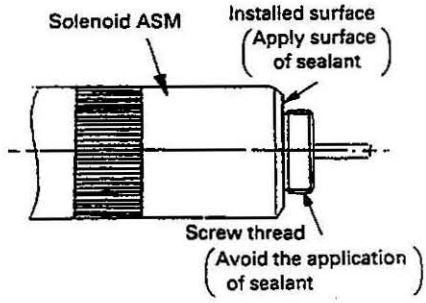
Note:

Avoid the application of sealant to the screw thread.

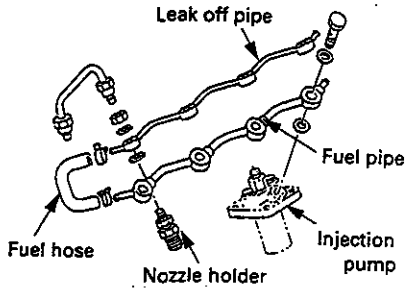
2. Screw in the solenoid from the rear of the cylinder block (the rear of the No. 3 injection pump rack), and then tighten it to the specified torque.

kg-m (ft. lbs.)

Tightening torque	1.5 – 2.5 (11.0 – 18.0)



(not adjustable, pull to run)



Fuel pipe

Leak off pipe

1. Install the fuel pipe to the injection pump and then tighten it to the specified torque.
2. Install the leak off pipe to the nozzle holder and then tighten it to the specified torque.

kg·m (ft. lbs.)

Tightening torque	
Fuel pipe	2.0 – 2.5 (14.0 – 18.0)
Leak off pipe	2.5 – 3.5 (18.0 – 25.0)

When tightening it, hold the pipe securely by hand so that it will not rotate.

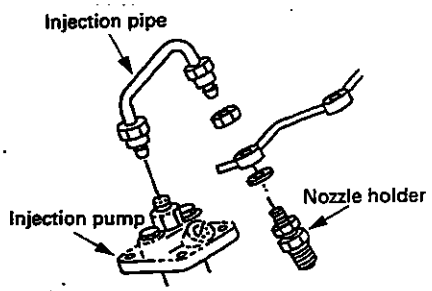
3. Connect the fuel pipe and the leak off pipe with the fuel hose and fix them with clips.

Injection pipe

Install the injection pipe to the injection pump and the nozzle holder and tighten them up with sleeve nuts.

kg·m (ft. lbs.)

Tightening torque	1.5 – 2.5 (11.0 – 18.0)



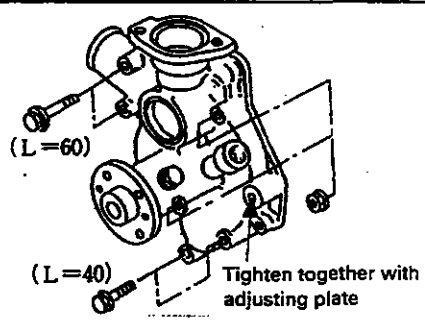
Set the thread of the sleeve nut securely before tightening it up.

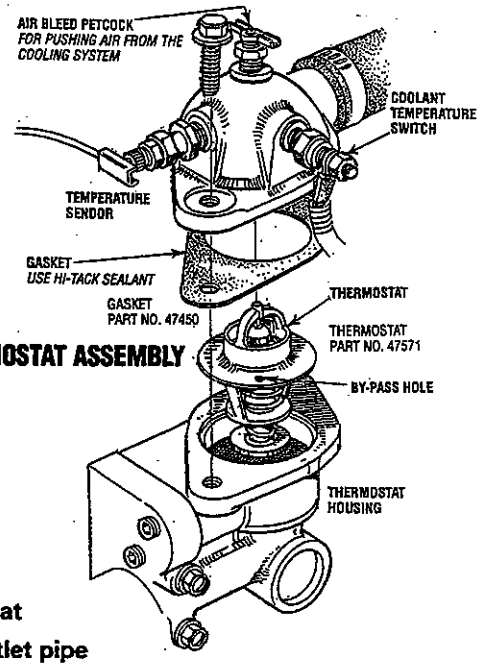
Water pump assembly

1. Put sealant on the water pump where it contacts the block and head.
2. Tighten to the specified torque.

kg·m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)





THERMOSTAT ASSEMBLY

Thermostat

Water outlet pipe

Assemble the thermostat, install the gasket and the water outlet pipe, and then tighten it to the specified torque.

kg·m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)

Adjust the Valve Clearance

Refer to the ENGINE ADJUSTMENTS section in this manual.

Cylinder head cover

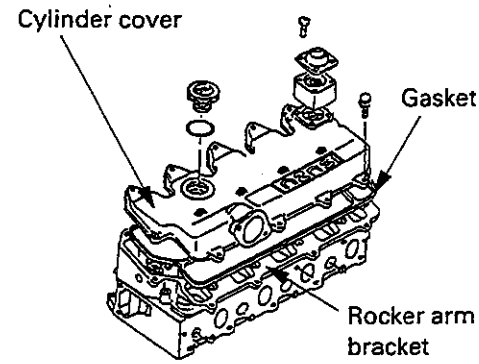
1. Install the gasket to the cylinder head cover.

Notes:

1. **Much care should be taken for the gasket not to get dislocated or twisted when installing the head cover.**
2. **Avoid the application of sealant to the rubber gasket.**
2. Install the cylinder head cover to the rocker arm bracket, and tighten it to the specified torque.

kg·m (ft. lbs.)

Tightening torque	0.2 – 0.4 (1.4 – 2.9)

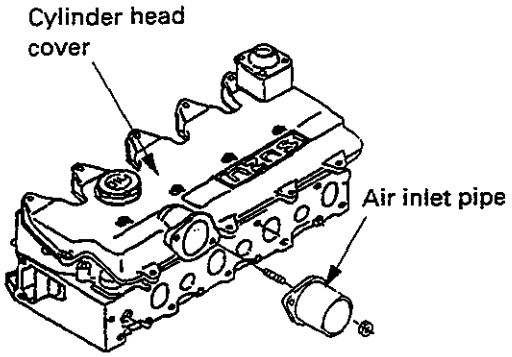


Air inlet pipe

1. Apply sealant (TB1207C) to the surface in which the air inlet pipe is installed.
2. Install the air inlet pipe to the cylinder head cover, and tighten it to the specified torque.

kg·m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)

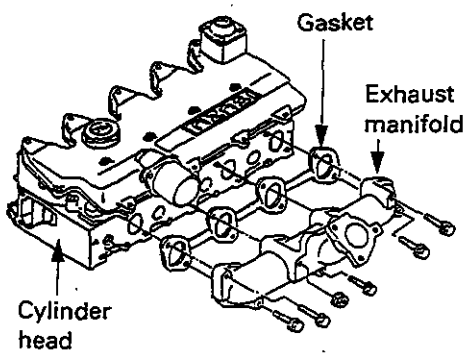


Exhaust manifold

Assemble the gasket to the cylinder head, install the exhaust manifold along the stud bolts and tighten it to the specified torque.

kg·m (ft. lbs.)

Tightening torque	1.9 – 2.9 (14.0 – 21.0)



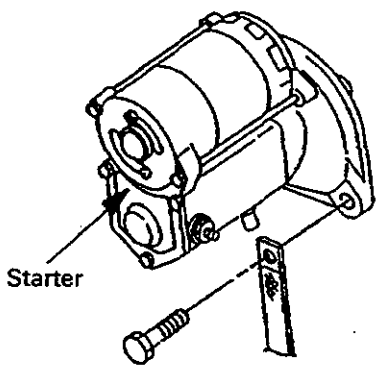
Starter

Install the starter to the flywheel housing, and tighten it to the specified torque.

kg·m (ft. lbs.)

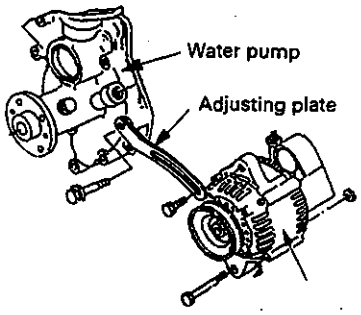
Tightening torque	9.5 – 11.5 (68.7 – 83.2)

For starter motor disassembly and repair, refer to the starter motor section in this manual.



Alternator

1. Tighten the adjustment plate together with the water pump, and then install them temporarily.
2. Install the bottom of the alternator to the timing gear case, and then tighten it temporarily with bolts and nuts.
3. Install the fixing bolts onto the top of the alternator through the adjusting plate (temporary tightening).



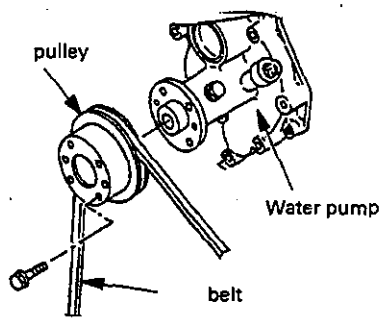
Drive pulley and belt

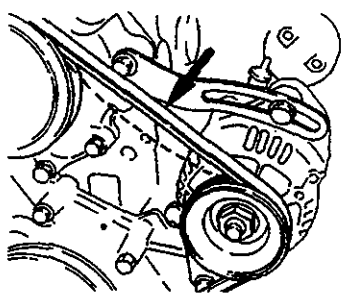
1. Install the drive pulley to the water pump and then tighten it up (2 locations).

kg·m (ft. lbs.)

Tightening torque	0.8 – 1.2 (6.0 – 9.0)

2. Set the drive belt to each pulley.





Drive belt tension should be very tight, about 1/2" deflection at mid-point.

For alternator disassembly and repair, refer to the MANDO ALTERNATOR SECTION in this manual.

NOTE:*The exhaust manifold, which was disassembled from the cylinder head, should be inspected before reassembly.*

a. Remove the exhaust elbows from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.

b. Remove the exhaust nipples, elbows and plugs from the manifold and heat exchanger.

c. Remove water connectors from the ends of the manifold. Be sure to note the proper location and arrangement of each for proper alignment.

d. Examine all parts for defects, corrosion and wear and replace as needed.

f. Flush out the coolant recovery tank and clear its hose passage. Set aside to re-install on the boat.

HEAT EXCHANGER

Install the heat exchanger, replace the heat exchanger zinc and attach new hoses with new clamps to the cooling system. Refer to the COOLING SECTION in this manuall for HEAT EXCHANGER SERVICE.

MARINE TRANSMISSION

1. **Assemble the damper plate to the flywheel.**
2. **Reinstall the marine transmission and fill with ATF Dextron III.**

NOTE: *Some transmissions, such as the Borg Warner Velvet Drive require oil coolers. Oil coolers should be cleaned, pressure tested and repainted at engine overhaul. The transmission oil cooler hoses should also be inspected. Refer to the text on Heat Exchangers.*

ENGINE TUNING OPERATION

After reassembly, the engine must be tuned. This will ensure that the engine operates at its maximum efficiency. Fill the engine cooling system with antifreeze mixture and the engine oil sump with lube oil (API spec. CF or CG-4)

1. **Mount the engine on a test bench and connect the fuel lines.**
2. **Connect the electrical wiring.** Refer to the *WIRING DIAGRAM.*
3. **Connect the air intake line to the air cleaner.**
4. **Connect the exhaust pipe.**
5. **Manually operate the fuel feed pump to feed fuel to the engine.**
6. **Bleed the fuel lines of air.**
7. **Crank the engine with the starter (non-ignition operation) for about twenty seconds.** This will pre-lubricate the engine internal components.
8. **Start the engine and allow it to run at 750 to 800 rpm for five minutes.**
9. **Remove the cylinder head cover while the engine is running.**
10. **Check that the engine oil is continuously circulating from the oil pump to the valve rockers through the cylinder head.**

    If there is no oil circulation or if the oil circulation is sluggish, stop the engine and make the appropriate repairs or adjustments.

    Reinstall the cylinder head cover.
11. **Increase the engine speed to 1500 rpm to do the engine warming-up operation.**
12. **Check the engine for oil, fuel, coolant, and air intake leakage.**
13. **Check for abnormal noise and odor.**
14. **Check for abnormal electrical charging.**
15. **Check the engine fastening parts for looseness.**
16. **When the engine coolant temperature reaches 75°C (167°F) or more, increase the engine speed to 2000 rpm and allow it to run for twenty seconds.**

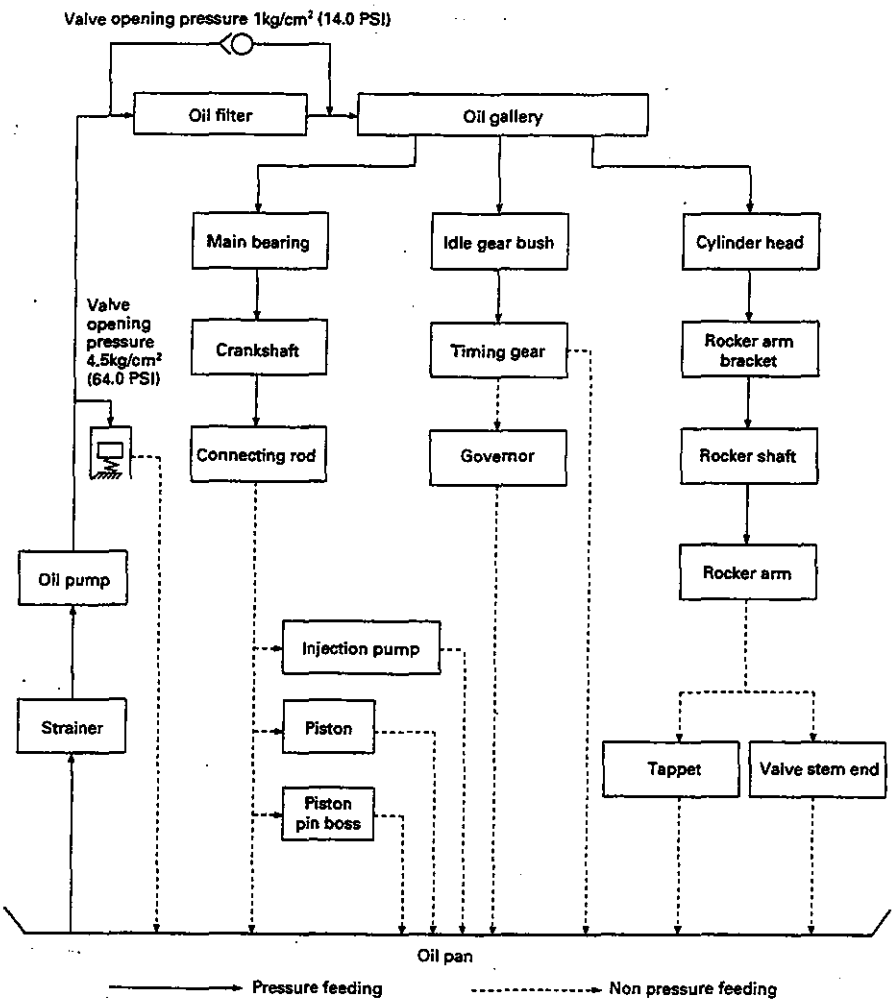
    This will give the engine the essential run-in operating time.
17. **Adjust the engine operation speed to the specified value.**
18. **Stop the engine to complete the tuning procedure.**

Refer to the following pages for details of sub-assemblies. These sections also include: Wiring Diagrams, Engine Specifications, Torque Diagrams, Starter Motor, Alternator, Raw Water Pump, and a detailed Troubleshooting Section.

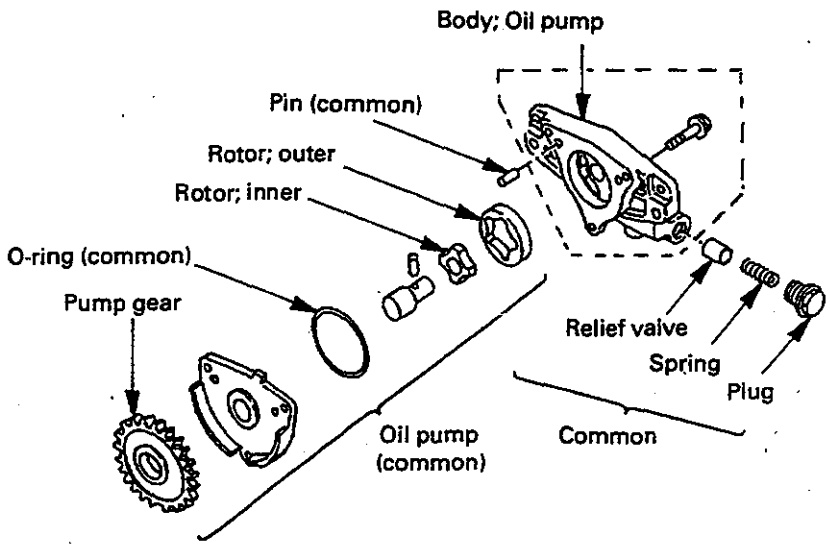
Adjust the Valve Clearance

Refer to the ENGINE ADJUSTMENTS section in this manual.

LUBRICATION SYSTEM



LUBRICATING OIL CIRCULATION DIAGRAM



OIL PUMP

Inspection and replacement

When there is wear, damages or any other defects found, repair or replace the rotor.

Clearance between the outer rotor or inner rotor and the pump cover

mm (in.)

Standard	Limit
0.040 – 0.085 (0.0016 – 0.0033)	0.15 (0.0059)

Clearance between the periphery of the outer rotor and the pump body

mm (in.)

Standard	Limit
0.10 – 0.185 (0.0039 – 0.0073)	0.4 (0.0157)

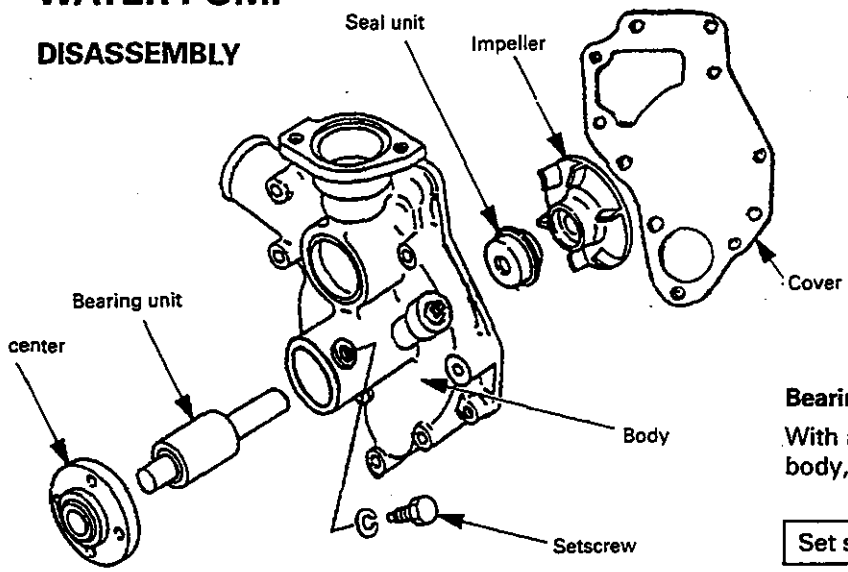
Clearance between the inner rotor and the outer rotor

mm (in.)

Standard	Limit
0.17 (0.0067)	0.2 (0.0079)

WATER PUMP

DISASSEMBLY

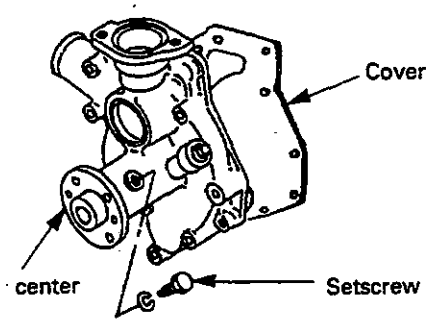


Cover

1. Loosen the set screw.
2. Remove the cover.

Note:

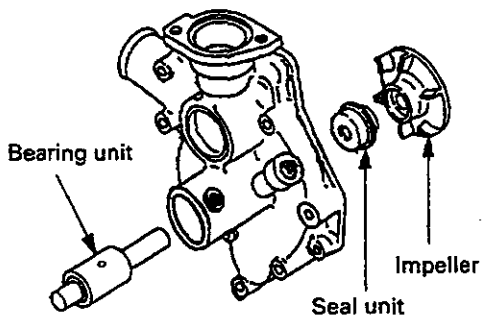
The cover is applied with sealant (TB1207B). When removing the cover, much care should be taken not to deform it by applying an excessive force to it.



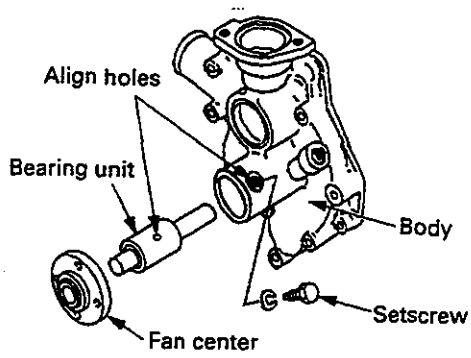
Impeller

Seal unit

Bearing unit



REASSEMBLY

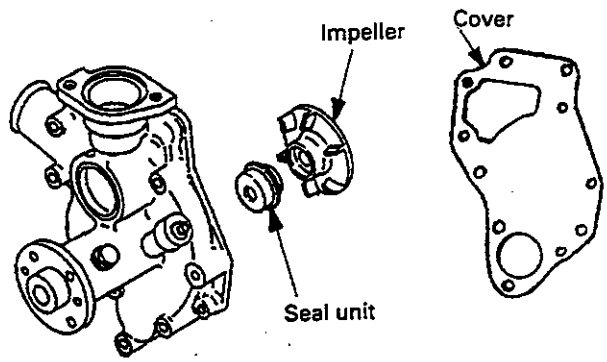


Bearing unit

With a hole in the bearing unit set in line with one in the body, lock the bearing unit with a setscrew.

kg·m (ft. lbs.)

Set screw tightening torque	0.8 – 1.2 (6.0 – 9.0)



Impeller Seal unit

1. Apply BELCO bond No. 4 to the surface where the seal unit comes into contact with the body, and then assemble the seal unit.
2. Press in the impeller with a press until the clearance between the pump impeller and the body gets to the specified value.

Cover

1. Apply liquid gasket to the surface to which the cover is installed, and then install the cover.
2. Apply Screw-lock to the cover installation screws, and then tighten them.

Clearance, play and tightening allowance between parts

1. Clearance between the pump impeller and the body

mm (in.)

Standard	0.53 – 2.17 (0.0209 – 0.0854)

2. Play in the water pump ball bearing

mm (in.)

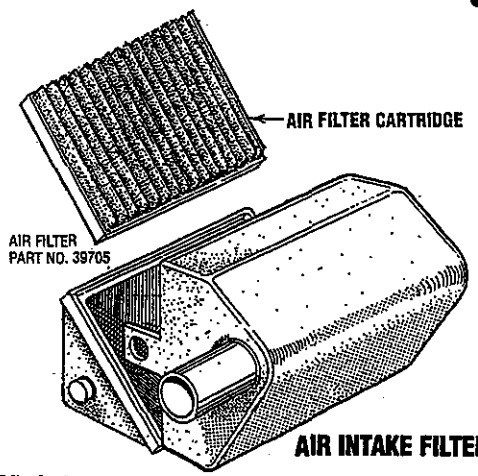
Standard	Limit
0.008 – 0.010 (0.0003 – 0.0004)	0.2 (0.0079)

3. Tightening allowance between center and the bearing shaft

mm (

Standard	0.026 – 0.061 (0.001 – 0.0024)

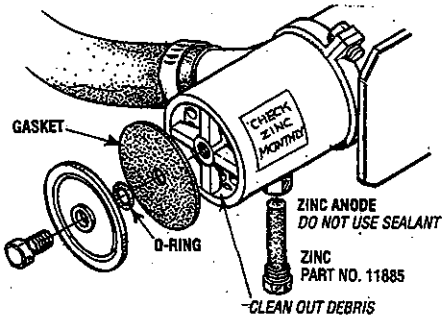
COOLING SYSTEM

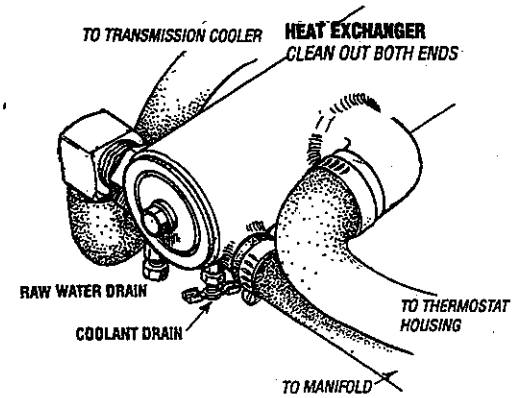


AIR INTAKE FILTER/SILENCER

Maintenance

The filter should be cleaned every 100 operating hours. Tap the cartridge on a flat surface to dislodge dirt or clean off with compressed air. If the cartridge is badly contaminated or oily, replace it.

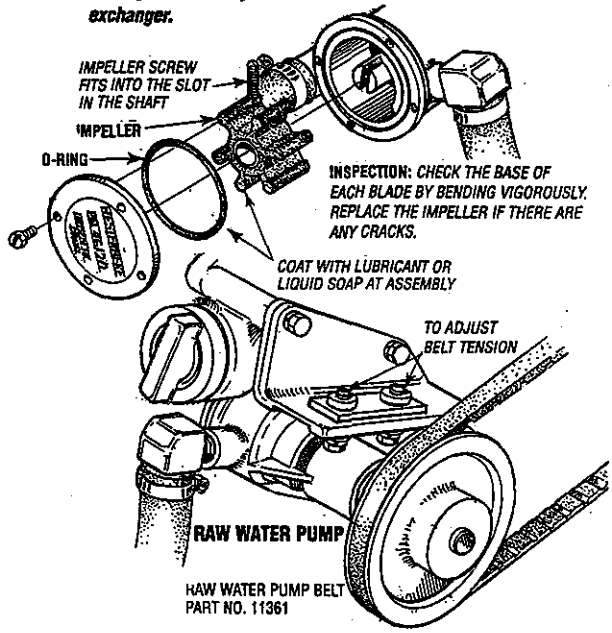




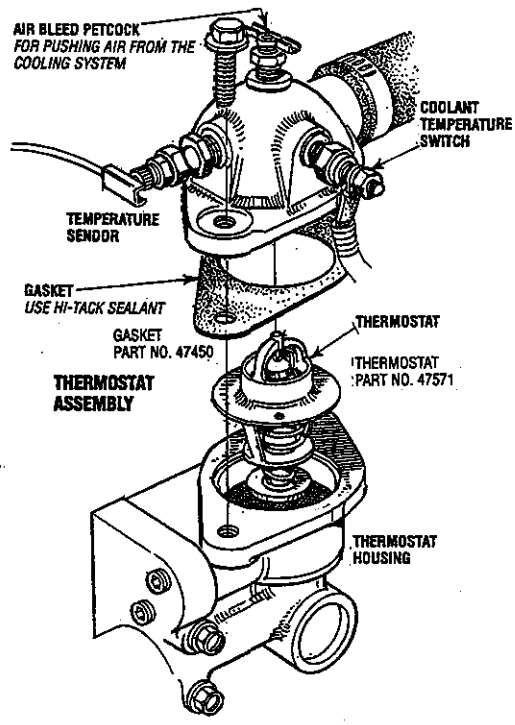
Heat Exchanger Service

After approximately 1000 hours of operation, remove, clean and pressure test the engine's heat exchanger. (A local automotive radiator shop should be able to clean and test the heat exchanger.)

⚠ CAUTION: ***If any of the vanes have broken off the impeller, they must be found to prevent blockage in the cooling circuit. They often can be found in the heat exchanger.***

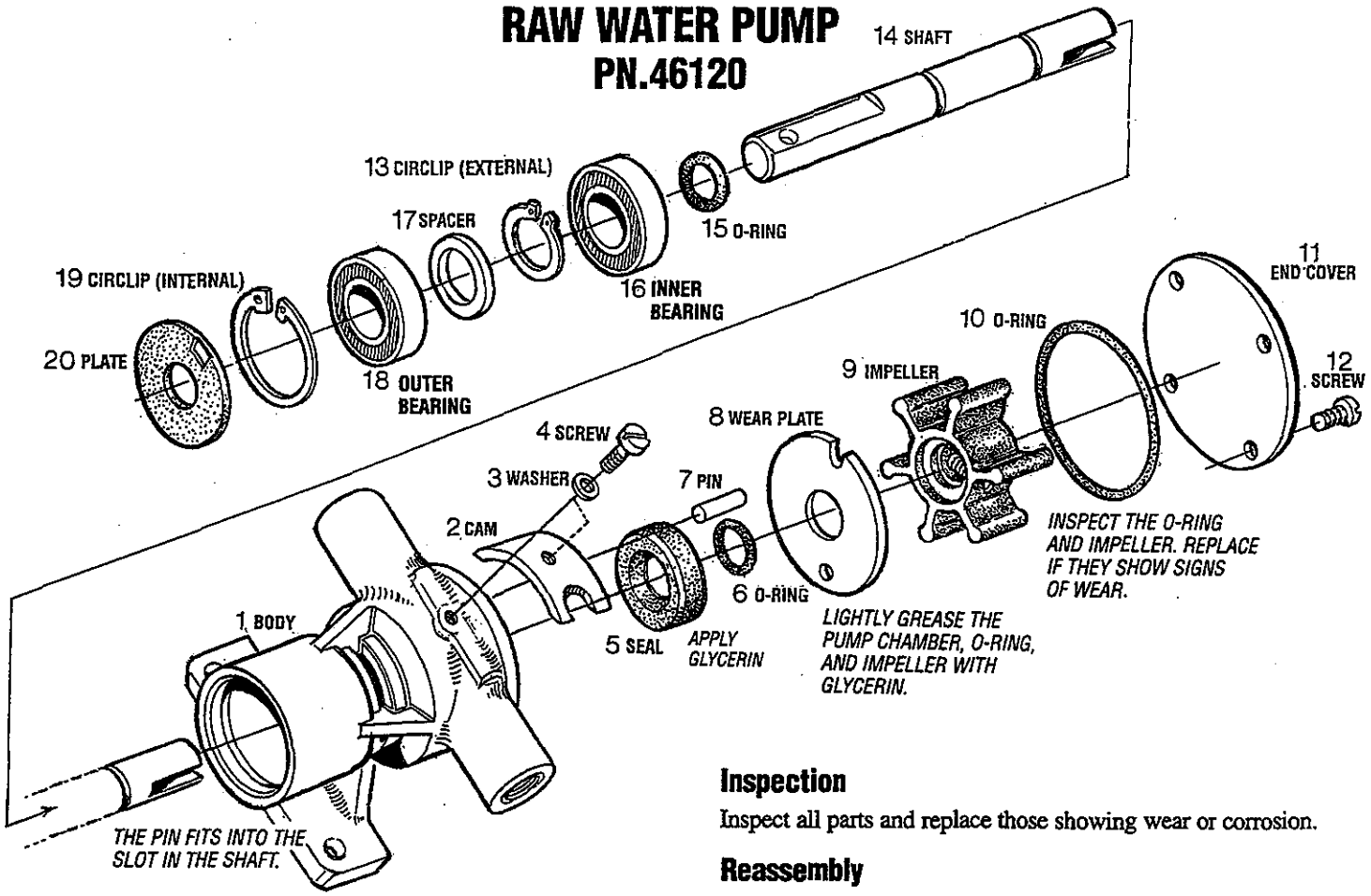


RAW WATER PUMP



THERMOSTAT ASSEMBLY

RAW WATER PUMP
PN.46120



PUMP OVERHAUL

Disassembly

The pump when removed from the engine will have the hose attachment nipple threaded into the inlet and outlet ports of the pump along with a drive pulley attached to the shaft of the pump. Remove these attachments noting their positions before starting the pump disassembly.

1. Remove the four cover plate screws #12, cover plate #11 and sealing O-ring #10.
2. Remove the impeller #9 using a pair of pliers, grasping the hub and pulling it out of the pump with a twisting motion.
3. Remove the screw #4 and sealing washer #3 that hold the cam in place. Remove the cam #2 and inner wear plate #8 behind it.
4. Remove dust plate #20 and circlip #19.
5. Support the pump body on an arbor press and with a drift, press the shaft and bearing assembly out the pulley end of the pump.
6. Remove the O-ring from the shaft.
7. Support the outer bearing #18 and push the shaft out of the bearing.
8. Remove the spacer #17 and circlip #13.

Inspection

Inspect all parts and replace those showing wear or corrosion.

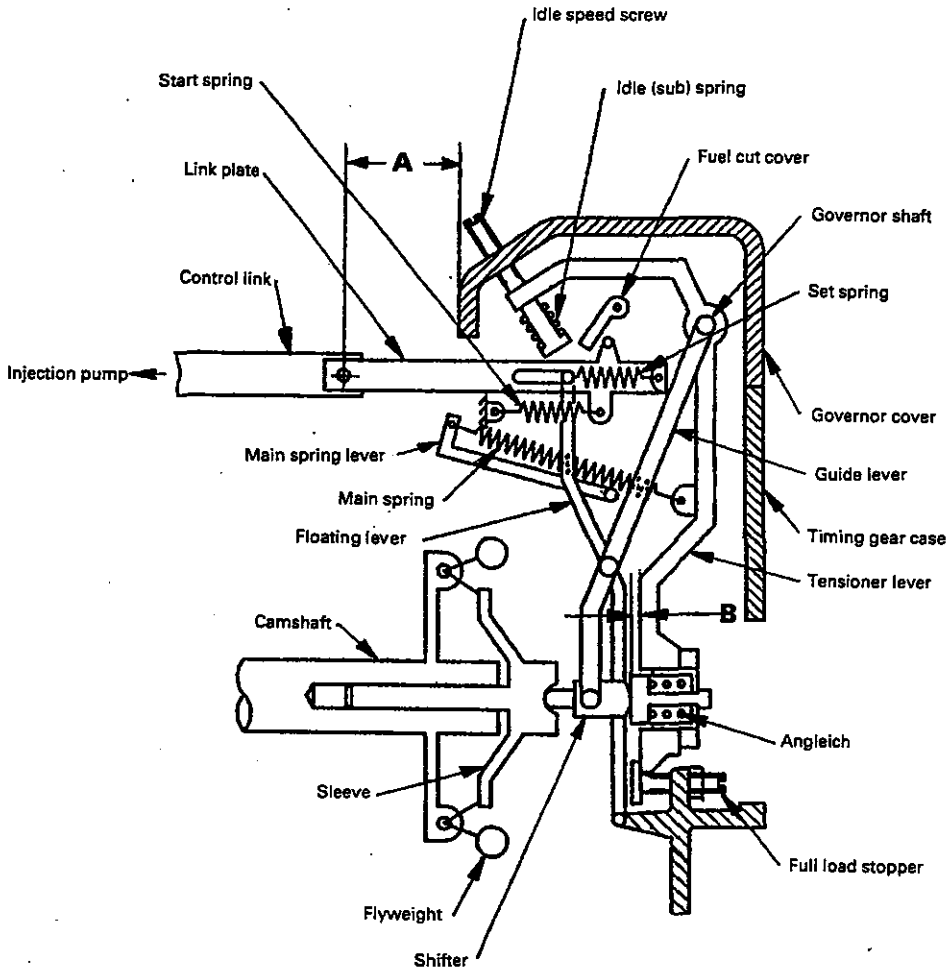
Reassembly

1. Install a new shaft seal #5 in the pump body. Apply some glycerin to the lip of the seal.
2. Install the circlip #13 on the shaft. Support the outer bearing #18 and push the shaft into the bearing until the bearing contacts circlip.
3. Install spacer #17 against the circlip. Support the inner bearing #16 and push the shaft into the bearing until it contacts the spacer.
4. Apply some glycerin onto the O-ring #6 and install it on the shaft approximately 1/8" away from the inner bearing.
5. Support the pump body on an arbor press. With a twisting motion, install the shaft and bearing assembly into the shaft seal #5 until the inner bearing contacts the pump body. Then with the push shaft and bearing, assembly into the pump body so that the outer bearing just clears the boss for circlip #19.
6. Install circlip #19 and push the shaft and bearing assembly so the outer bearing #18 contacts the circlip #19.
7. Install the dust plate #20.
8. Install wear plate #8, cam 32 and secure it in place with washers and screw #4.
9. Apply some glycerin to the surface of the impeller housing, impeller inner surface of the cover plate #11 and O-ring #10.
10. With a twisting motion, install the impeller #9 into the pump. Install the O-ring #10 and secure the cover plate #11 with the four screws #12.
11. Install the pulley on the shaft and the hose nipples back into the pump. Mount the pump on the engine. Check pulley alignment. Attach the raw water hoses.

GOVERNOR

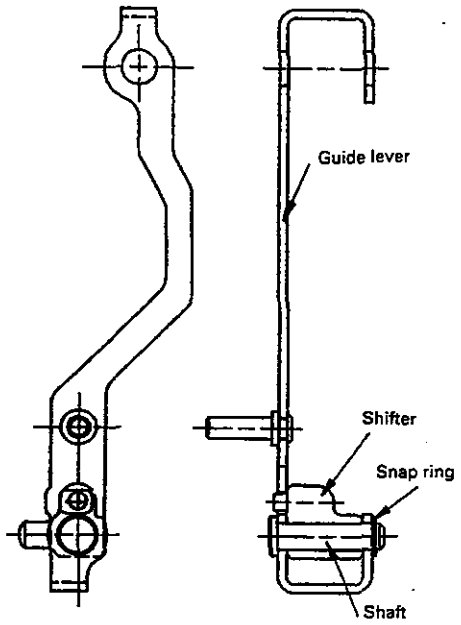
1. The adjustments of the governor-related parts require the engine performance test.
2. Before disassembling the governor, measure the dimensions "A" and "B" given in the structural drawing to ensure the same dimensions in reassembly.
3. Do not disassemble the governor when the performance test cannot be conducted after reassembly.

STRUCTURAL DRAWING OF GOVERNOR



Reassembly of shifter

(1) Assemble the shifter to the guide lever, put the shaft through it, and then assemble the snap ring.
(2) After assembly, confirm that the shaft moves smoothly.
(3) Also, confirm that the shifter shakes smoothly.



Reassembly of governor cover

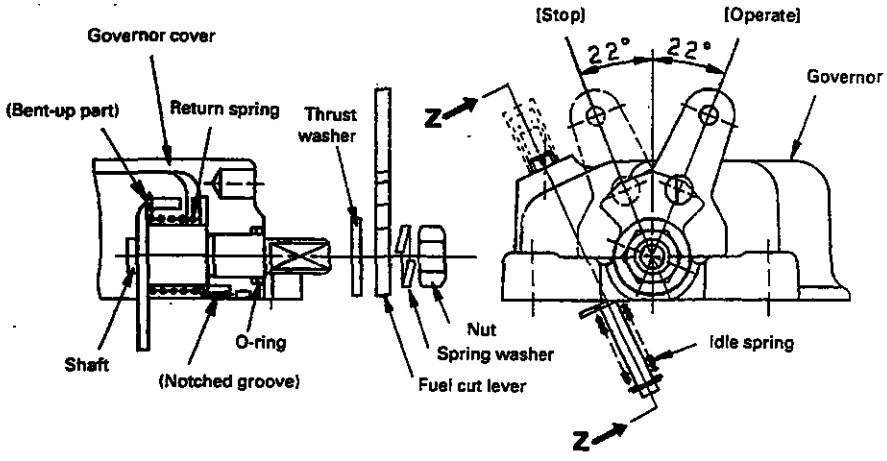
Assemble the related parts such as the fuel cut lever and the idle spring to the governor cover.

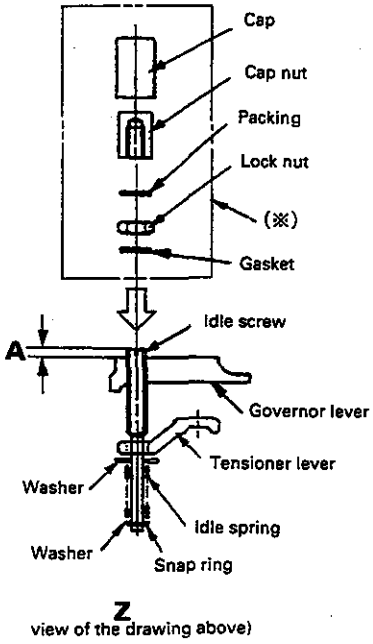
(1) When assembling the shaft, apply engine oil to the sliding portion with the governor cover.
(2) Set both ends of the return spring securely to the notched groove at the bottom of the cover and the bent-up arm of the lever respectively.
(3) After reassembling the governor cover, confirm that the governor moves smoothly.
(4) When assembling the timing gear case to the governor cover, tighten the "A" dimension shown in the illustration to 2 – 3 mm temporarily.

The parts given in the square indicated by (*) are assembled after performance test.

mm (in.)

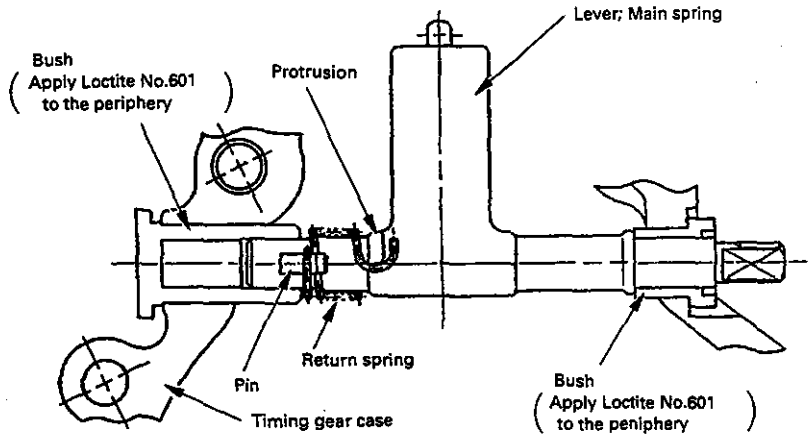
"A" dimension	(When assembling temporarily) 2 – 3 (0.0787 – 0.0118)





Z
view of the drawing above)

REASSEMBLY OF CONTROL LEVER RELATED PARTS



(1) Put the lever (main spring) through the hole of the timing gear case lever.

Note:

Before hammering in the bushes, put both shafts of the lever through the holes of the timing gear case lever respectively.

(2) Put the return spring of the control lever through the shaft of the lever (main spring).

(3) Assemble the bushes.
Assemble the bush of the lever (main spring) first, and then the control lever bush.

Note:

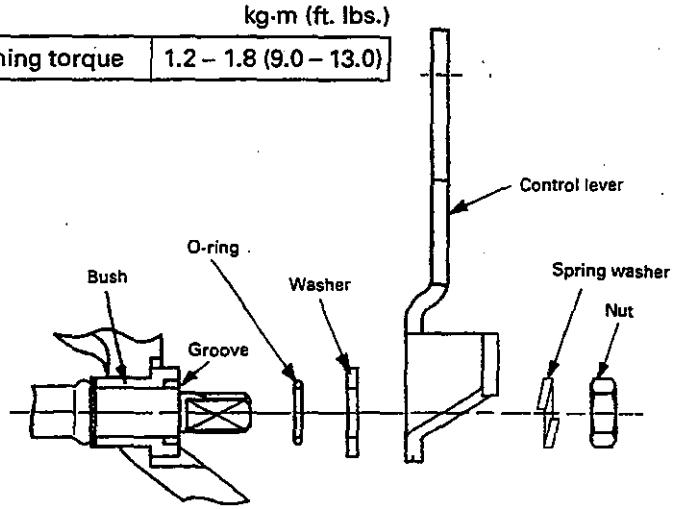
When assembling the bushes, apply Loctite (#601) to the periphery of the bushes.

(4) Hook both ends of the return spring (control lever) securely to the protrusion and the pin of the lever (main spring) respectively.

Assemble the control lever.
Assemble the O-ring to the groove of the bushes (control lever) first, and then assemble the washers and the control lever before tightening up the control lever with a nut.

kg·m (ft. lbs.)

Control lever tightening torque	1.2 – 1.8 (9.0 – 13.0)

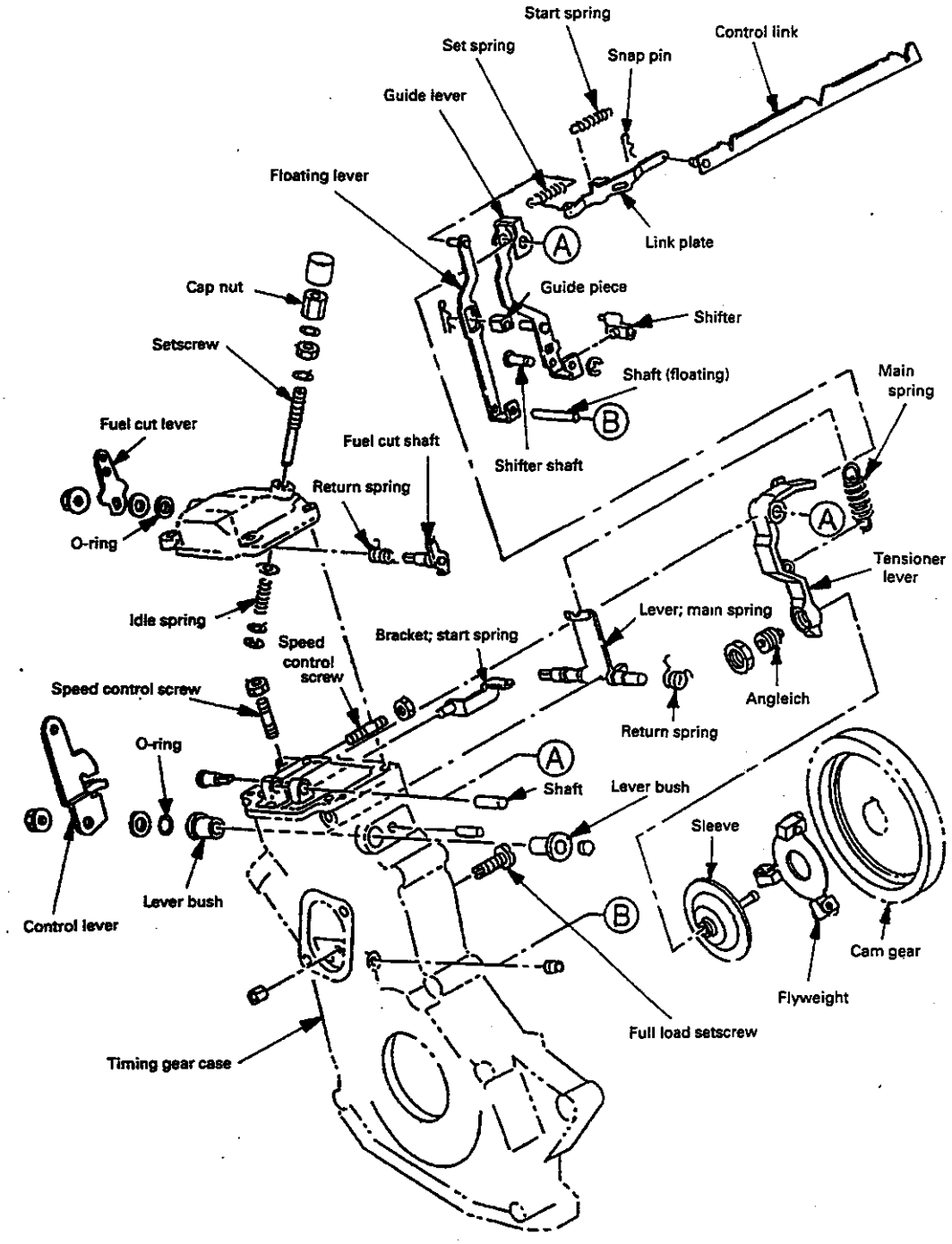


Notes:

1. **Tighten the control lever after locking the control lever firmly.**
   (Do not tighten the control lever after locking the main spring lever.)
2. **After assembly, confirm that the control lever moves smoothly.**

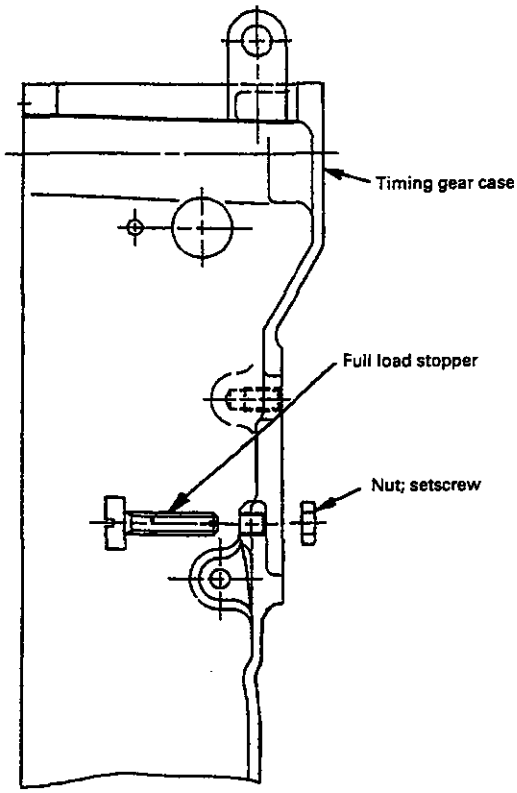
FUEL SYSTEM

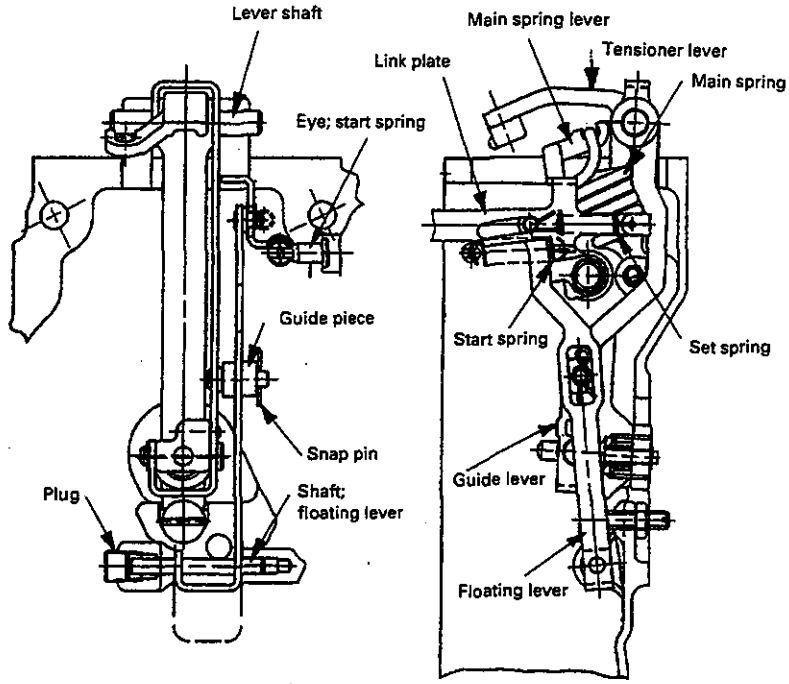
STRUCTURAL DRAWING OF GOVERNOR



Reassembly of full-load stopper

Install the full-load stopper to the timing gear case, and then tighten it with a nut temporarily.





Reassembly of governor lever related components

Assemble each lever and spring to the timing gear case.

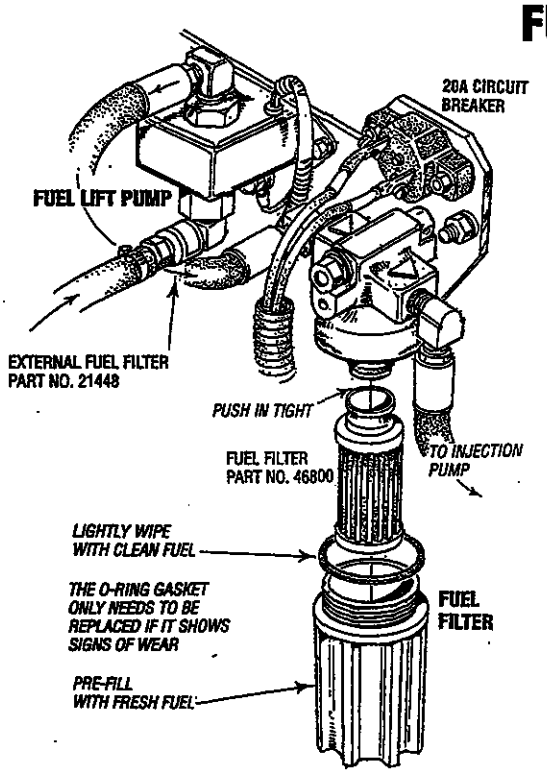
Notes when assembling governor related components

(1) When assembling components, apply engine oil to each slide (such as the end face of the lever, the hole in the shaft, and the periphery of the shaft).

(2) Install the set spring securely to the groove of the pin connecting the floating lever, with much care to its assembling direction.

(3) Confirm that each lever moves by its dead weight before installing the start spring.

(4) After assembly, confirm that each lever moves smoothly.
And also confirm that each spring operates properly.



Changing the Fuel Filter Element

Refer to the illustration above.

1. Shut off the fuel supply.
2. Turn the fuel filter bowl counterclockwise to remove.
3. Pull the filter element straight down and off.
4. Inspect both O-rings and replace if worn.
5. Wipe the O-rings with clean fuel and snap the new filter up into place over the small O-ring.
6. Clean off the filter bowl and threads. (The bowl can be pre-filled with fuel). Screw the bowl into place when the O-ring contacts the housing. Tighten the bowl firmly by hand.
7. The key-on preheat sequence will allow the lift pump to fill the fuel filter.
8. Run the engines and inspect for leaks.

FUEL INJECTION PUMP

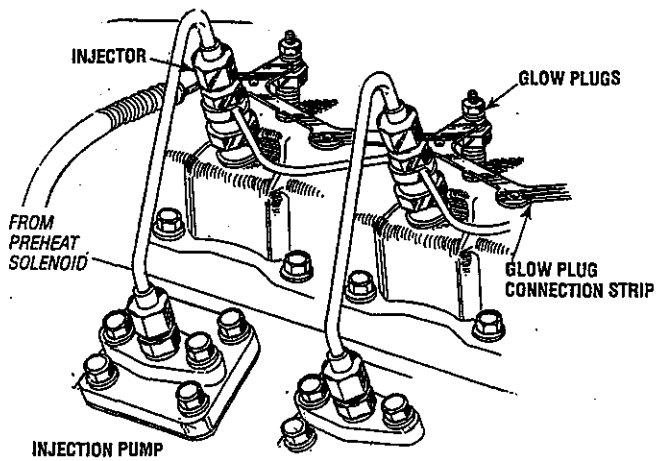
The fuel injection pump is a very important component of the diesel engine, requiring the utmost care in handling. The fuel injection pump has been thoroughly bench-tested and the owner-operator is cautioned not to attempt to service it. If it requires servicing, remove it and take it to an authorized fuel injection pump service facility. Do not attempt to disassemble and repair it.

FUEL LIFT PUMP

Periodically check the fuel connections to and out of the pump and make sure that no leakage is present and that the fittings are tight and secure. The DC ground connection at one of the pumps mounting bolts should be clean and well secured by the mounting bolt to ensure proper pump operations.

When energized thru the preheat circuit, the fuel lift pump will purge air from the fuel system and provide a continuous flow of fuel as the engine is running.

A small fuel filter has been added to the incoming fuel line to ensure that filtered fuel enters the fuel lift pump.

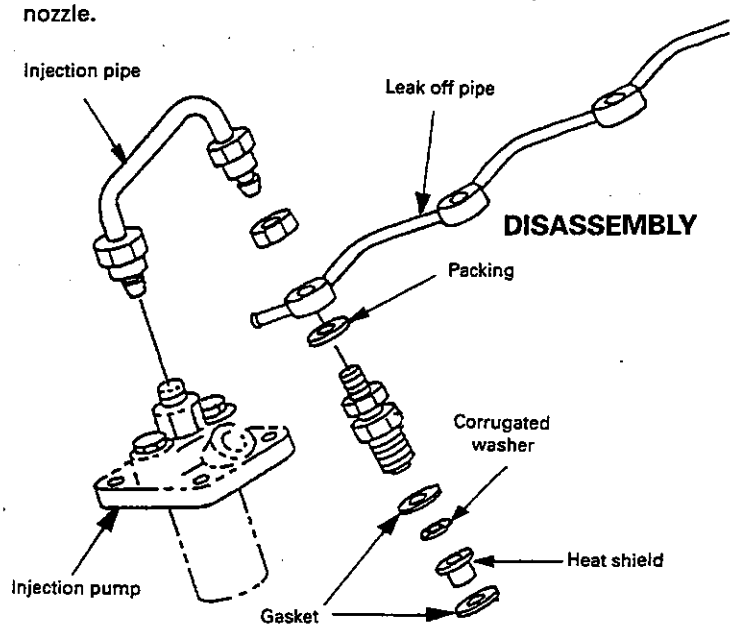


NOZZLE ASSEMBLY

Inspection and replacement

Place the removed nozzle in the clean light oil, disassemble it into the nozzle body and the needle valve and clean them thoroughly. Then check to see if the valve moves smoothly in the body.

When it does not move smoothly, repair or replace the nozzle.



INJECTION TESTING

1. Using the nozzle tester, check the spray pattern and injection starting pressure of nozzle and, if it exceeds the limit, adjust or replace the nozzle. When using nozzle tester, take the following precautions:

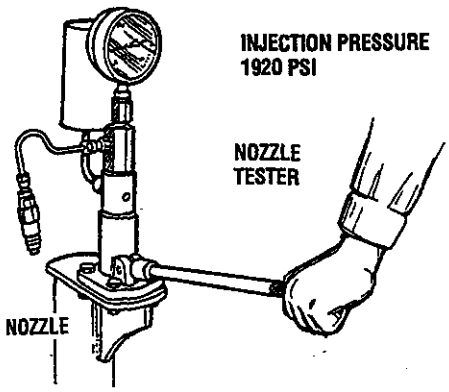
a. If the diesel fuel of the nozzle tester is discolored, replace it. At the same time, clean or replace the filter.

b. Set the nozzle tester in a clean place where there is no dust or dirt.

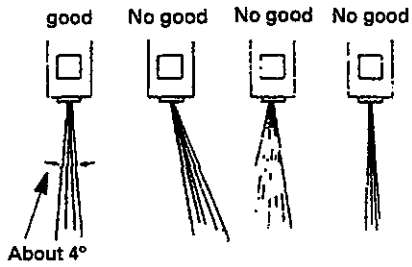
c. Mount the nozzle and nozzle holder on the nozzle tester.

d. Use the fuel at the approximate temperature of 68° F (20° C)

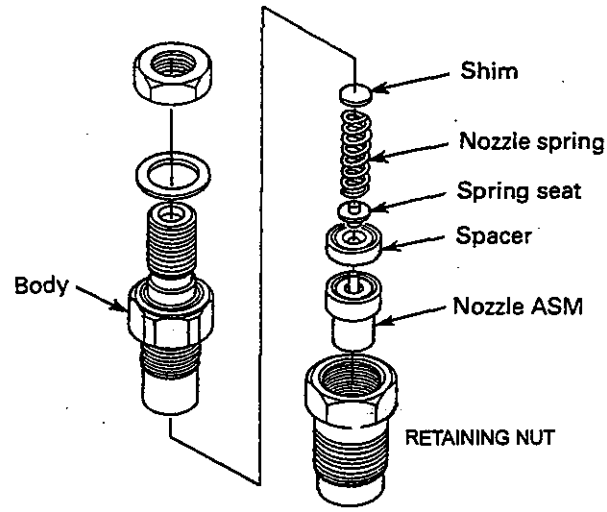
e. Operate the hand lever of nozzle tester several times to bleed the air in the nozzle line, then move the hand lever at intervals of one stroke per second while reading the injection starting pressure.



⚠ CAUTION: ***The spray injected from the nozzle is of such velocity that it may penetrate deeply into the skin of fingers and hands, destroying tissue. If it enters the bloodstream, it may cause blood poisoning.***



Check to see if the spray condition and the injection pressure are normal. Adjust them to the specified value respectively when they do not meet the standard value. Use shims to adjust the injection pressure.



Nozzle holder ASM

GLOW PLUGS

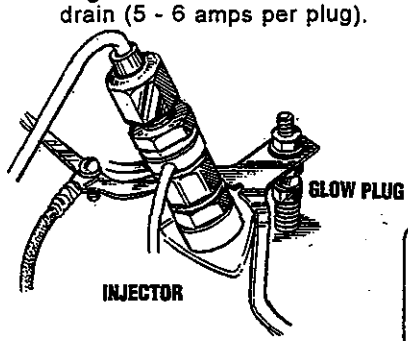
The glow plugs are wired through the preheat solenoid. When PREHEAT is pressed at the control panel this solenoid should "click" on and the glow plug should begin to get hot.

Inspection

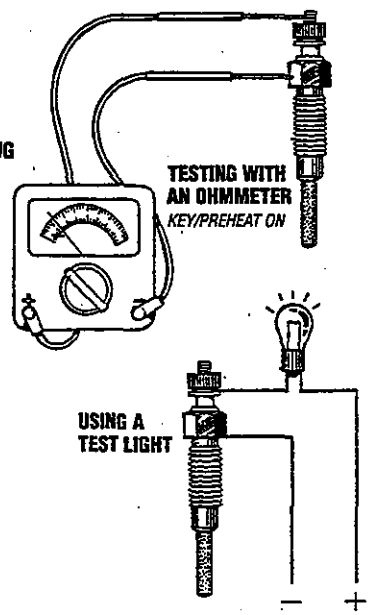
To inspect the plug, remove the electrical terminal connections, then unscrew or unclamp each plug from the cylinder head. Thoroughly clean each plug's tip and threads with a soft brush and cleaning solution to remove all the carbon and oil deposits. While cleaning, examine the tip for wear and burn erosion; if it has eroded too much, replace the plug.

Testing

An accurate way to test glow plugs is with an ohmmeter. Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 0.4 - 0.6 ohm resistance. This method can be used with the plug in or out of the engine. You can also use an ammeter to test the power drain (5 - 6 amps per plug).



GLOW PLUG TIGHTENING TORQUE
1.0 - 1.5 M-KG (7 -11 FT-LB)

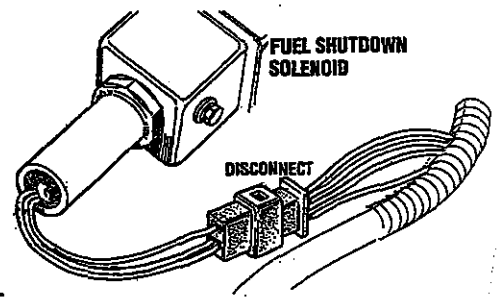


ENGINE ADJUSTMENTS

TESTING ENGINE COMPRESSION

Make certain the oil level (dipstick) is at the correct level and the air intake filter is clean. The battery and starter motor must also be in good condition.

1. Warm the engine to normal operating temperature.
2. Disconnect the wire to the fuel shutdown solenoid.
3. Remove all the glow plugs from the engine and install the compression gauge/adapter combination to the cylinder on which the compression is to be measured.



Note:

Compression pressure may be measured starting at any cylinder and in no particular cylinder order. However, it is very important that the compression pressure be measured in each cylinder.

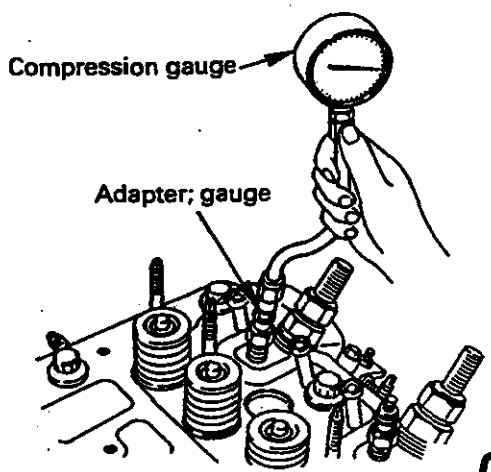
Therefore, start at the No. 1 cylinder and work back. In this way, you will be sure to measure the compression pressure in each cylinder.

4. Close the raw water seacock (thru-hull).
5. Crank the engine and allow the gauge to reach a maximum reading, then record that reading.
6. Repeat this process for each cylinder.

NOTE: *If the readings are below the limit, the engine needs an overhaul.*

55B FOUR COMPRESSION PRESSURE
441 PSI (3.04 MPa) NORMAL AT CRANKING SPEED OF 250 RPM.
44.1 PSI BETWEEN CYLINDERS

7. Re-install the glow plugs (use anti-seize compound on the threads) and reset the fuel shut-off to the run position.
8. **Open the raw water seacock (thru-hull).**



Low Compression

When low compression is found, determine the cause by applying a small amount of oil in the cylinder thru the glow plug hole. Allow the oil to settle.

Install the pressure gauge and repeat the above test. If the compression reading rises dramatically, the fault is with the rings. If the compression valve does not rise, the problem is with the valves.

A slight rise in compression would indicate a problem with both the rings and the valves.

OIL PRESSURE

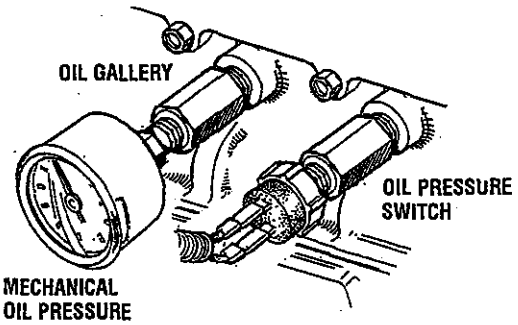
Low Oil Pressure

The specified safe minimum oil pressure is 5 - 10 psi. A gradual loss of oil pressure usually indicates worn bearings. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

Testing Oil Pressure

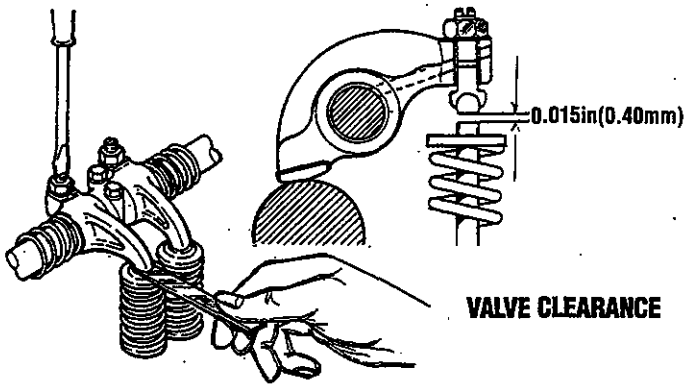
To test oil pressure, remove the oil pressure sender then install a mechanical oil pressure gauge in its place. After warming up the engine, set the engine speed at idle and read the oil pressure gauge.

55B FOUR OIL PRESSURE
43 TO 85 PSI (290 TO 590 KPa) NORMAL



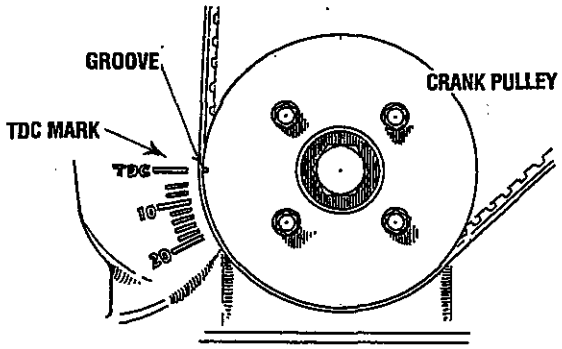
VALVE CLEARANCE ADJUSTMENT

The valve clearance must be adjusted every 500 operating hours or whenever the valve rocker is abnormally noisy. Valve adjustment should only be done when engine is cold. Cold engine valve clearance is 0.015in (0.40mm).

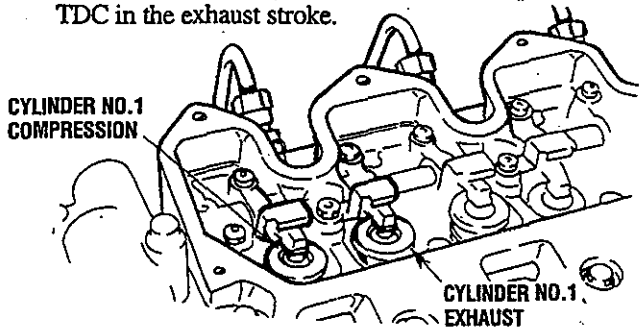


NOTE: *The cylinder head bolts have been tightened with the "Angular Tightening Method". Therefore, it is not necessary to retighten the cylinder head bolts before adjusting the valve clearances.*

ADJUSTMENT PROCEDURE



1. Turn the crankshaft clockwise so that the mark groove on the crank pulley is aligned with the TDC mark (cast out) on the timing gear case cover.
2. Remove the cylinder head cover and check to see if cylinder No.1 is at TDC in the compression stroke or at TDC in the exhaust stroke. When the intake and exhaust valves are closed, the cylinder is at TDC in the compression stroke, and when only the exhaust valve is open, it is at TDC in the exhaust stroke.



3. In accordance with the conditions of cylinder No.1, measure and adjust if required the clearance of the valves marked with either ◎ or ● in the table below.

Cylinder No.	1		2		3		4	
Valve arrangement	I	E	I	E	I	E	I	E
When No. 1 cylinder is at TDC in the compression stroke	●	●	●			●		
When No. 4 cylinder is at TDC in the compression stroke				◎	◎		◎	◎

I: Inlet E: Exhaust

4. On completion of the valve clearance alignment make a mark alignment as in 1 by giving a turn to the crankshaft in the normal direction. Then measure and adjust the clearance of the other valves.

> ⚠ **CAUTION:** ***The rocker arm is made of die-cast aluminum. Therefore, be careful not to tighten the adjusting screw to excess.***

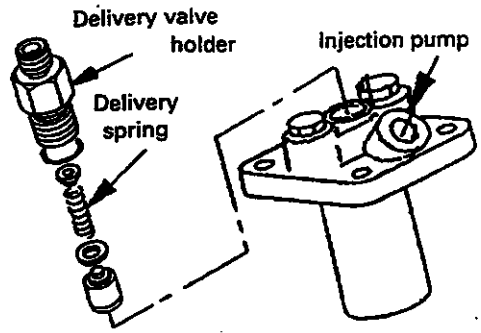
Adjustment of Injection Timing

The injection timing may not be re-adjusted. Take care not to forget to insert a shim in the mounting surface when reassembling the injection pump after disassembly.

INJECTION TIMING

Take care to avoid entry of dust or foreign particles into the pump interior when the timing adjustment is made.

1. Remove the injection pipe of the No. 1 cylinder.
2. Remove the delivery valve holder of the injection pump of the No. 1 cylinder, and then pull out the delivery spring.
3. With the spring left removed, install the delivery valve holder.



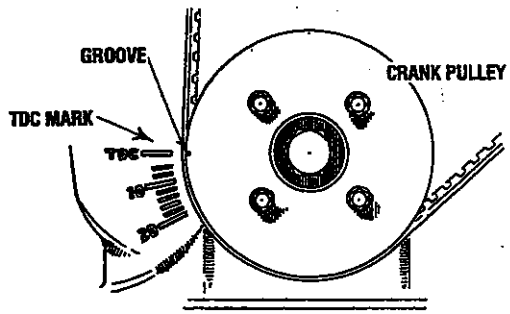
4. Slowly turn the crankshaft pulley clockwise, at the same time, continue to feed the fuel.

   When the fuel stop flowing out from the No. 1 delivery valve holder, stop turning the crankshaft.

   This crank angle position is the starting point of injection.

5. In the condition at Step (4) above, confirm what degree the "groove mark" of the crank pulley is at, when seen by the "timing mark", provided in the timing gear case.

   When the value is out of the range of the normal injection timing, adjust it accordingly.



Injection timing		BTDC 16°

Note:

The injection timing varies according to the specifications of the machine.

6. Adjust the injection timing with a shim between the injection pump and the cylinder block.

   Shim is available in the following 9 types, and "identification mark" is stamped (or imprinted) on the top face.

Identification mark of shim and its thickness (mm)

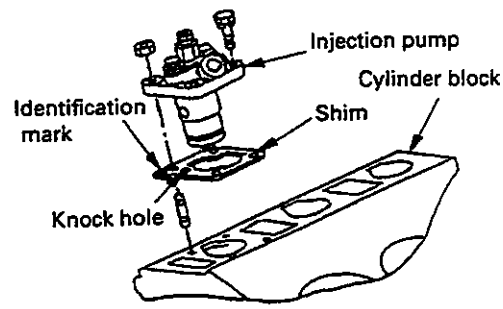
Mark	Thickness	Mark	Thickness	Mark	Thickness
2	0.2	5	0.5	8	0.8
3	0.3	6	0.6	10	1.0
4	0.4	7	0.7	12	1.2

Note:

For each of the injection pumps of three cylinders, the shim adjustment is made at the same time.

When a shim is missing while overhauling the engine and the shim thickness is unknown, assemble the engine with provisional shim inserted. After assembling the engine, check the injection timing and adjust the shim until the normal injection timing is obtained.

Reference:
To add the 0.1 mm shim thickness corresponds to the 1 degree of crankshaft angle advance.



WARNING LIGHTS, ALARMS & CIRCUIT BREAKER

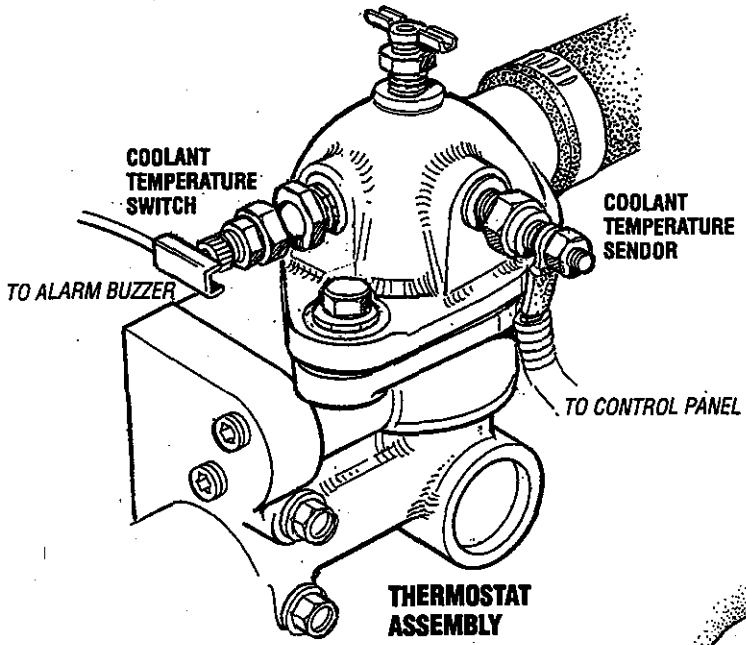
ALTERNATOR WARNINGS

The Captain Control Panel indicates alternator low discharge with a red warning light.

The Admiral Control Panel uses a voltmeter to monitor the performance of the alternator.

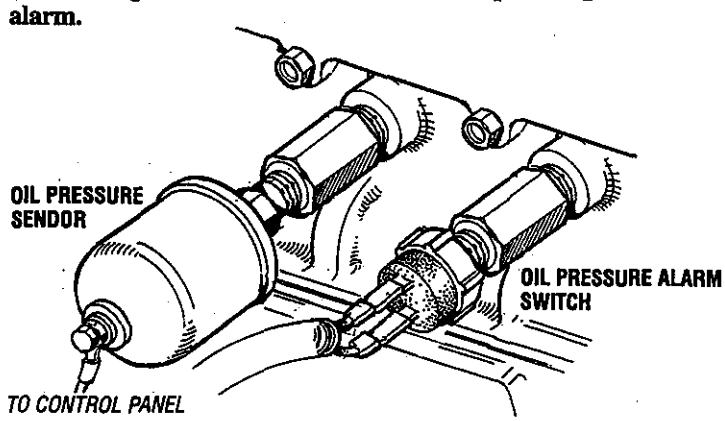
COOLANT TEMPERATURE SWITCH

A coolant temperature switch is located on the thermostat housing. **This switch will activate a continuous alarm** if the coolant's operating temperature reaches approximately 210°F (99°C).



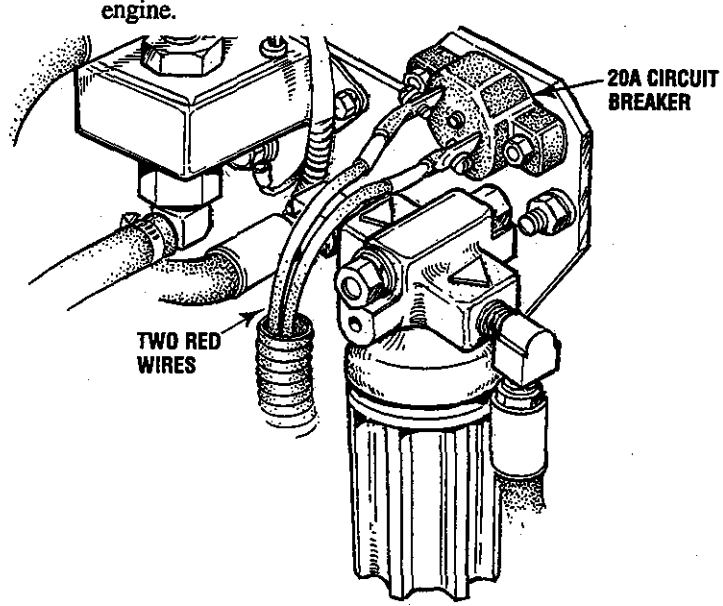
LOW OIL PRESSURE ALARM SWITCH

A low oil pressure alarm switch is located on the engine block. This switch's sensor monitors the engine's oil pressure. Should the engine's oil pressure fall to 5 – 10 psi (0.4 – 0.7 kg/cm²), **this switch will activate a pulsating alarm.**



ENGINE CIRCUIT BREAKER

The DC harness on the engine is protected by an engine mounted manual reset circuit breaker (20 amps DC). Excessive current draw or electrical overload anywhere in the instrument panel wiring or engine wiring will cause the breaker to trip. In this event most engines will shut down because the opened breaker disconnects the fuel supply. If this should occur, check and repair the source of the problem. After repairing the fault, reset the breaker and restart the engine.



STARTER MOTOR

DESCRIPTION

The starter can be roughly divided into the following sections:

- A motor section which generates a drive power.
- An overrunning clutch section which transmits an armature torque, preventing motor overrun after starting.
- A switch section (solenoid) which is operated when actuating the overrunning clutch through a lever and which supplies load current to the motor.

The starter is a new type, small, light-weight and is called a high-speed internal-reduction starter. The pinion shaft is separate from the motor shaft; the pinion slides only on the pinion shaft. A reduction gear is installed between the motor shaft and a pinion shaft. The pinion sliding part is not exposed outside the starter so that the pinion may slide smoothly without becoming fouled with dust and grease. The motor shaft is supported at both ends on ball bearings. The lever mechanism, switch and overrunning clutch inner circuit are identical to conventional ones.

ADJUSTMENT AND REPAIR

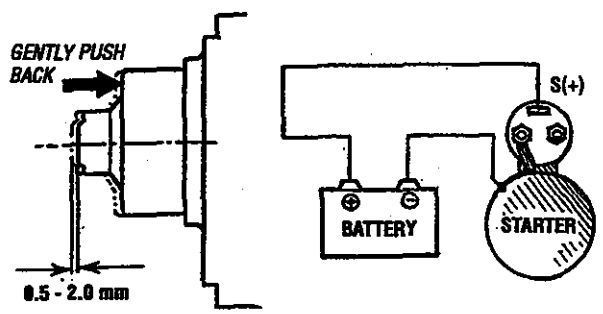
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

Pinion Gap Inspection

1. Connect a battery (12V) between the starter terminal S and the starter body, and the pinion drive should rotate out and stop.

> ⚠ **CAUTION:** ***Never apply battery voltage for over 10 seconds continuously.***

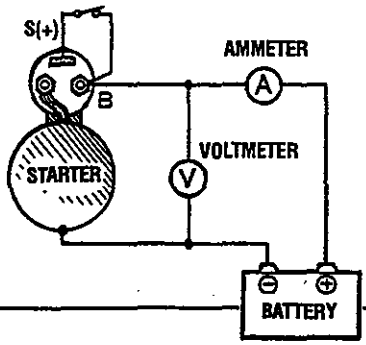
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, (0.5 to 2.0 mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



PINION GAP

No-Load Test

1. Connect the ammeter, voltmeter, and battery to the starter as illustrated.
2. When the switch is closed, the pinion must protrude and the starter must run smoothly (at 3000 rpm or more). If the current or starter speed is out of specification, disassemble the starter and repair it.

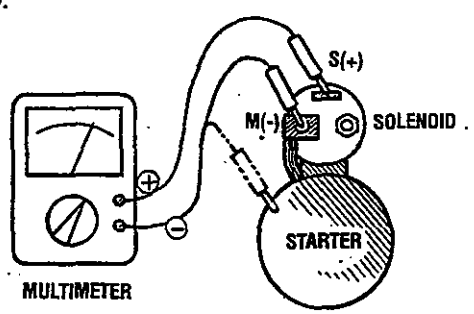


> ⚠ **CAUTION:** ***Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the pinion gear when it protrudes.***

SOLENOID

Perform the following tests. If any test result is not satisfactory, replace the solenoid assembly.

1. Inspect the solenoid for continuity between terminals (+) and (-) and between terminals S and the body and M and the body. There should be no continuity found between terminals S and M. Continuity will be found between terminals S and the body and terminal M and the body.

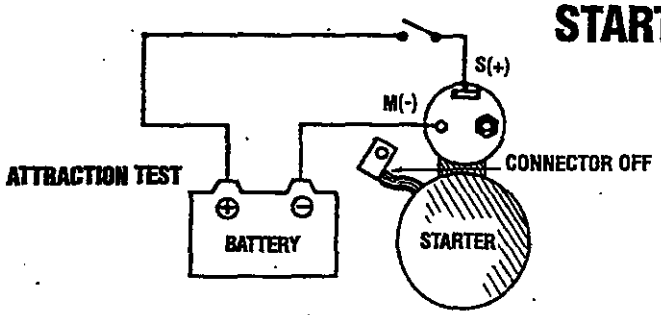


NOTE: *Disconnect the wire from terminal M.*

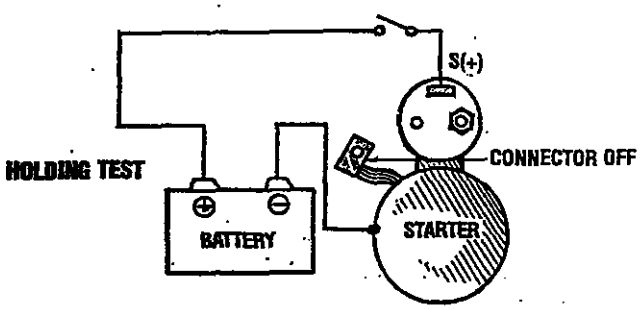
2. Connect a battery to the solenoid's terminal S for (+) and M for (-). Have a switch in the + lead and close it. The pinion drive should extend fully out.

> ⚠ **CAUTION:** ***Do not apply battery current for more than 10 seconds when testing the solenoid.***

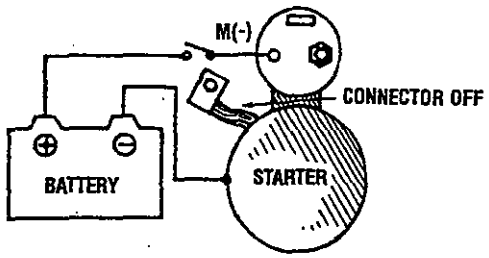
STARTER MOTOR



3. *Holding test.* With a battery connected to the solenoid terminal S (+) and to the starter body, manually pull out the pinion fully. The pinion must remain at that position even when released from holding with your hand.



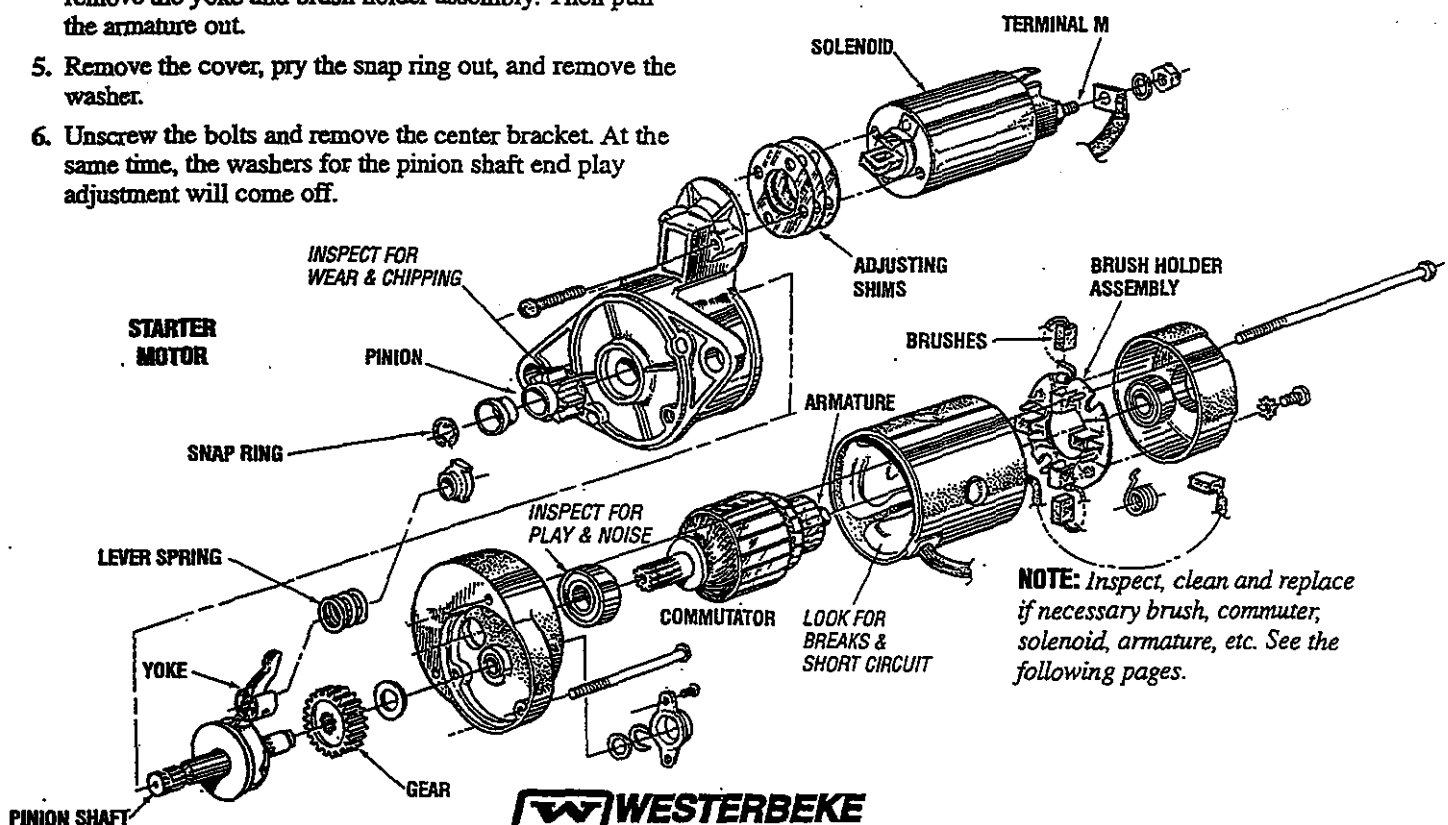
4. *Return test:*. With a battery connected to the solenoid terminal M (-) and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.



RETURN TEST

STARTER DISASSEMBLY

1. Disconnect the wire from the solenoid terminal M (-).
2. Loosen the two screws fastening the solenoid. Remove the solenoid assembly.
3. Remove the two long through bolts and two screws fastening the brush holder. Remove the rear bracket.
4. With the brushes pulled away from the armature, remove the yoke and brush holder assembly. Then pull the armature out.
5. Remove the cover, pry the snap ring out, and remove the washer.
6. Unscrew the bolts and remove the center bracket. At the same time, the washers for the pinion shaft end play adjustment will come off.
7. Pull out the reduction gear lever and lever spring from the front bracket.
8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.
9. At each end of the armature, remove the ball bearing with a bearing puller. It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn off, replace the front bracket assembly.

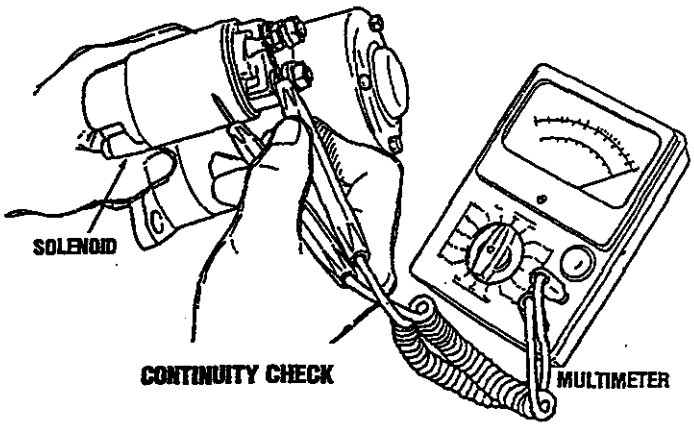


NOTE: *Inspect, clean and replace if necessary brush, commuter, solenoid, armature, etc. See the following pages.*

STARTER INSPECTION

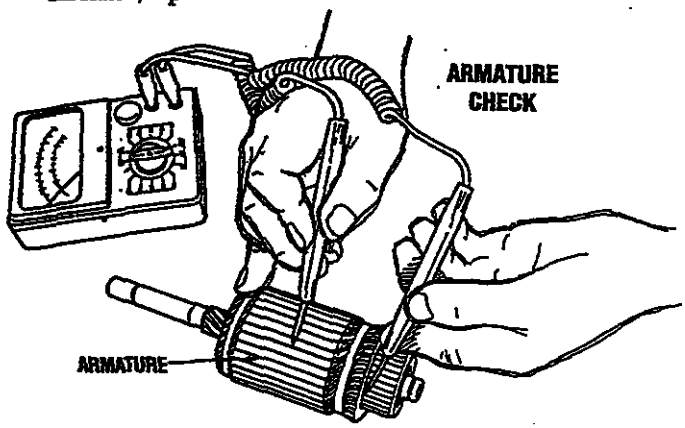
Solenoid

Inspect the solenoid for continuity between terminals S and M and between terminals S and body. No continuity should be found between S and M. Continuity should be found between S and the body and M and the body.

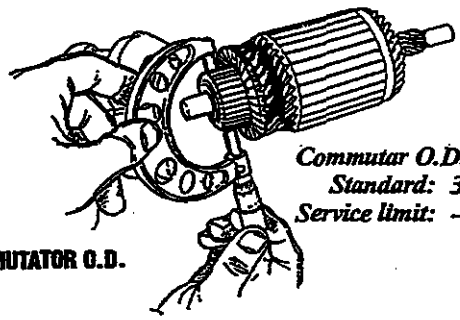


Inspecting The Armature

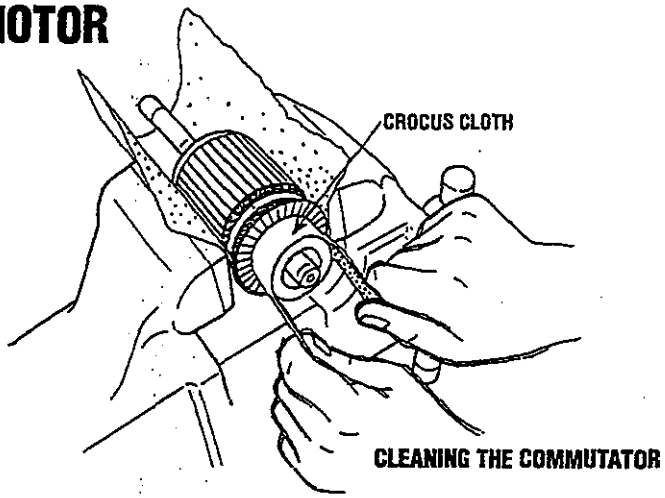
1. Check the armature with a growler tester. If it's short circuited, replace the armature. Also check for insulation between the communicator and its shaft. If poorly insulated, replace the armature.



2. Measure the commutator O.D. and the depth of undercut. Repair or replace it if the service limit is exceeded. Also check the commutator outside surface for dirtiness and roughness. If rough, polish the commutator with fine crocus cloth.



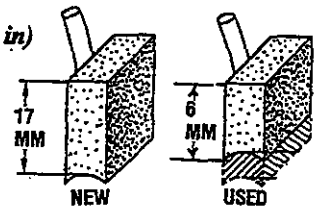
Commutar O.D. Standard
Standard: 38.7 mm (1.523 in)
Service limit: -1.0 mm (-0.039 in)



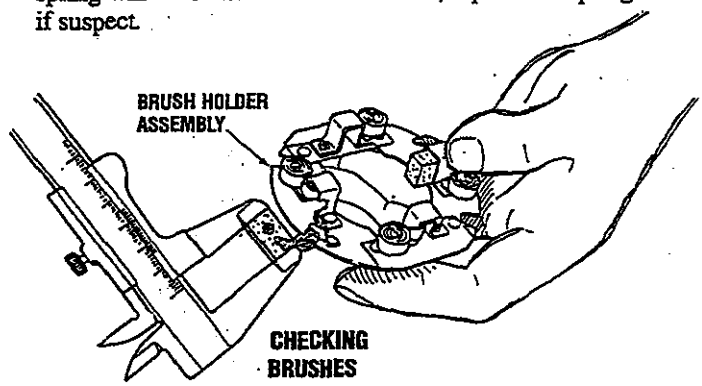
Brush and Brush Holder Inspection

1. Check the brushes. If worn out beyond the service limit, replace the brushes.

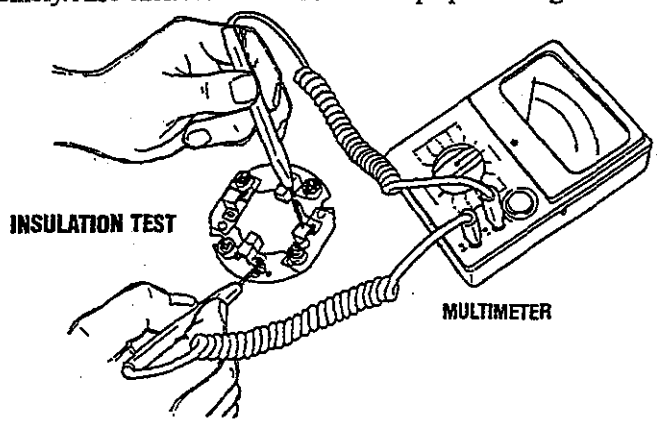
Brush Height
Standard 17 mm (0.669 in)
Limit 6 mm (0.236 in)



2. Check the brush spring tension. A weak or defective spring will cause excessive brush wear; replace the springs if suspect.

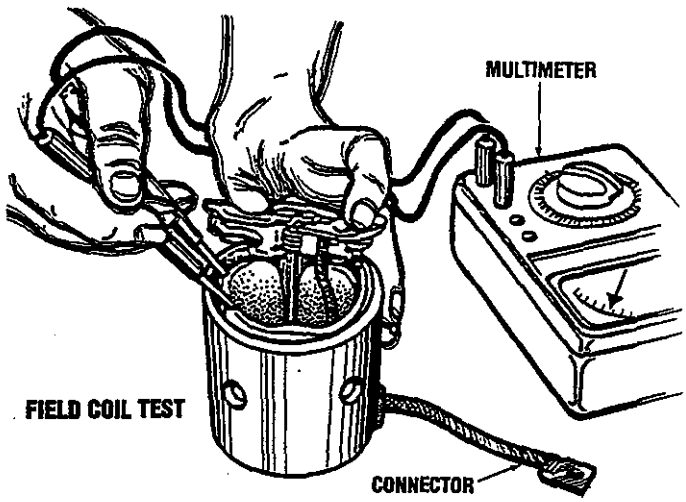


3. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also check the brush holders for proper staking.



Field Coil Inspection

1. Check for insulation between one end (brush) of the coil and yoke.
2. Check for continuity between both ends (brushes) of the coil
3. Check the poles and coil for tightness.



STARTER ADJUSTMENT AND REASSEMBLY

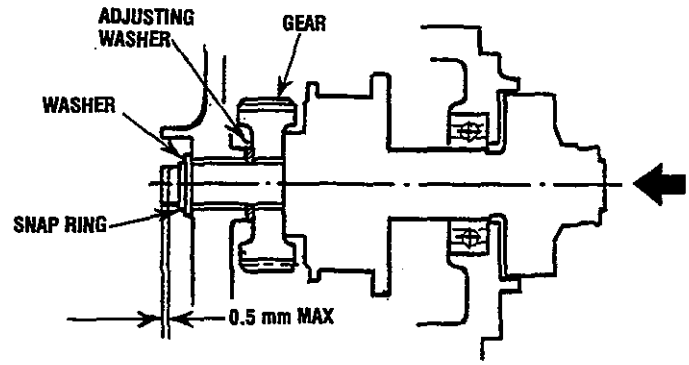
> ⚠ **CAUTION:** ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all oil, old paint, and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.***

Reassemble the starter assembly in the reverse order of disassembly, making sure of the following:

1. *Pinion shaft end play adjustment.* Set the end play (thrust gap) to between 0.5 to 2 mm by inserting an adjusting washer between the center bracket and the reduction gear.
   a. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.
   b. Measure end play by moving the pinion shaft in the axial direction. If the end play exceeds 0.5 mm, increase the number of adjusting washers inserted.
2. *Greasing.* Whenever the starter has been overhauled, apply grease to the following parts:
   a. Armature shaft gear and reduction gear.
   b. All bearings.
   c. Bearing shaft washers and snap rings.
   d. Bearing sleeves.
   e. Pinion.
   f. Sliding portion of lever.

> ⚠ **CAUTION:** ***Never smear the starter fitting surface, terminals, brushes, or commutator with grease.***

3. After reassembly, check by conducting a no-load test again.



PINION SHAFT END PLAY

DUAL OUTPUT ALTERNATORS

DESCRIPTION

Dual output and high output alternators are available as optional equipment on most WESTERBEKE engines. These alternators can be installed during factory assembly or as add-on equipment at anytime.

Dual alternators can be configured to charge two banks of batteries at the same time or, using a battery selector switch, charge each set of batteries separately.

INSTALLATION

If an optional dual alternator has already been factory installed, simply follow the WESTERBEKE wiring diagram and the engine installation instructions.

If the new dual alternator is being added to an existing "in-the-boat" engine, carefully follow the alternator installation instructions below:

1. Disconnect the alternators negative cable from the battery.
2. Remove the alternator and disconnect or tape off the output [positive] cable. Do not reuse.
3. Install the new alternator.
4. Attach a new heavy gauge output cable[s] from the alternator's output terminal [s]. Using the cable sizes indicated.

LENGTH REQUIRED		
	UP TO 6'	#4 WIRE
	UP TO 12'	#2 WIRE
	UP TO 20'	#0 WIRE

[ALWAYS USE FINE STRAND CABLE]

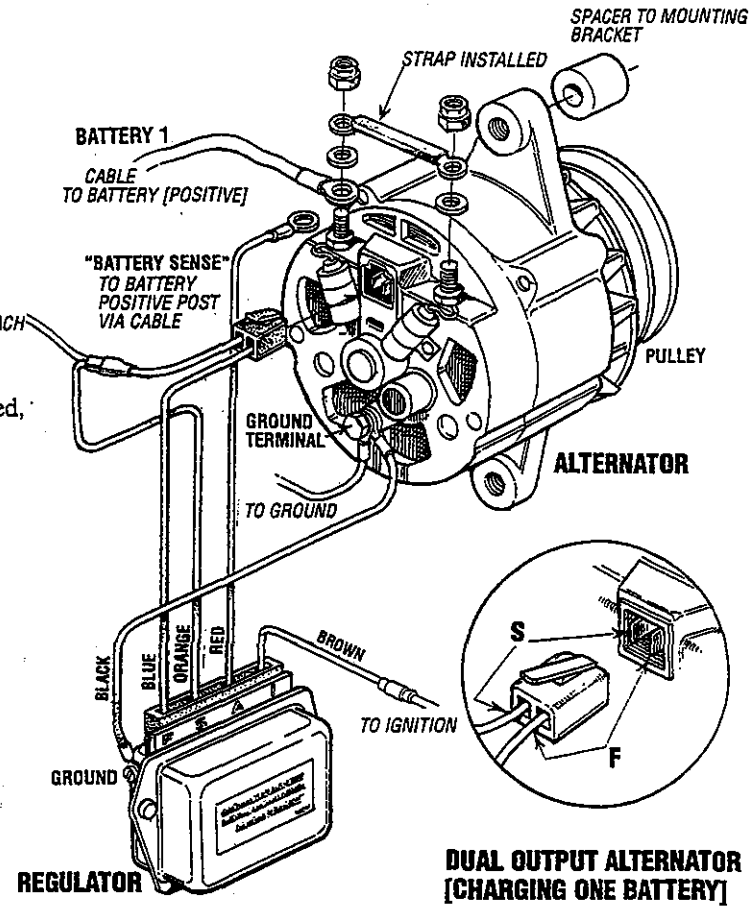
5. Make certain that the batteries negative post ground cable to the engine block is the same heavy gauge as the positive cable.
6. Mount the regulator to a flat surface in a cool dry location.
   a. Connect the black wire to the ground terminal on the alternator.

> **⚠ CAUTION:** ***Do not connect any power source without first grounding the regulator.***

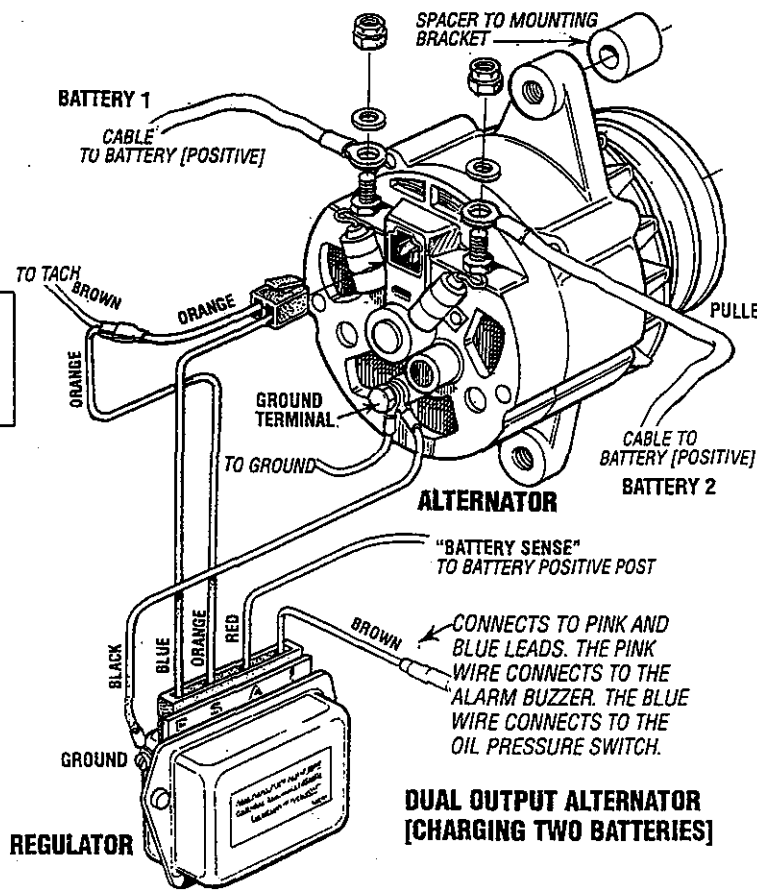
   b. Plug the 2-pin connector into the alternator, make certain it is firmly seated.
   c. The red "battery sense" wire should be connected to the batteries positive [+] post [or the positive cable].
   d. The brown wire "keyed ignition" is the key circuit which actuates the regulator, this wire must connect to a switched [+] 12 volt source. Refer to the *WESTERBEKE WIRING DIAGRAM* for the proper connection.

Dual Pulleys

A variety of accessory pulleys for high powered and dual charging alternators are available from your dealer.



DUAL OUTPUT ALTERNATOR [CHARGING ONE BATTERY]



DUAL OUTPUT ALTERNATOR [CHARGING TWO BATTERIES]

DUAL OUTPUT ALTERNATORS

TROUBLESHOOTING

NOTE: *Before troubleshooting, make certain that the drive belts are tight and the batteries are in good condition.*

Regulator Testing

The red "battery sensing" **wire A** connects to the battery, it must always read battery voltage. If battery voltage is not present, trace the wire for a bad connection.

The orange **wire S** should read 0 volts with the key off, 12 volts [approximately] with the key on. If the readings are incorrect, trace the wire for a bad connection.

The blue **wire F** supplies current to the alternator fields, its voltage will vary depending on the battery charge or actual load/rpm. The readings can vary from 4 to 12 volts with the key on, 0 volts with the key off.

KEY ON - NO VOLTAGE REGULATOR IS DEFECTIVE
KEY OFF - BATTERY VOLTAGE REGULATOR IS DEFECTIVE

REGULATOR TEST POINTS AND PROPER VOLTAGE

Terminal/Color	Ignition Off	Ignition On	Engine Running
I Brown	0 volts	2 -12 volts	14.2 volts
A Red	12.6 volts	12 volts	14.2 volts
S Orange	0 volts	0 volts	6 - 8 volts
F Blue	0 volts	10 - 11 volts	4 - 12 volts
Alt. Output	12.6 volts	12 volts	14.2 volts

Alternator Testing

The regulator is functioning properly and the batteries are in good condition.

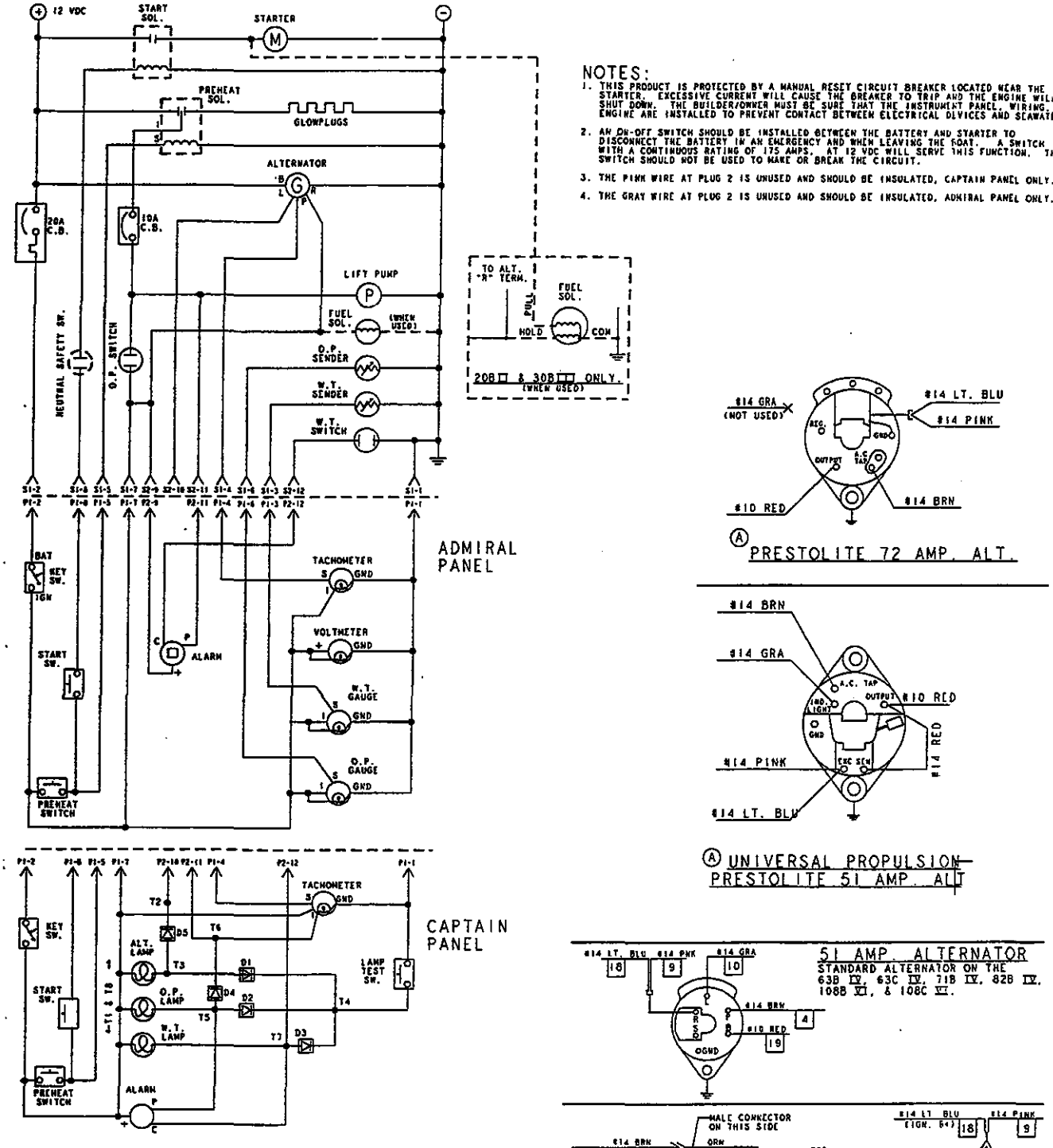
1. Test the voltage at the alternator plug with the **engine off-key on**. The voltage at the alternator terminal **F** and the voltage in the plug [blue wire F] from the regulator should read the same.
2. Hold a screw driver close [1/2"] to the alternator pulley. If voltage is present you should feel the magnetic field. If not, the problem may be the brushes [worn] or the rotor [open circuit].
3. Start the engine, at fast idle the output terminals should indicate 14.2 volts [no load]. A reading of 12.6 would indicate the alternator is not performing properly.

   Apply a load such as an electric bilge pump, the voltage should maintain at least 13.8 volts. 13 volts or less indicates the alternator is faulty.

NOTES:

- ☐ *When the engine is first started, it takes a few moments for the alternator to "kick in" and take the load. There is a noticeable change in the sound of the engine and the RPM gauge will excite.*
- ☐ *A slight whine is normal when running with a full load on the alternator.*
- ☐ *When the alternator is producing high amperage, it will become very hot.*
- ☐ *When replacing the alternator drive belts, always purchase and replace dual belts in matched pairs.*

WIRING SCHEMATIC



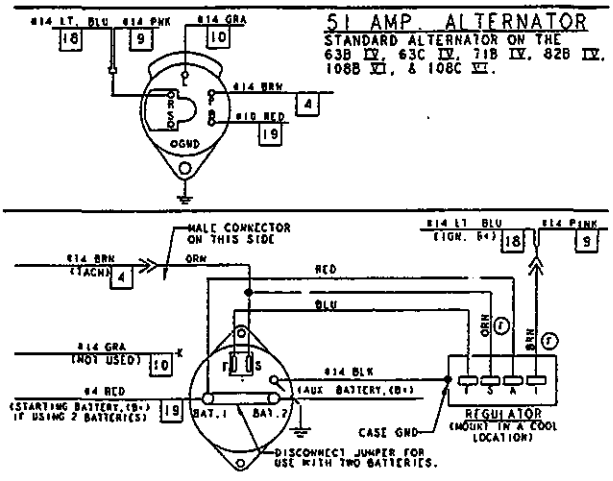
WIRING SCHEMATIC #39144

NOTES:

1. THIS PRODUCT IS PROTECTED BY A MANUAL RESET CIRCUIT BREAKER LOCATED NEAR THE STARTER. EXCESSIVE CURRENT WILL CAUSE THE BREAKER TO TRIP AND THE ENGINE WILL SHUT DOWN. THE BUILDER/OWNER MUST BE SURE THAT THE INSTRUMENT PANEL, WIRING, & ENGINE ARE INSTALLED TO PREVENT CONTACT BETWEEN ELECTRICAL DEVICES AND SEAWATER!
2. AN ON-OFF SWITCH SHOULD BE INSTALLED BETWEEN THE BATTERY AND STARTER TO DISCONNECT THE BATTERY IN AN EMERGENCY AND WHEN LEAVING THE BOAT. A SWITCH WITH A CONTINUOUS RATING OF 175 AMPS, AT 12 VDC WILL SERVE THIS FUNCTION. THIS SWITCH SHOULD NOT BE USED TO MAKE OR BREAK THE CIRCUIT.
3. THE PINK WIRE AT PLUG 2 IS UNUSED AND SHOULD BE INSULATED, CAPTAIN PANEL ONLY.
4. THE GRAY WIRE AT PLUG 2 IS UNUSED AND SHOULD BE INSULATED, ADMIRAL PANEL ONLY.

Ⓐ PRESTOLITE 72 AMP. ALT.

Ⓐ UNIVERSAL PROPULSION PRESTOLITE 51 AMP. ALT

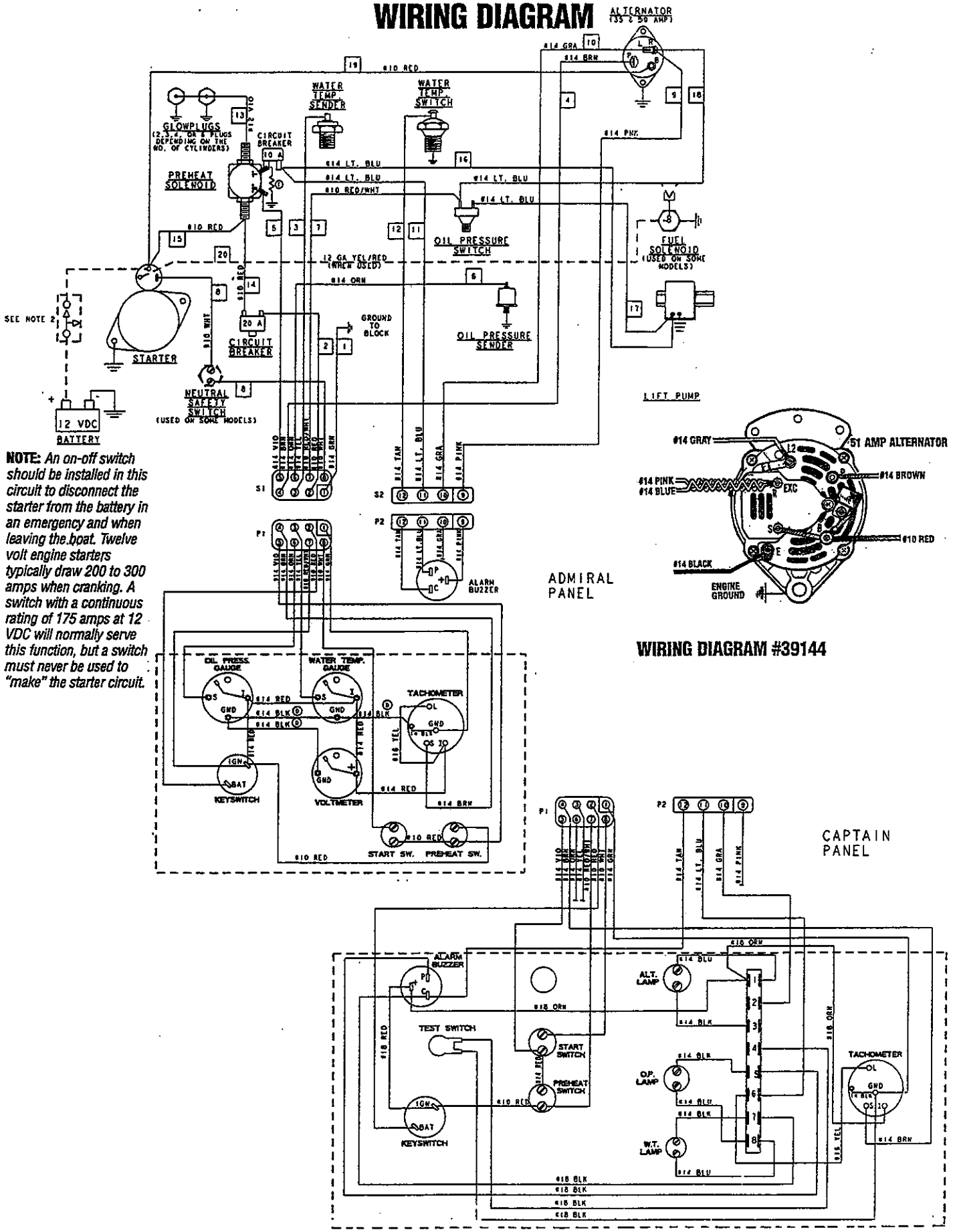


OPTIONAL ALTERNATORS Ⓓ

135A, 160A, 190A, LESTEK ALTERNATORS

AVAILABLE ON THE 63B IV, 63C IV, 71B IV, 82B IV, 108B VI, & 108C VI ONLY

WIRING DIAGRAM



NOTE: *An on-off switch should be installed in this circuit to disconnect the starter from the battery in an emergency and when leaving the boat. Twelve volt engine starters typically draw 200 to 300 amps when cranking. A switch with a continuous rating of 175 amps at 12 VDC will normally serve this function, but a switch must never be used to "make" the starter circuit.*

WIRING DIAGRAM #39144

TACHOMETER/HOUR METER

The tachometer/hour meter used in propulsion engine instrument panels contains two separate electrical circuits with a common ground. One circuit operates the hour meter and the other the tachometer. The hour meter circuit operates on 12 volts alternator charging voltage supplied to the (+) terminal on the back of the instrument.

The tachometer circuit operates on AC voltage 6-8 volts, fed from one of the diodes in the alternator and supplied to the tachometer input terminal while the engine is running, and the alternator producing battery charging voltage 13.0-14.8 volts DC.

The following are procedures to follow when troubleshooting a fault in either of the two circuits in a tachometer/hour meter.

Hour meter Inoperative

Check for the proper DC voltage between (+) and (-) terminals.

1. Voltage present - meter is defective - repair or replace.
2. Voltage not present - trace (+) and (-) electrical connections for fault. (Jump 12 volts DC to meter (+) terminal to verify the operation.)

Tachometer Inoperative

Check for the proper AC voltage between tachometer input terminal and (-) terminal with the engine running.

1. Voltage present - attempt adjusting meter through calibration access hole. No results, repair or replace meter.
2. AC voltage not present - check for proper alternator DC output voltage.
3. Check for AC voltage at tach terminal on alternator to ground.
4. Check electrical connections from tachometer input terminal to alternator connection.

Tachometer Sticking

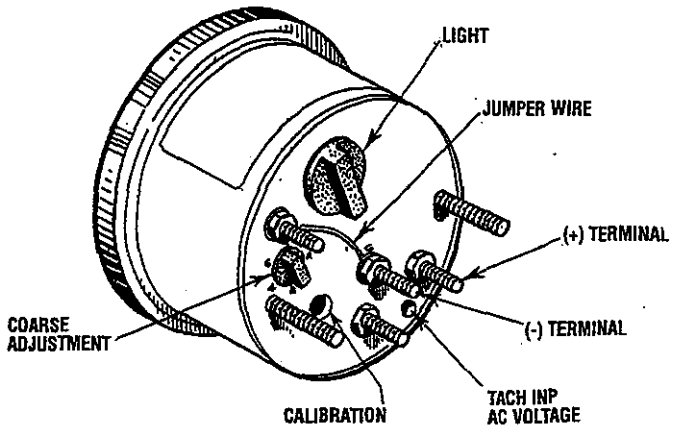
1. Check for proper AC voltage between "tach inp." terminal and (-) terminal.
2. Check for good ground connection between meter (-) terminal and alternator.
3. Check that alternator is well grounded to engine block at alternator pivot bolt.

Tachometer Inaccurate

a. With a hand-held tach on the front of the crankshaft pulley retaining nut or with a strobe-type tach, read the front crankshaft pulley rpm at idle.

b. Adjust the tachometer with a small Phillips type screwdriver through the calibration access hole in the rear of the tachometer. Zero the tach and bring it to the rpm indicated by the strobe or hand tach. (Verify the rpm at idle and at high speed and adjust the tach as needed).

NOTE: *Current model tachometers use a coarse adjustment dial to set the tachometer to the crankshaft pulley rpms. The calibrating screw is then used for fine tuning.*

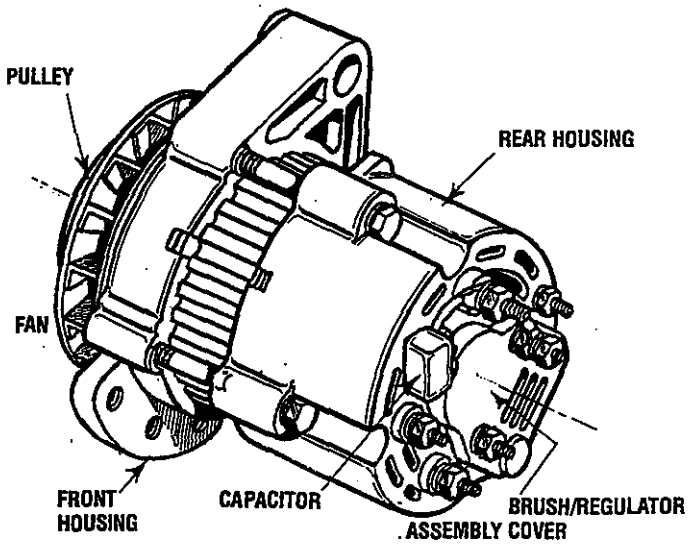


TACHOMETER CHECK (New Installation)

NOTE: *In a new installation having new instrument panels, the tachometer may not always be correctly calibrated to the engine's rpm. This calibration should be checked in all new installations.*

1. Warm up the engine to normal operating temperature. Remove any specks on the crankshaft pulley with a clean cloth and place a piece of suitable reflecting tape on the pulley to facilitate use of a photoelectric type tachometer.
2. Start and idle the engine.
3. Aim the light of the tachometer onto the reflecting tape to confirm the engine speed. Check the instrument panel tachometer reading. Adjust the tachometer in the panel by using the instrument coarse adjustment to calibrate the instrument reading to the closest R.P.M. that the photo tach is showing. Then use the fine calibration adjustment to bring the instrument to the exact reading as the photo tach.

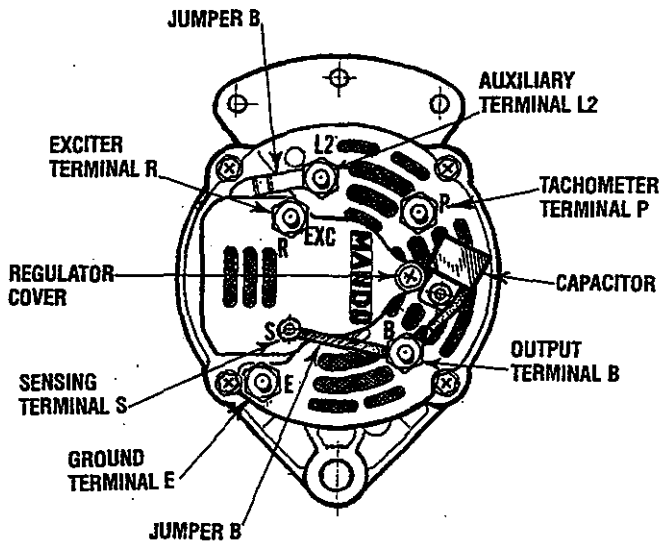
WESTERBEKE 51A MANDO ALTERNATOR
DISASSEMBLY AND TESTING

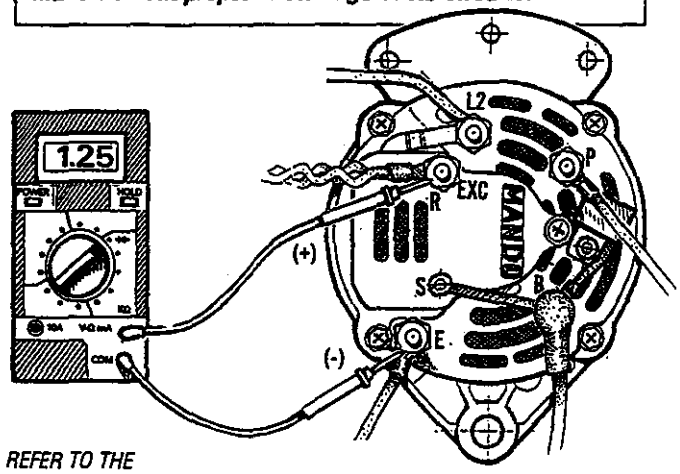


⚠ WARNING: ***A failed alternator can become very hot. Do not touch until the alternator has cooled down.***

⚠ WARNING ***Before starting the engine, make certain that everyone is clear of moving parts! Keep away from sheaves and belts during test procedures.***

⚠ WARNING ***Multimeters and DC Circuits***
DC and AC circuits are ofter mixed together in marine applications. Always disconnect shore power cords, isolate DC and AC converters and shut down generators before performing DC testing. No AC tests should be made without proper knowledge of AC circuits.





REFER TO THE WIRING DIAGRAMS FOR THE ABOVE WIRING HARNESS CONNECTIONS

TESTING THE OUTPUT CIRCUIT

1. Connect the positive voltmeter lead to the output terminal B and connect the negative lead to the ground terminal E on the alternator.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is obtained, or if the reading varies, check the alternator output circuit for loose or dirty connections or damaged wiring.

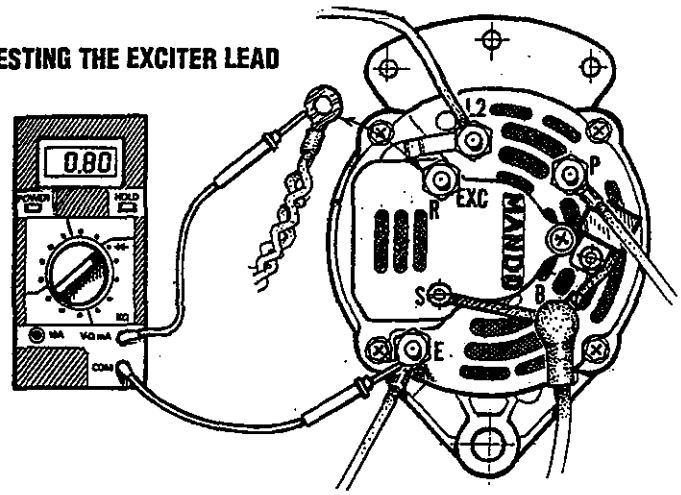
NOTE: *Prior to any alternator testing, inspect the entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly battery cable clamps and battery terminals. Inspect the alternator drive belt for excessive wear and replace if necessary. Also adjust for proper belt tension.*

TESTING THE EXCITATION CIRCUIT

1. Connect the positive (+) voltmeter lead to the excitation terminal R on the alternator and the negative (–) lead to the ground terminal E on the alternator.
2. Turn the ignition switch to the on position and note the voltmeter reading. The reading should be 1.3 to 2.5 volts (see illustration).
3. **If the reading is between .75 and 1.1 volts,** the rotor field circuit probably is shorted or grounded. Disassemble the alternator and test the rotor as described under *CLEAN AND TEST ALTERNATOR COMPONENTS* in this section.
4. **If the reading is between 6.0 and 7.0 volts,** the rotor field circuit probably is open. Remove the regulator and inspect it for worn brushes or dirty slip rings. Replace the brushes if they are less than 1/4in. (6 mm) long. If the brushes and slip rings are in good condition, disassemble the alternator and test the rotor, as outlined under *CLEAN AND TEST ALTERNATOR COMPONENTS* in this section.

MANDO ALTERNATOR SERVICE

TESTING THE EXCITER LEAD



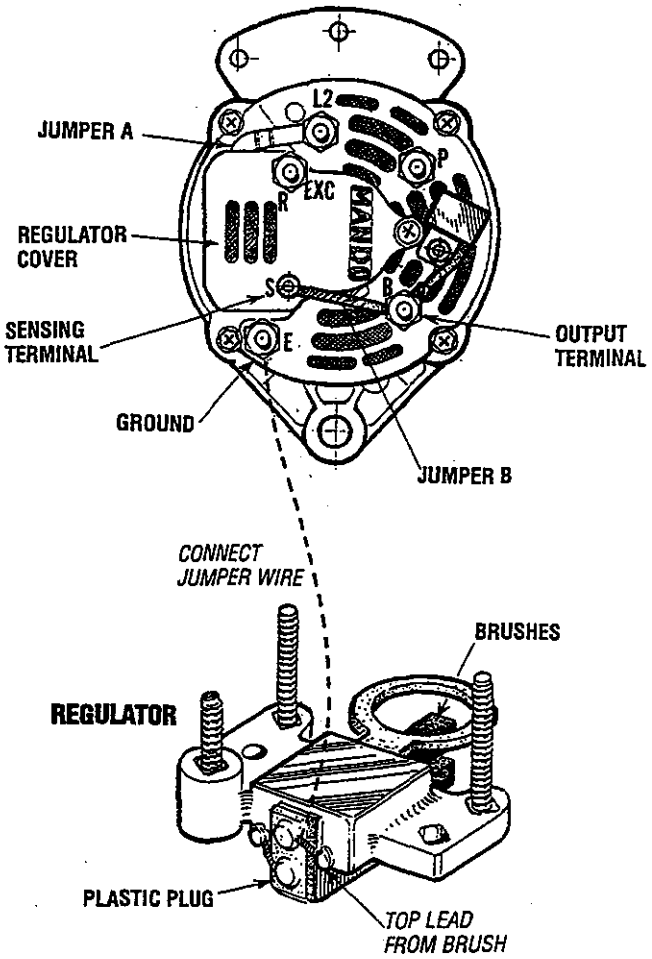
5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal R. Connect the positive voltmeter lead to the excitation lead and the negative voltmeter lead to ground terminal E. If the voltmeter now indicates an approximate battery voltage, the voltage regulator is defective and must be replaced. If no voltage is indicated, check the excitation circuit for loose or dirty connections or damaged wiring.

TEST VOLTAGE REGULATOR

Perform this test to determine if the voltage regulator is operating correctly, using a 0 – 20 volt DC voltmeter.

NOTE: *The battery must be fully charged to obtain a proper voltage reading in this test. If necessary, charge the battery with a battery chargeror allow the engine to run a sufficient length of time to fully charge the battery before taking a reading.*

1. Connect the positive (+) voltmeter lead to the positive battery terminal and the negative (–) voltmeter lead to the negative terminal.
2. Start the engine and run it at fast idle until the engine reaches its normal operating temperature. Adjust the engine speed to 1500 – 2000 rpm and observe the voltmeter for the highest reading. The reading should be between 13.7 and 14.7 volts.
3. If the reading is high, check for a loose or dirty alternator ground lead connection. If the connection is good, the voltage regulator is faulty and must be replaced. Be sure to disconnect the battery cables before attempting to remove the alternator.
4. If the reading is low:
   a. Stop the engine and remove the alternator wiring connections.
   b. Remove the Phillips cover screw from the regulator cover (see illustration).
   c. Remove the nut from the output terminal and the nut from the sensing terminal, and remove Jumper (A).
   d. Remove another nut from the sensing terminal, and the nut from the excitation terminal.
   e. Remove the regulator cover.
   f. Temporarily re-install Jumper (A) and all associated nuts. Leave Jumper (B) installed.
   g. Remove the plastic plug from the side of the regulator.
   h. Connect a jumper between the top brush lead and the ground.



   i. Repeat steps 1 and 2.

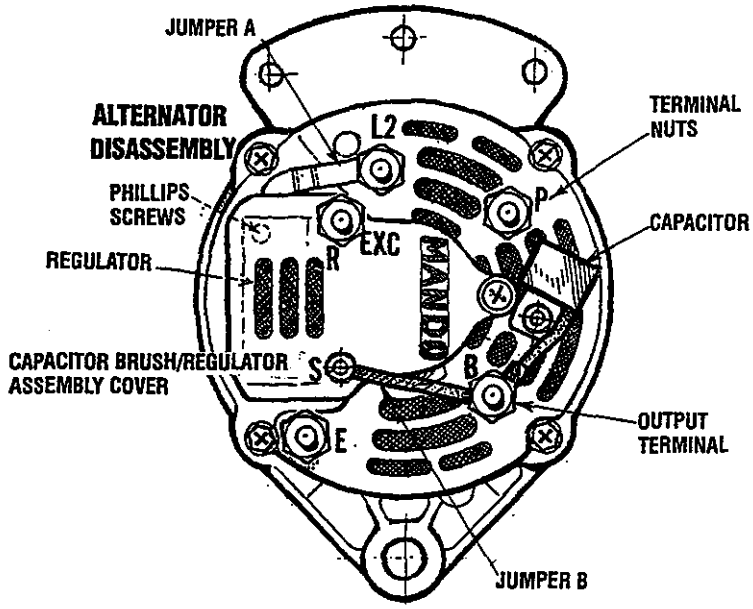
NOTE: *Do not let the voltage exceed 16 volts.*

   j. If a voltmeter reading of 14.5 volts or above is now obtained, the voltage regulator is faulty and must be replaced. If the voltmeter reading is below 14.5 volts, inspect the brushes and slip rings for wear, dirt or damage. If the brushes and slip rings are good, the alternator is fault internally. Disassemble the alternator and test the components, as outlined in this section.

MANDO ALTERNATOR SERVICE

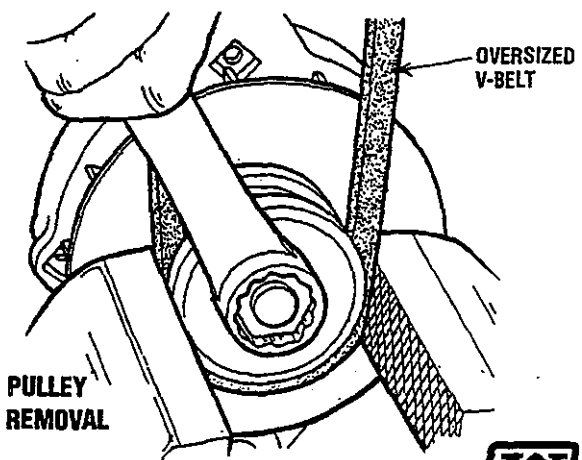
REMOVE ALTERNATOR

1. Disconnect the negative (–) battery ground cable.
2. Disconnect the wiring leads.
3. Loosen the screws. Holding the alternator, rotate it toward the engine and lift the belt off the pulley.
4. Remove the screws and washers and remove the alternator.

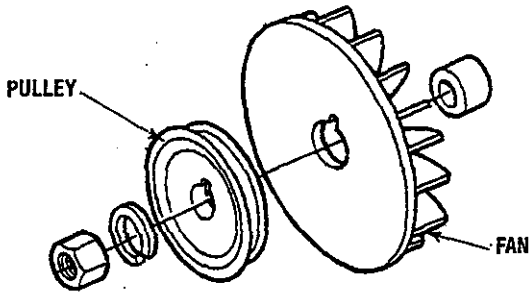


DISASSEMBLE ALTERNATOR

1. Remove the terminal nuts to remove the jumper (see illustration).
2. Remove the remaining terminal nuts.
3. Remove the capacitor.
4. Remove the Phillips screw from the regulator cover.
5. Remove the brush/regulator-assembly cover.
6. Remove the nut from the terminal.
7. Remove the jumper.
8. Remove the terminal insulators.
9. Remove the two Phillips screws and remove the brush/regulator assembly.



10. Place an oversized V-belt around the pulley and fasten the pulley in a vise.
11. Use a 7/8 in. box wrench to loosen and remove the pulley nut.
12. Remove the pulley nut, lockwasher, pulley, fan, and spacer.

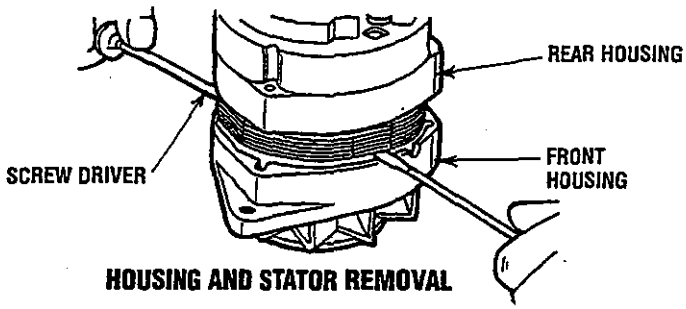


PULLEY AND FAN COMPONENTS

> ⚠ **CAUTION:** ***DO NOT insert screwdriver blades more than 1/16 in. (1.6 mm). Damage to the stator winding could result from deeper penetration.***

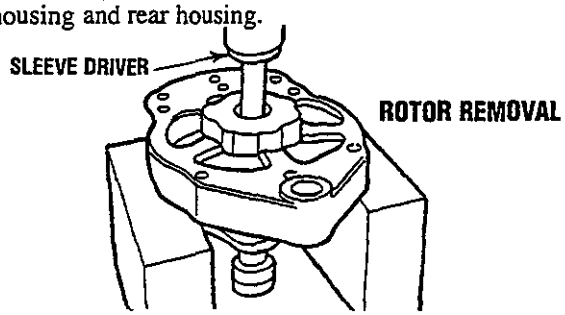
NOTE: *Score the stator, and the front and rear housings so the unit may be reassembled correctly.*

13. Remove the four through-bolts and carefully pry the front housing away from the rear housing using two screwdrivers.



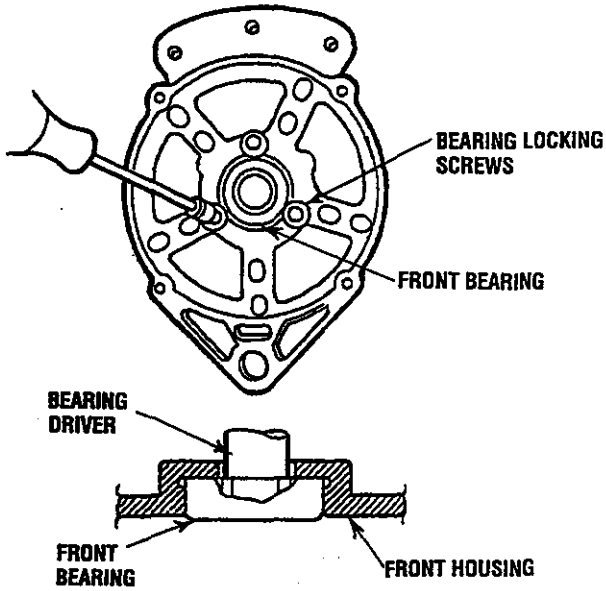
HOUSING AND STATOR REMOVAL

14. Carefully push the rotor assembly out of the front housing and rear housing.

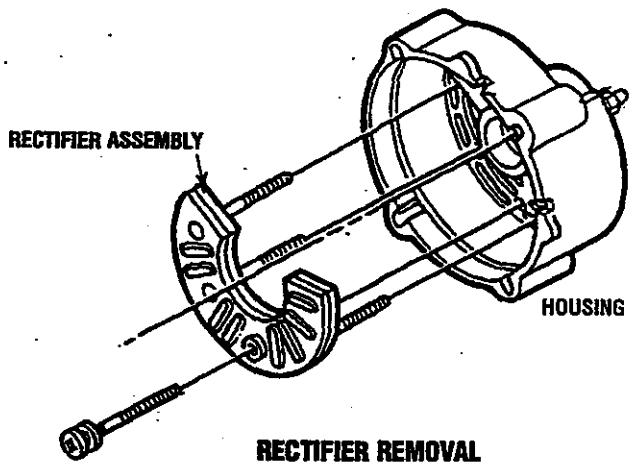


NOTE: *If the bearing is removed from the housing, a new bearing must be installed.*

15. After removing the three bearing locking screws, care fully press the front bearing out of the housing. Press against the inner race of the bearing.



16. Remove the rectifier assembly by removing the Phillips screw and lifting out the assembly.

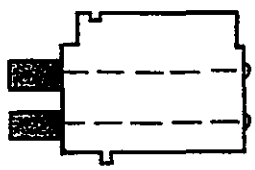


RECTIFIER REMOVAL

CLEAN AND TEST ALTERNATOR COMPONENTS

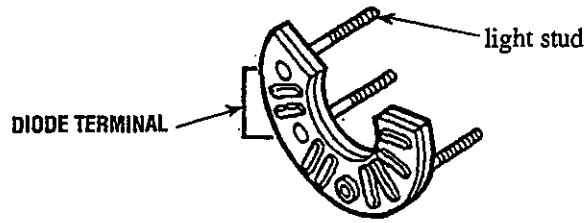
1. Inspect and test the brush/regulator assembly. The brush set may be reused if the brushes are 1/4 in. (6 mm) or longer. The brushes must not be oil soaked, cracked or grooved.

   Test for continuity between 1 and 2, and 3 and 4 using a test lamp or an ohmmeter. These checks will indicate a good brush/regulator assembly; replace the complete assembly, if necessary.



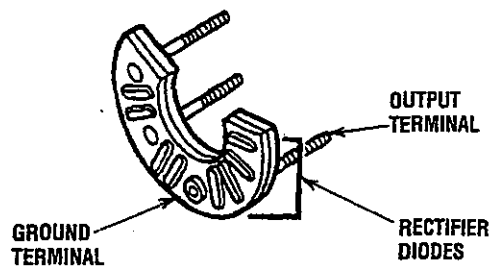
TESTING BRUSH ASSEMBLY

2. Inspect and test the diode-trio assembly:
   a. Using a commercial diode tester, a 12-volt DC test lamp or an ohmmeter, check the resistance between each of the three diode terminals and the indicator light stud.



DIODE TRIO ASSEMBLY

   b. Reverse the tester leads and repeat the resistance checks.
   c. A very low resistance should be indicated in one direction and a very high resistance should be indicated in the other direction if the diodes are normal.
   d. If any diode appears to be defective, replace the complete assembly. Do not attempt to replace an individual diode.
3. Test the diode-rectifier bridge as follows:
   a. Using a commercial diode tester, check for continuity from each of three terminals to the ouput terminal.



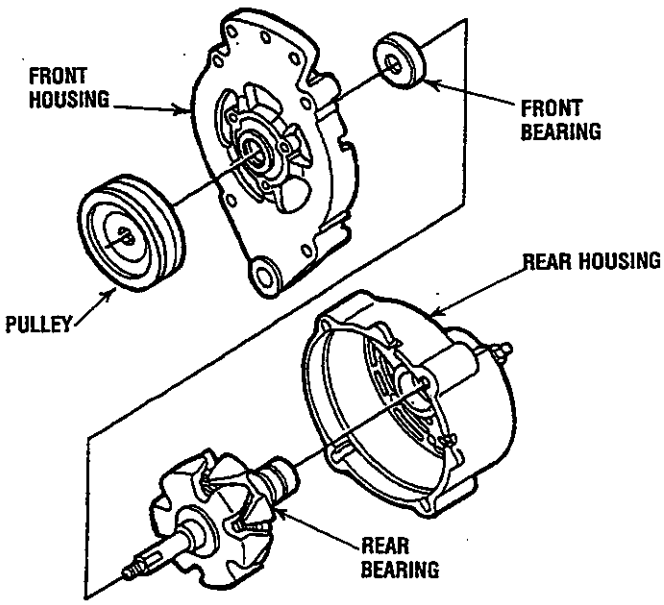
   b. Reverse the tester leads and repeat Step a.
   c. Continuity should exist in only one direction and all diodes should check alike.
   d. Perform the same continuity checks between the three terminals and strap ground terminal. This should show continuity in only one direction through the diodes and all diodes should check alike.
   e. If any diode appears to be defective, replace the rectifier assembly.

4. Clean and inspect the front and rear housings:
   a. Inspect the rear housing for cracks or breaks in the casting, stripped threads or a damaged bearing bore. Replace the housing if any of these conditions exist.
   b. Inspect the front housing for cracks, stripped or damaged threads in the adjusting ear, or an out-of-round bore in the mounting foot. If possible, correct slightly damaged threads using a tap. Replace the housing, if necessary.
   c. If the housings are to be reused, clean them in solvent and dry with compressed air.
5. Clean and inspect the rotor shaft bearings:

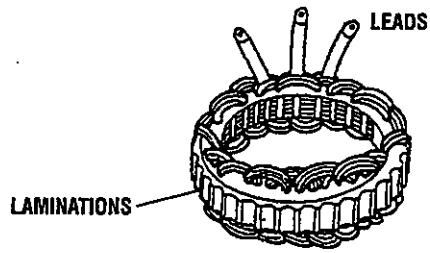
   NOTE: *Do not use a solvent on the rear rotor bearing since it is serviced as a unit with the rotor.*

   a. The bearings should be wiped clean with a lint-free cloth containing a moderate amount of commercial solvent. Do not immerse a bearing in solvent, or use pressurized solvent or air.
   b. Check the bearings for obvious damage, looseness or rough rotation. Replace a bearing if any doubt exists as to its condition.

      NOTE: *If the rear rotor bearing needs replacement, replace the entire rotor.*
6. Inspect the belt pulley for rough or badly worn belt grooves or keyway, and for cracks or breaks. Remove minor burrs and correct minor surface damage; replace a badly worn or damaged pulley.



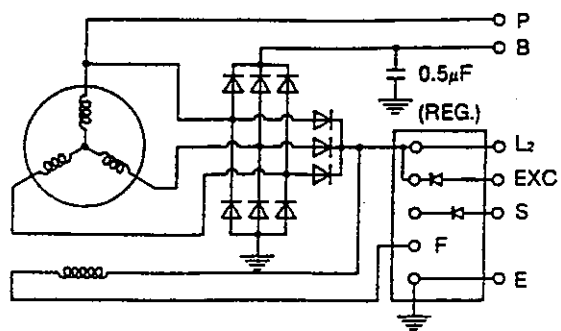
7. Test the stator windings as follows:
   a. Using an ohmmeter or test lamp, check for continuity between all three leads (1, 2, and 3). A low ohm reading or lit test lamp should be observed.



   b. Check the resistance from each lead (1, 2, and 3) to the laminations (4). There should be no continuity if the insulation is good.
   c. Inspect the stator windings for signs of discoloration. A discolored winding should be replaced.
   d. If a winding shows a high resistance or an open circuit between any two of the three winding terminals or indicates poor insulation between the windings and the laminations, the stator must be replaced.
8. Check the rotor assembly as follows:

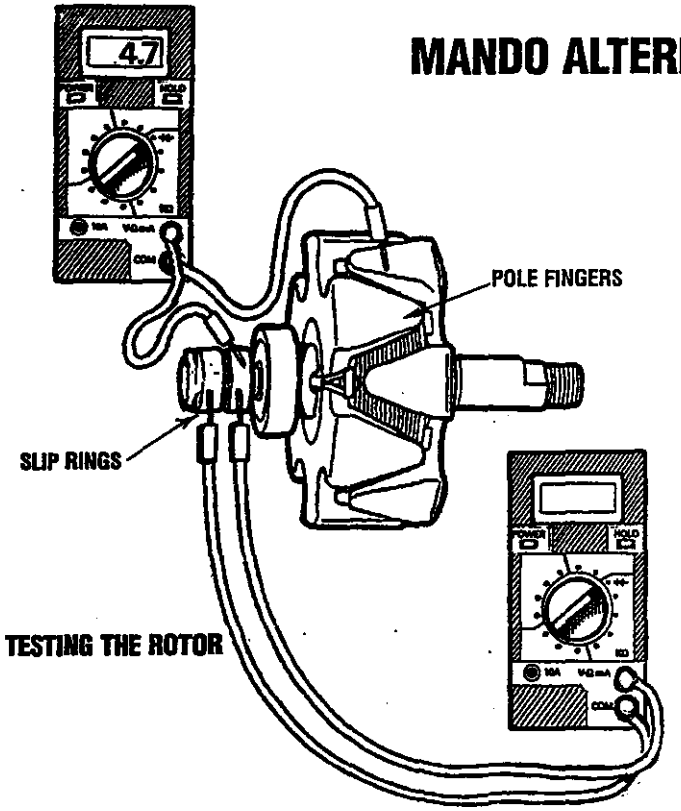
   NOTE: *If slip rings need to be replaced, you must replace the entire rotor.*

   a. Visually inspect for physical defects such as damaged shaft threads, worn or damaged bearing areas, burned or pitted slip rings or scuffed pole fingers.
   b. Measure the winding resistance across the slip rings (A). Place the ohmmeter leads on the edges of the slip rings, not on the brush contact surfaces. The correct winding resistance at 70 – 80° F (21 – 27° C) is 4.1 to 4.7 ohms.
   c. Minor burning or pitting of the slip ring surfaces can be removed using a crocus cloth. Thoroughly wipe the slip rings clean after polishing, removing all grit and dust.
   d. Check for a grounded slip ring or rotor winding by measuring the resistance from each slip ring to the rotor body or pole finger (B). An open circuit should be indicated in both cases for a good rotor.
   e. If the windings are defective or physical damage cannot be corrected, replace the rotor assembly.
9. Use a commercial capacitor checker to test the capacitor for capacity, shorts, leakage, and series resistance.



INTERNAL CIRCUIT WIRING

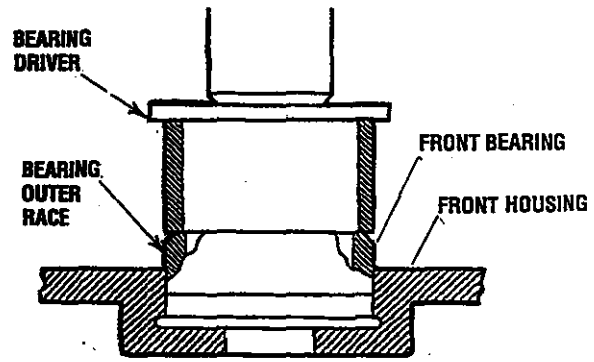
MANDO ALTERNATOR SERVICE



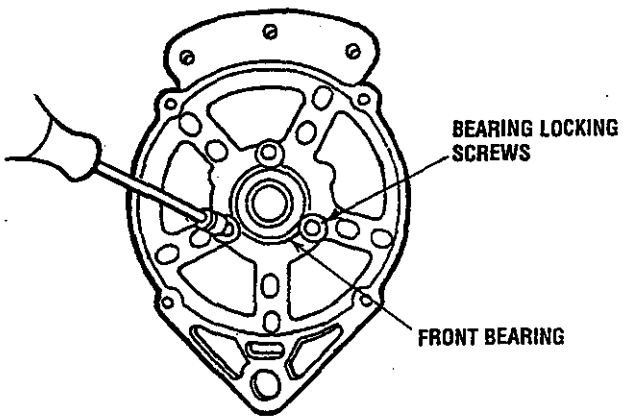
TESTING THE ROTOR

ASSEMBLE ALTERNATOR

1. Carefully press the front bearing into the front housing, pushing against the bearing's outer race using a bearing driver. Lock the bearing in place with screws.
   TORQUE: 25 - 35 lb-in (2.8 - 4.0 Nm)

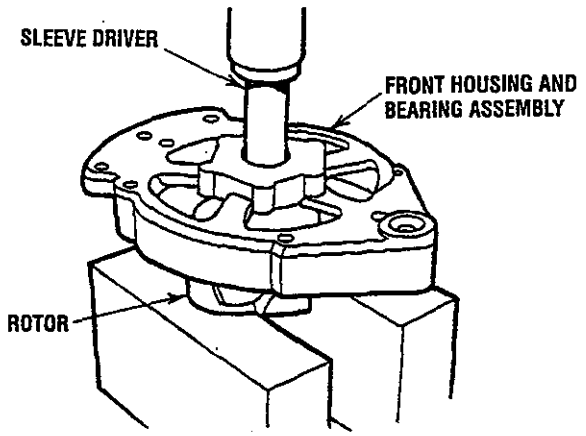


FRONT BEARING ASSEMBLY



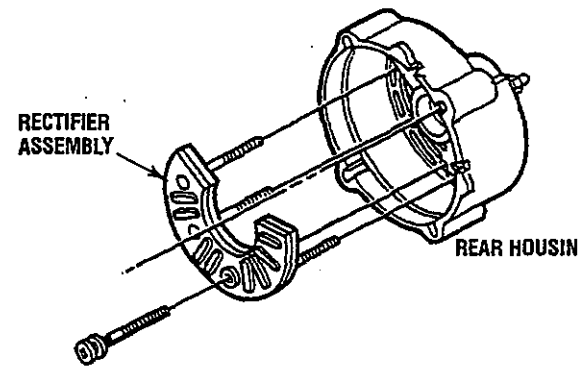
ASSEMBLING THE BEARINGS

2. Place the rotor (pulley end up) on the bed of an arbor press, on two steel blocks.
3. Press the front housing and bearing assembly down onto the rotor shaft. Press against the bearing's inner race only, using a sleeve driver. Take care to insure that the rotor leads clear the steel blocks.



INSTALLING THE FRONT HOUSING ON THE ROTOR ASSEMBLY

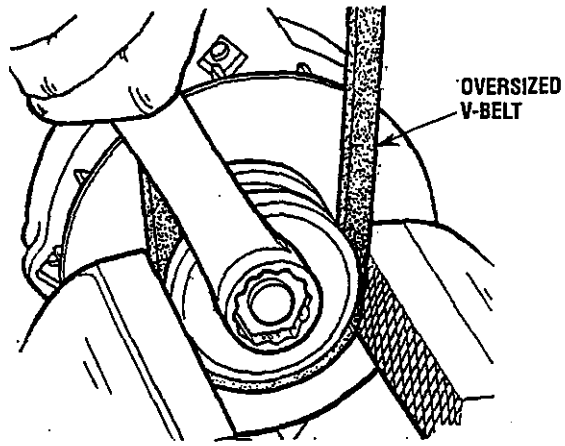
4. Install the rectifier assembly into the rear housing.
5. Insert the Phillips screw and tighten it.



6. Assemble the front and rear housings as follows:
   a. Put the stator winding in the front housing with the stator leads away from the front housing and the notches in the stator laminations aligned with the four through-bolt holes in the housing.
   b. Align the scribe marks you made in the stator, and front and rear housings during disassembly.
   c. Slip the rear housing into place over the rotor shaft. Align the mounting holes and put the stator leads through the holes at the top of the rear housing.
   d. Install the four bolts and tighten them.
      TORQUE: 35 - 65 lb-ft (4.0 - 7.3 Nm)

      NOTE: *If the front housing is new, the through-bolt will not be tapped.*

7. Install the spacer and the fan. Then push the pulley, lockwasher and nut onto the shaft. Turn the nut a few turns.
8. Place an oversized V-belt around the pulley and fasten the pulley in a vise.



INSTALLING THE PULLEY AND THE FAN NUT

9. Use a torque wrench to the tighten the nut.
   TORQUE: 35 - 50 lb-ft (47 - 68 Nm)
10. Carefully install the brush/regulator assembly on the rear housing with the two mounting screws.
11. Install the small terminal insulators.
12. Install the large terminal insulator.
13. Install the jumper.
14. Install the nut on the terminal.
15. Install the brush/regulator assembly cover.
16. Install the Phillips screw for the brush/regulator assembly cover.
    TORQUE: 25 - 35 lb-ft (2.8 - 5.1 Nm)
17. Install the capacitor.
18. Install the terminal nuts.
19. Install the jumper.
20. Install the last terminal nut.

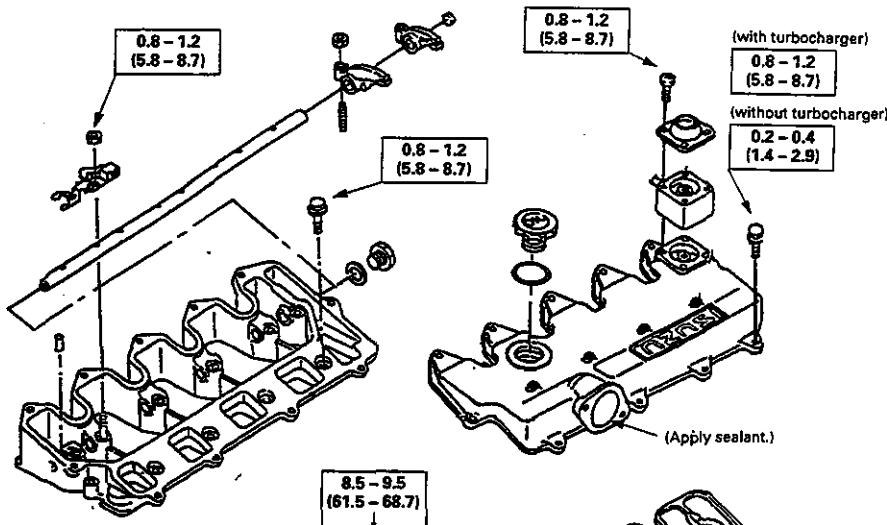
INSTALL ALTERNATOR

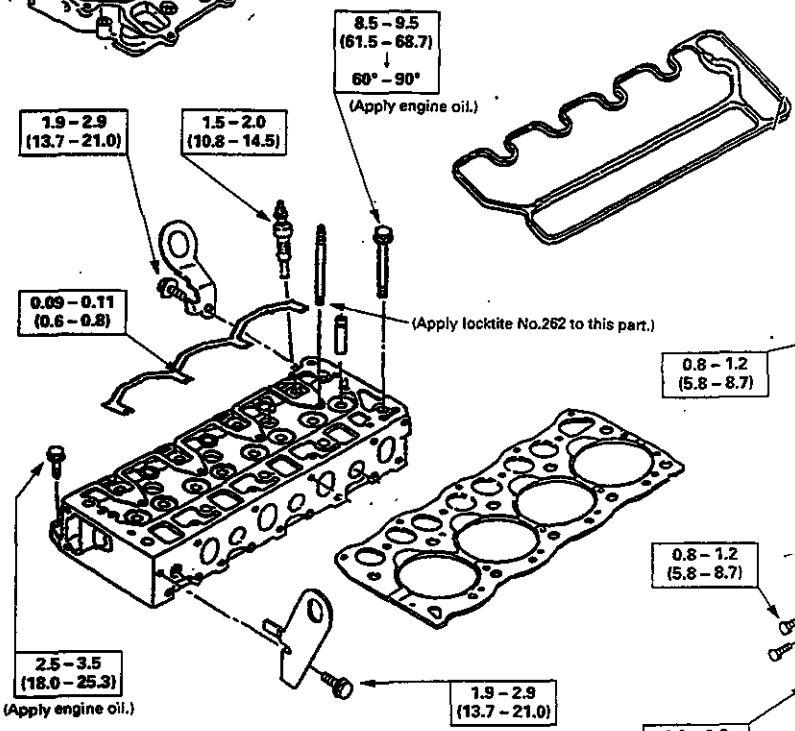
1. Install the alternator, screws and washers.
2. Connect the wiring leads.
3. Put the belt on the alternator, crankshaft and coolant pump pulleys.
4. Adjust the alternator belt's tension (see *DRIVE BELT ADJUSTMENT* under *ENGINE ADJUSTMENTS*).

MANDO ALTERNATOR SPECIFICATIONS	
Battery Voltage	12 Volt
Maximum Speed	13500 RPM
Cut in Speed	Max. 2000 RPM (at exc.) Max. 1500 RPM (at L2)
Reg. Set Voltage	14.7 Volts
Ambient Temp.	-20°C - 100°C
Ground	Negative

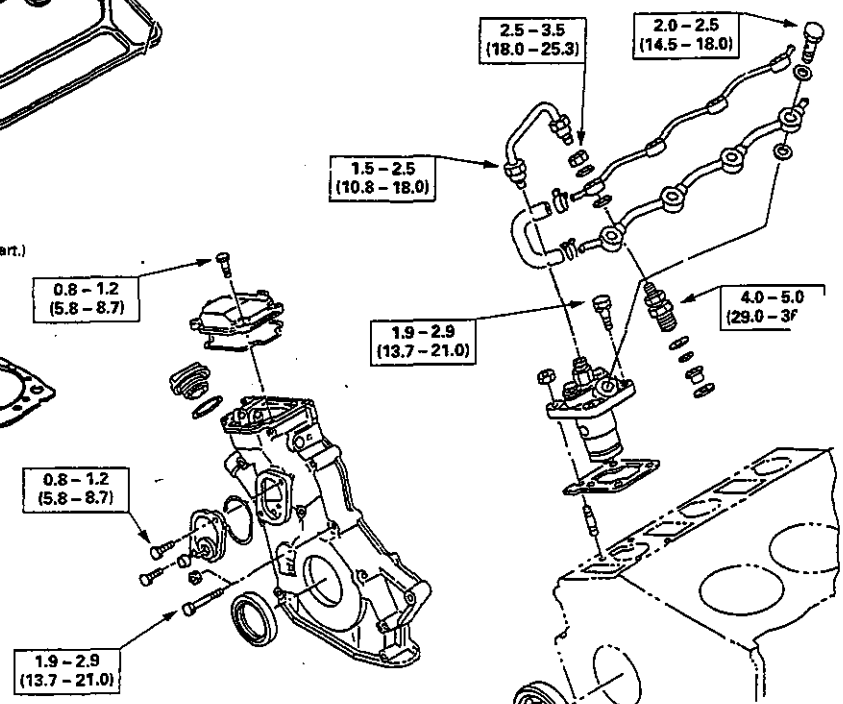
TORQUE DATA

Kg-m (lb-ft)

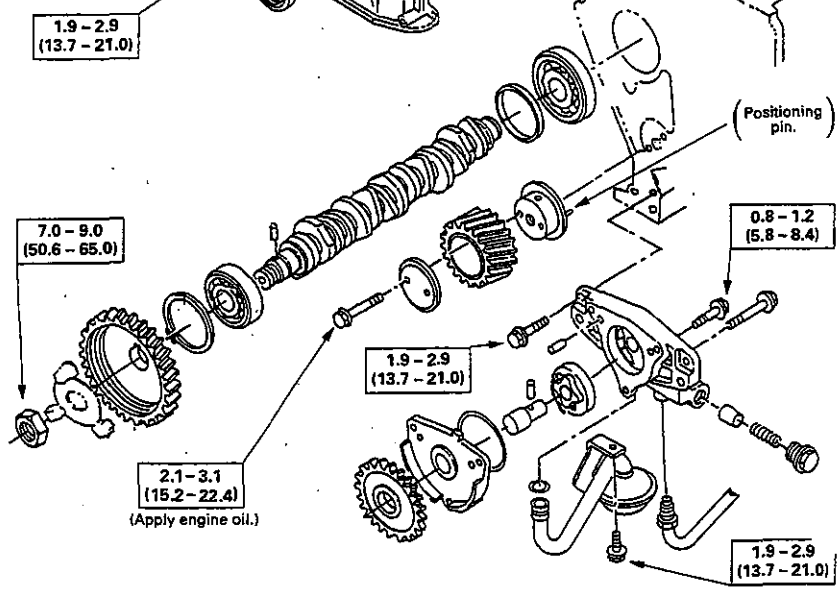




CYLINDER BLOCK AND OTHER COMPONENTS



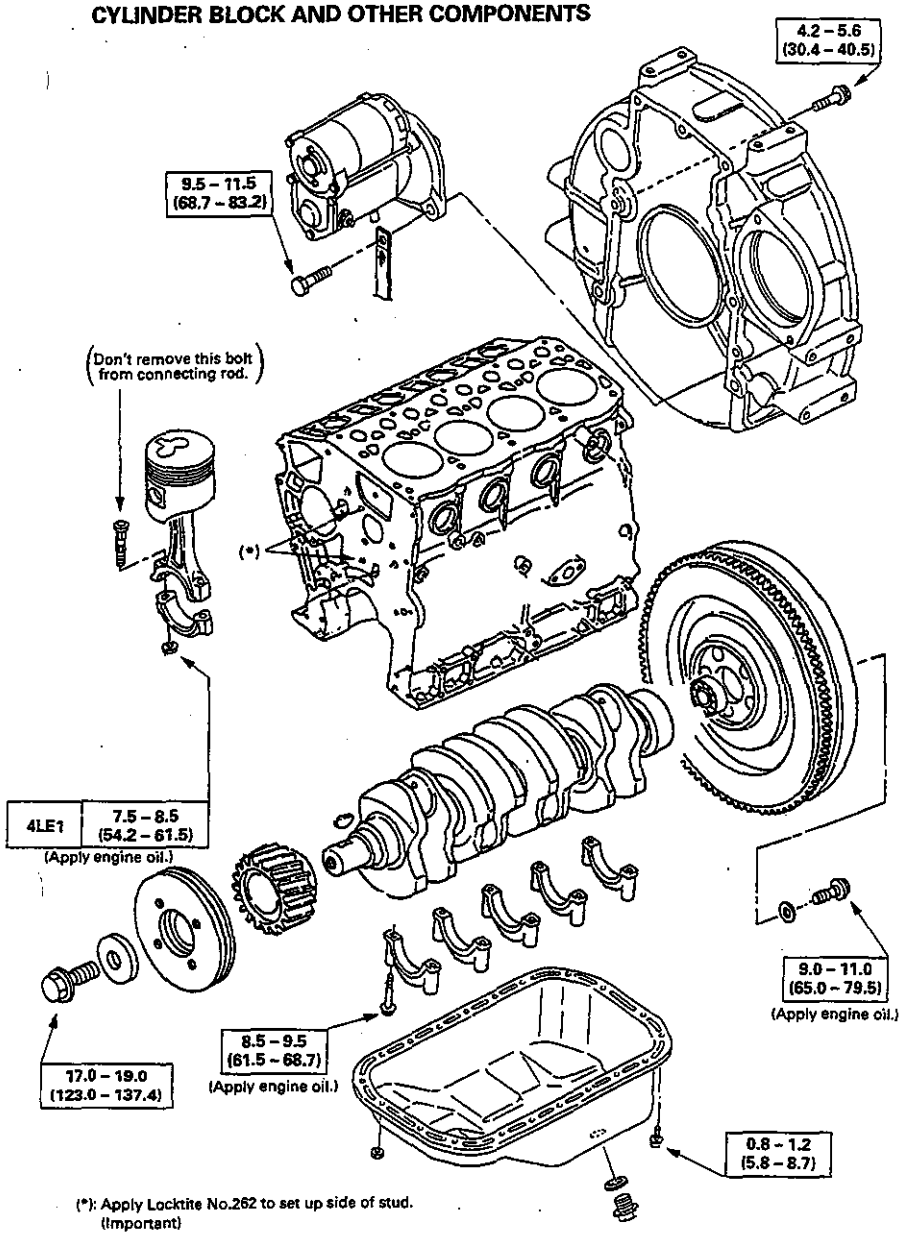
CYLINDER HEAD AND CYLINDER HEAD COVER



TORQUE DATA

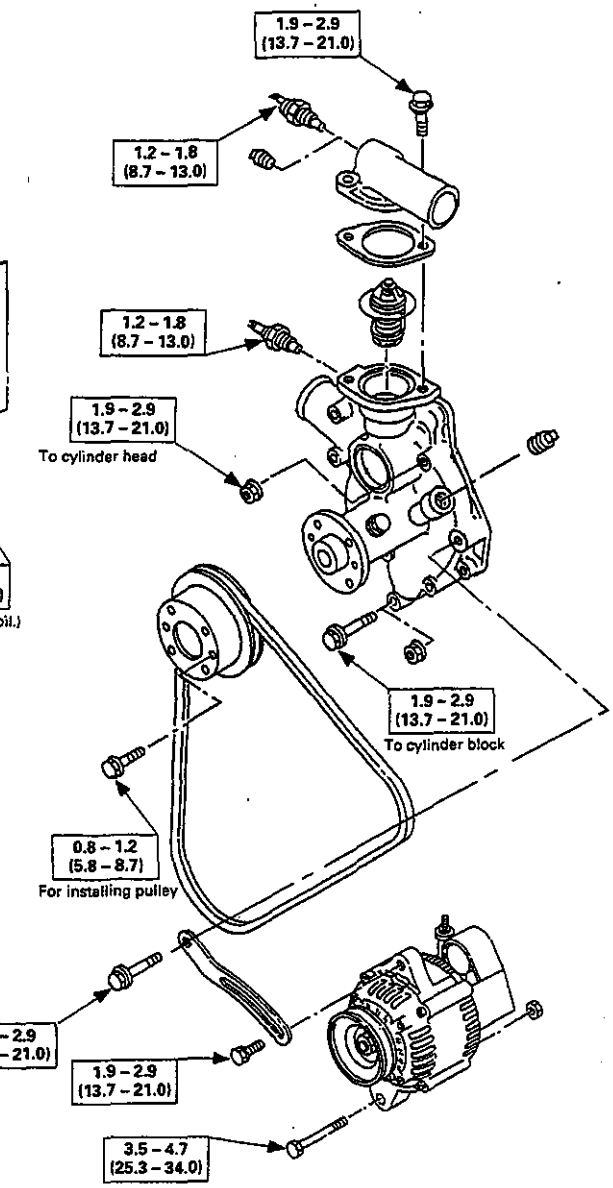
Kg-m (lb-ft)

CYLINDER BLOCK AND OTHER COMPONENTS



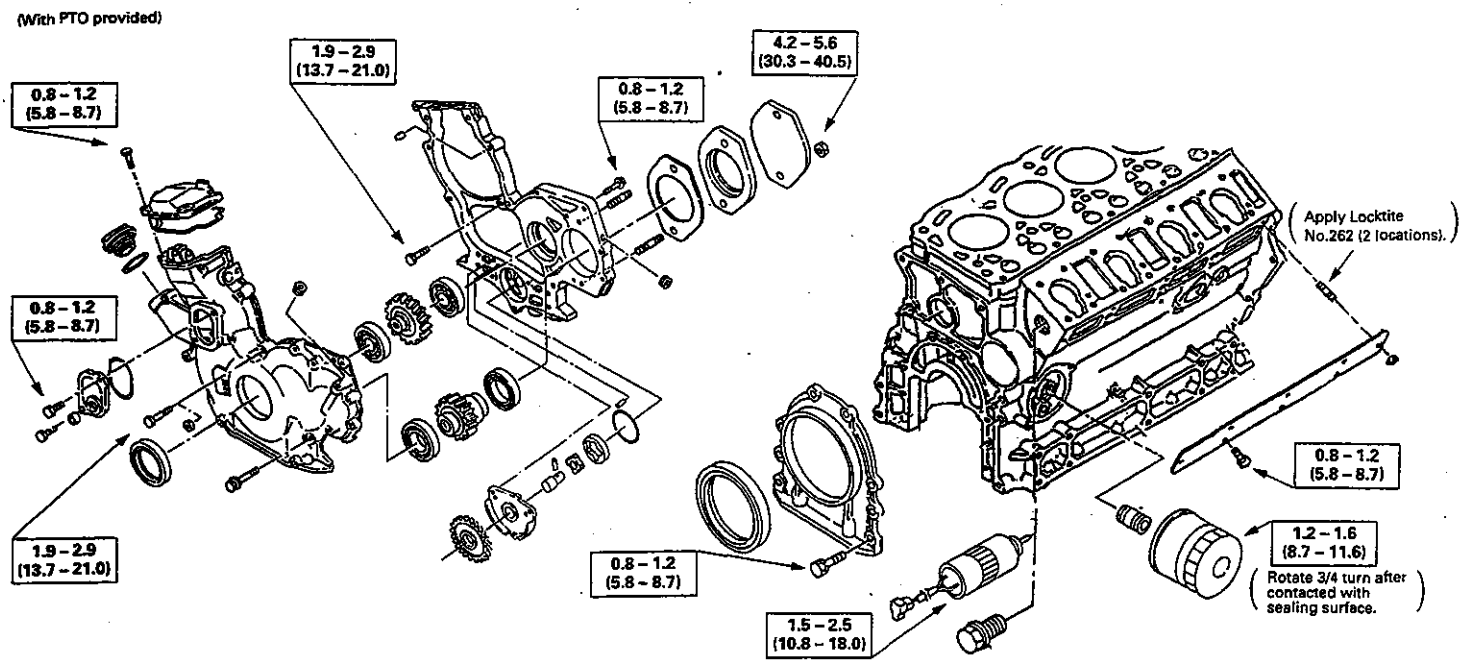
(*): Apply Locktite No.262 to set up side of stud.
(Important)

COOLING FAN AND WATER PUMP



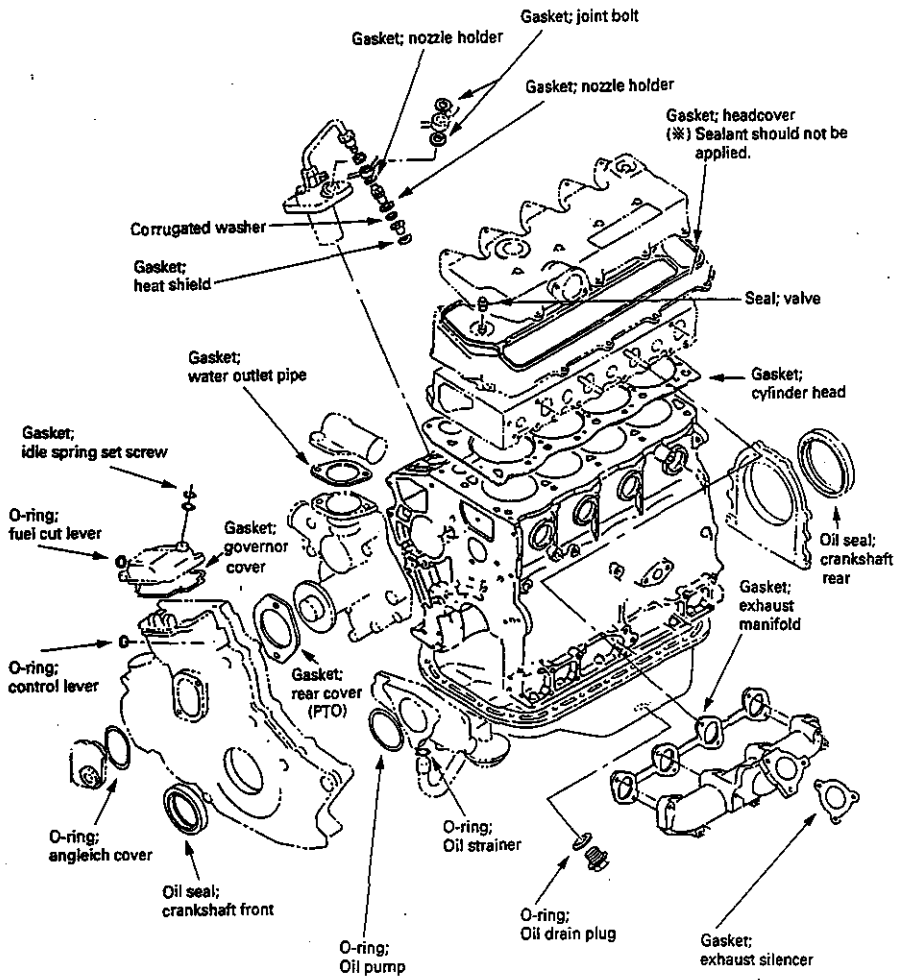
TORQUE DATA

Kg-m (lb-ft)



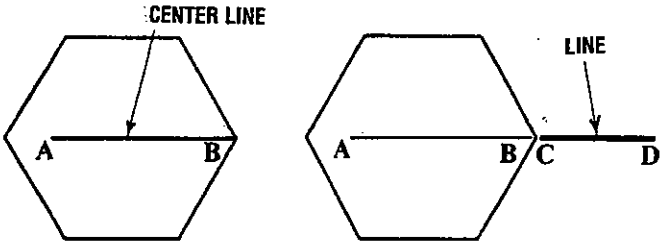
GASKET LOCATION

LOCATIONS WHERE GASKETS ARE USED

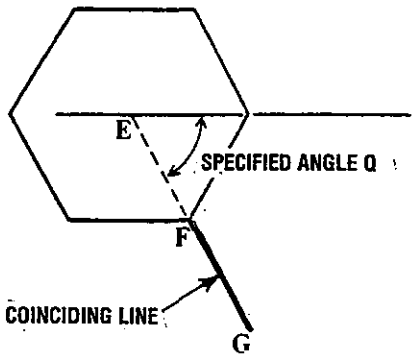


ANGULAR NUT AND BOLT TIGHTENING METHOD

1. Carefully wash the nuts and bolts to remove all oil and grease.
2. Apply a coat of molybdenum disulfide grease to the threads and setting faces of the nuts and bolts.
3. Tighten the nuts and bolts to the specified torque (snug torque) with a torque wrench.



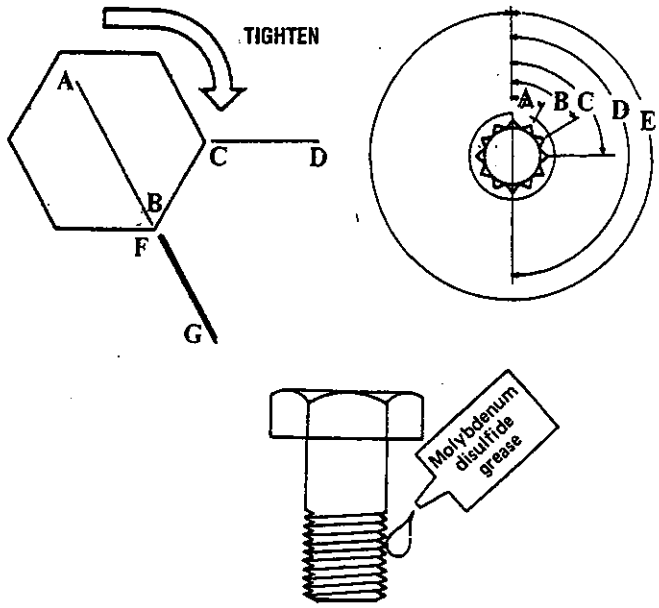
4. Draw a line (A-B) across the center of each bolt.
5. Draw another line (C-D) on the face of each of the parts to be clamped. This line should be an extension of the line (A-B).



6. Draw another line (F-G) on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center (E) of the nut or bolt.
7. Use a socket wrench to tighten each nut or bolt to the point where the line (A-B) is aligned with the line (F-G).

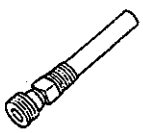
Example: Specified Angle and Tightening Rotation

A	30°	1/12 of a turn
B	60°	1/6 of a turn
C	90°	1/4 of a turn
D	180°	1/2 of a turn
E	360°	One full turn



Apply a coat of molybdenum disulfide grease to the threads and setting faces of the nuts and bolts.

TOOLS AND TESTING GEAR



COMPRESSION GAUGE ADAPTER

REAR OIL SEAL SETTING TOOL WITH DRIVE HANDLE

FRONT OIL SEAL SETTING TOOL WITH DRIVE HANDLE

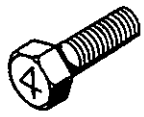
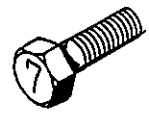
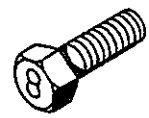
VALVE GUIDE SEAL SETTING TOOL

CONTACT THE WESTERBEKE CORPORATION FOR INFORMATION ON THESE AND OTHER SPECIAL TOOLS

STANDARD BOLTS / TIGHTENING TORQUE SPECIFICATIONS

NOTE: *The torque values given in the following table should be applied where a particular torque is not specified.*

kg-m

Bolt identification / Bolt diameter × pitch (mm)					
M 6 × 1.0	0.6 ±0.2	0.7 $^{+0.2}_{-0.3}$	0.8 $^{+0.2}_{-0.3}$	0.9 $^{+0.2}_{-0.3}$	———
M 8 × 1.25	1.3 ±0.5	1.6 $^{+0.4}_{-0.6}$	1.8 $^{+0.5}_{-0.6}$	2.1 $^{+0.5}_{-0.7}$	2.4 ±0.7
M10 × 1.25	2.8 ±0.7	3.3 $^{+0.8}_{-0.9}$	3.8 $^{+0.9}_{-1.0}$	4.3 ±0.9	5.1 ±1.3
*M10 × 1.5	2.7 ±0.7	3.2 ±0.8	3.7 ±0.9	4.2 ±1.0	4.9 ±1.2
M12 × 1.25	6.2 $^{+1.3}_{-1.2}$	6.7 $^{+1.4}_{-1.3}$	7.7 $^{+1.6}_{-1.5}$	8.8 $^{+1.8}_{-1.7}$	9.7 $^{+1.9}_{-2.0}$
*M12 × 1.75	5.8 ±1.2	6.3 ±1.2	7.2 ±1.4	8.2 ±1.6	9.1 ±1.8
M14 × 1.5	9.7 $^{+2}_{-1.9}$	10.4 $^{+2}_{-2.1}$	11.9 $^{+2.3}_{-2.4}$	13.6 $^{+2.6}_{-2.8}$	14.5 ±2.9
*M14 × 2.0	9.1 ±1.8	9.8 ±1.9	11.2 ±2.2	12.8 ±2.5	13.6 ±2.7
M16 × 1.5	13.3 +2.7	15.1 ±3.1	17.3 ±3.5	19.7 ±4.0	20.4 ±4.1
*M16 × 2.0	12.7 ±2.5	14.4 ±2.9	16.5 ±3.3	18.8 ±3.8	19.5 ±3.9
M18 × 1.5	19.2 ±3.8	21.7 $^{+4.4}_{-4.3}$	24.9 ±5.0	28.4 ±5.7	29.3 ±5.9
*M18 × 2.5	19.2 ±3.8	21.8 $^{+4.4}_{-4.3}$	25.0 ±5.0	28.5 ±5.7	29.4 $^{+5.9}_{-5.8}$
M20 × 1.5	26.3 ±5.3	30.0 $^{+6.1}_{-6}$	34.4 ±6.9	39.2 $^{+7.9}_{-7.8}$	40.4 ±8.1
*M20 × 2.5	24.3 ±4.9	27.8 $^{+5.5}_{-5.6}$	31.8 ±6.4	36.3 $^{+7.2}_{-7.3}$	37.4 ±7.5
M22 × 1.5	32.0 $^{+10.2}_{-6.4}$	40.4 ±8.1	46.3 $^{+9.2}_{-9.3}$	52.8 $^{+10.5}_{-10.6}$	54.1 ±10.8
*M22 × 2.5	27.8 ±5.6	37.6 ±7.5	43.1 ±8.6	49.1 ±9.8	50.3 ±10.1
M24 × 2.0	45.8 ±9.2	47.9 $^{+15.4}_{-9.6}$	54.9 $^{+17.6}_{-11.0}$	62.6 $^{+20.1}_{-12.6}$	70.6 ±14.1
*M24 × 3.0	43.1 ±8.6	45.1 ±9.0	51.7 ±10.3	58.9 $^{+11.8}_{-11.7}$	66.4 ±13.3

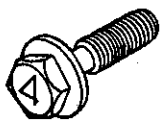
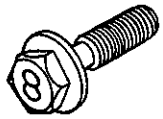
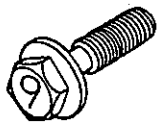
NOTE: *Bolts marked with an asterisk are used for female threaded parts made of soft materials such as castings.*

TIGHTENING TORQUE SPECIFICATIONS

NOTE: *The torque values given in the following table should be applied where a particular torque is not specified.*

FLANGED HEAD BOLT

kg·m (lb.ft/N·m)

Bolt head marking / Nominal size (dia. x pitch)			
M6 x 1	0.5~0.9 (3.61~6.50/4.6~8.5)	0.6~1.2 (4.33~8.67/5.88~11.76)	———
M8 x 1.25	1.1~2.0 (7.95~14.46/10.78~19.61)	1.4~2.9 (4.33~8.67/5.88~11.76)	1.9~3.4 (13.74~24.59/18.63~33.34)
M10 x 1.25	2.3~3.9 (17.35~28.20/23.53~38.24)	3.6~6.4 (26.03~44.12/35.30~59.82)	4.3~7.2 (31.10~52.07/42.16~70.60)
*M10 x 1.5	2.3~3.8 (16.63~27.48/22.55~37.26)	3.5~5.8 (25.31~41.95/34.32~56.87)	4.1~6.8 (29.65~49.18/40.20~66.68)
M12 x 1.25	5.6~8.4 (40.50~60.75/54.91~82.37)	7.9~11.9 (57.14~86.07/77.47~116.69)	8.7~13.0 (62.92~94.02/85.31~127.48)
*M12 x 1.75	3.5~9.5 (37.61~56.41/50.99~76.49)	7.3~10.9 (52.80~78.83/71.58~106.89)	8.1~12.2 (58.58~88.24/79.43~119.64)
M14 x 1.5	8.5~12.7 (61.48~91.85/83.35~124.54)	11.7~17.6 (84.62~127.30/114.73~172.59)	12.6~18.9 (91.13~136.70/123.56~185.34)
*M14 x 2	7.6~11.5 (57.14~85.34/77.47~115.71)	11.1~16.6 (80.28~120.06/108.85~162.79)	11.8~17.7 (85.34~128.02/115.71~173.57)
M16 x 1.5	11.8~17.7 (85.34~128.02/115.71~173.57)	17.1~26.5 (125.85~189.50/170.63~256.93)	18.0~27.1 (130.19~196.01/176.52~265.76)
*M16 x 2	11.2~16.7 (81.00~120.79/109.83~163.77)	16.6~24.9 (120.06~180.10/162.79~244.18)	17.2~25.7 (124.40~186.61/168.67~253.01)

A bolt with an asterisk (*) is used for female screws of soft material such as cast iron.

STANDARD AND METRIC CONVERSION DATA

LENGTH-DISTANCE

Inches (in) x 25.4 = Millimeters (mm) x .0394 = Inches
Feet (ft) x .305 = Meters (m) x 3.281 = Feet
Miles x 1.609 = Kilometers (km) x .0621 = Miles

DISTANCE EQUIVALENTS

1 Degree of Latitude = 60 Nm = 111.120 km
1 Minute of Latitude = 1 Nm = 1.852 km

VOLUME

Cubic Inches (in^3) x 16.387 = Cubic Centimeters x .061 = in^3
Imperial Pints (IMP pt) x .568 = Liters (L) x 1.76 = IMP pt
Imperial Quarts (IMP qt) x 1.137 = Liters (L) x.88 = IMP qt
Imperial Gallons (IMP gal) x 4.546 = Liters (L) x .22 = IMP gal
Imperial Quarts (IMP qt) x 1.201 = US Quarts (US qt) x .833 = IMP qt
Imperial Gallons (IMP gal) x 1.201 = US Gallons (US gal) x .833 = IMP gal
Fluid Ounces x 29.573 = Milliliters x .034 = Ounces
US Pints (US pt) x .473 = Liters(L) x 2.113 = Pints
US Quarts (US qt) x .946 = Liters (L) x 1.057 = Quarts
US Gallons (US gal) x 3.785 = Liters (L) x .264 = Gallons

MASS-WEIGHT

Ounces (oz) x 28.35 = Grams (g) x .035 = Ounces
Pounds (lb) x .454 = Kilograms (kg) x 2.205 = Pounds

PRESSURE

Pounds Per Sq In (psi) x 6.895 = Kilopascals (kPa) x .145 = psi
Inches of Mercury (Hg) x .4912 = psi x 2.036 = Hg
Inches of Mercury (Hg) x 3.377 = Kilopascals (kPa) x .2961 = Hg
Inches of Water (H_2O) x .07355 = Inches of Mercury x 13.783 = H_2O
Inches of Water (H_2O) x .03613 = psi x 27.684 = H_2O
Inches of Water (H_2O) x .248 = Kilopascals (kPa) x 4.026 = H_2O

TORQUE

Pounds-Force Inches (in-lb) x .113 = Newton Meters (Nm) x 8.85 =in-lb
Pounds-Force Feet (ft-lb) x 1.356 = Newton Meters (Nm) x .738 = ft-lb

VELOCITY

Miles Per Hour (MPH) x 1.609 = Kilometers Per Hour (KPH) x .621 = MPH

POWER

Horsepower (Hp) x .745 = Kilowatts (Kw) x 1.34 = MPH

FUEL CONSUMPTION

Miles Per Hour IMP (MPG) x .354 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = IMP MPG
Miles Per Gallons US (MPG) x .425 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = US MPG

TEMPERATURE

Degree Fahrenheit (°F) = (°C X 1.8) + 32
Degree Celsius (°C) = (°F - 32) x .56

LIQUID WEIGHTS

Diesel Oil = 1 US gallon = 7.13 lbs
Fresh Water = 1 US gallon = 8.33 lbs
Gasoline = 1 US gallon = 6.1 lbs
Salt Water = 1 US gallon = 8.56 lbs

ENGLISH TO METRIC CONVERSION CHART

Multiply Temperature	By	To get equivalent number of:
Degree Fahrenheit (°F)	(°F-32) ÷ 1.8	Degree Celsius °C)
Multiply Acceleration	**By**	**To get equivalent number of:**
Foot/second^2(ft/sec^2)	0.3048	Meter/second^2(m/s^2)
Inch/second^2(in./sec^2)	0.0254	Meter/second^2 (m/s^2)
Multiply Torque	**By**	**To get equivalent number of:**
Pound-inch (lb·in.)	0.11298	Newton-meters (N·m)
Pound-foot (lb·ft)	1.3558	Newton-meters (N·m)
Multiply Power	**By**	**To get equivalent number of:**
Horsepower (hp)	0.746	Kilowatts (kW)
Multiply Pressure or Stress	**By**	**To get equivalent number of:**
Inches of water (in. H_2O)	0.2491	Kilopascals (kPa)
Pounds/square in. (lb/in.^{2})	6.895	Kilopascals (kPa)
Multiply Energy or Work	**By**	**To get equivalent number of:**
British Thermal Unit (Btu)	1055	Joules (J)
Foot-pound (ft·lb)	1.3558	Joules (J)
kilowatt-hour (kW·hr)	3,600,000. or 3.6×10^6	Joules (J = one W/s)
Multiply Light	**By**	**To get equivalent number of:**
Foot candle (fc)	1.0764	Lumens/meter^2(lm/m^2)
Multiply Fuel Performance	**By**	**To get equivalent number of:**
Miles/gal (mile/gal)	0.4251	Kilometers/liter (km/L)
Gallons/mile (gal/mile)	2.3527	Liter/kilometer (L/km)
Multiply Velocity	**By**	**To get equivalent number of:**
Miles/hour (mile/hr)	1.6093	Kilometers/hour (km/hr)

Multiply Length	By	To get equivalent number of:
Inch (in.)	25.4	Millimeters (mm)
Foot (ft)	0.3048	Meters (m)
Yard (yd)	0.9144	Meters (m)
Mile (mile)	1.609	Kilometers (km)
Multiply Area	**By**	**To get equivalent number of:**
Inch^2(in.^{2})	6452	Millimeters^2(mm^2)
Inch^2(in.^{2})	6.45	Centimeters^2(cm^2)
Foot^2(ft^2)	0.0929	Meters^2(m^2)
Yard^2(yd^2)	0.8361	Meters^2(m^2)
Multiply Volume	**By**	**To get equivalent number of:**
Inch^3(in.^{3})	16387	Millimeters^3(mm^3)
Inch^3(in.^{3})	16.387	Centimeters^3(cm^3)
Inch^3(in.^{3})	0.0164	Liters (L)
Quart (qt)	0.9464	Liters (L)
Gallon (gal)	3.785	Liters (L)
Yard^3(yd^3)	0.7646	Meters^3(m^3)
Multiply Mass	**By**	**To get equivalent number of:**
Pound (lb)	0.4536	Kilograms (kg)
Ton (ton)	907.18	Kilograms (kg)
Ton (ton)	0.907	Tonne (t)
Multiply Force	**By**	**To get equivalent number of:**
Kilogram (kg)	9.807	Newtons (N)
Ounce (oz)	0.2780	Newtons (N)
Pound (lb)	4.448	Newtons (N)

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