SERVICE MANUAL

71B-FOUR / 71C-FOUR
MARINE DIESEL ENGINES
and
20.0KW-60Hz/16.0KW-50Hz BED
20.0KW-60Hz/16.0KW-50Hz BEDA
MARINE DIESEL GENERATORS
SINGLE AND THREE PHASE

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WESTERBEKE

WESTERBEKE CORPORATION • MYLES STANDISH INDUSTRIAL PARK
150 JOHN HANCOCK ROAD • TAUNTON MA 02780-7319 • TEL. 1-508-823-7677
FAX 1-508-884-9688 • WEBSITE: WWW.WESTERBEKE.COM

CALIFORNIA
PROPOSITION 65 WARNING

Diesel engine exhaust 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.

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 vessel's AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessel's 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 vessel's 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 are securely attached and no warping exists. Pay close attention to the manifold, water injection elbow, and exhaust pipe nipple.
- Be sure the unit and its surroundings are well ventilated.
- In addition to routine inspection of the exhaust system, install a carbon monoxide detector. 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

  Dizziness

  Throbbing in temples

  Muscular twitching

  Intense headache

  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.

SAFETY INSTRUCTIONS

- Do not wear loose clothing or jewelry when servicing equipment; 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 belt's 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.

ENGINE 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 UNIVERSAL engine

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

Order From:

ABYC
15 East 26th Street
New York, NY 10010

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

Order From:

NFPA
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101

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 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 18" 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.***

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.

WESTERBEKE
Engines & Generators

TABLE OF CONTENTS

INTRODUCTION

PRODUCT SOFTWARE

Product software (tech 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 also keep in mind the time span between printings of WESTERBEKE product software and the unavoidable existence of earlier WESTERBEKE manuals. 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.

NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the disassembly, inspection and assembly procedure of your engine/generator, critical information will be highlighted by NOTES, CAUTIONS, and WARNINGS. An explanation follows:

NOTE: *An operating procedure essential to note.*

⚠ CAUTION: ***Procedures, which if not strictly observed, can result in the damage or destruction of your engine/generator.***

⚠ WARNING: ***Procedures, which if not properly followed, can result in personal injury or loss of life.***

ORDERING PARTS

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

CUSTOMER IDENTIFICATION CARD

WESTERBEKE

Customer Identification
WESTERBEKE OWNER
MAIN STREET
HOMETOWN, USA

Model 71C Ser. #UOOOO-D702
Expires 4/4/98

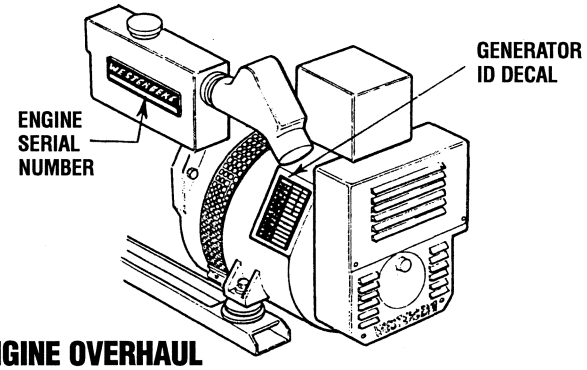
The WESTERBEKE serial number is an alphanumeric number that can assist in determining the date of manufacture of your WESTERBEKE engine/generator. The first character indicates the decade (A=1960s, B=1970s, C=1980s, D=1990s), the second character represents the year in the decade, and the fourth and fifth number represents the month of manufacture.

SERIAL NUMBER LOCATION

The engine and generator serial numbers and model numbers are located on a decal on the generator housing.

The engine serial number can also be found stamped into the engine block just above the injection pump. The generator serial number is stamped into the generator housing on the flat surface on the left side of the generator.

An identification plate on the engine manifold also displays the engine model and serial number.



ENGINE OVERHAUL

The following sections contain detailed information relating to the proper operation characteristics of the major components and systems of the engine. Included are disassembly, inspection and reassembly instructions for the guidance of suitable equipped and staffed marine engine service and rebuilding facilities. The necessary procedures should be undertaken only by such facilities.

Additional detailed information and specifications are provided in other sections of this manual, covering the generator, alternator, starter motor, engine adjustments, cooling pumps, etc.

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, in the case of diesel engines, is not necessarily due to trouble with the engine itself, but is sometimes caused by injector nozzle wear or injection pump wear. It is most reasonable to judge by a decrease in compression pressure. 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 plugs and nozzles. 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. In diesel engines, 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.*

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 valves are at minimum or below. *Engine compression should be 30 kg/cm2, 427 psi at 200 rpm.*

Precautions for Disassembly and Reassembly

When servicing an engine, keep in mind the following precautions.

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.

Reassembly

1. Clean or wash the parts. Apply oil on surfaces where needed or specified.
2. Carefully check gaskets, packings and oil seals even if checking is not specified. Replace with new ones if defective.
3. Be sure to install components in proper directions and positions. (Pay attention to dowel pins, mating marks and specified directions.) Where tightening torque is not specified, tighten evenly to an ordinary torque. Apply sealant where specified.
4. After completion of reassembly, recheck for any abnormalities. Prepare for starting the engine, and idle the engine sufficiently for a test run.

ENGINE TROUBLESHOOTING

The following *ENGINE TROUBLESHOOTING* section may be of assistance in determining the need for planning and engine overhaul.

SERVICE MANUAL

The engine block of the 71C-FOUR differs from it's predecessor, the 71B-FOUR, with variations in service data (tolerances, limits and torques). In this service manual **71B** or **71C** designates this service data and a small 71B or 71C will identify the artwork. Components that are common to both engines such as the Raw Water Pump will have no designation.

The 71B-FOUR engine powers the 20.0KW BED generator. The 71C-FOUR engine powers the 20.0KW BEDA generator.

NOTE: *Make certain the engine model has been correctly identified, see* SERIAL NUMBER LOCATION.

ENGINE TROUBLESHOOTING

The following troubleshooting table describes certain problems relating to engine service, the probable causes of these problems, and the recommendations to overcome these problems.

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.
	6. Defective main drive section.	**6.** Check clutch for disengagement.
	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.
	5. Governor spring out fo POSITION	**5.** Correct spring
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 plug.	**4.** Retighten plug.
	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.	
	a. Worn plunger.	**a.** Replace.
	b. Pinion is not in mesh with control rack.	**b.** Correct.
	c. Broken delivery valve spring.	**c.** Replace.
	d. Worn delivery valve seat.	**d.** Replace.
	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. Fuel pipe sucks air.	**2.** Retighten pipe joints or replace pipe.
	3. Water mixed in fuel	**3.** 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

GENERATOR

Disconnect the AC wiring, unplug the DC wiring harness at the control panel and remove the speed sensor from the bellhousing. Carefully support and then unbolt the generator back end from the engine.

For generator maintenance and service, refer to the *GENERATOR SECTION* of this manual.

PROPULSION ENGINE

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.

For transmission service and maintenance refer to your transmission owners manual.

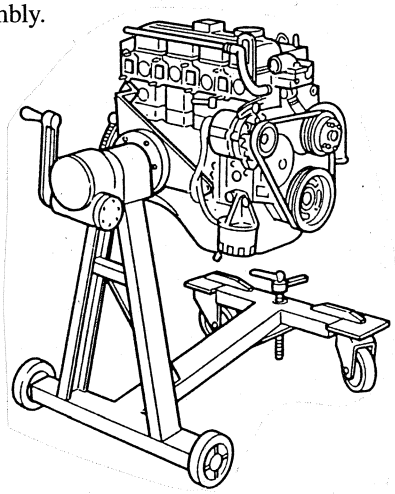
To rebuild a transmission contact your WESTERBEKE dealer or your local marine transmission shop.

With the transmission or generator separated from the engine, begin the following step by step procedure of engine disassembly.

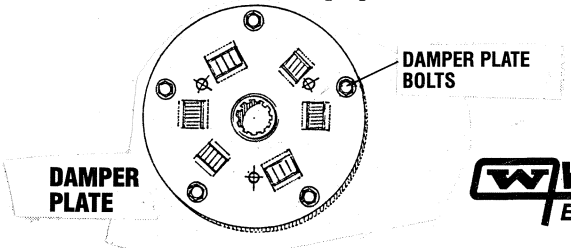
ENGINE DISASSEMBLY

Take the following precautions:

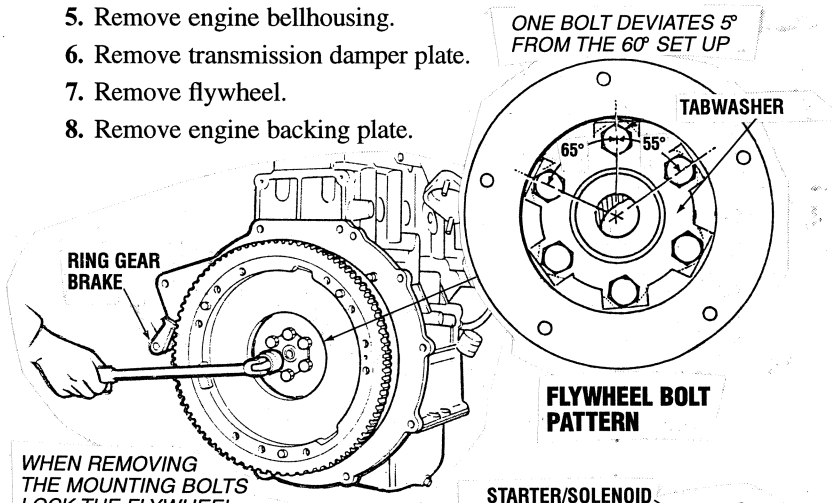
- Clean the exterior of the engine of any deposits of dirt and oil.
- Be careful not to damage the disassembled parts.
- Arrange parts in the order of disassembly. Mark or label parts as needed to insure proper mating and reassembly. Keep parts clean.
- Mount the engine on suitable engine stand for disassembly.

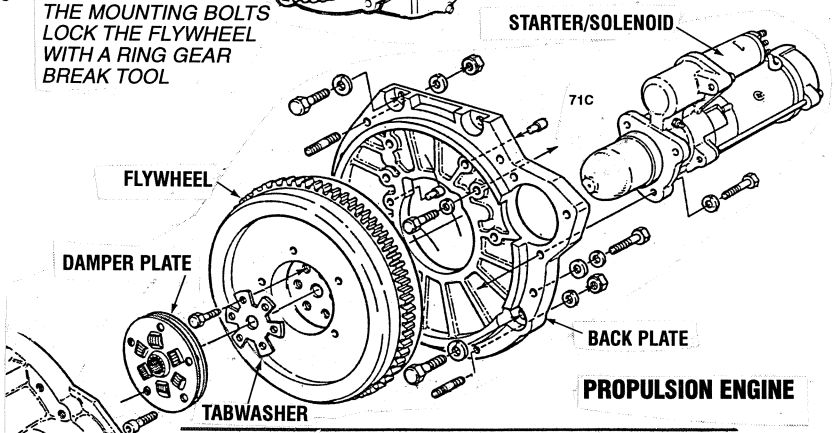


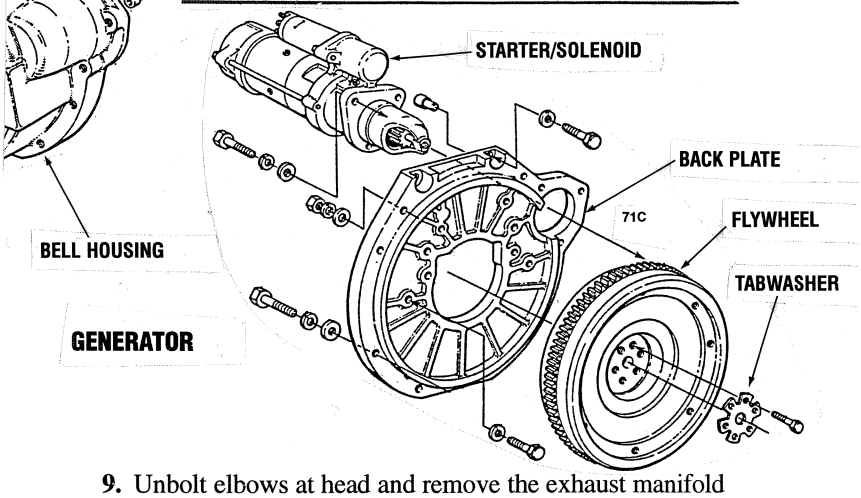
1. Drain the engine oil and coolant from the engine and heat exchangers.
2. Remove engine wiring harness in its entirety. Label terminal connections to insure proper reattachment.



3. Remove engine heat exchanger and engine cooler. If possible, leave one end of each hose connection attached to the part being removed.
4. Remove starter motor.
5. Remove engine bellhousing.
6. Remove transmission damper plate.
7. Remove flywheel.
8. Remove engine backing plate.







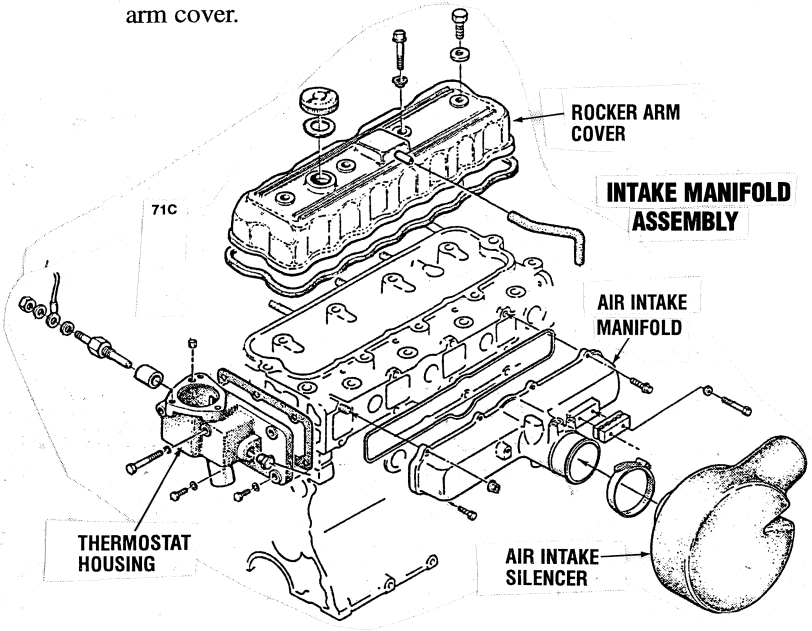
9. Unbolt elbows at head and remove the exhaust manifold in its entirety.
10. Remove the engine alternator and raw water pump.
11. Remove the engine mounted fuel filter and fuel line to injection pump. (Note the arrangement of sealing washers on banjo bolts at fuel filter and injection pump.)

ENGINE DISASSEMBLY

12. Remove the thermostat housing and the thermostat. Leave temperature sending unit in place.
13. Remove the coolant circulating pump.
14. Remove the air intake silencer.
15. Remove all the high pressure injector lines from the injection pump to the injectors. Leave the two upper line clamps in place.

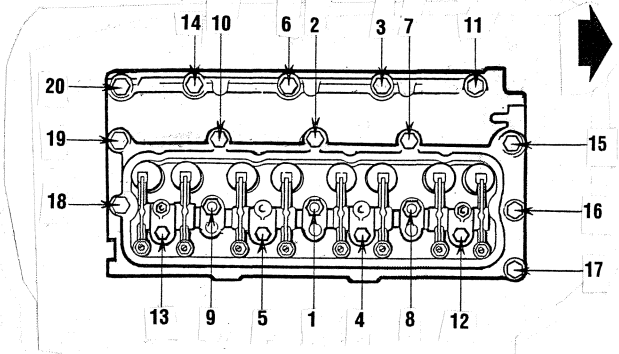
NOTE: *Cap the ends of the lines and the connections at the injection pump and at the injectors to prevent entry of foreign material.*

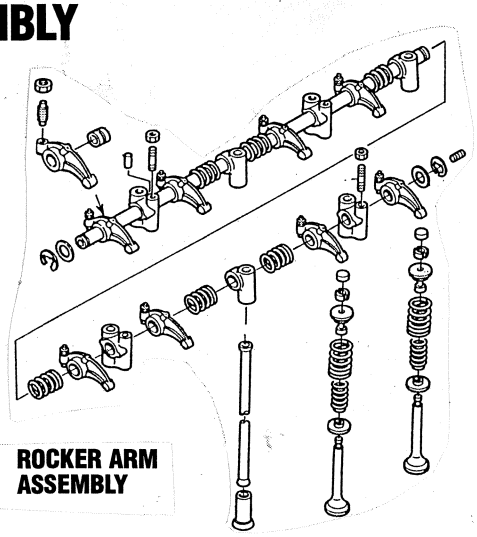
16. Remove the intake manifold.
17. Remove the fuel return line from the top of the injectors and from the fuel injection pump. (Note the washer arrangement on fuel return line banjo bolts. Cap all the openings on the fuel return line, injectors and injection pump.)
    a. Remove the fuel injectors, dust seals and sealing washers from the cylinder head.
    b. Remove the glow plugs.
18. Remove the crankcase breather hose and rocker arm cover.



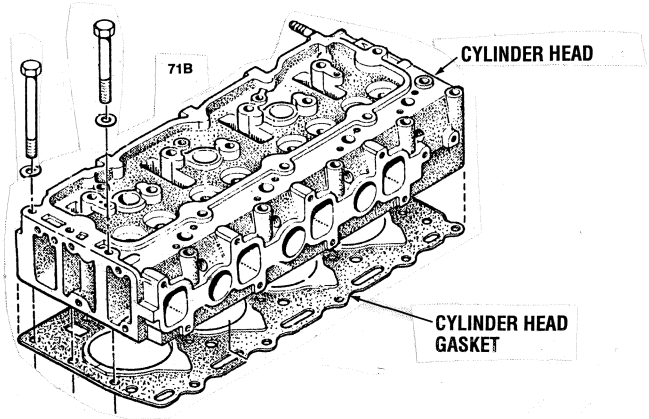
19. Remove the cylinder head.

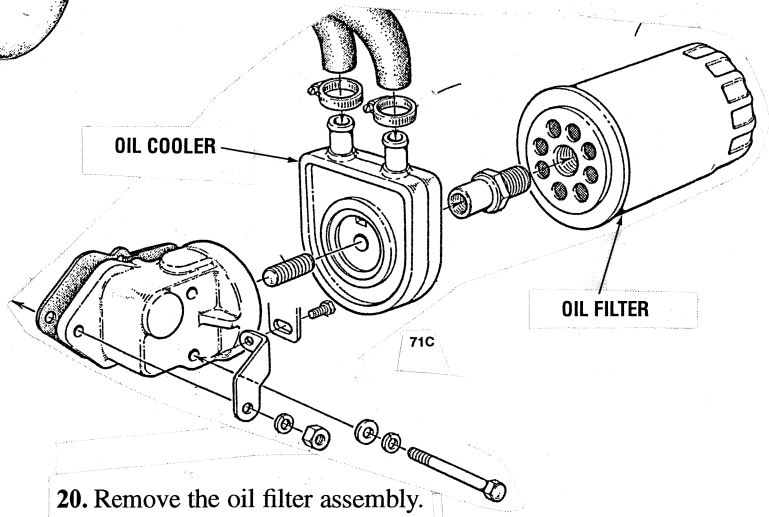
NOTE: *Loosen the cylinder head bolts equally and gradually in the order shown in the diagram.*





a. Remove the rocker arm assembly.
b. Remove the valve stem caps so as not to lose them when removing the cylinder head. **Label each cap as top which valve it belongs.**
c. Remove the push rods. **Label each rod as to which valve it belongs.**
d. Lift the cylinder head off the engine.

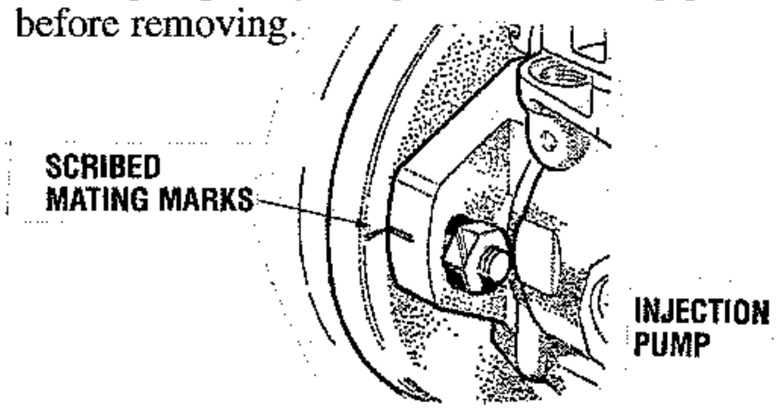




20. Remove the oil filter assembly.

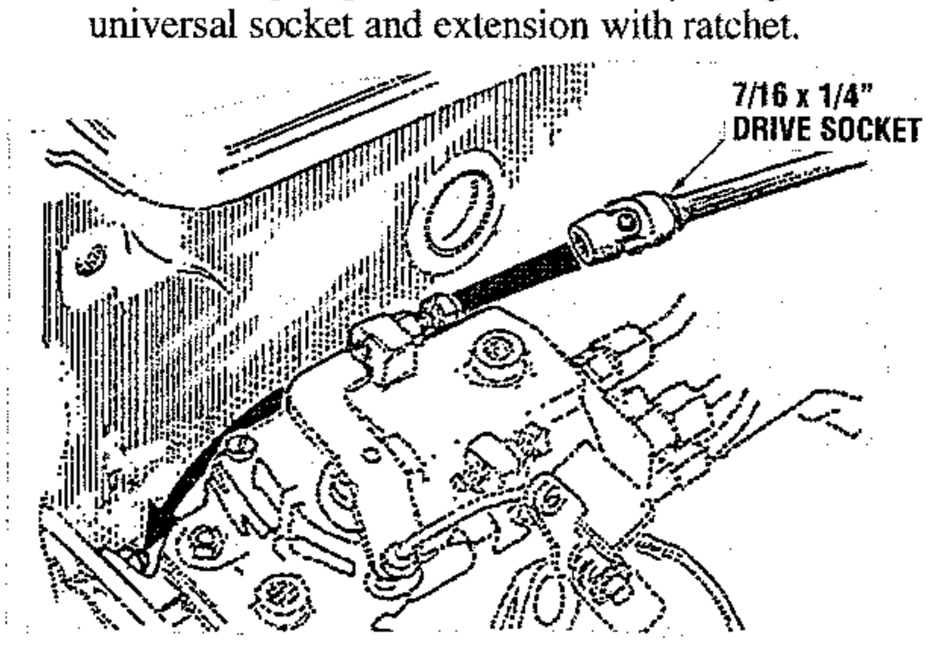
ENGINE DISASSEMBLY

21. Remove the injection pump. Scribe the mating marks on the pump body flange and the timing gear case before removing.



a. Remove the cover and the lock nuts.

b. Loosen the two injection pump hold down nuts. Do not remove entirely. The hold down nut on the engine side of the pump can be loosened by using a 1/4" universal socket and extension with ratchet.

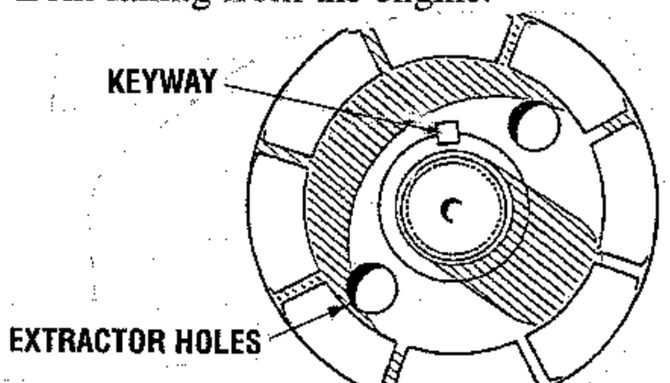


c. Remove the nut and lockwasher from the injection pump shaft.

NOTE: *Take care not to drop the nut and the washer into timing gear case.*

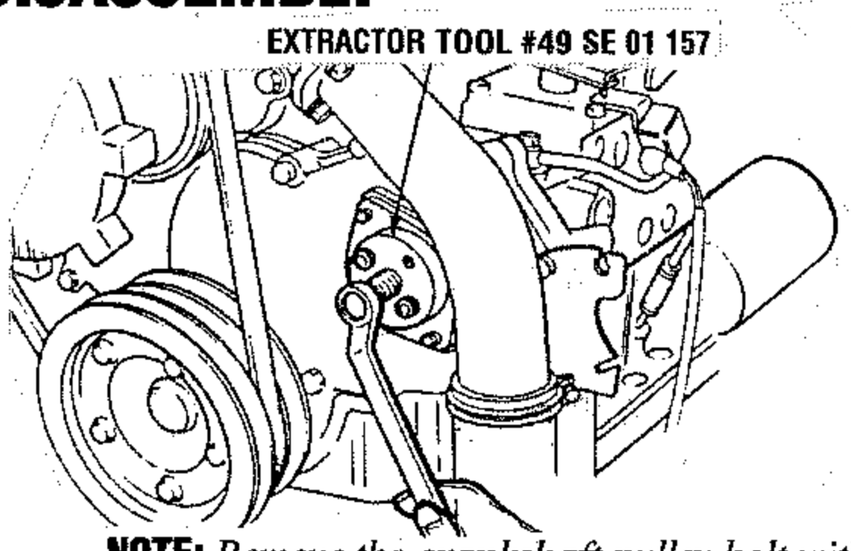
d. Place the keyway on the injection pump shaft in the 12:00 position with the aid of the front crankshaft pulley bolt before attempting to remove the injection pump.

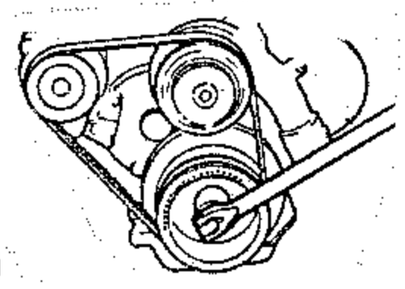
e. With the use of extractor #49 SE 01 157 apply sufficient pressure to loosen the pump from the keyed gear. The loose hold down nuts will prevent the pump from falling from the engine.



NOTE: *If an extractor is not available, replace the nut on the injection pump shaft loosely and with a nylon drift and hammer gently tap the injection pump shaft to dislodge it from the keyed drive gear.*

f. Once loosened, remove the hold down nuts and washers and carefully withdraw the pump from the drive gear and engine so as to avoid losing the injection pump drive key inside the timing case.





REMOVING THE CRANKSHAFT PULLEY

NOTE: *Remove the crankshaft pulley bolt with the aid of a 38 mm socket and draw the pulley off the front crankshaft.*

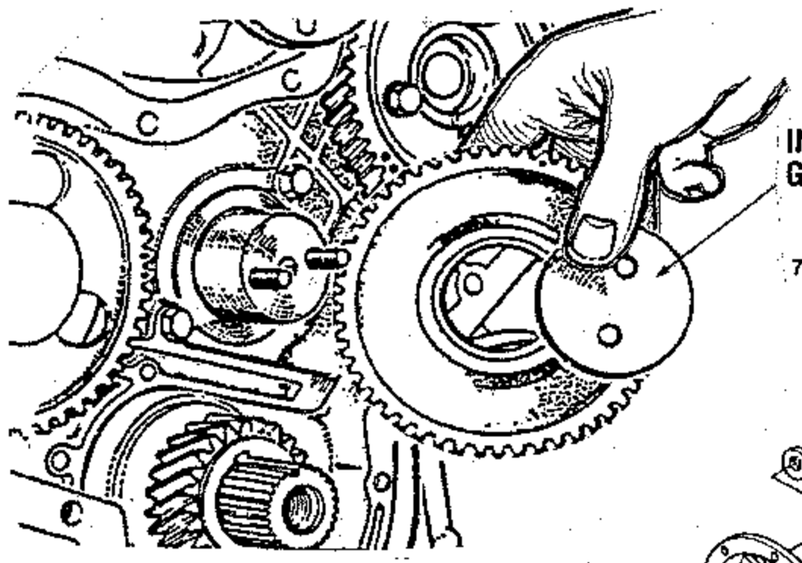
22. Remove the timing gear cover.

23. Remove the injection pump gear and the oil baffle plate.

24. Remove the central idler gear and idler gear spindle.

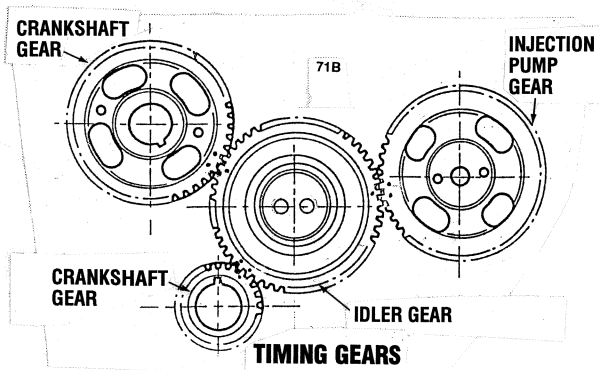
25. With a suitable puller remove the crankshaft gear and key.

26. Remove the camshaft gear using a suitable puller.



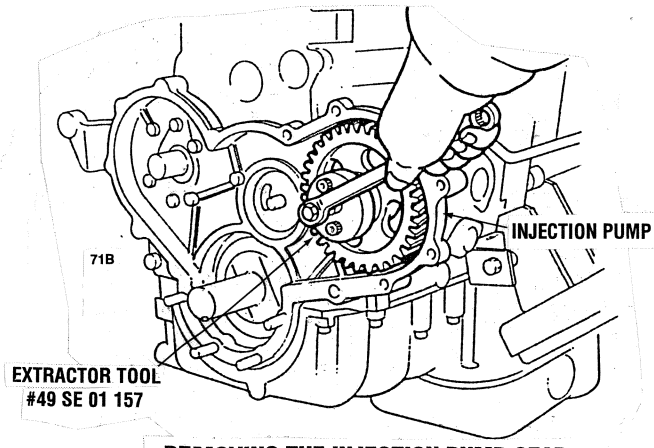
TIMING GEARS - 71B

ENGINE DISASSEMBLY

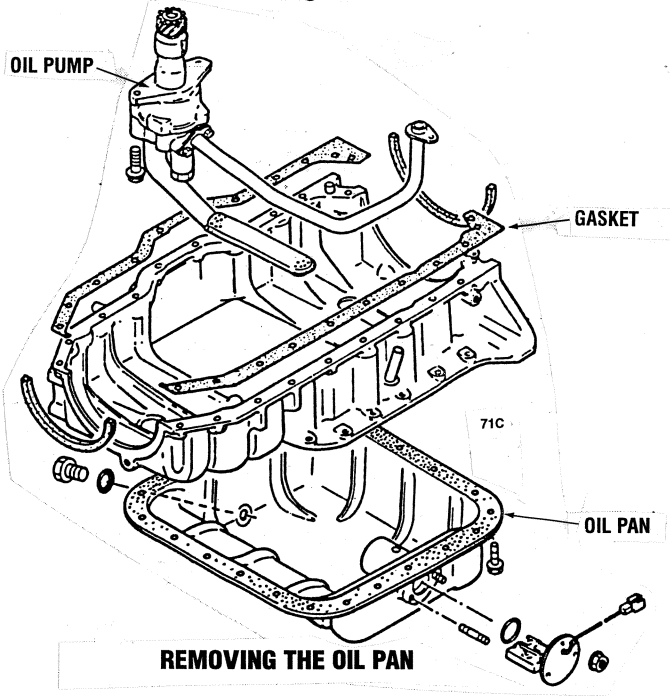


TIMING GEARS

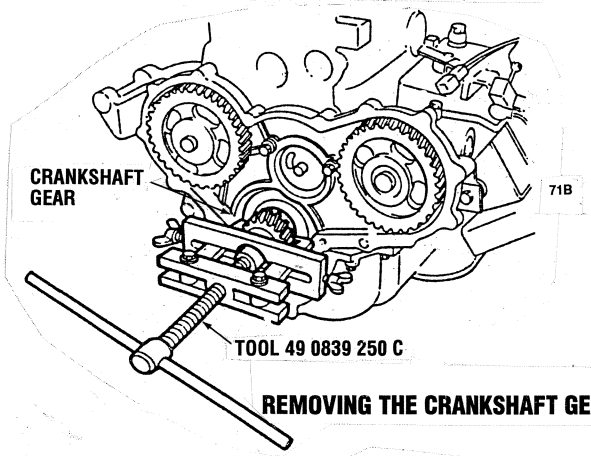
27. Turn the engine over and remove the oil pan.
28. Loosen the set screw, then remove the oil pump assembly.
29. Remove the camshaft carefully. Insure that all the pushrod tappets are seated into the engine block prior to attempting to remove the camshaft from the block.
30. Remove the timing gear case from the front of the engine block. Discard the old gasket.



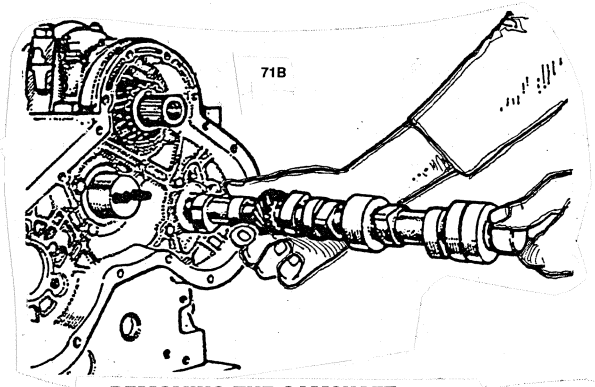
REMOVING THE INJECTION PUMP GEAR



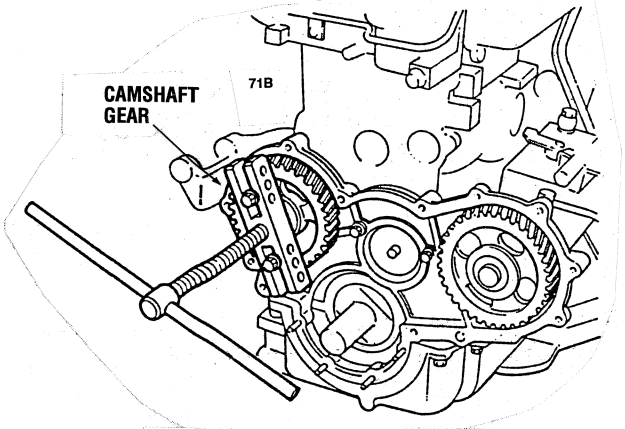
REMOVING THE OIL PAN



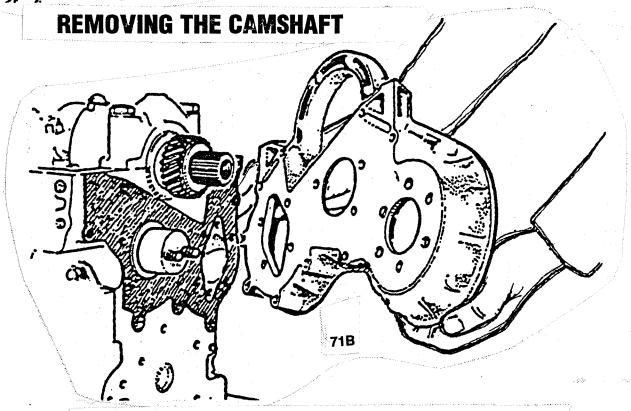
REMOVING THE CRANKSHAFT GEAR



REMOVING THE CAMSHAFT



REMOVING THE CAMSHAFT GEAR



REMOVING THE TIMING GEAR CASE

ENGINE DISASSEMBLY

31. Remove the rear oil seal.

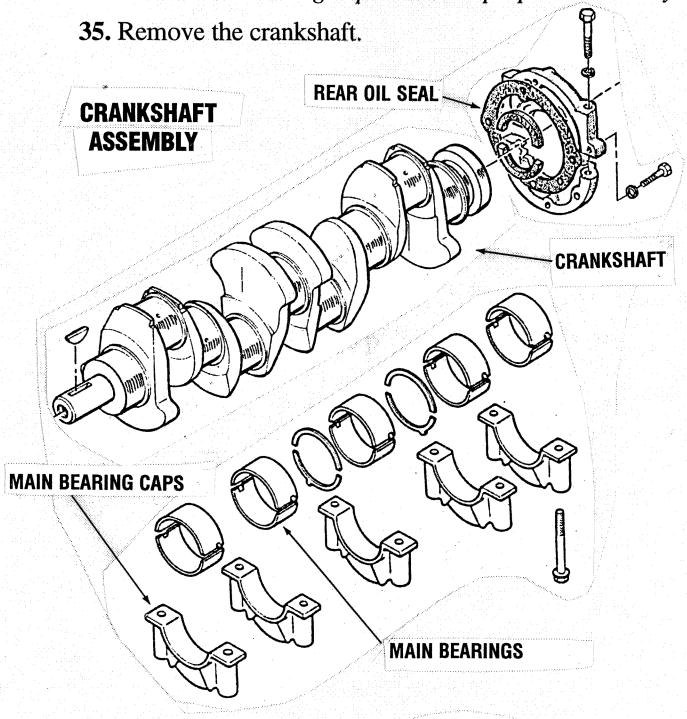
32. Remove the connecting rod bearing caps.

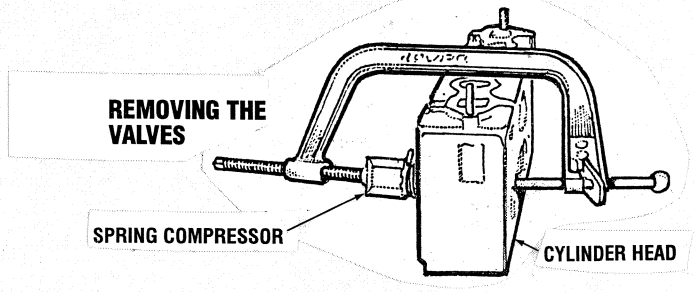
33. Remove the piston and connecting rod assemblies from the top of the cylinder block.

34. Remove the main bearing caps.

NOTE: *Mark the bearing caps to insure proper reassembly.*

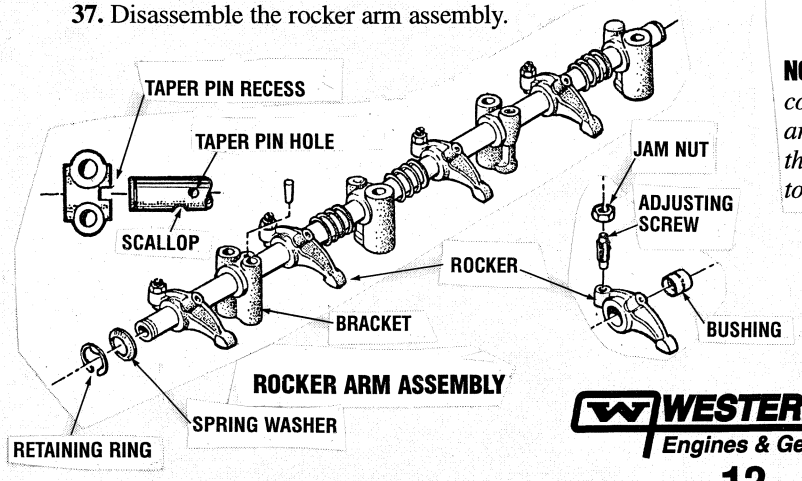
35. Remove the crankshaft.





36. Remove each valve from the cylinder head assembly. Use an appropriate valve spring compressor to aid in disassembly. Arrange or label valves so as to replace them in the cylinder and the guide from which they were removed.

37. Disassemble the rocker arm assembly.

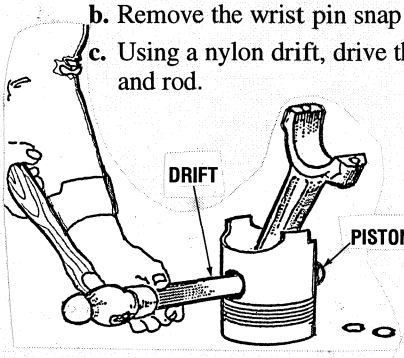


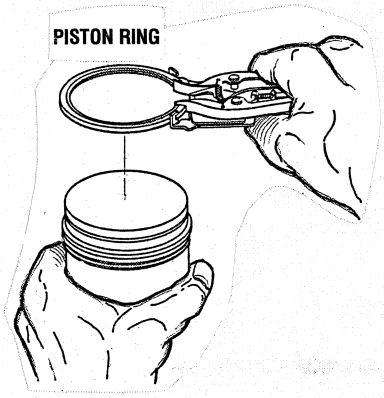
38. Disassemble the piston assembly.

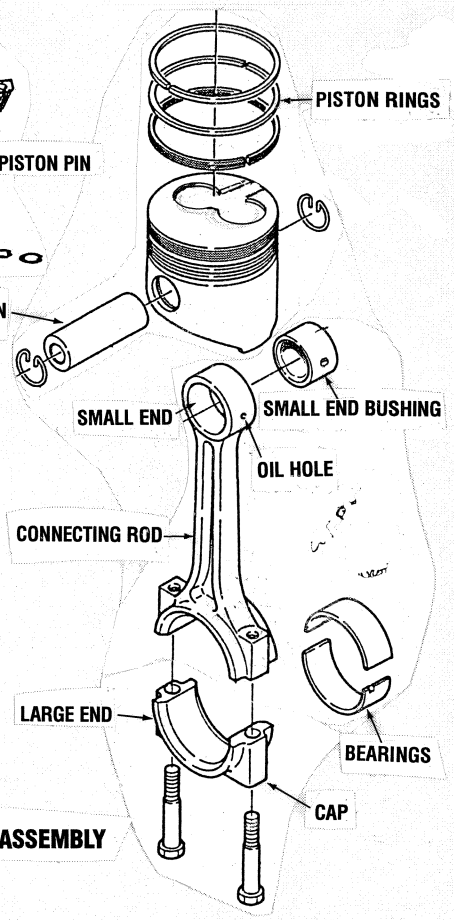
a. Using the piston ring remover, remove the piston rings.

b. Remove the wrist pin snap rings.

c. Using a nylon drift, drive the wrist pin from the piston and rod.



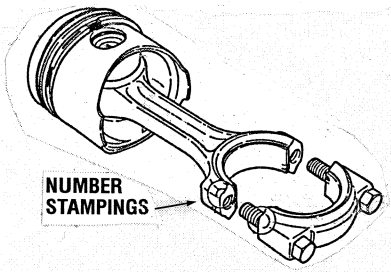




d. Protecting your eyes with safety glasses, disengage and withdraw the snap rings. Although mechanics generally press out (and sometimes hammer out) pistons pins, these practices should be discouraged. Instead, take the time to heat the pistons, either with a heat gun or on a hot plate. Pins will almost fall out.

e. While the piston is still warm, check for bore integrity. Insert the pin from each side. If the pin binds at the center, the bore might be tapered; if the bore is misaligned, the pin will click or bind as it enters the far boss.

NOTE: *The number stamped on the rod shank and cap should correspond to the cylinder number. Sometimes these numbers are scrambled or missing, and the mechanic must supply them. Stamp the correct numbers on the pads provided and, to prevent confusion, deface the originals.*



ENGINE INSPECTION

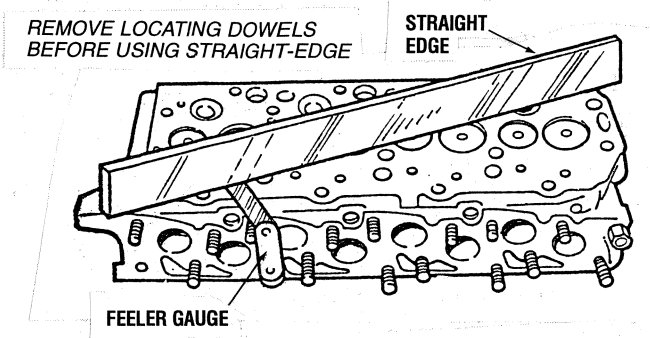
CYLINDER HEAD

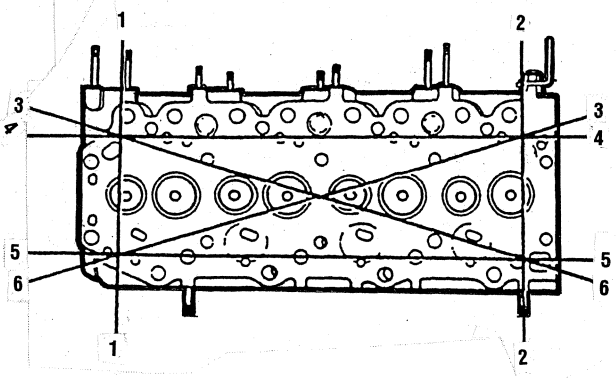
1. Visual Inspection. Check the cylinder head for cracks or any other damage and, if necessary, repair or replace it.

2. Distortion Inspection. Measure the cylinder head surface distortion with a straight edge and the thickness gauge. Take 6 measuring positions as shown in the diagram. If the distortion exceeds permissible limit, replace the cylinder head. (The head has no allowance for planing and must be replaced, not renewed.)

Cylinder Head Distortion Limit

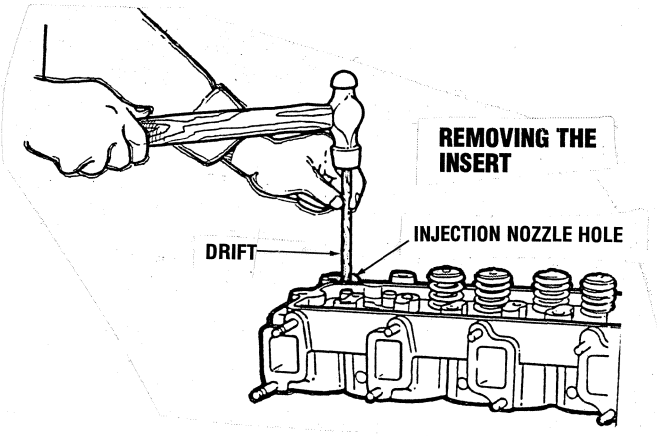
71B/71C	*Positions: 1, 2*	*0.10 mm (0.004 in)*
	3, 4, 5, 6	*0.25 mm (0.010 in)*





3. Insert Inspection. Check for cracks or damage on the insert and, if detected, replace it.

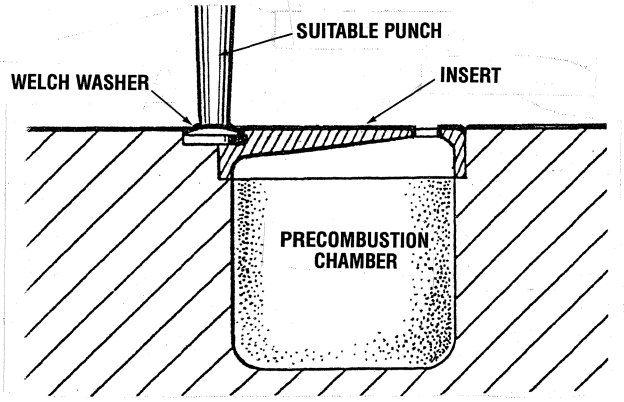
4. Insert Replacement. To remove the insert, place a suitable drift into the injection nozzle hole, then tap the drift with a hammer. To install, set the insert in position and insert the welch washer into the insert guide hole. Secure the welch washer by tapping the raised center of the welch washer.



a Use a new welch washer.

b. Insert the welch washer so that its convex surface is toward the cylinder head gasket.

c. After installation, check to see if the insert is completely fixed in place.



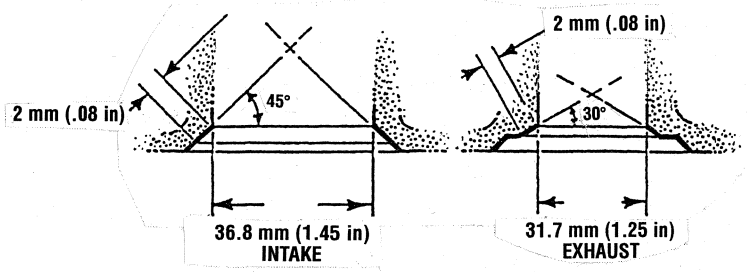
VALVE SEAT

NOTE: *Valve seat inserts cannot be fitted to this engine.*

1. Valve Seat Angle. Valve seat angle is 45° and 30° respectively for intake and exhaust sides. The standard contact width of the valve seat is 2.0 mm (0.08 in) for both intake and exhaust sides. If the valve margin is less than the permissible limit, replace the valve.

Valve margin limit

71B/71C	*1.35 mm (0.053 in)*

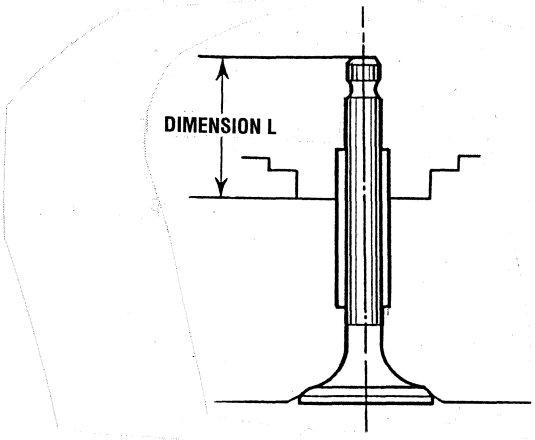


2. Dimension L. Check the protruding length of the valve stem, if it exceeds the specification, correct it as follows:

Dimension L Standard

71B/71C ***48.0 mm (1.890 in)***

a. When dimension L becomes large 0 - 0.5 mm (0 - 0.0202 in) from the standard, it is possible to use both the valve and the cylinder head.



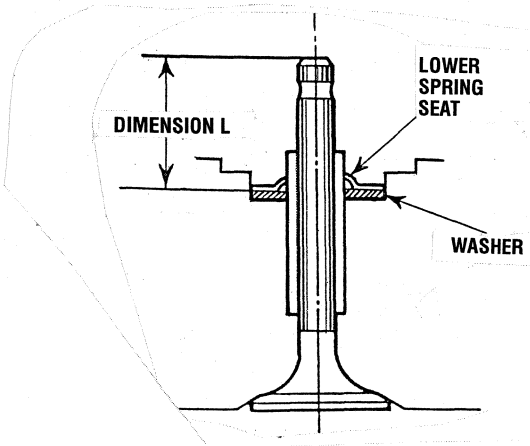
b. When dimension L becomes to large 0.5 - 1.5 mm (0.20 - 0.059 in) from the standard , adjust the dimension L to the standard by adding some washers (inner diameter 12.8 mm (0.504 in), outer diameter 39 mm (1.535 in) between the lower spring seat and the cylinder head.

c. When dimension L becomes to large (more than 1.5 mm, 0.059 in) from the standards, install the valve with a new one, and recheck dimension L.

d. When dimension L becomes to large 0 - 0.5 mm (0 - 0.0202 from the standard, replace the valve.

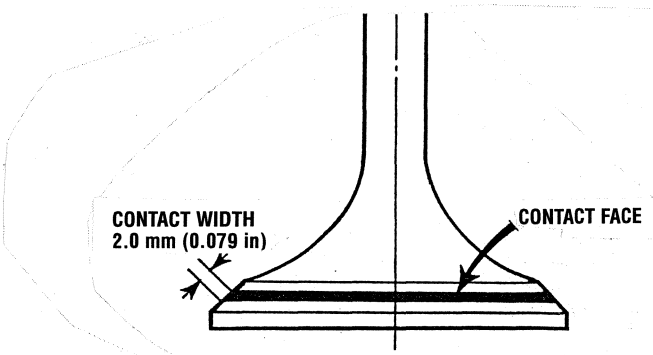
e. When dimension L becomes to large 0.5 - 1.5 mm (0.020 - 0.059 in) from the standard, replace the valve and adjust the dimension L to the standard by adding some washers between the lower spring seat and the cylinder head.

f. When dimension L becomes to large (more than 1.5 mm (0.059 in) from the standard, replace both the valve and the cylinder head.



g. Check for contact between the valve and valve seat by applying a thin coat of Prussion Blue (or Redlead) on the valve seat contact face, then insert the valve into the valve guide and press fit the valve on the valve seat.

NOTE: *Do not rotate the valve!*

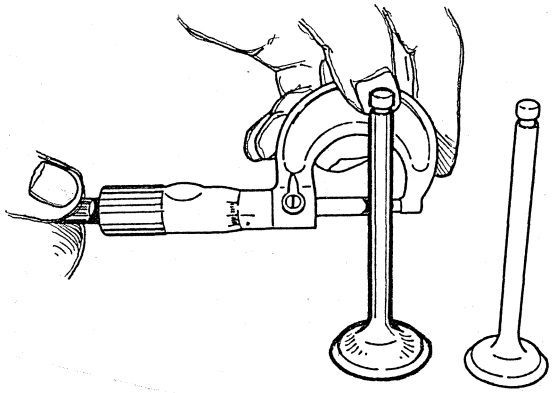


h. Check if the valve seat contact face contacts the center position of the valve contact face. If the contact position is not centered, repair the valve and the valve seat.

2. Stem Wear Inspection. If the valve stem is bent or its diameter is less than the limit, replace the valve.

Stem diameter limit

71B	***Intake***	***8.884 mm (0.350 in)***
	Exhaust	***8.864 mm (0.349 in)***
71C	***Intake***	***7.880 mm (0.3102 in)***
	Exhaust	***7.867 mm (0.3097 in)***



CHECKING VALVE STEM WEAR

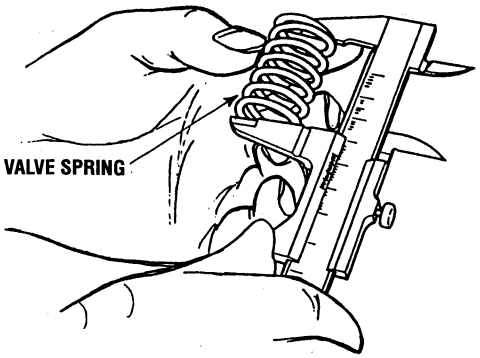
ENGINE INSPECTION

VALVE SPRING

1. Free Length Check. Measure the free length of the valve spring and if free length is less than the limit, replace it.

Valve Spring Limit

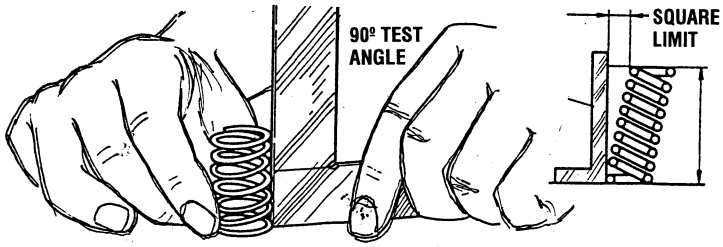
71B	*Inner spring*	*42 mm (1.654 in)*
	Outer spring	*43.6 mm (2.083 in)*
71C	*Inner spring*	*43.6 mm (1.717 in)*
	Outer spring	*52.9 mm (1.717 in)*



2. Squareness Check. Check the squareness of the valve spring and, if it is more than the limit, replace the spring.

Squareness Limit

71B/71C	*Inner spring*	*1.25 mm (0.049 in)*
	Outer spring	*1.37 mm (0.054 in)*

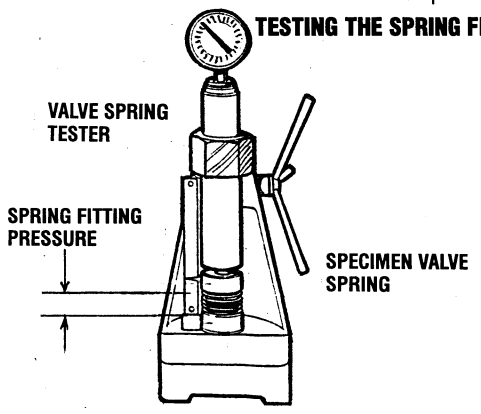


3. Fitting Pressure Check. Check the valve spring fitting pressure with a valve spring tester and, if the pressure is less than the limit, replace the spring.

NOTE: *Measure the fitting pressure after compressing the spring several times.*

71B/71C *Spring Fitting Pressure*

	Inner Spring	Outer Spring
Fitting Length	37.8 mm (1.49 in)	40.3 mm (1.59 in)
Fitting Pressure Limit	10/3 kg (22.7 lb)	14.5 kg (32.0 lb)

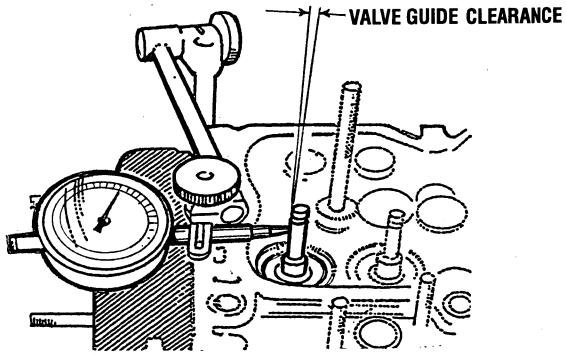


VALVE GUIDE

1. Inspecting clearance between valve and guide. Set a dial gauge with a magnet and check the clearance between the valve stem and the valve guide. If the clearance is more than the limit, replace the valve or valve guide.

Clearance Limit

71B/71C *0.127 mm (0.005 in)*

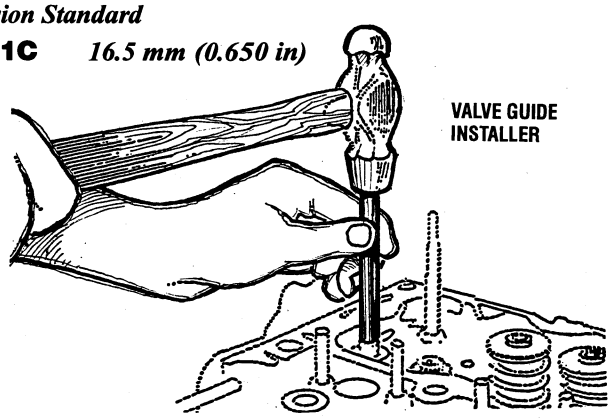


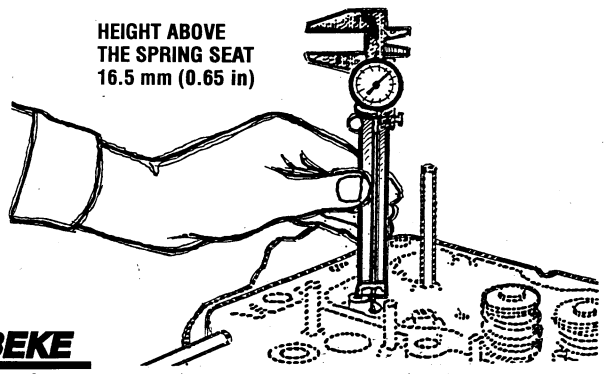
2. Valve guide replacement. To remove the valve guide, press out the valve guide towards the combustion chamber side, using the valve guide installer (49 0636 165A). Again using the valve guide installer, press in the valve guide into the cylinder head until the valve guide height reaches the indicated scale on the valve guide installer.

NOTE: *Be sure to press in the valve guide so that the inside chamber on the valve guide end faces to the combustion chamber side. After the pressure fit, check the length of the protruding portion of the valve guide.*

Protrusion Standard

71B/71C *16.5 mm (0.650 in)*

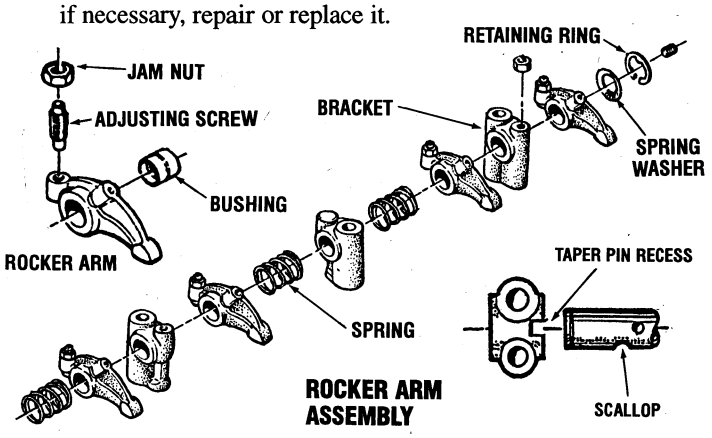




ENGINE INSPECTION

ROCKER ARM

1. Visual Inspection. Check each component part of rocker arm assembly for cracks or other damage. Check if the oil passages of the rocker arm and shaft are clogging and, if necessary, repair or replace it.



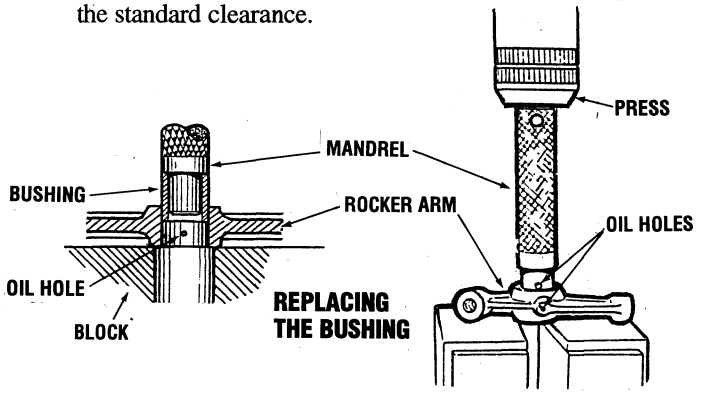
ROCKER ARM ASSEMBLY

2. Inspecting clearance between rocker arm and shaft. Check the clearance between the rocker arm and shaft and, if it exceeds the limit, replace the rocker arm bushing or shaft.

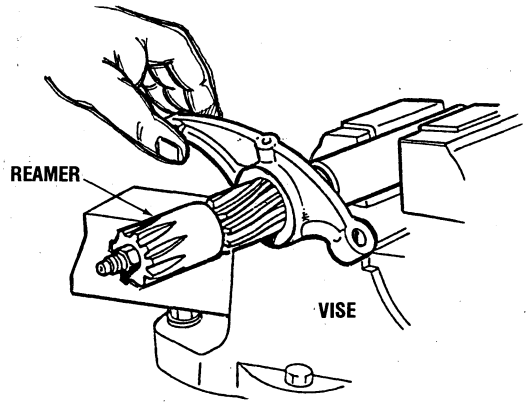
Clearance Standard

71B/71C *0.016 - 0.061 (0.0006 - 0.0024 in)*
limit - 0.07mm (0.003 in)

3. Rocker Arm Bushing Replacement Using a suitable mandrel and press, press out the bushing. Aligning the oil passages of the rocker arm bushing, press the bushing into the rocker arm. After the rocker arm bushing has been replaced, ream the bushing bore with a reamer so that the clearance between the bushing and shaft becomes equal to the standard clearance.



REPLACING THE BUSHING



REAMING THE BUSHING BORE

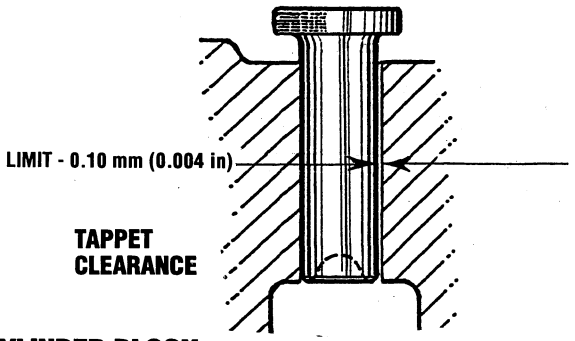
TAPPET

1. Visual inspection. Check the tappet for cracks and other damage and, if damaged replace the tappet. Check for abnormal wear of the portion of the tappets that contact with the cam, and if any one is abnormally worn, replace the tappet.

2. Inspecting Clearance Between Tappet and Tappet Bore. Check the clearance between the tappet and tappet bore and, if the clearance is greater than the limit, replace the tappet or cylinder block.

Clearance Limit

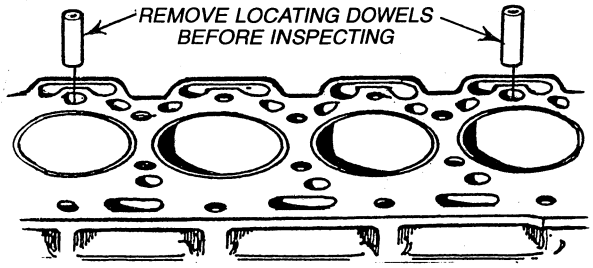
71B/71C *0.10 mm (0.004 in)*



TAPPET CLEARANCE

CYLINDER BLOCK

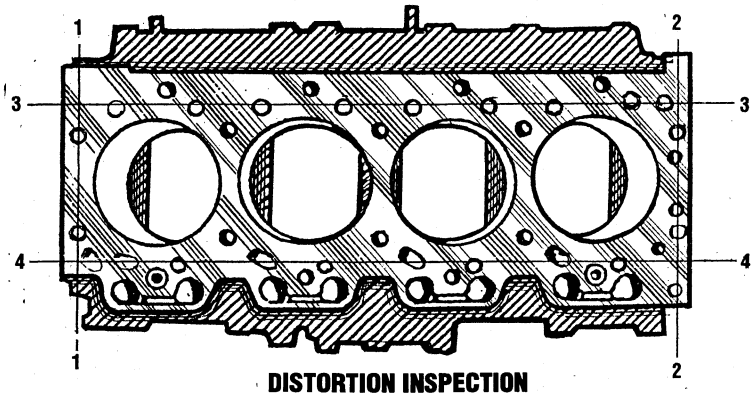
1. Visual Inspection. Check the cylinder block for cracks and damage. If necessary, repair or replace it entirely Check to see that oil or cooling water passages are not clogged and, if clogged, remove with compressed air or a wire probe.



2. Distortion Inspection. Check the gasket face distortion of the cylinder block and if it exceeds the limit, repair or replace it.

Distortion limit:

71B/71C *(1) (2) 0.10 mm (0.004 in)*
(3) (4) 0.25 mm (0.010 in)



DISTORTION INSPECTION

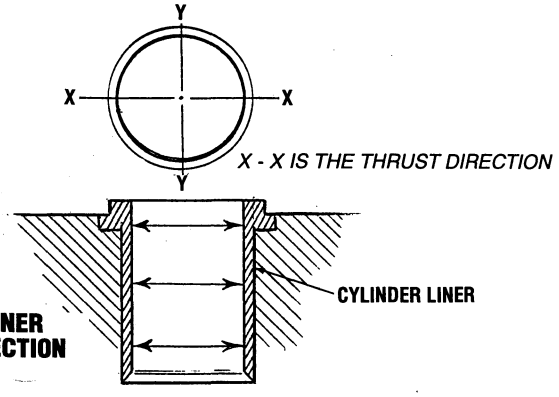
ENGINE INSPECTION

CYLINDER LINER

1. Wear Inspection. Measure the liner bore at three positions of upper, middle and lower portions with a cylinder gauge in X-X and Y-Y directions as shown. If wearing exceeds the limit, replace the liner.

Cylinder Liner Bore

71B/71C *88.925 - 88.950 mm (3.5010 - 3.5020 in)*
Wear Limit 0.20 mm (0.008 in)



CYLINDER LINER WEAR INSPECTION

2. Cylinder Liner Replacement. Hydraulic press or similar device is needed.

a. Attach the cylinder liner puller and installer to the lower rim of the cylinder liner, then press out the liner.

b. Check for scratches on the cylinder block side and, if any, remove them by using extremely fine emery paper with engine oil.

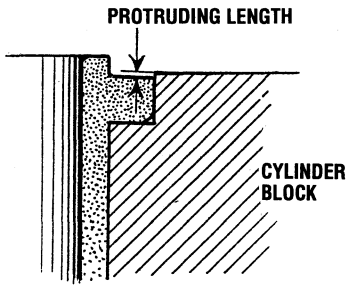
c. To install the liner, apply engine oil on the cylinder block bore and the liner exterior, then set the liner on the cylinder block. Using the cylinder liner puller and installer, press the liner into the cylinder block.

NOTE: *Press the liner in straight. When press fitting the liner, keep the pressure within a range of 1-3 tons (2,200 - 6,600 lb).*

Measure the liner protrusion and correct it if necessary.

Protrusion Limits

71B *0.101 - 0.000 mm (0.0040 - 0.0000 in)*
71C *0.659 - 0.790 mm (0.026 - 0.031 in)*

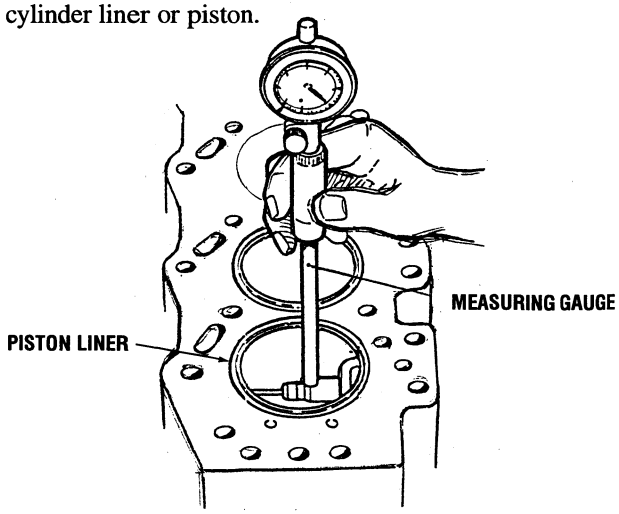


PISTON AND PISTON RING

1. Visual Inspection Check the sliding surface and ring groove of the piston for wear, scratches or any other damage.

a. Inspecting the clearance between the piston and the cylinder liner.

b. Check the clearance between the piston and the cylinder liner by measuring the cylinder bore and the piston diameter and, if the clearance exceeds the limit, replace the cylinder liner or piston.



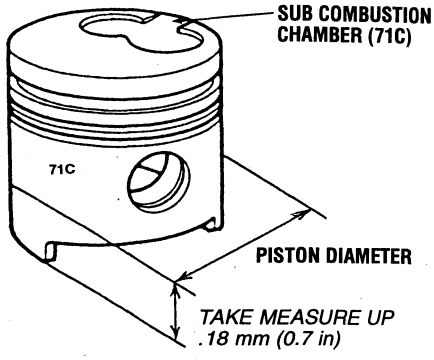
c. To measure the piston diameter, measure 18 mm (0.7 in) above from the piston bottom at right angle to the piston pin.

Piston and Cylinder Clearance

71B *0.044 - 0.70 mm (0.0017 - 0.0028 in)*
71C *0.054 - 0.080 mm (0.0021 - 0.0031 in)*

Standard Piston Diameter

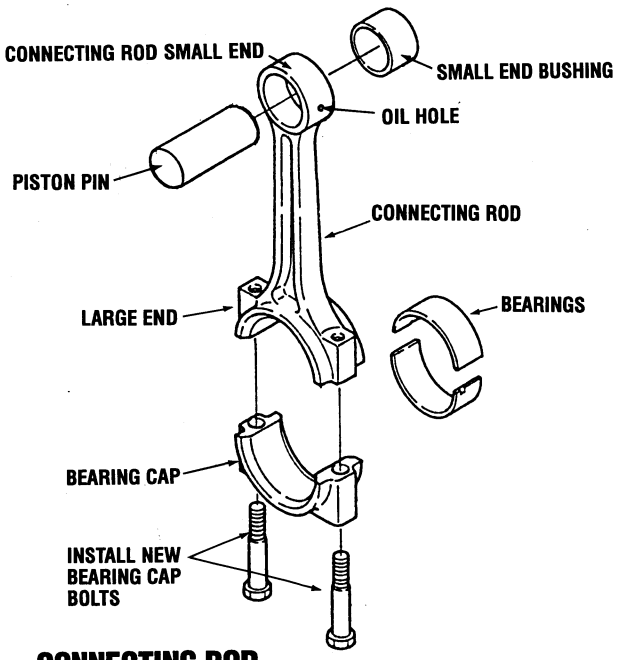
71B *88.880 ± 0.013 mm (3.4989 ± 0.0005 in)*
71C *88.872 - 88.898 mm (3.499 - 3.500 in)*



3. Piston Ring Inspection Check the piston ring for breaks, seizure and wear and, if any of these conditions exist, replace the ring. Check the clearance between the piston ring and the ring groove and, if it exceeds the limit, replace the ring.

Clearance limit

71B/71C *0.30 mm (0.012 in)*



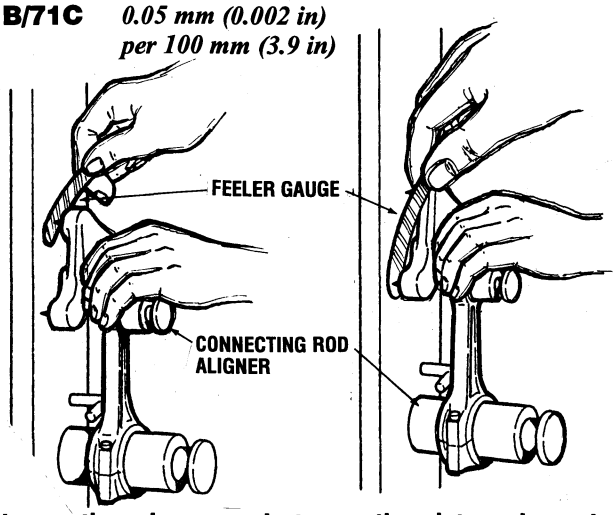
CONNECTING ROD

1. Visual Inspection. Check the connecting rod for cracks or other damage and, if necessary, replace it.

2. Bend Inspection. Using a connecting rod aligner, check the bend and twist of the connecting rod and, if exceeding the limit, repair it with a press or replace it.

Bend Limit

71B/71C *0.05 mm (0.002 in) per 100 mm (3.9 in)*

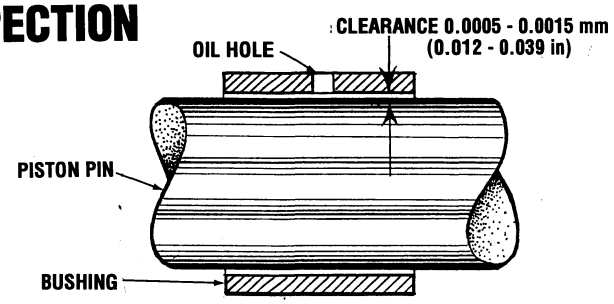


3. Inspecting clearance between the piston pin and small end bushing. Check the clearance between the piston pin and the small end bushing and, if it exceeds the limit, replace the piston pin or small bushing.

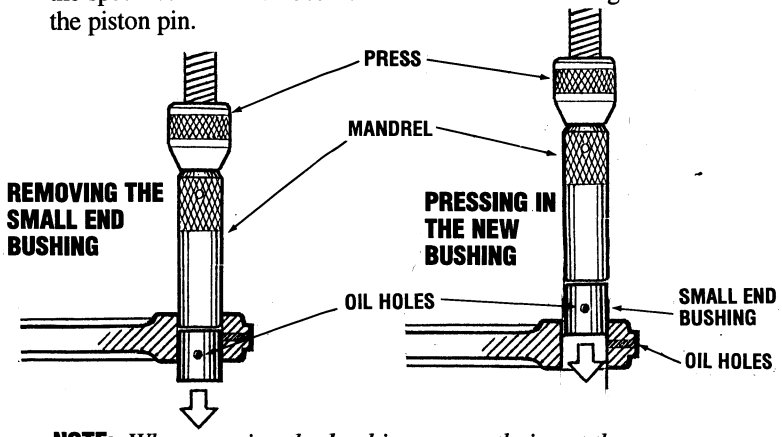
Clearance

71B *Standard: 0.012 - 0.031 mm (0.0005 - 0.0015 in)*
Limit: 0.05mm (0.002 in)

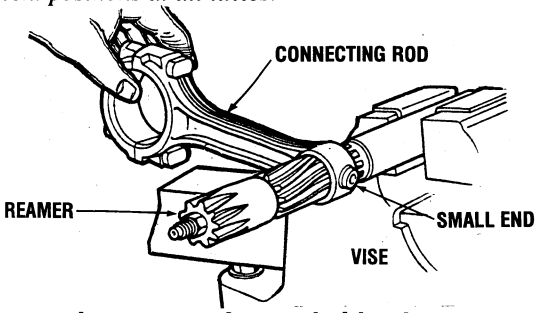
71C *Standard: 0.014 - 0.041 mm (0.0006 - 0.0016 in)*
Limit: 0.05 mm (0.002 in)



4. Small end bushing replacement. Using a press, press out the bushing. Align the oil passages of the connecting rod and the small end bushing; press in the bushing to the connecting rod bore. After a small end bushing has been replaced, ream the bushing bore to obtain the specified clearance between the small end bushing and the piston pin.



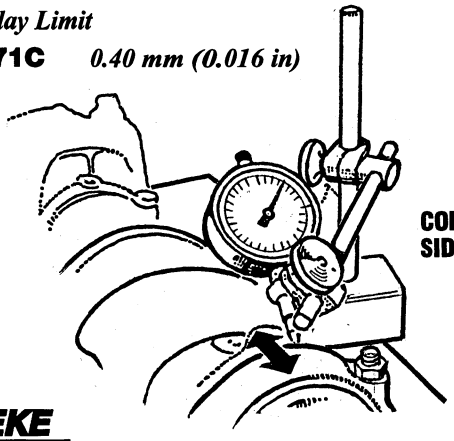
NOTE: *When reaming the bushing, correctly insert the reamer in the bushing. In order to prevent unevenness on the bushing surface, the reaming should always be made in the cutting direction. Make certain the reamer is stopped at different positions at all times.*



5. Inspecting connecting rod side play. Check the connecting rod side play with the dial gauge and, if it exceeds the limit, replace the connecting rod and crankshaft.

Side Play Limit

71B/71C *0.40 mm (0.016 in)*



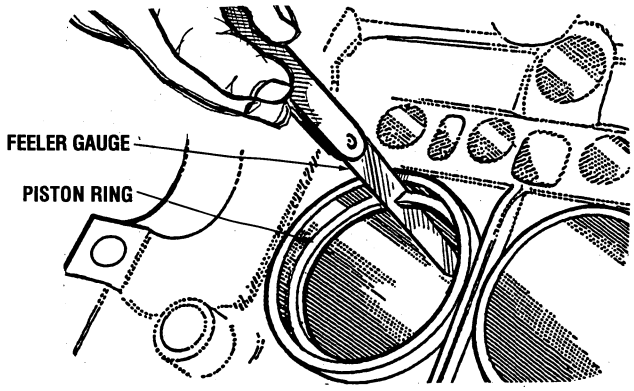
CONNECTING ROD SIDE PLAY TEST

5. Inspecting piston ring end gap. Position the piston ring into the bottom of the cylinder liner. Measure the piston ring end gap and, if it exceeds the limit, replace the ring.

Piston Ring End Gap Limit

71B/71C *1.5 mm (0.591 in)*

Be sure to position the piston ring below the ring sliding surface of the cylinder liner.



6. Inspecting connecting rod bearing. Check the connecting rod bearing for peeling and thermal damage. If it is severe, replace the bearing.

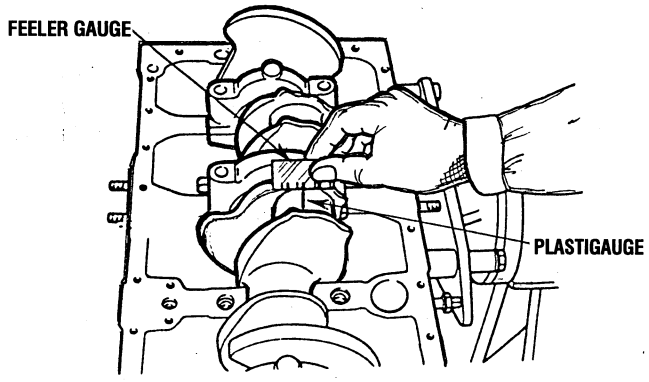
7. Inspecting connecting rod bearing clearance. Using the plastigauge, measure the oil clearance of the connecting rod bearing and, if it exceeds the limit, replace the connecting rod bearing.

Connecting Rod Bearing Clearance

71B *Standard: 0.012 - 0.031 mm (0.0005 - 0.0012 in)*
Limit: 0.05 mm (0.002 in)

71C *Standard: 0.036 - 0.076 mm (0.0014 - 0.0030 in)*
Limit: 0.10 mm (0.004 in)

Undersize Bearing: 0.254 mm (0.010 in)
0.508 mm (0.020 in)
0.762 mm (0.030 in)



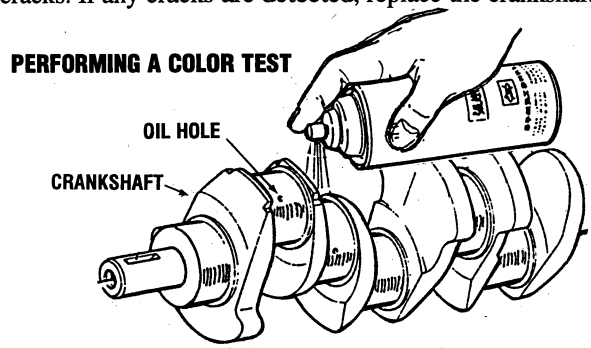
CONNECTING ROD BEARING CLEARANCE

Connecting Rod Cap Tightening Torque

71B *7.8 - 8.0 m-kg (56 - 58 ft-lb)*
71C *6.9 - 7.5 m-kg (50 - 54 ft-lb)*

CRANKSHAFT

1. Visual Inspection. Check the crankshaft for cracks or other damage. If cracking is suspected, thoroughly clean the crankshaft and perform a color test on the shaft, or run a candle flame over the crankshaft and look for oil seepage from cracks. If any cracks are detected, replace the crankshaft.

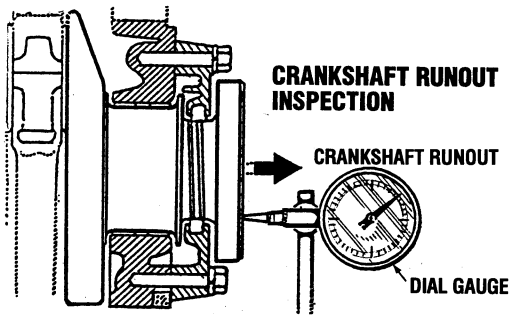


Check for clogging of oil passages and, if clogged, remove with compressed air or wire.

2. Runout inspection. Check the crankshaft runout and, if it exceeds the limit, replace the crankshaft.

Runout Limit

71B/71C *0.05 mm (0.0020 in)*



3. Inspecting crank pin and journal. Support the crankshaft on both ends using V-blocks. Measure the diameter of each crank pin and crankshaft main journal and, if the diameter is less than the limit, refinish the crank pin and main journal to size for the next undersize bearing.

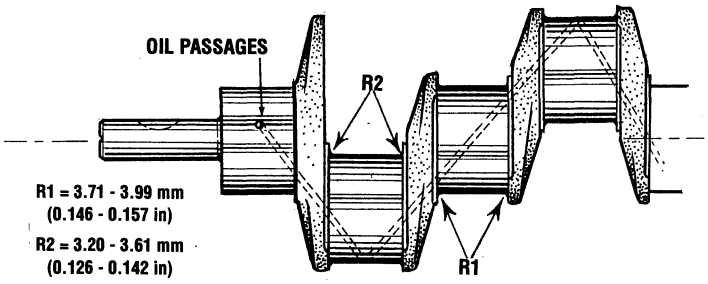
71B	
Crank pin standard diameter 57.112 - 57.125 mm (2.2485 - 2.2491 in)	*Wear limit 0.05 mm (0.002 in)*
Main journal standard diameter 69.812 - 69.825 mm (2.7485 - 2.7491 in)	*Wear limit 0.05 mm (0.002 in)*

71C	
Crank pin standard diameter 53.0 - 53.013 mm (2.0866 - 2.0861 in)	*Wear limit 0.05 mm (0.0020 in)*
Main journal standard diameter 65.0 - 65.013 mm (2.5591 - 2.5596 in)	*Wear limit 0.05 mm (0.0020 in)*

a, For the measurement on both the crank pin and the main journal, measure them at vertical and horizontal directions on front and rear places.

b, When refinishing the crankshaft, it's finish to R1 mm as shown in the diagram.

c, Refer to the chart for refinishing dimensions of the crankshaft where an undersize bearing is used.



71B

Undersize bearing	*Crank pin diameter*
0.254 mm (0.01 in)	*56.868 - 56.871 mm (2.2389 - 2.2391 in)*
0.508 mm (0.02 in)	*56.604 - 56.617 mm (2.2285 - 2.2312 in)*
0.762 mm (0.03 in)	*56.350 - 56.363 mm (2.2185 - 2.2191 in)*
Undersize bearing	*Main journal diameter*
0.254 mm (0.01 in)	*69.558 - 69.571 mm (2.7385 - 2.7391 in)*
0.508 mm (0.02 in)	*69.304 - 69.317 mm (2.7182 - 2.7291 in)*
0.762 mm (0.03 in)	*69.050 - 69.063 mm (2.7185 - 2.7191 in)*

71C

Undersize bearing	*Crank pin diameter*
0.254 mm (0.01 in)	*52.733 - 52.746 mm (2.0761 - 2.0766 in)*
0.508 mm (0.02 in)	*52.479 - 52.492 mm (2.0661 - 2.0666 in)*
0.762 mm (0.03 in)	*52.225 - 52.238 mm (2.0561 - 2.0566 in)*
Undersize bearing	*Main journal diameter*
0.254 mm (0.01 in)	*64.733 - 64.746 mm (2.5485 - 2.5491 in)*
0.508 mm (0.02 in)	*64.479 - 64.492 mm (2.5385 - 2.5391 in)*
0.762 mm (0.03 in)	*64.225 - 64.238 mm (2.5285 - 2.5291 in)*

4. Inspecting crankshaft end play. Check the end play of the crankshaft and, if the end play exceeds the limit, replace the thrustwasher with 0.178 mm (0.007 in) oversize.

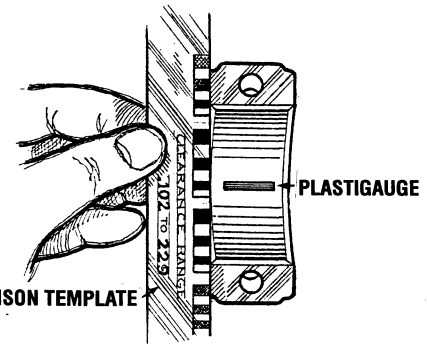
Crankshaft end play is measured by setting a dial gauge on the rear end of the crankshaft and moving the crankshaft in the axial direction.

Crankshaft End Play

71B/71C *Standard: 0.14 - 0.39 mm (0.0055 - 0.0153 in)*
End play limit: 0.40 mm (0.0157 in)

5. Inspecting main bearing. Check the main bearing for peeling, seizure or fusion and, if necessary, replace the bearing.

6. Inspecting main bearing clearance. Using the plastigauge, measure the oil clearance and, if it exceeds the limit, replace the main bearing.



Oil Clearance

71B *Standard: 0.059 - 0.090 mm (0.0020 - 0.0040 in)*
Limit: 0.12 mm (0.005 in)

71C *Standard: 0.040 - 0.091 mm (0.0016 - 0.0036 in)*
Limit: 0.12 mm (0.005 in)

Main Bearing Cap

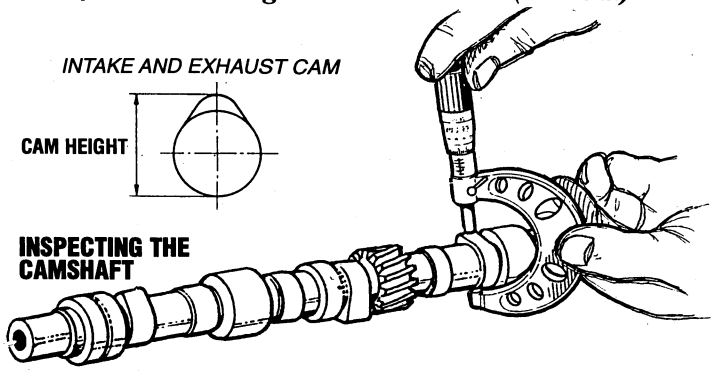
71B/71C *Tightening torque: 11.0 - 11.7 m-kg (80 - 85 ft-lb)*

CAMSHAFT

1. Visual Inspection. Check the camshaft for cracks and damage. If necessary, replace the camshaft.

2. Inspecting cam height. Measure the cam height and, if it is less than the limit, replace the camshaft.

71B/71C *Cam height limit: 42.478 mm (1.6724 in)*



3. Inspecting camshaft journal. Check the camshaft journal and, if wearing exceeds the limit, replace the camshaft.

	71B *Diameter of Journal*	*Wear Limit*
No. 1	*51.910 - 51.940 mm (2.0437 - 2.0449 in)*	*0.008 mm (0.0003 in)*
No. 2	*51.660 - 51.690 mm (2.0339 - 2.0351 in)*	
No. 3	*51.410 - 51.440 mm (2.0240 - 2.0252 in)*	
No. 4	*51.160 - 51.190 mm (2.0142 - 2.0154 in)*	

	71C *Diameter of Journal*	*Wear Limit*
Front	*52.06 - 52.09 mm (2.0497 - 2.0508 in)*	*0.008 mm (0.0003 in)*
Center	*51.81 - 51.84 mm (2.0398 - 2.0409 in)*	
Rear	*51.31 - 51.34 mm (2.0201 - 2.0212 in)*	

4. Inspecting camshaft oil clearance. Check the oil clearance of the camshaft by measuring the camshaft bore in the cylinder block and camshaft journal diameter. If the oil clearance is more than the limit, replace the camshaft or cylinder block.

71B/71C *Oil clearance limit: 0.145 mm (0.0057 in)*

5. Inspecting camshaft runout. Check the camshaft runout and, if it exceeds the limit, replace the camshaft.

71B/71C *Runout limit: 0.08 mm (0.003 in)*

6. Camshaft front bearing replacement. Mount the camshaft assembly in a vise equipped with copper or aluminum plate, then remove the bolt, lock plate, cam gear, thrust plate, bearing outer face and key.

a, Using a press, press out the bearing.

b, Check the removed parts for wear or other damage and replace the parts as necessary.

c, Install the bearing onto the camshaft with a press.

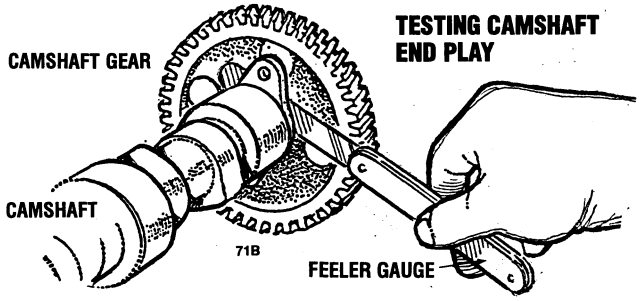
d, Assemble the thrust plate and camshaft gear onto the camshaft.

71B *Tightening torque: 6.4 - 9.5 m-kg (46 - 69 ft-lb)*

71C *Tightening torque: 6.2 - 7.0 m-kg (45 - 51 ft-lb)*

7. Inspecting camshaft end play. Measure the end play of the camshaft with the thickness gauge and if the end play is more than the limit, replace the thrust plate.

71B/71C *End play limit: 0.3 mm (0.012 in)*



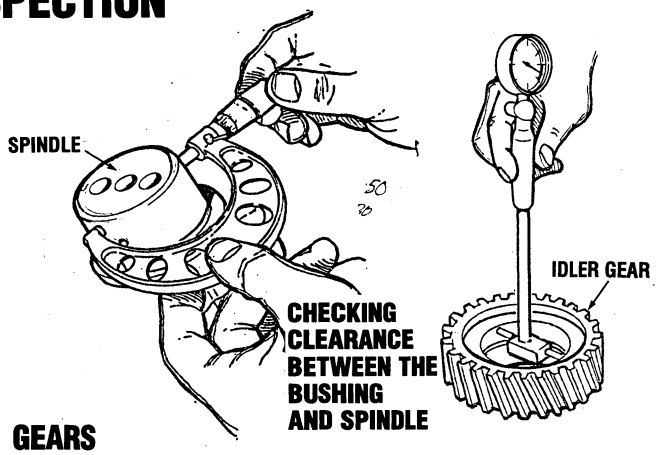
IDLER GEAR AND IDLER GEAR SPINDLE

1. Visual inspection. Check the damage on the bushing inner surface of the idler gear and the spindle sliding surface and, if necessary, replace the idler gear or spindle. Check the oil passage for clogging and, if necessary, clean the passage with compressed air or wire.

2. Inspecting clearance between bushing and spindle. Check the clearance between the idler gear bushing and the spindle and, if it exceeds the limit, replace the idler gear or spindle.

Clearance

71B/71C *Standard: 0.034 - 0.084 mm (0.0013 - 0.0033 in)*
Limit: 0.15 mm (0.006 in)



GEARS

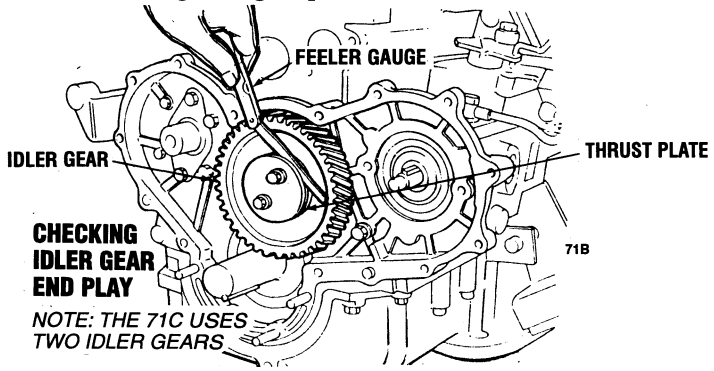
1. Visual Inspection Check each gear tooth for cracks or other damage.

2. Inspecting end play of idler gear. Check the end play of the idler gear and, if it exceeds the limit, replace the thrust plate or idler gear.

71B *Standard end play: 0.15 - 0.30 mm (0.0059 - 0.0118 in)*

71C *Standard end play: 0.20 - 0.030 mm (0.0079 - 0.0118 in)*

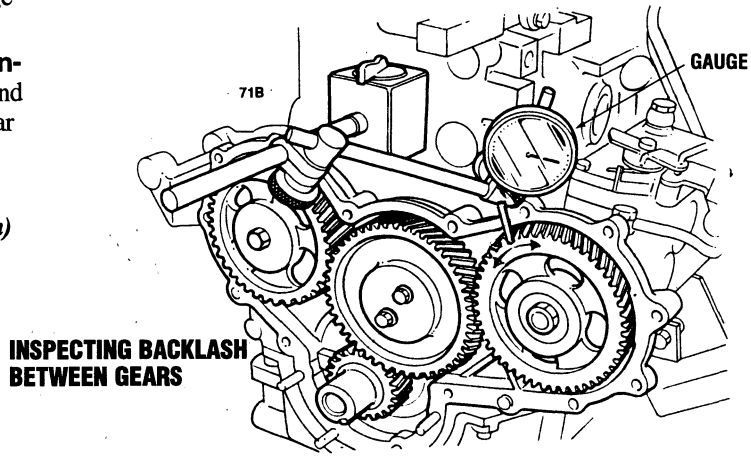
71B/71C *Tightening torque: 2.3 - 3.2 m-kg (16.6 - 23.1 ft-lb)*



3. Inspecting backlash between gears. Check the backlash between each gear and, if it exceeds the limit, replace the gears.

NOTE: *Before inspecting the backlash, check the end play of the idler gear and clearance between the idler gear bushing and spindle.*

71B/71C *Standard: 0.10 - 0.17 mm (0.004 - 0.007 in)*
Backlash limit: 0.30 mm (0.012 in)



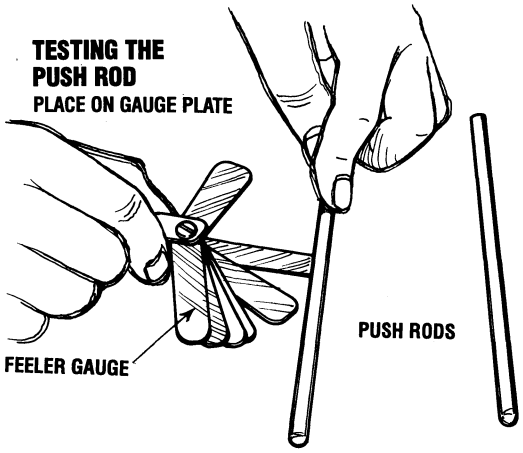
ENGINE INSPECTION

PUSH ROD

1. Visual Inspection. Check the push rod for damage on both ends. If it is severe, replace it.

2. Bend Inspection. Check the push rod for bend and, if it exceeds the limit, replace it. Place the push rod on a flat surface and measure the clearance between the center of the push rod and the flat surface. Replace the push rod if the wear limit is exceeded.

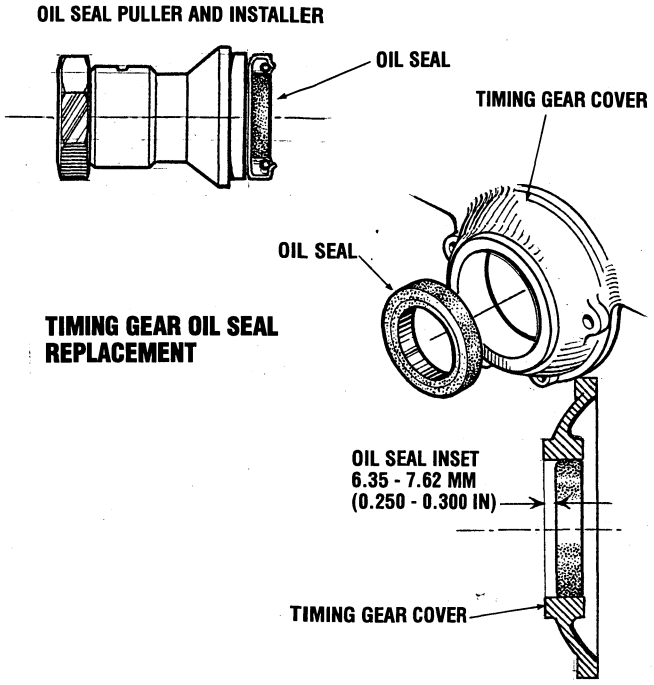
71B/71C ***Bend limit: 0.19 mm (0.0075 in)***



TIMING GEAR COVER

1. Inspecting timing gear cover. Check the timing gear cover and oil seal for any damage. If necessary, replace the cover or oil seal.

2. Oil seal replacement. To remove the oil seal, use the oil seal puller and installer and pull out the oil seal. To install, apply the engine oil on the outer periphery of the oil seal, then press in the oil seal with oil seal puller and installer.



REAR OIL SEAL

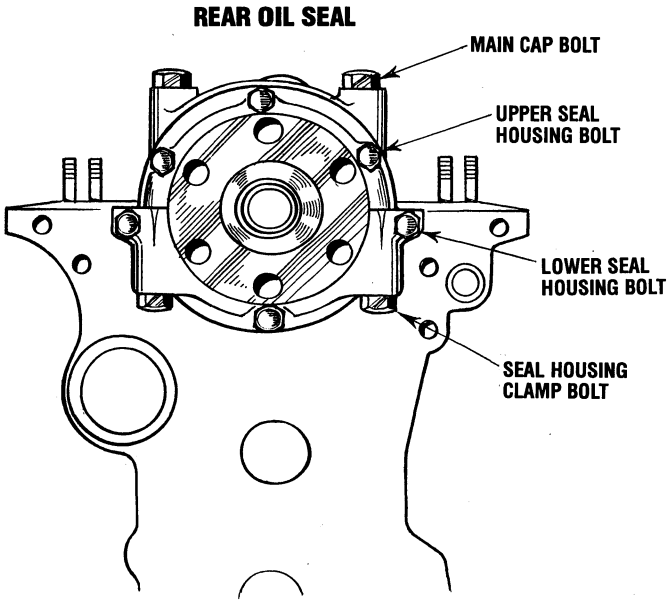
1. Inspecting oil seal. Check the oil seal lip for wear or other damage and, if necessary, replace it.

2. Oil seal replacement. Upon inspection, finding the existing seal worn or frayed, pick the old seal halves out of their grooves and thoroughly clean the half-housings.

a. With half-housing held in a soft-jawed vise and the seal recess uppermost, settle one inch (25 mm) of the seal wick at each end into the groove. Make certain that each end of the seal projects 0.25/0.51 mm (0.010/0.020 in) beyond the joining faces of the two-piece housing.

b. Press the remainder of the seal wick into the groove starting from the center and working outwards.

c. Using a suitable round bar, roll and press the seal into place in both half-housings.



3. To refit the assembly: Thoroughly clean the butt joint between the half-housings.

a. Lightly coat the butt joint faces with a liquid gasket compound similar to Dow Corning Silastic 732 RTV adhesive/sealant. Lubricate the exposed diameter of the wick seals with graphite grease.

b. Oil the crankshaft at the oil return groove. Place the half-housings in position against the gasket and the engine block and locate all the bolts into the block and bearing cap face finger tight only.

c. Tighten the clamping bolts to a temporary torque of 0.55 - 0.83 kg m (4 - 6 lb ft).

d. Tighten the bolts in the block and cap to a torque of 1.66 kgf m (12 lb ft).

e. Finally, tighten the clamping bolts to a torque of 1.66 kgf m (12 lb ft).

ENGINE REASSEMBLY

Take the following precautions:

- 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, etc.
- Tighten the bolts and nuts on important parts of engine to specified torques using a reliable torque wrench.
- Use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.

Be aware of these common problems that can occur during assembly.

Insufficient Lubrication. Heavily oil sliding and reciprocating parts, lightly oil head bolts and other fasteners, except those that penetrate into the water jacket. These fasteners should be sealed with Permatex No. 2 or the high-tack equivalent.

Reversed orientation. Most gaskets, many bolt washers, and all thermostats are asymmetrical.

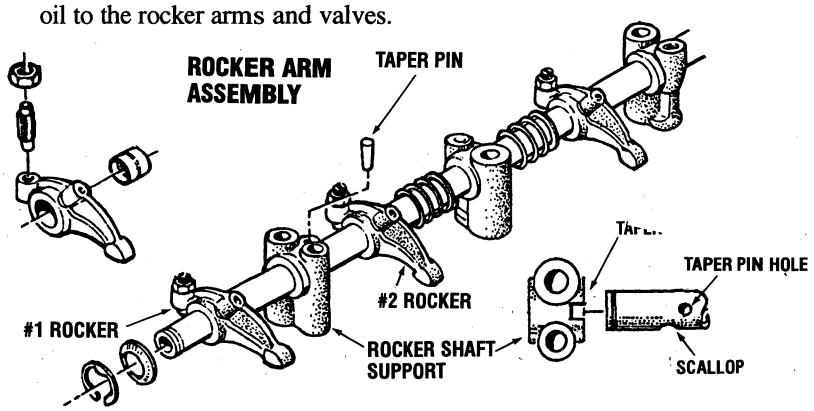
Mechanical damage. Run fasteners down in approved torque sequences and in three steps–1/2, 2/3, and 1/1 torque. Exceptions are torque-to-yield bolts and rocker arm shaft fasteners. The former are torqued as indicated. The latter–rocker shaft fasteners–should be brought down in very small increments, working from the center bolts out. Gaskets, especially head gaskets, might also be damaged during assembly, they should be positioned with great care.

ENGINE ASSEMBLY

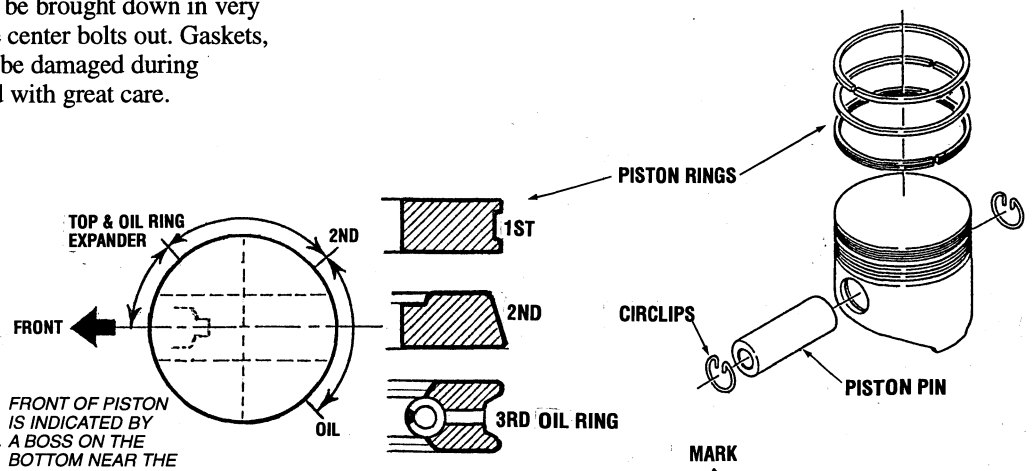
1. Install the valves in cylinder head. Using the valve spring lifter arm and pivot, assemble the valve, lower spring seat, oil deflector, inner valve spring, outer valve spring, upper spring seat and taper sleeve in this order.

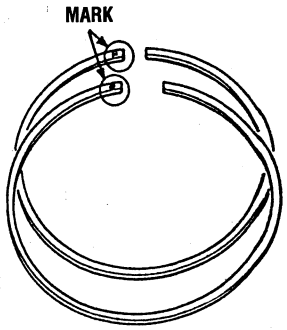
NOTE: *The oil deflector should be installed on the intake valve only.*

2. Assemble the rocker arm shaft, rocker shaft brackets and rocker arms. Note that the front end of the rocker shaft is identified by a pin protruding from the top and a larger oil hole between the supply holes serving #1 and #2 rocker arms. This pin fits a slot in the #1 rocker shaft support which prevents the shaft from turning and cutting off the lube oil to the rocker arms and valves.



3. Assemble the connecting rod, piston and piston rings. Arrange the piston and the connecting rod as shown and, using the piston pin installer, insert the piston pin through the piston and connecting rod until the piston pin circlips can be fitted. Fit the piston pin circlips to their respective grooves. Install the piston rings to ring grooves on the piston with the inscription mark on ring upward.





CHECK THE PISTON RING GAPS WITH CARE. NEW RINGS ARE PACKAGED WITH DETAILED INSTRUCTIONS THAT OFTEN SUPERSEDE THE SERVICE MANUAL.

4. Install the crankshaft.

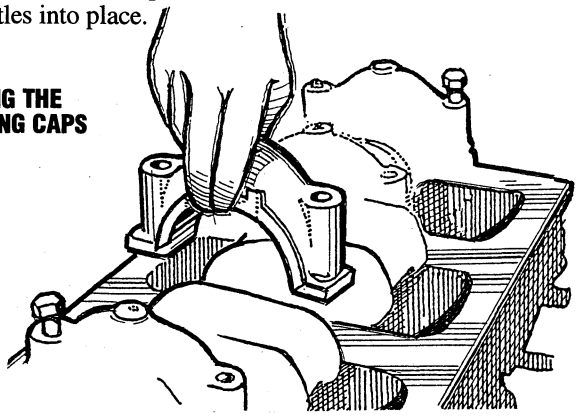
NOTE: *Do not apply oil to the backsides of the main bearing shells.*

a. Fit the main bearings on the cylinder block and the bearing caps respectively. Check that the oil ways align perfectly with those in the block.

b. Fit the thrustwashers to the cylinder block so that the oil grooves on thrustwashers face to crankshaft side.

c. Position the crankshaft to the cylinder block, being careful not to drop the thrustwashers as the crankshaft settles into place.

FITTING THE BEARING CAPS



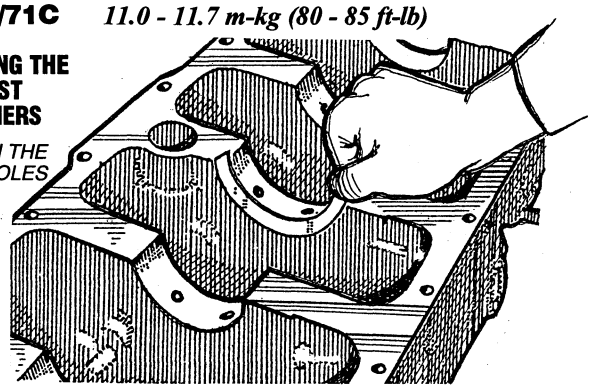
d. Fit the thrustwasher to the main bearing cap so that the oil grooves on thrustwasher face to crankshaft side. Then install the main bearing cap to the cylinder block with arrow mark of the main bearing cap facing the crankshaft pulley side.

Main Bearing Cap Tightening Torque

71B/71C *11.0 - 11.7 m-kg (80 - 85 ft-lb)*

FITTING THE THRUST WASHERS

ALIGN THE OIL HOLES



5. Install the rear oil seal. Apply engine oil to the oil seal lip.

6. Install the piston and connecting rod assembly.

a. Place the piston rings so that the ring ends are properly spaced around the circumference of the piston as shown on the previous page.

b. Using a ring compressor, fit the piston into the cylinder in the position as is shown.

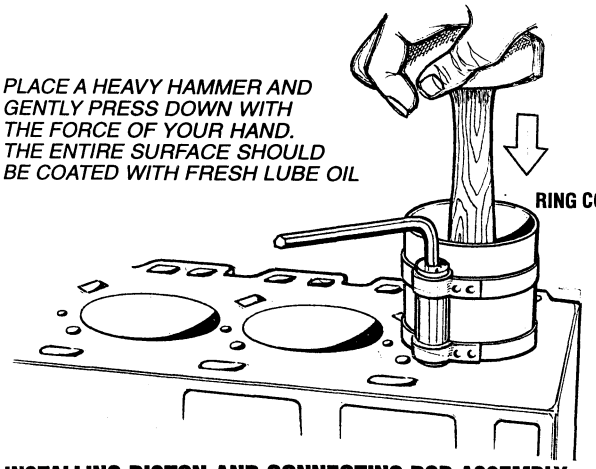
c. Install the caps to the connecting rods, ensuring that the identification numbers on the cap and connecting rod are matched.

Cap Tightening Torque (install new connecting rod bolts)

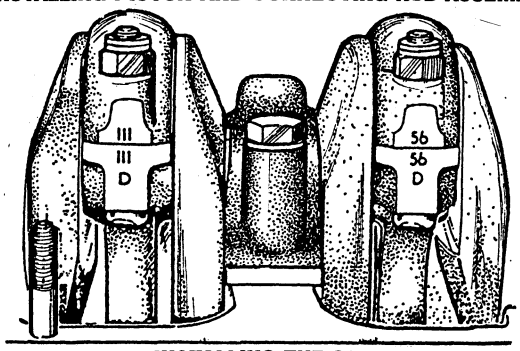
71B *8.2 - 9.0 m-kg (59 - 65 ft-lb)*
71C *6.9 - 7.5 m-kg (50 - 54 ft-lb)*

PLACE A HEAVY HAMMER AND GENTLY PRESS DOWN WITH THE FORCE OF YOUR HAND. THE ENTIRE SURFACE SHOULD BE COATED WITH FRESH LUBE OIL

RING COMPRESSOR



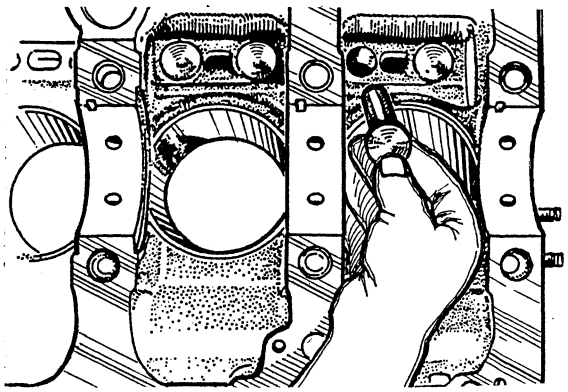
INSTALLING PISTON AND CONNECTING ROD ASSEMBLY



INSTALLING THE CAPS

7. Install the idler gear spindle. Align the oil passages of the idler gear spindle and cylinder block.

8. Install the timing gear case. Attach the straight edge on the cylinder block, then match the surfaces of the timing gear case end and that of the cylinder block. If the gasket protrudes from the mating surface, cut away the excess with a knife.



INSTALLING THE TAPPETS

9. Installation of the crankshaft.

a. Insert the tappet into the cylinder block.

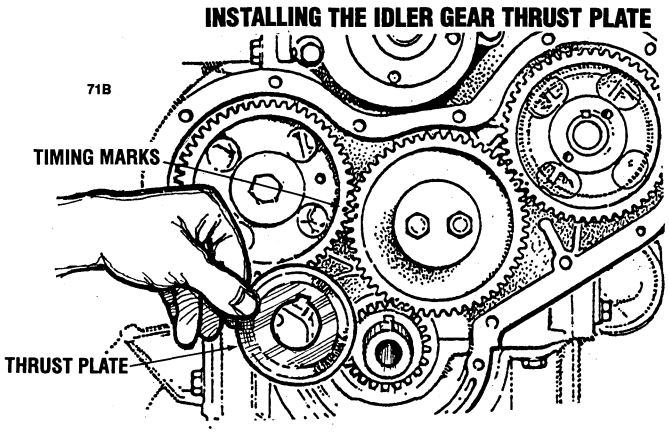
b. Insert the camshaft into the cylinder block.

c. Install the camshaft thrust plate.

Thrust Plate Tightening Torque

71B/71C *1.6 - 2.4 m-kg (11.6 - 17.4 ft-lb)*

ENGINE REASSEMBLY



10. Install each gear. While aligning the timing mark of each gear, install the following gears on each position.

a. Timing gear

b. Camshaft gear

c. Idler gear (**71C** uses two idler gears)

d. Injection pump drive gear

e. Install the idler gear thrust plate, then tighten the nuts.

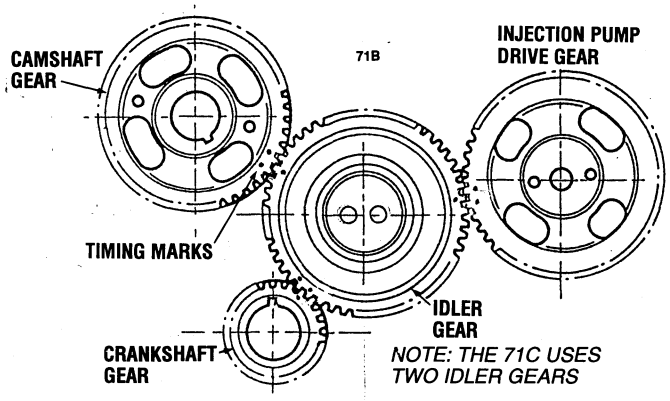
Tightening Torque

71B/71C *2.3 - 3.2 m-kg (16.6 - 23.1 ft-lb)*

f. Tighten the camshaft gear attaching bolts.

Tightening Torque

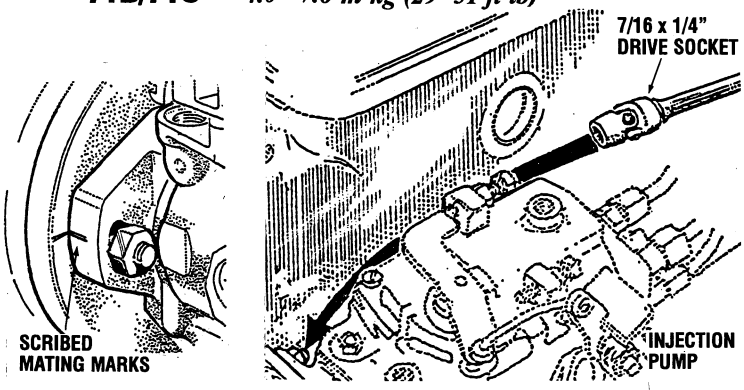
71B/71C *6.4 - 9.5 m-kg (45 - 51 ft-lb)*



g. Mount the injection pump on the gear case, then tighten the pump drive gear attaching nuts.

Tightening Torque

71B/71C *4.0 - 7.0 m-kg (29 -51 ft-lb)*



h. Install the oil deflector on the crankshaft.

11. Install the timing gear cover.

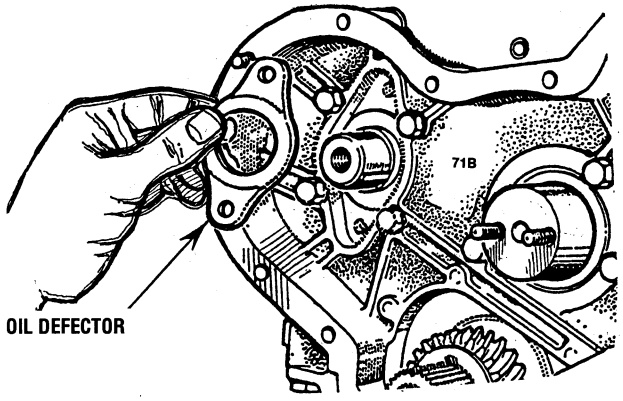
a. Install the bearing housing cover on the timing gear cover.

b. Install the injection pump drive gear cover on the timing gear cover.

c. Install the timing gear cover and tighten the timing gear cover attaching nuts and bolts after the crankshaft pulley has been installed temporarily to center the seal.

Timing Gear Cover Tightening Torque

71B/71C *1.6 - 2.4 m-kg (11.6 - 17.4 ft-lb)*



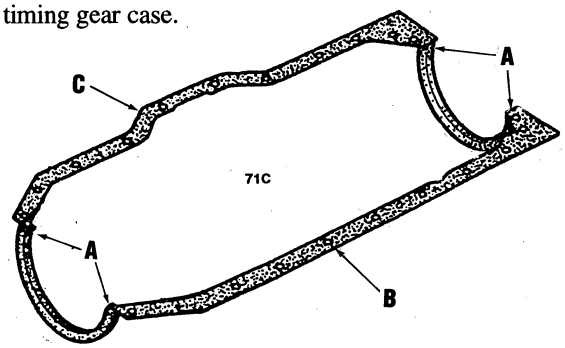
12. Install the crankshaft pulley. Then temporarily tighten the pulley attaching bolt.

13. Mount the oil pump. Apply the sealing agent on set screw thread and tighten screw.

14. Position the new oil pan gasket set.

a. Position the gasket ends (A) on the gaskets (B) and (C).

b. Apply a silicon sealing agent on the mating surfaces of the gasket and that between the cylinder block and the timing gear case.



15. Install the oil pan.

Tightening Torque

71B/71C *1.60 - 2.30 m-kg (12 - 17 ft-lb)*

16. Attach the backing plate.

Tightening Torque

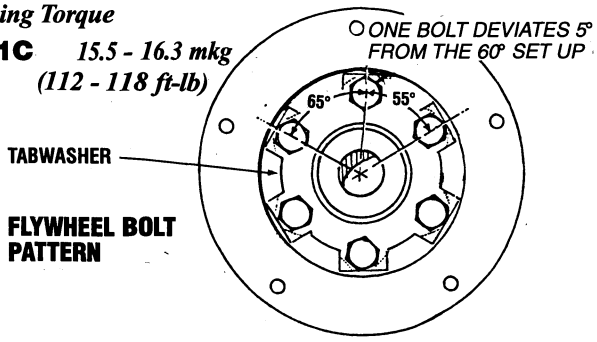
71B/71C *3.3 - 4.8 m-kg (23.9 - 34.7 ft-lb)*

17. Install the flywheel. Install the flywheel onto the rear end of the crankshaft.

18. Install the tabwasher plate and the flywheel bolts. Torque the bolts. Bend the tabwasher to lock the bolts in place.

Tightening Torque

71B/71C *15.5 - 16.3 mkg (112 - 118 ft-lb)*

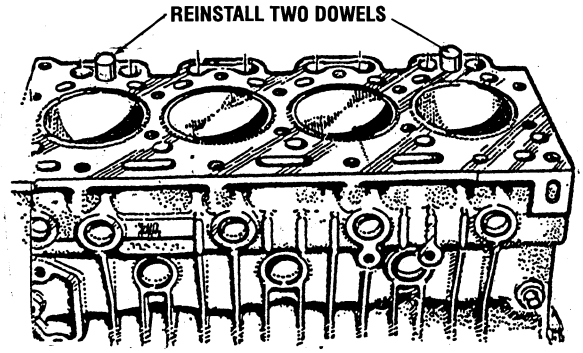


19. Tighten the front crankshaft pulley bolt.

Tightening Torque

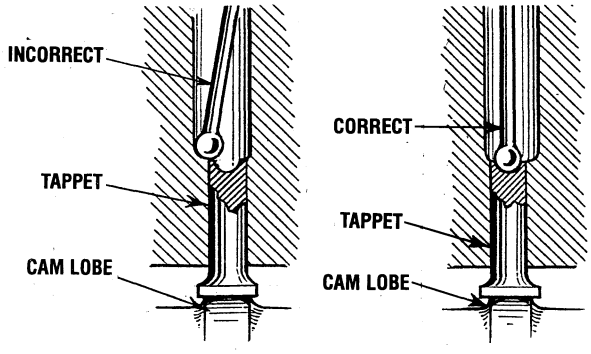
71B/71C *35 - 40 m-kg (253 - 289 ft-lb)*

20. Install the two tubular dowels adjacent to cylinders 1 and 4 if they were removed earlier during disassembly. Position the gasket on cylinder block. Do not use any liquid seal or cement.



21. Position the cylinder head.

22. Insert the pushrod. Check if the push rod is securely set in the tappet concavity.



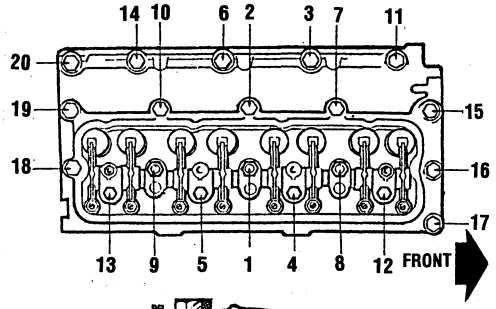
23. Position the valve cap on the top of the valve stem.

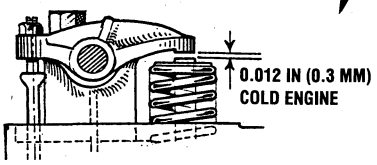
24. Install the rocker arm assembly onto the cylinder head. Remember that the end of the rocker shaft having the pin occupying the slot in #1 rocker support points toward the front (pulley) end of the engine.

25. Tighten the cylinder head bolts. Tighten the cylinder head bolts evenly in the sequence shown.

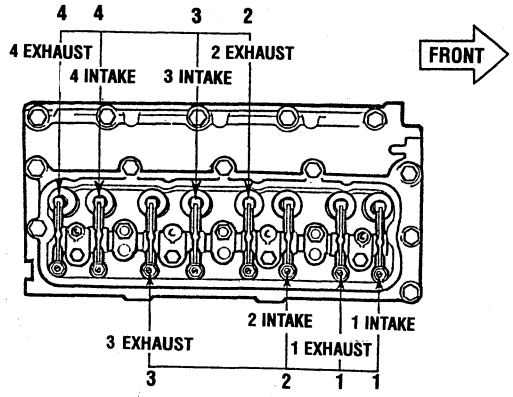
Tightening Torque

71B *11.8 - 12.5 m-kg (85 - 90 ft-lb)*
71C *11.0 - 11.7 m-kg (80 - 85 ft-lb)*





WHEN NO 4 CYLINDER IS AT TOP DEAD CENTER



WHEN NO 1 CYLINDER IS AT TOP DEAD CENTER

26. Adjust valve clearance. Adjust the valve clearance. Set No. 1 cylinder to TDC (top dead clearance) of the compression stroke and adjust the valve clearance on No. 1 and No. 2 intake cylinders... and No. 1 and No. 3 exhaust cylinders.

a. Turn the crankshaft once, setting the No. 4 cylinder piston at TDC (compression) and adjust the No. 3 and No.4 intake cylinders... and the No.2 and No.4 exhaust cylinders.

b. Adjust each valve's clearance by inserting a 0.012 in (0.03 mm) feeler gauge between the rocker arm and the valve stem.

Valve Clearance

71B/71C *0.30 mm (.12 in) cold*

27. Install the cylinder head cover.

Torque

71B/71C *0.3 - 0.4 m-kg (2 - 3 ft-lb)*

NOTE: *After the engine has been reassembled, readjust the valve clearances with a warm engine, see* ENGINE ADJUSTMENTS.

ENGINE REASSEMBLY

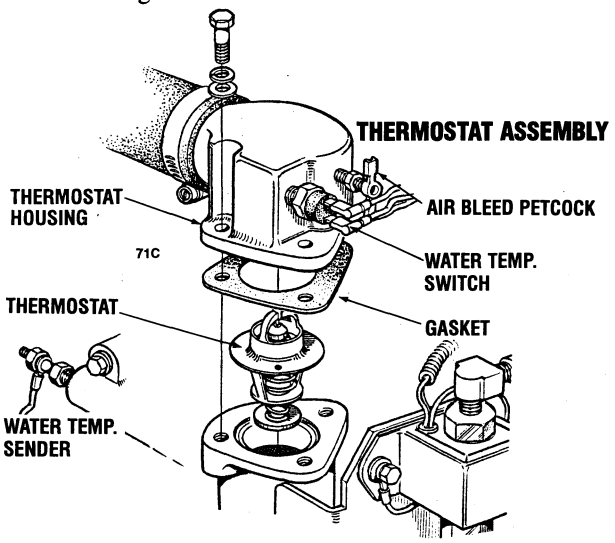
28. Install the thermostat and thermostat housing.

a. Inspect the thermostat housing and the housing gasket. Apply some sealant to the gasket when reassembling.

b. Install the temperature switch and sendor and reconnect their wires.

c. Install a new thermostat and gasket (the old thermostat can become a spare). When installing the new thermostat and gasket, apply a thin coat of sealant to both sides of the gasket.

d. The thermostat can be checked for proper operation by placing it in a pan of cold water and then raising the temperature of the water to a boil. The thermostat should open noticeably (with travel on the order of 1/4 in - 1/2 in) and be fully opened when the water is boiling.



29. Install the coolant pump assembly.

Tightening Torque

71B/71C *1.6 - 2.3 m-kg (12 - 17 ft-lb)*

A complete breakdown of the COOLANT PUMP ASSEMBLY is covered on another page in this manual.

30. Adjust the injection timing.

See INJECTION TIMING.

31. Mount the oil filter bracket and install a new filter. When installing the new filter apply a thin coat of clean engine oil to the rubber gasket. Tighten by hand.

32. Mount the front engine mounting bracket.

Tightening Torque

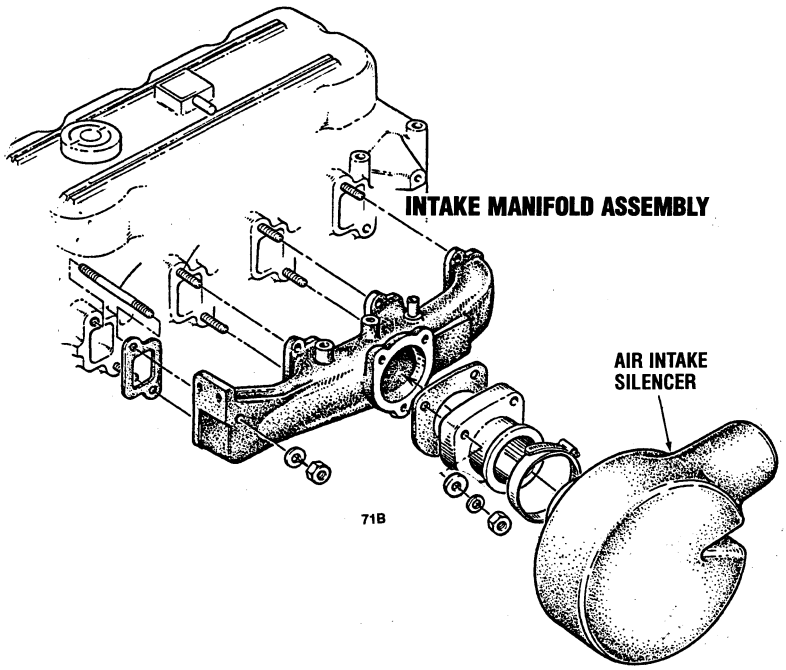
71B/71C *4.6 - 6.8 m-kg (33 - 49 ft-lb)*

33. Install the intake manifold.

Tightening Torque

71B/71C *1.6 - 2.4 m-kg (11.6 - 17.4 ft-lb)*

34. Mount the fuel filter assembly.



35. Install the fuel injection nozzles. Install the fuel overflow pipe. Use new sealing washers throughout, in the same order as were the old washers.

Injection Nozzle Hold Down Nuts Torque

71B *1.6 - 2.4 m-kg (11.6 - 17.4 ft-lb)*

Injector Tightening Torque

71C *6.0 - 7.0 m-kg (43 - 51 ft-lb)*

See FUEL INJECTORS

36. Install the glow plugs and connectors. Use anti-seize compound on the threads.

Glow Plug Tightening Torque

71B/71C *1.0 - 1.5 m-kg (7.2 - 10.8 ft-lb)*

To test the glow plugs, see GLOW PLUGS

37. Mount the rocker arm cover and crankcase vent hose.

Rocker Arm Cover Tightening Torque

71B/71C *0.25 - 0.40 m-kg (1.8 - 2.9 ft-lb)*

38. Connect the fuel line to the engine mounted fuel filter and the line to the injection pump. Use new sealing washers.

39. Connect the high pressure injector lines from the injection pump to injectors. Reinstall the line clamp.

Torque Attaching Nuts

71B/71C *2.5 - 3.0 m-kg (18 - 22 ft-lb)*

40. Install the bellhousing.

41. Install the air intake silencer.

42. Mount the engine heat exchanger and engine oil cooler on the flywheel bellhousing.

The heat exchanger should be serviced at engine overhaul. Refer to HEAT EXCHANGER.

43. Install the alternator and drive belt.

> ⚠ **CAUTION:** ***Connect the alternator properly. Should the polarity be reversed, a powerful current would flow from the battery into the alternator, damaging the diodes and wiring harness.***

a. Install the alternator support bolt through the alternator leg (underside) into the engine casting.

b. Swing the alternator into position on the adjusting bracket and fasten. Lightly tighten.

c. Adjust belt tension.

d. Tighten both bolts and recheck belt tension.

Torque Values

71B/71C ***Support bolt 20 - 24 Nm (15 - 18 ft-lbs)***
Adjusting bracket bolt 12 - 14 Nm (9 -10 ft-lbs)

NOTE: *Make certain the belts are perfectly aligned with the alternator and engine pulleys. If not, insert or remove spacers as needed, to align the alternator.*

See ALTERNATOR for testing.

44. Install the raw water pump and drive belt. Insure it is in proper alignment with the crankshaft pulley. Check tension.

Refer to RAW WATER PUMP

45. Install the oil and water sender and switch.

46. Install the starter motor.

47. Install the breaker panel and the preheat solenoid.

48. Reinstall the engine electrical harness.

49. Mount the complete exhaust manifold and the expansion tank to the cylinder head.

Torque Mounting Bolts

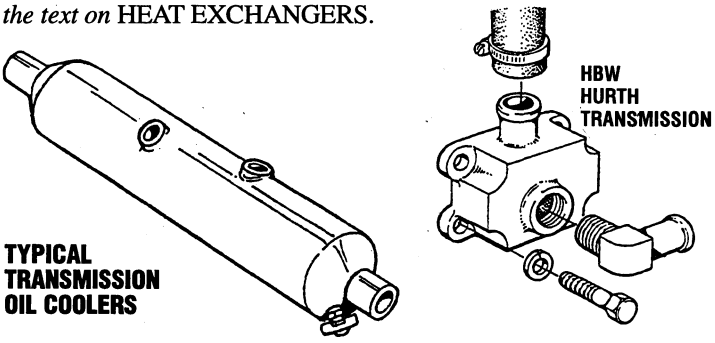
2.7 - 3.3 m-kg (20 - 24 ft-lb)

See EXHAUST MANIFOLD for service and inspection.

50. Install new hose connections and clamps for cooling system.

51. Marine Engine. 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.



50. Generator. Mount the generator back end assembly with it's control panel. Reconnect all DC wiring and reconnect all AC connections.

> ⚠ **CAUTION:** ***Check all AC and DC wiring connections to WESTERBEKES wiring schematics and diagrams.***

Fill the engine cooling system with antifreeze mixture and the engine oil sump with lube oil (A.P.I. spec. CF or CG-4).

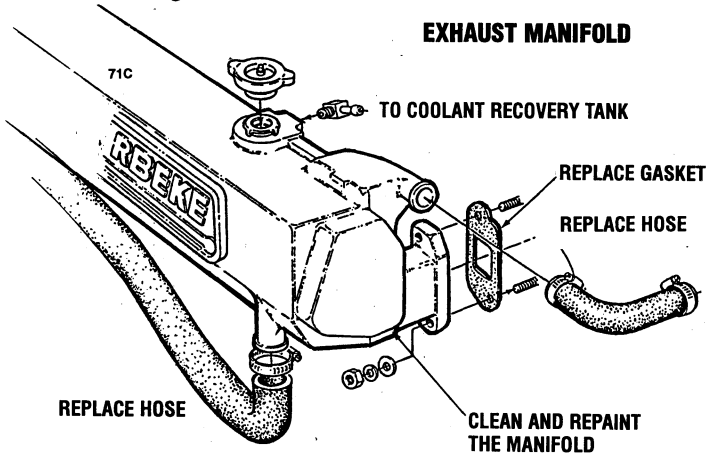
The engine should be test run under load prior to reinstalling. At this time readjust the valve clearances on the hot engine.

EXHAUST MANIFOLD / HEAT EXCHANGER

EXHAUST MANIFOLD

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

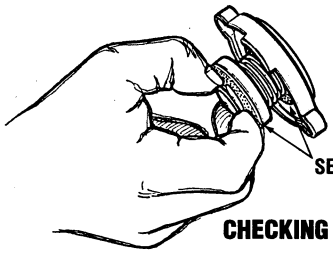
1. Remove the exhaust elbows from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.
2. Remove the exhaust nipples, elbows and plugs from the manifold.
3. Remove water connectors from the ends of the manifold and the end plates (71B). Be sure to note the proper location and arrangement of each for proper alignment.
4. Examine all parts for defects, corrosion and wear and replace as needed.
5. Flush out the manifolds interior with a liquid cleaner and rinse thoroughly with fresh water.
6. Use a pipe cleaner to clear the passage that connects the coolant recovery tank tubing.
7. Flush out the coolant recovery tank and it's connecting tube.



ASSEMBLY

1. If the manifold was removed as an assembly and left intact, it can be replaced on the cylinder head in the reverse order of removal. Do not reuse the gaskets; install new ones and torque the bolts or nuts to the proper specification (10-12 lb-ft).
2. If the manifold has been disassembled, follow the steps below.
   a. Loosely attach the elbows to the cylinder head and the manifold using new gaskets. Do not use any gasket sealant.
   b. Gradually tighten each fitting to make sure of proper alignment of all the parts. This should be done in three steps. Torque to 10-12 lb-ft.
   c. Reassemble the manifold end plates (71B), and the connectors on the manifold. Be sure to use new gaskets and coat the gasket surfaces with a suitable gasket cement such as High Tack. Torque the nuts to 8-10 lb-ft.
   d. Reinstall the exhaust connections and plugs into the manifold using Locktite-Anti-Seize on the threads.

Check the manifold pressure cap. Open the valve by pulling it and make sure it closes when released. Make certain the upper and lower seals are in good condition. If any doubt, replace the cap.



CHECKING THE PRESSURE CAP

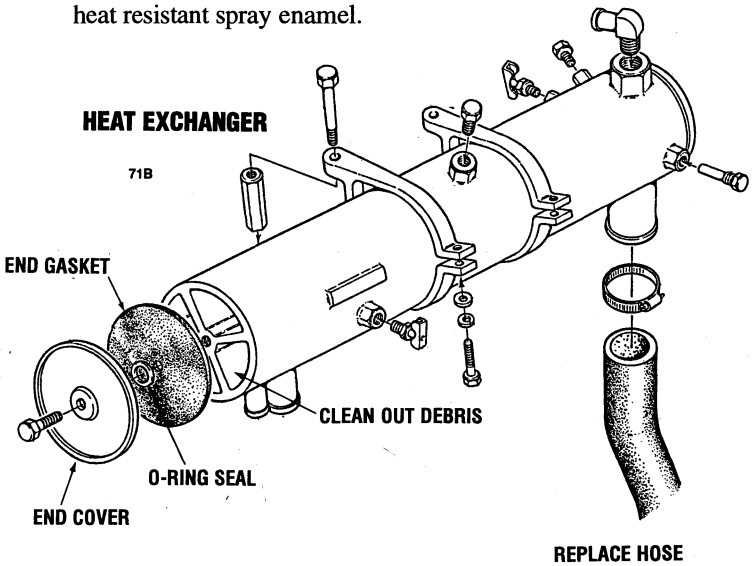
HEAT EXCHANGER

The heat exchanger should be inspected and serviced during an engine overhaul.

1. Disconnect the hoses and remove the hose fittings, petcock, drain plugs and zinc anode. Also, remove the end fittings and gaskets.
2. Inspect the tube (casing) for wear and dents, if at all suspect replace the heat exchanger.
3. Clean out any zinc debris and pressure test the coolant and raw water passages.
4. When reassembling, install new gaskets and O-rings. Apply some lubricant to the new gaskets and to the petcocks and fittings as you install them.
5. Install a new zinc anode.

NOTE: *All of the above can be accomplished by sending the heat exchanger to a heat exchanger service shop. They will also service transmission and engine oil coolers.*

6. Repaint the assembled heat exchanger with Westerbeke heat resistant spray enamel.



AFTER COMPLETED ENGINE ASSEMBLY

5. Reconnect all hoses, replacing them as needed.
6. Refill the system with coolant as detailed above.
7. Pressure test system and check for leaks.

FUEL INJECTION PUMP

SPEED ADJUSTMENT (PROPULSION ENGINE)

The fuel injection pump is the most important component of the diesel engine and, therefore, calls for the utmost caution in handling.

Speed (hertz) and timing are the only adjustments the service dealer can perform on the injection pump. Other types of adjustments or repairs must be performed by a qualified injection service shop.

Early Models without Electronic Governing

When servicing the injection pump, the service shop must be advised if the pump is to be used in a generator application. The service shop will have to remove and replace the governor spring with a propulsion spring. Once the injector pump is set up to propulsion specifications, the generator governor spring is reinstalled in the injection pump and the pump remounted on the engine. Then set the throttle for proper engine no-load speed (hertz).

For the disassembling, inspecting, reassembling and internal adjusting of the injection pump, it is recommended that the pump be taken to a qualified injection service shop authorized to service Diesel KiKi injection equipment.

The only adjustment the servicing mechanic should make to the injection pump is the adjustment for engine idle speed.

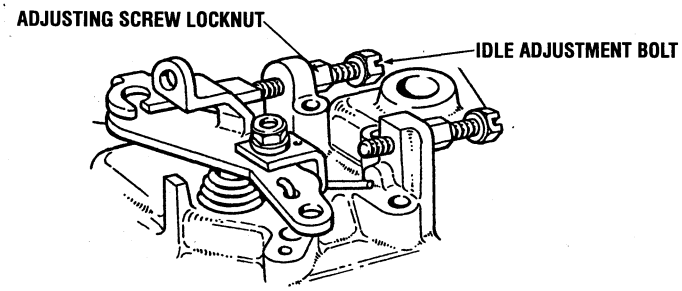
1. Checking Idle Speed.
   - **a.** Warm up the engine.
   - **b.** Remove any specks on the crankshaft pulley with a clean cloth and place a piece of suitable reflecting tape on the pulley to facilitate use of a photo-electric type tachometer.
   - **c.** Start and idle the engine.
   - **d.** Aim the light of the tachometer onto the reflecting tape to confirm the engine speed.
   - **e.** Adjust the idle speed if the engine speed is not within the specified value.

Normal Idle Speed

71B *600 - 700 RPM*
71C *580 - 630 RPM*

2. To adjust the engine idle speed, loosen the lock nut of the idle adjustment bolt and turn the bolt clockwise to increase idle speed and counterclockwise to reduce.

NOTE: *Should engine RPM be in question, verify tachometer readings as shown at the instrument panel with a mechanical or strobe type tachometer at the engine crankshaft.*



ADJUSTING IDLE SPEED

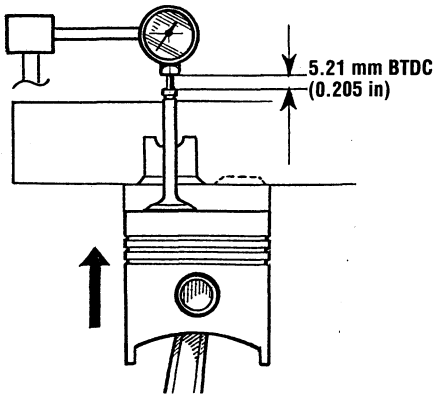
3. Inspecting and adjusting the injection pump timing.
   - **a.** Remove the air intake/silencer assembly.
   - **b.** Remove the 4 high pressure injector lines that connect between the injection pump and injectors.
   - **c.** Remove the bolt and gasket installed on the distributor head of the injection pump.
   - **d.** Remove the valve rocker cover.
   - **e.** Rotate the crankshaft in normal direction of rotation (use front crankshaft pulley nut) and place No. 1 piston at TDC of its compression stroke.

NOTE: *To verify, the rocker arms of No.4 cylinder should be rocking (one opening, the other closing).*

   - **f.** Remove the snap ring circlip from the end of the rocker shaft at cylinder No.1 along with the retaining washer.
   - **g.** Loosen the rocker arm adjusting bolt so as to allow the arm to be removed from the push rod and slide it off the rocker shaft.
   - **h.** Press down on the valve and spring assembly and note that the valve is hitting the top of No.1 piston. Then remove the cap, keepers and valve springs from the No.1 valve.

NOTE: *Insure the valve moves freely in its guide. Take care not to drop keepers down push rod hole.*

   - **i.** Position a dial indicator gauge on the valve stem and with the front crankshaft pulley nut, rock the crankshaft counter-clockwise and clockwise to locate exact TDC of the compression stroke for No.1 piston and then zero the dial indicator gauge to the valve stem. (The gauge should be able to measure up to .300 inch of valve movement.)



   - **j.** Turn the crankshaft until the indicator shows the valve drip to be at .264 inch. This is 30 degrees BTDC.
   - **k.** Install the measuring device (Diesel Kit #57828 - 3520) in the bolt hole of the injection pump distributor head. (Refer to step **c.**) Insure that the feeler needle of the measuring device is in contact with the plunger inside of the pump. Zero the measuring device scale.

4. Turn the crankshaft in the direction of normal rotation until the No.1 piston is at TDC by referencing the indicator on the valve stem.
   a. The measuring device indicator needle should move 1.00 mm from the zero setting.

Beginning of Static Injection

71B/71C *Cam lift 1.00 mm (0.0394 in)*

NOTE: *If the measuring device show movement at the plunger to be more or less than specified above, the injection pump must be adjusted to correct the movement.*

5. Adjusting the injection pump.
   a. Disconnect the fuel supply and return line connections from the pump.
   b. Disconnect the support bracket at the back of the injection pump as it attaches to the lube oil filter adapter.
   c. Loosen the two injection pump hold down nuts that secure the injection pump to the engine.
   d. Rotate the injection pump either towards the engine or away from the engine to adjust the measuring device indicator to show 1.0 mm of movement.
   e. Secure the pump by tightening the two hold down nuts.
   f. Remove the measuring device and replace the bolt and gasket and reattach all fuel lines using new sealing washer.
6. Installing injection pump.

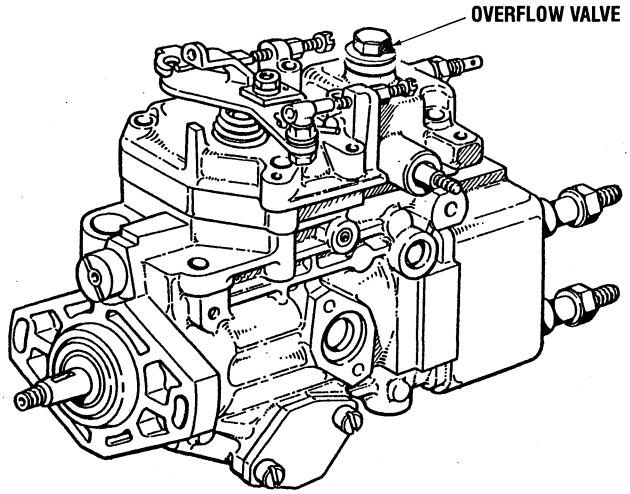
Install the injection pump in the reverse order of removal, noting the following points:

   a. Tighten the lock nut of injection pump drive gear to the specified torque.

Tightening Torque - Injection Pump

71B/71C *4.0 - 7.4 m-kg (29 - 51 ft-lb)*

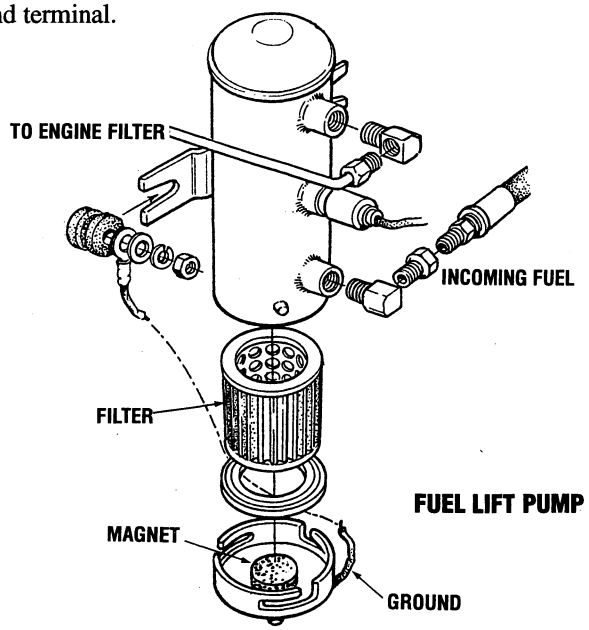
   b. After the injection pump has been installed, loosen the overflow valve, and bleed the air by operating the priming pump.



INJECTION PUMP

FUEL LIFT PUMP (Early Models)

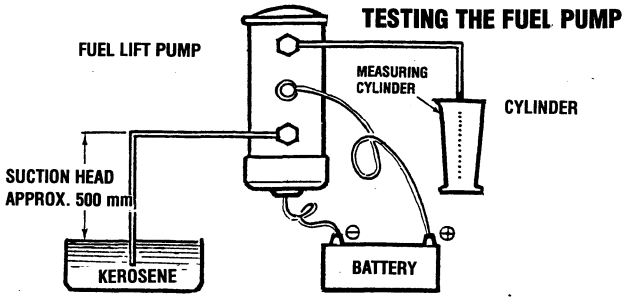
The Fuel Lift pump should be cleaned and repainted. Install a new filter as illustrated and clean the ground wire end terminal.



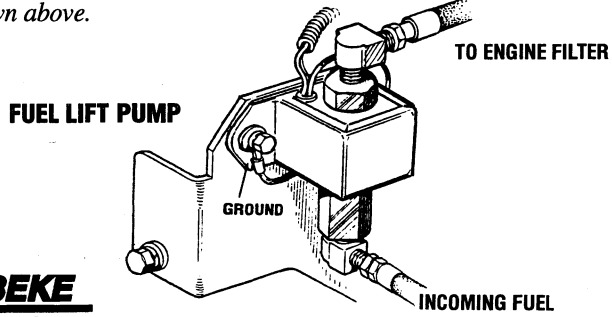
Troubleshooting

This lift pump operates during the start sequence when pre-heat is depressed. Simulate a start and depress preheat, the pump should produce a clicking sound indicating the piston in the pump is operating. If no clicking is heard, check that there is 12 volts at the pump connection and that the pump is properly grounded.

1. Test the pump by connecting a battery and fuel line as illustrated. Fuel delivery must be 225 cc (0.5 pints) or more every 15 seconds.



NOTE: *Later model WESTERBEKE engines and generators use a solid state fuel lift pump that requires no maintenance. This lift pump can also be adapted to replace the pump shown above.*



FUEL INJECTORS

REMOVING THE INJECTORS.

1. Disconnect the high pressure lines from the injectors and loosen the lines at their attachment to the injection pump and move them out of the way of the injectors. Avoid bending the lines.
2. Remove the fuel return line in its entirety from the top of the injectors. Take care not to lose the two sealing washers and banjo bolt that attaches the fuel return line to each injector.
3. **71B** Remove the two nuts and washers that hold the injector on the cylinder head.

   71C Unscrew the injector from the cylinder head.

NOTE: *Clean the area around the base of the injector prior to lifting it out of the cylinder head to help prevent any rust or debris from falling down into the injector hole. If the injector will not lift out easily and is held in by carbon build up or the like, work the injector side to side with the aid of an adjustable or open end wrench to free it and then lift it out.*

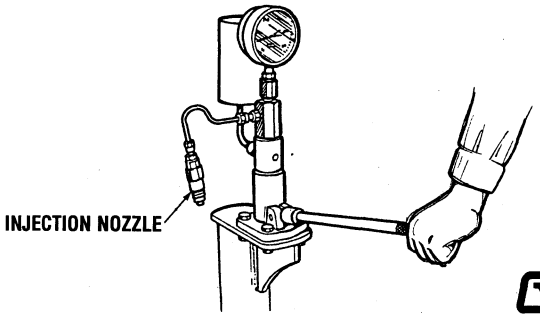
4. The injector seats in the cylinder head on a copper sealing washer. This washer should be removed with the injector and replaced with a new washer when the injector is reinstalled.

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:

> ⚠ **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.***

   a. If the diesel fuel of the nozzle tester is stained, 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 tempurature of 20° C (68° F)
   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.



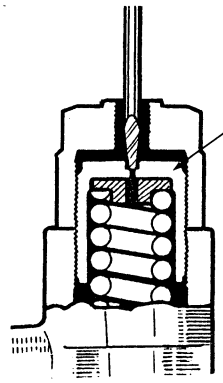
Start to Injection

71B/71C *135 - 140 kg/cm² (1920 - 1990 lb/in²)*

71B If the injection starting pressure of the nozzle is not within the limit, loosen the cap nut on the nozzle holder, insert flat screwdriver through the bolt hole of the cap nut, then turn the pressure adjusting screw to set the injection starting pressure to 200 kg/cm2 (2.844 lb/in2). Then, gradually decrease the pressure until the injection starting pressure is 135 kg/cm2 (1920 lb/in2). After the injection starting pressure has been adjusted, hold the pressure adjusting screw with flat screwdriver, then tighten the cap nut. Then check the injection starting pressure again if it does not change.

Cap Nut Tightening Torque - Injector

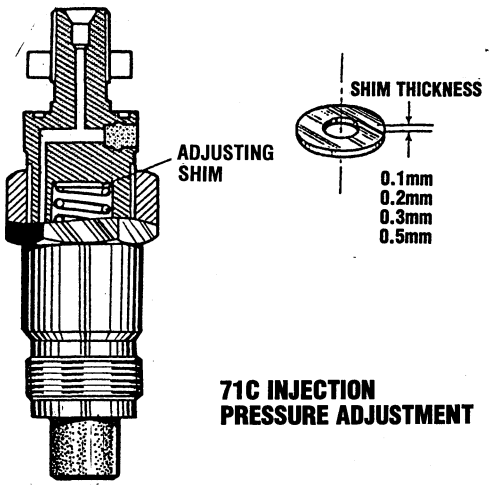
71B *4- 5 m-kg (8.82 - 11.02 lb)*



71B INJECTION PRESSURE ADJUSTMENT

The injection starting pressure for the **71C** injectors is adjusted by increasing or decreasing the thickness of the adjusting shim.

The shim has 20 different thickness for every 0.05 mm (0.0020 in), from 1.0 mm (0.0393 in) to 1.95 mm (0.0768 in). As 0.05 mm (0.0020 in) is increased, approximately 5.0 kg/cm² (71.1 lb/in²) of injection pressure. When replacing the shim, grip the retaining nut in a vise and remove the body with a wrench. Tighten the retaining nut to the specified torque.

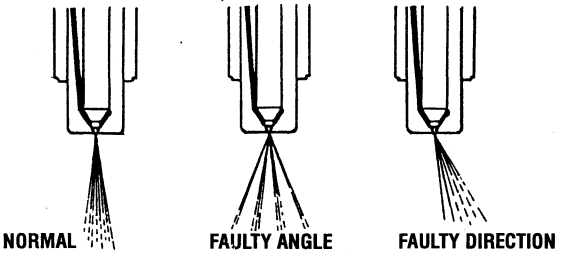


71C INJECTION PRESSURE ADJUSTMENT

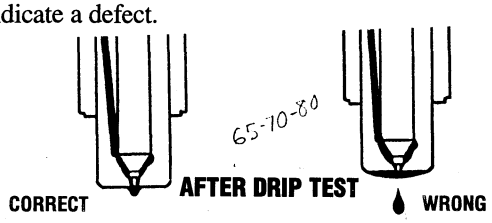
FUEL INJECTORS

INSPECTING SPRAY PATTERN

1. Operate the hand lever of the nozzle tester at intervals of one stroke per second to check if the fuel is injected correctly in its axial direction. A nozzle is defective if it injects fuel in an oblique direction or in several separate strips. Also, a spray in the form of particles indicates a defect. These defects may sometimes be caused by clogging with dust and, therefore, all parts should be carefully cleaned before reassembly. (Care should be taken not to expose ones skin to this spray as it may penetrate the skin and cause infection.)



2. Apply the pressure of 115 kg/cm2 (1635 lb/in2) to nozzle by operating the hand lever, and check the drips from the nozzle tip. If it drips or has a large accumulation of fuel on the bottom, it is considered defective and should be replaced. A very small amount of fuel may sometimes remain on the tip of the nozzle; however, this does not indicate a defect.

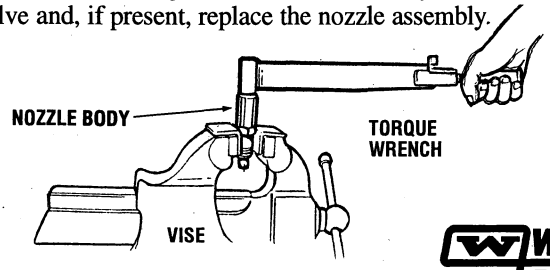


DISASSEMBLING AND INSPECTING

1. Clamp the nozzle holder in a vise, then remove the cap nut.
2. Remove the pressure adjusting screw, then pull out the upper seat, spring and the push rod.
3. Clamp the nozzle holder in a vise, remove the nozzle nut then pull the nozzle out.
4. Clean the disassembled parts with clean diesel fuel, then remove the carbon adhering on the nozzle.

NOTE: *Do not use a metal tool to remove the carbon.*

5. After cleaning, check to see if the needle valve comes down into the valve seat by its own weight when setting the nozzle body upright position and inserting needle valve.
6. Check that there is no flaw or other damage on mating surfaces and sliding surfaces of nozzle body and needle valve and, if present, replace the nozzle assembly.



ASSEMBLING

Assemble in the reverse order of disassembly, noting the following points:

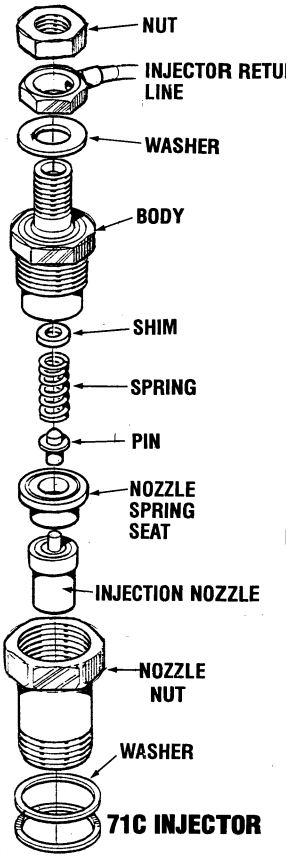
1. To assemble the nozzle and nozzle holder, first assemble the pressure adjusting nut side, and temporarily tighten the nut. Mount the nozzle and set the needle valve to proper position, then mount the nozzle nut.
2. After the nozzle and nozzle holder have been assembled, check the injection starting pressure and spray condition.

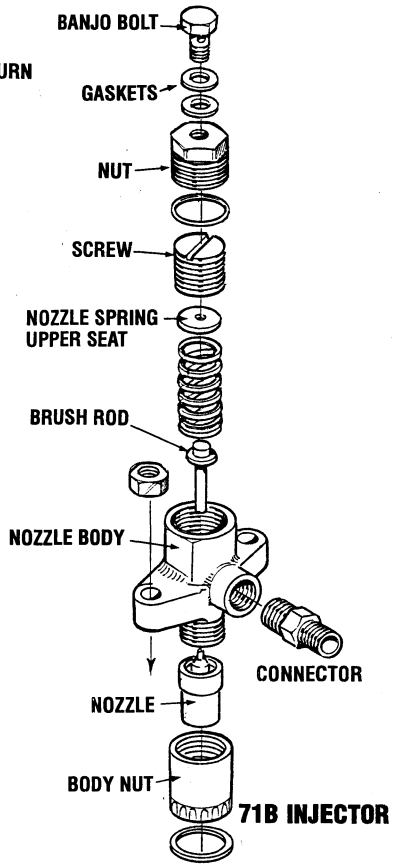
Nozzle Nut Tightening Torque

71B/71C *8 - 10 m-kg (58 -72 ft-lb)*

Cap Nut Tightening Torque

71B *4 - 5 m-kg (29 - 36 ft-lb)*





INSTALLING

Install the nozzle and nozzle holder assembly in the reverse order of removal, noting the following points:

1. When installing the nozzle and nozzle holder assembly, use a new copper washer.
2. **71B** Tighten the nozzle and nozzle holder assembly to the specified torque. Switch back and forth between the nuts; do not tighten one completely with the other loose.

Tightening Torque

71B *1.6 - 2.4 m-kg (11.6 - 17.4 ft-lb)*

Tightening Torque

71C *(27 mm) 6.0 - 7.0 m-kg (43 - 51 ft-lb)*

GLOW PLUGS

DESCRIPTION

The glow plugs are wired through the preheat soleniod. 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.

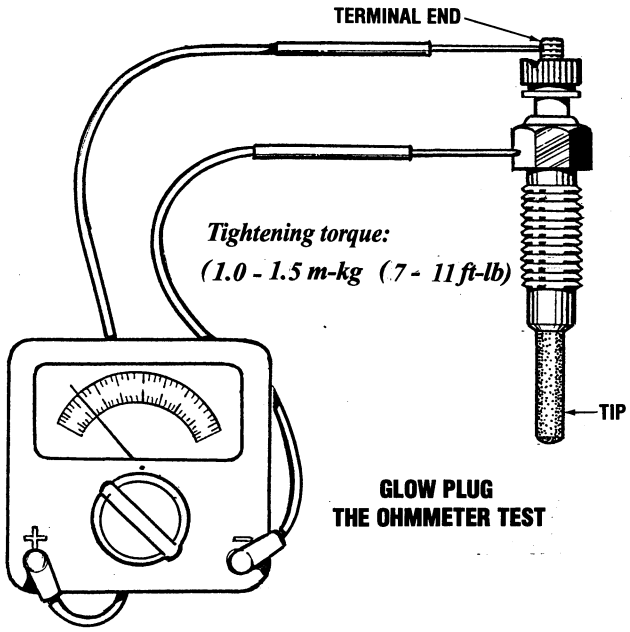
TESTING

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 1.0- to 1.5-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 (8 to 9 amps per plug).

⚠ WARNING: ***These glow plugs will become very hot to the touch. Be careful not to burn your fingers when testing the plugs***

Re-install the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) within 20 to 25 seconds. If the plugs don't heat up quickly, check for a short circuit. When reinstalling the glow plugs, use anti-seize compound on the threads.

⚠ WARNING: ***Do not keep a glow plug on for more than 30 seconds***



GLOW PLUG THE OHMMETER TEST

ENGINE ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

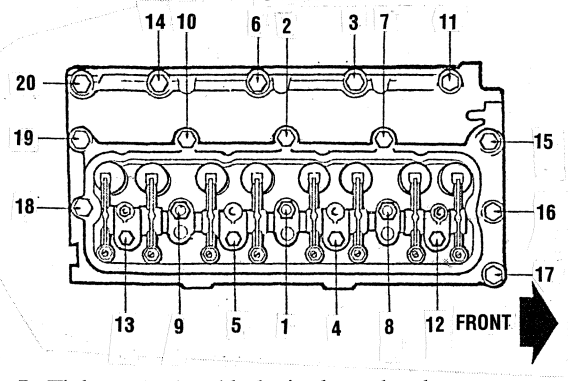
1. Warm the engine to normal operating temperature.
2. Pull off the air breather pipe from the rocker cover, and take off the rocker cover bolts and the rocker cover to expose the rocker shaft and valve assembly.
3. Remove the glow plugs from each of the cylinders to enable the engine to be easily rotated by hand to position each cylinder for valve adjustment.

Valves are adjusted with the piston in the cylinder being adjusted at TDC (top dead clearance) of its compression stroke.

NOTE: *Retorque the cylinder head bolts before adjusting the engine's valves.*

4. Loosen the head bolts in the reverse order of tightening.

CYLINDER HEAD BOLT PATTERN



5. Tighten the head bolts in the order shown.

Cylinder Head Bolt Tightening Torque

71B *11.8 - 12.5 m-kg (85 - 89 ft-lb)*

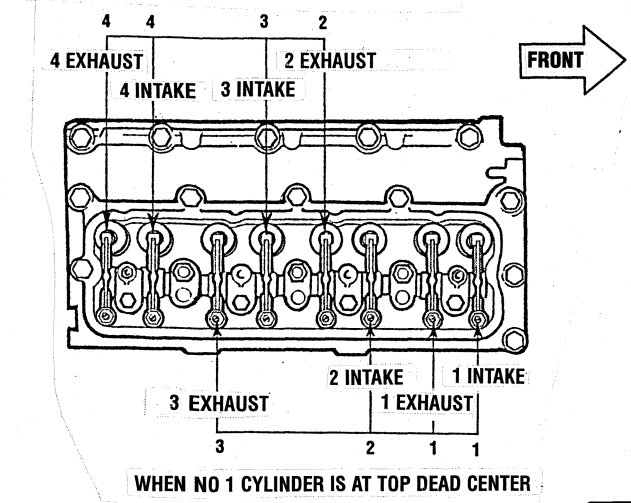
71C *11.0 - 11.7 m-kg (80 - 85 ft-lb)*

6. Set the piston of No. 1 cylinder to TDC (compression) and check the valve clearance at each position indicated. Adjust, if the clearance is incorrect.

Intake - No. 1 and No. 2 cylinders
Exhaust - No. 1 and No. 3 cylinders

VALVE ADJUSTMENT SEQUENCE

WHEN NO 4 CYLINDER IS AT TOP DEAD CENTER

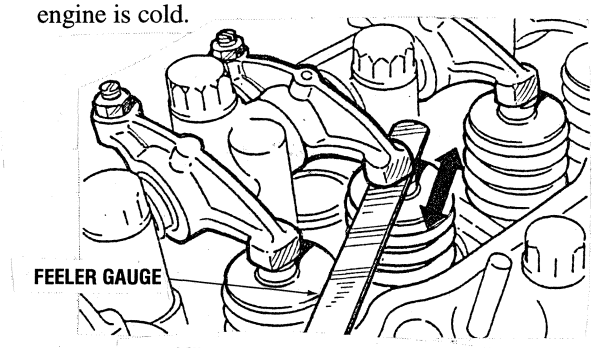


WHEN NO 1 CYLINDER IS AT TOP DEAD CENTER

7. Turn the crankshaft once, setting the piston of No. 4 cylinder at TDC (compression) and adjust to the following values:

Intake - No. 3 and No. 4 cylinders
Exhaust - No. 2 and No. 4 cylinders

8. Adjust each valve's clearance by inserting a 0.012 in (0.03 mm) feeler gauge between the rocker arm and the valve stem. Make sure to adjust all valves when the engine is cold.



9. Install the cylinder head cover.

Head Cover Bolt Torque

71B/71C *0.3 - 0.45 m-kg (2 - 3 ft-lb)*

ENGINE COMPRESSION

Check the compression pressure. To do this warm the engine, remove all fuel injectors, or glow plugs, disconnect the fuel shut-off solenoid wire, and install a compression adapter in the injector hole or glow plug hole, Connect a compression tester on the adapter and crank the engine with the starter motor until the pressure reaches a maximum value. Repeat this process for each cylinder. Look for cylinders with dramatically (at least 20%) lower compression than the average of the others. Compression pressure should not differ by more than 42.7 psi (3.0 kg/cm²) at 200 rpm.

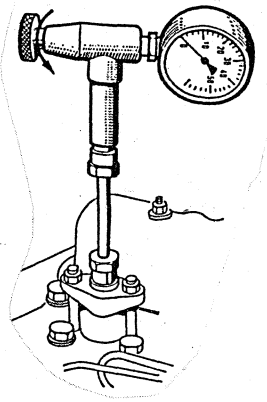
Compression Pressure Standard

71B/71C *30.0 kg/cm² (427 lb/in²) at 200 rpm*

Compression Pressure Limit

71B/71C *27.0 kg/cm² (384 lb/in²) at 200 rpm*

MEASURING COMPRESSION



If a weak cylinder is flanked by healthy cylinder, the problem is either valve or piston related. Check the valve clearances for the weak cylinder, adjust as needed and test again. If the cylinder is still low, apply a small amount of oil into the cylinder to seal the rings and repeat the test. If compression comes up - the rings are faulty.

Abnormally high readings on all cylinders indicates heavy carbon accumulations, a condition that might be accompanied by high pressures and noise.

NOTE: *In case of severe vibrations and detonation noise, have the injectors checked and overhauled by an authorized fuel injection service center. Poor fuel quality, contaminates and loss of positive fuel pressure to the injection pump will result in injector faults.*

When re-installing the glow plugs use anti-seize compound.

SETTING THE IDLE SPEED

1. Warm the engine to normal operating temperature.
2. Stick a piece of suitable reflecting tape on the crankshaft pulley.
3. Idle the engine.
4. Use the light of a photoelectric strobe type tachometer on the reflecting tape and check the valve shown by the tachometer.

Idle Speed

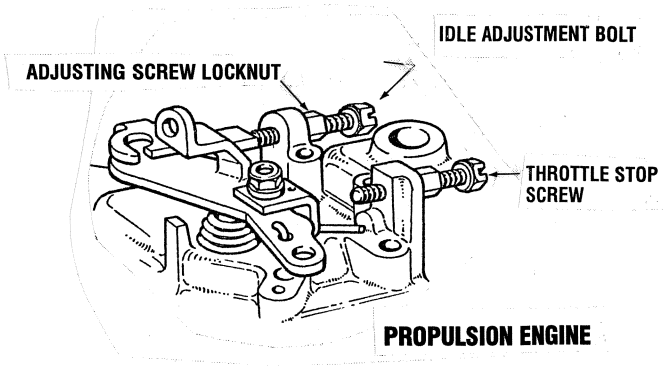
71B *600 - 700 rpm*

71C *580 - 630 rpm*

ADJUSTMENT - 71B/71C

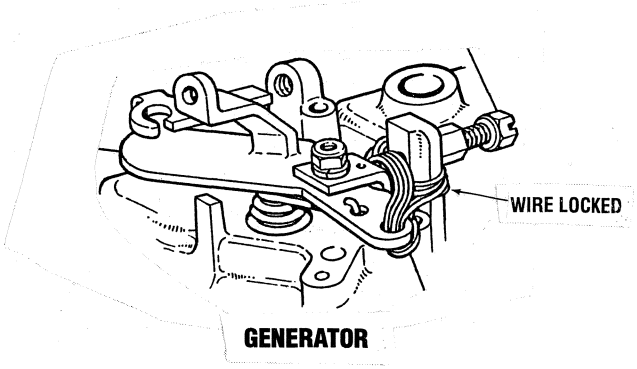
Make the necessary adjustment by turning the idle adjustment bolt on the fuel injection pump.

1. Loosen the locknut on the idle adjustment bolt on the injection pump.
2. Turn the idle adjustment bolt until the idling speed is at the standard range.
3. Tighten the locknut.
4. Race the engine several times to ensure the idle speed is at the standard range.



ADJUSTMENT - 20KW

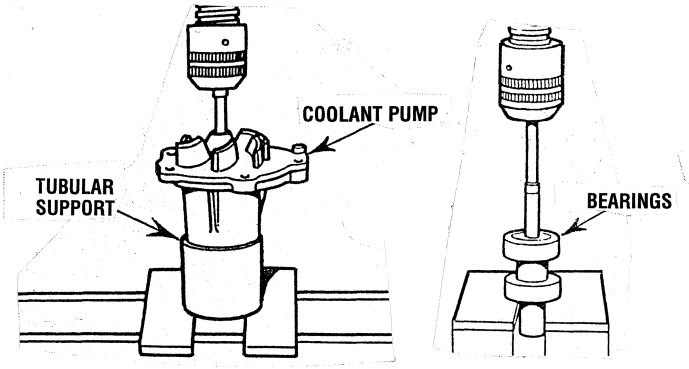
Note: *Speed adjustment of the generator (hertz) is controlled by the electronic governor see* ELECTRONIC GOVERNOR *for speed and gain adjustments.*

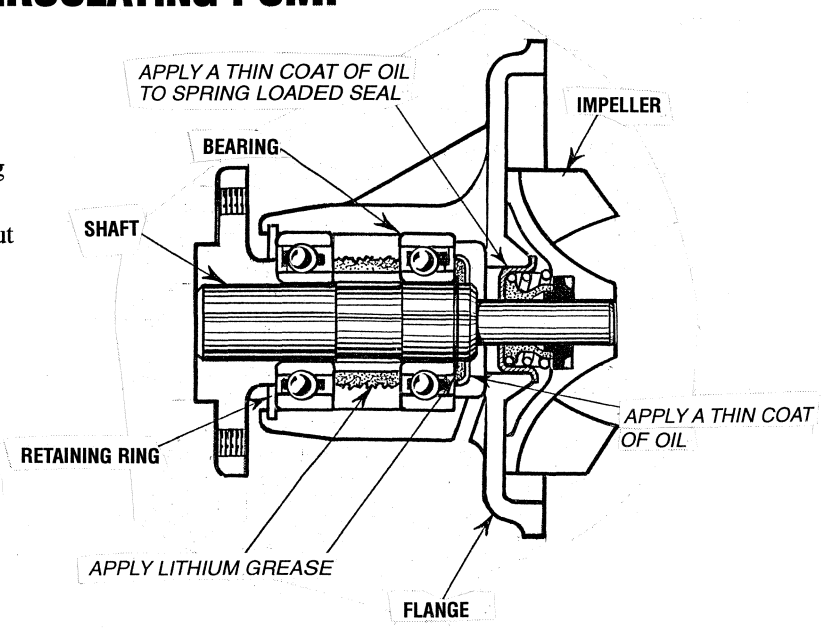


COOLANT CIRCULATING PUMP

DISASSEMBLY

1. Remove the pump pulley boss by using a support and press.
2. Remove the bearing shaft from the impeller and bearing housing by using a support block and press.
3. Remove the snap ring with snap ring pliers and press out the water pump shaft from the bearings.





INSPECTION

Inspect the shaft, bearings and impeller. Look for cracks and damage. Check the housing gasket and inspect the rear seals and small end gaskets.

Replace any parts that show wear.

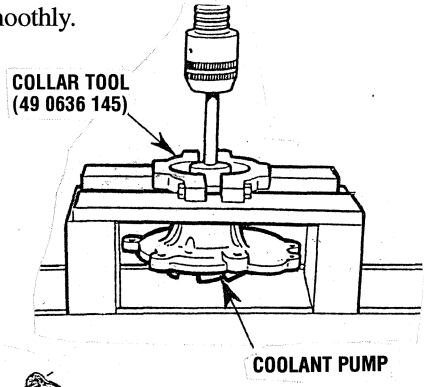
ASSEMBLY

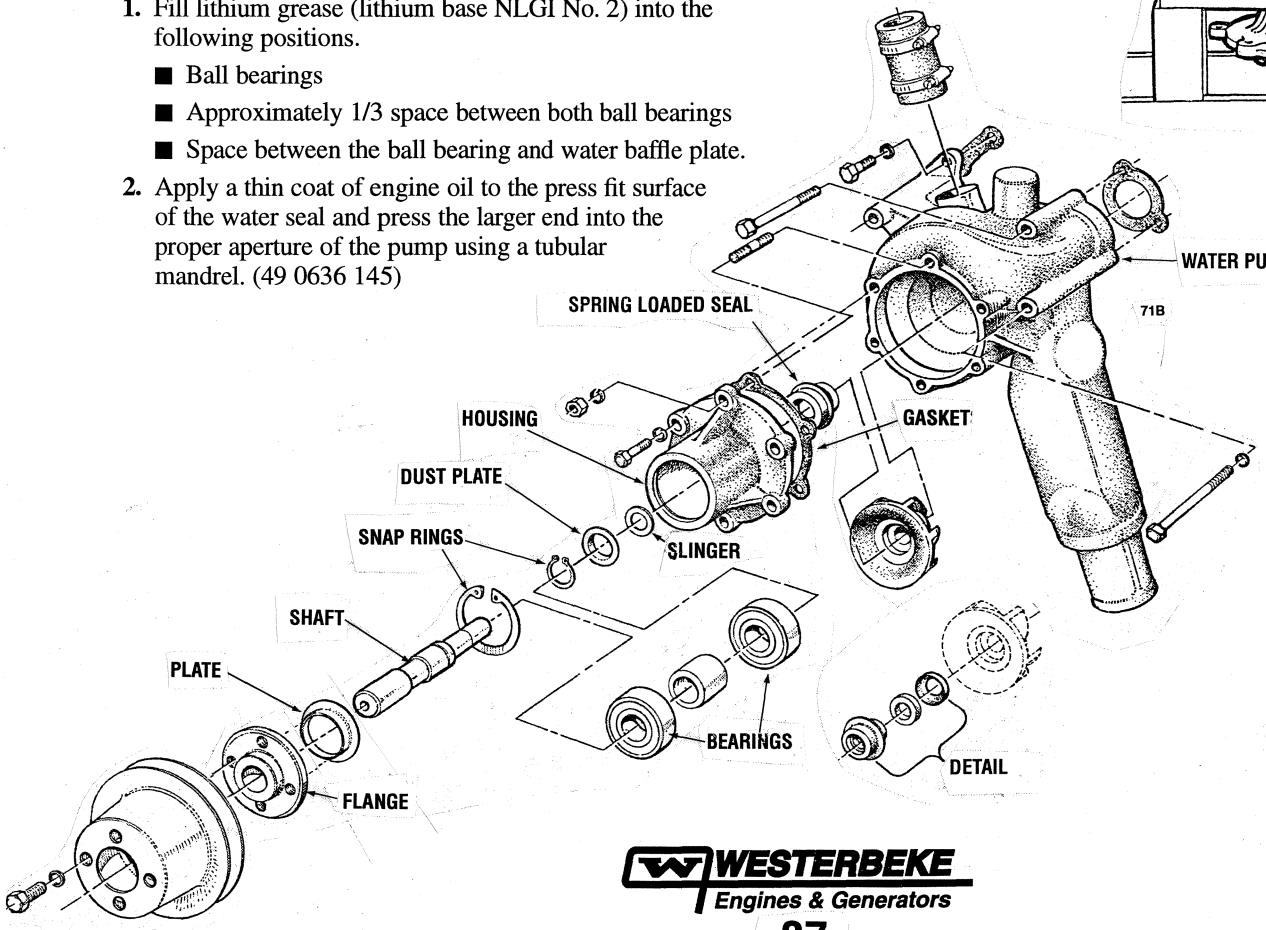
Assemble the water pump in the reverse order of disassembly, using the following procedure:

1. Fill lithium grease (lithium base NLGI No. 2) into the following positions.
   - Ball bearings
   - Approximately 1/3 space between both ball bearings
   - Space between the ball bearing and water baffle plate.
2. Apply a thin coat of engine oil to the press fit surface of the water seal and press the larger end into the proper aperture of the pump using a tubular mandrel. (49 0636 145)

NOTE: *Do not allow oil or grease to contaminate the surfaces of the ceramic ring or the graphite (small end) of the spring-loaded seal.*

3. After the water pump has been assembled, check if the pump shaft rotates smoothly.

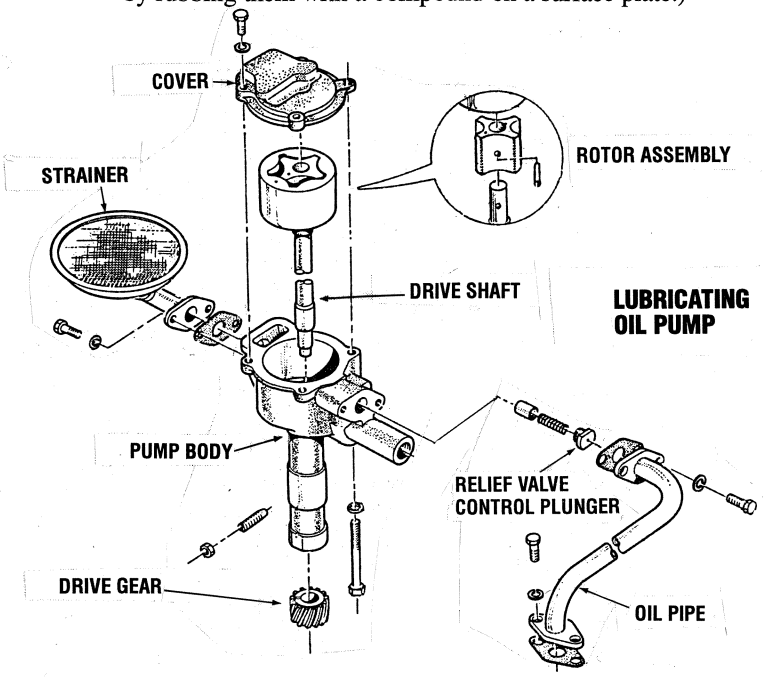




LUBRICATING OIL PUMP

INSPECTION

1. Visually check the disassembled parts and replace faulty parts. Check the sliding surface of pump cover with special care and replace the cover if the surface has steps or excessive streaks. (Minor steps streaks may be repaired by rubbing them with a compound on a surface plate.)

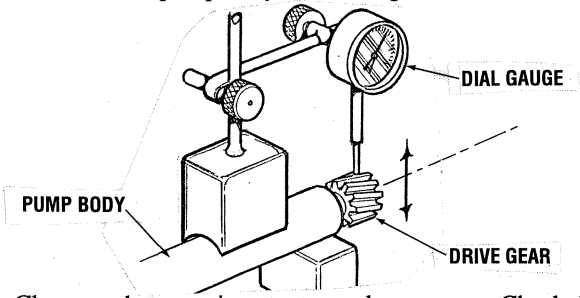


2. Clearance between pump body and shaft. Measure the above clearance with a dial gauge and magnet base.

Clearance Limit

71B/71C *0.1 mm (0.0039 in)*

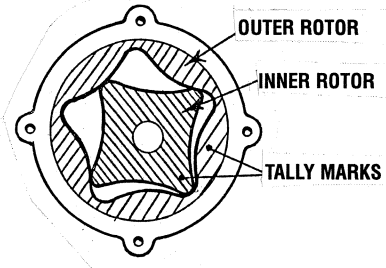
When the clearance exceeds the limit, replace the pump drive shaft inner rotor, pump body and drive gear.



3. Clearance between inner rotor and outer rotor. Check the clearance between the lobes of the rotors with a feeler gauge. If the clearance exceeds the limit, replace both rotors.

Clearance Limit

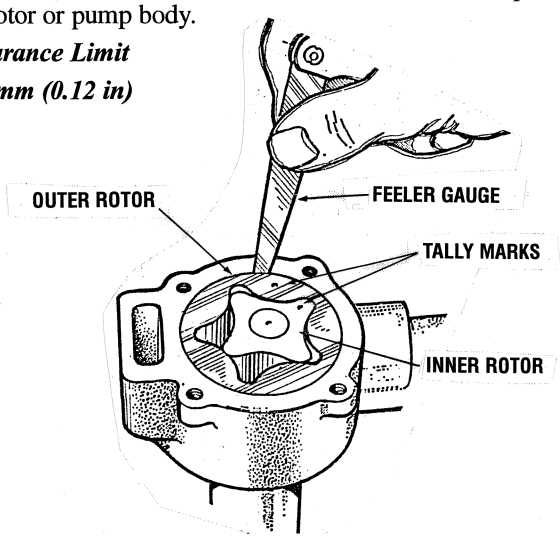
71B/71C *0.3 mm (0.012 in)*



4. Clearance between outer rotor and pump body. Check the clearance between the outer rotor and pump body with a feeler gauge. If the clearance exceeds the limit, replace the rotor or pump body.

Clearance Limit

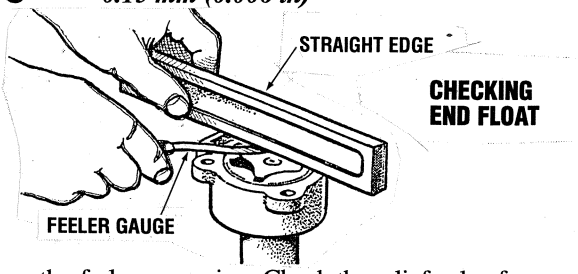
0.3 mm (0.12 in)



5. Clearance between rotor and pump cover. Check the end float of the rotors. Place a straight edge across the pump body and measure the clearance between the rotor and straight edge with a feeler gauge. If the clearance exceeds the limit, replace the drive gear, drive shaft, inner rotor, outer rotor and pump body.

Clearance Limit

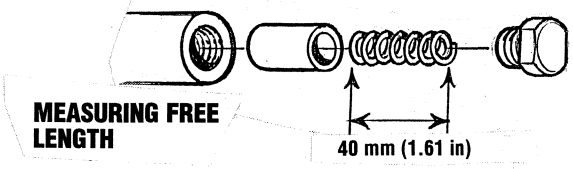
71B/71C *0.15 mm (0.006 in)*



6. Free length of plunger spring. Check the relief valve for worn plunger and fatigued spring.

Spring free Limit

71B/71C *40 mm (1.61 in)*



7. Assembly. Assemble in the reverse order of disassembly.

NOTE: *When installing the rotors into the body, be sure that the tally marks on the rotors are positioned toward the cover.*

Cover Tightening Torque

71B/71C *0.8 - 1.2 m-kg (5.8 - 8.7 ft-lb)*

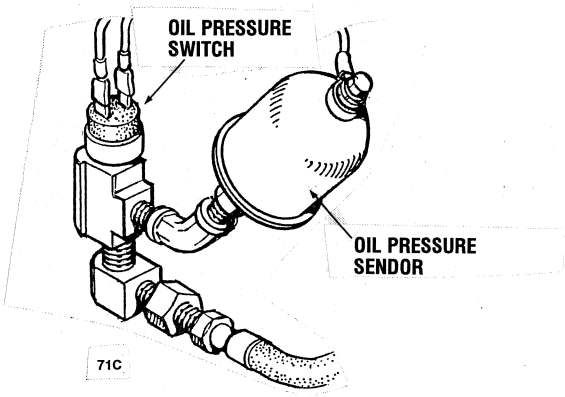
OIL PRESSURE SWITCH/OIL PRESSURE

OIL PRESSURE SWITCH/SENDER

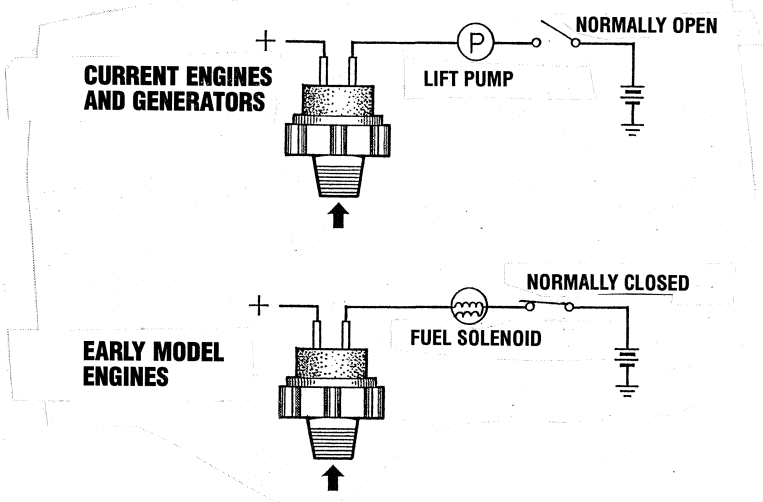
When performing an engine overhaul, replace the oil pressure switch and the oil pressure sender. When installing the new parts apply a teflon sealant to the threaded ends being careful not to close off the oil hole in the sender.

Oil Pressure Sender and Switch Torque

71B/71C *1.2 - 1.8 m-kg (9 - 13 ft-lb)*



⚠ CAUTION: ***Oil Pressure Switch - Do not use lock pliers, vise grips or pipe wrenches on the oil pressure switch. Use the correct socket which is available from Snap-On, Proto, New Britain and others. Damage to the switch will cause oil leaks and/or switch failure.***

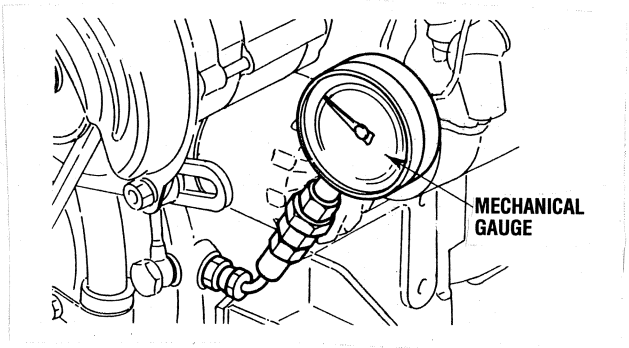


OIL PRESSURE

To test the oil pressure, remove the oil pressure sender, then install a mechanical oil pressure gauge in it's place. After warmer up the engine; set the engine speed at 2400 rpm and read the oil pressure gauge.

Oil Pressure

71B/71C *3.8 kg/cm² (54 lb/in²) or more at 3600 rpm*



LOW OIL PRESSURE

A gradual loss of oil pressure usually indicates a specific bearing failure. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

RAW WATER PUMP

PUMP OVERHAUL

Disassembly

The pump, as removed from the engine, will have hose attachment nipples threaded into its inlet and outlet port. They may be left in place or removed if they interfere with the pump disassembly. Note the port location and positioning if removed.

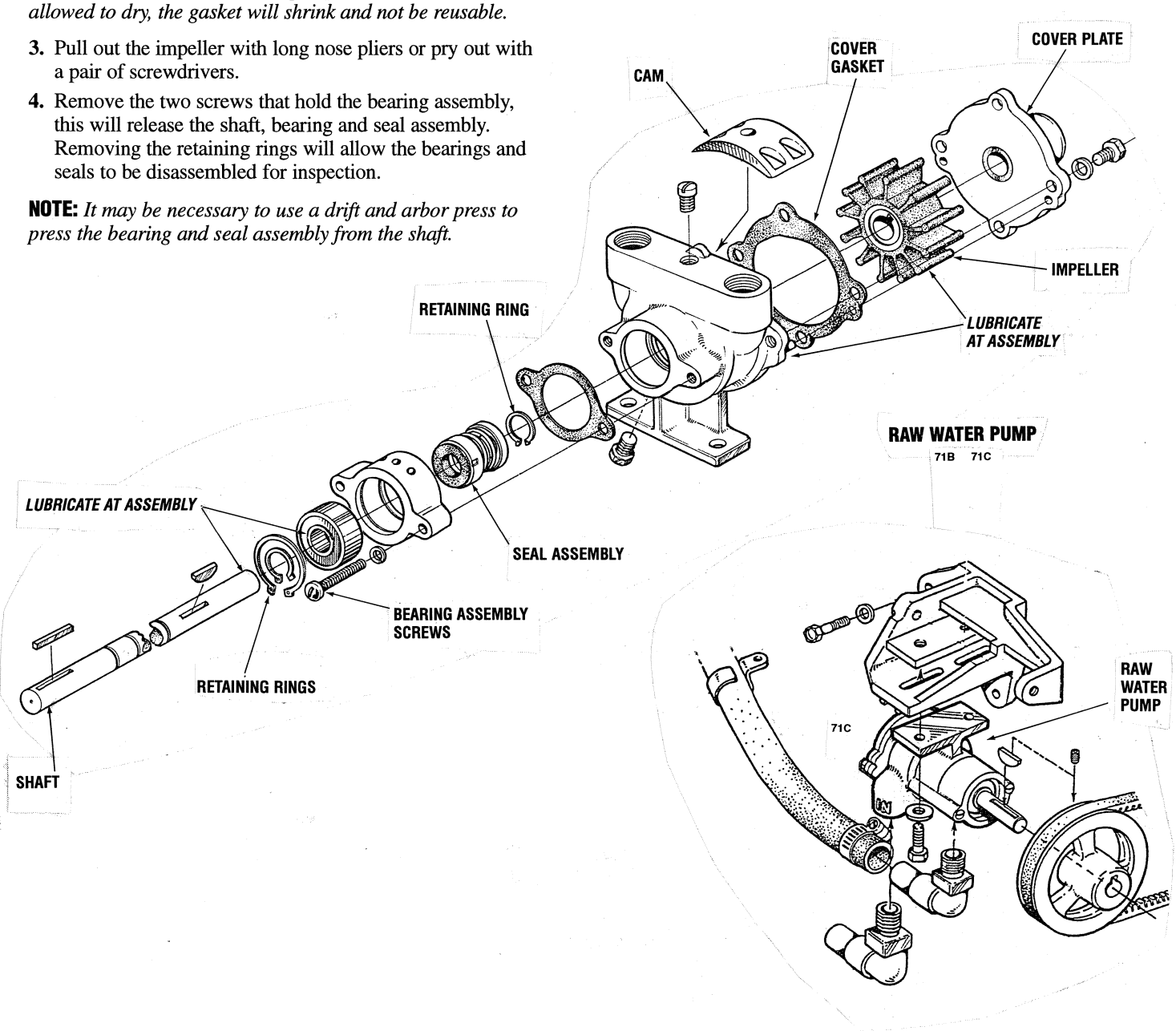
1. Loosen the set screw with an allen wrench and remove the water pump pulley from the shaft
2. Remove the 4 cover plate screws, cover plate, and cover gasket.

NOTE: *Replacement of the cover plate gasket is recommended; however, if you are going to reuse it, keep the gasket well lubricated until the pump is reassembled. If it's allowed to dry, the gasket will shrink and not be reusable.*

3. Pull out the impeller with long nose pliers or pry out with a pair of screwdrivers.
4. Remove the two screws that hold the bearing assembly, this will release the shaft, bearing and seal assembly. Removing the retaining rings will allow the bearings and seals to be disassembled for inspection.

NOTE: *It may be necessary to use a drift and arbor press to press the bearing and seal assembly from the shaft.*

6. Inspect all parts and replace those showing wear or erosion.
7. Use the illustration below to assist in reassembling the raw water pump.
   a. apply a small amount of petroleum jelly to the seal's inner race and to the impeller shaft at reassembly.
   b. When positioning the cam in the housing use a small amount of Permatex #1 on the inner cam surface and cam screw threads, remove any excess from the impeller housing.
   c. Apply a light film of silicone or petroleum jelly to the inner surface of the housing for the impeller.
8. When the pump is assembled reposition and tighten the hose nipples. Assemble the pump to the engine and attach the hoses and belt.



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

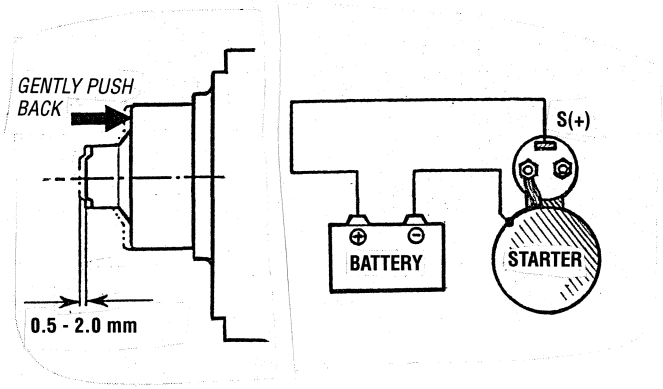
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

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.***

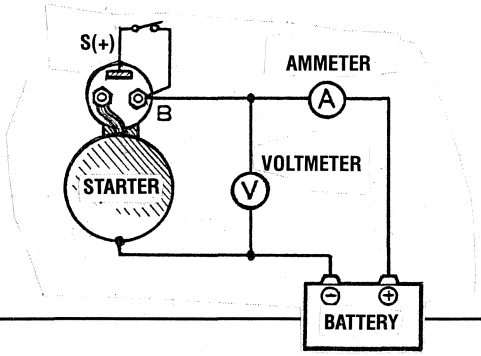
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, (0.5 to 2.0 mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



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.

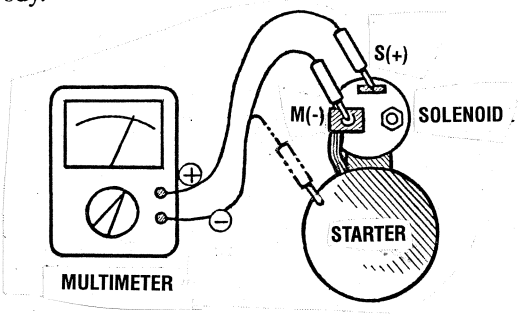


> ⚠ **CAUTION:** ***Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the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

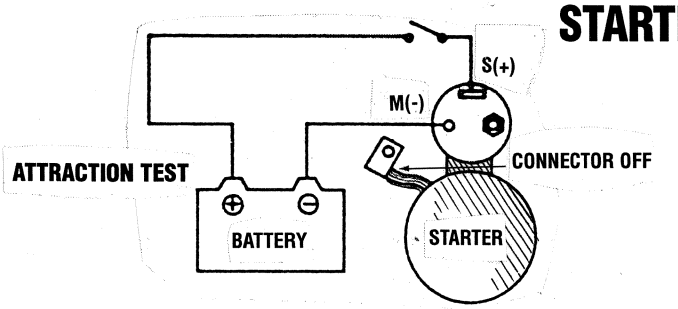


NOTE: *Disconnect the wire from terminal M.*

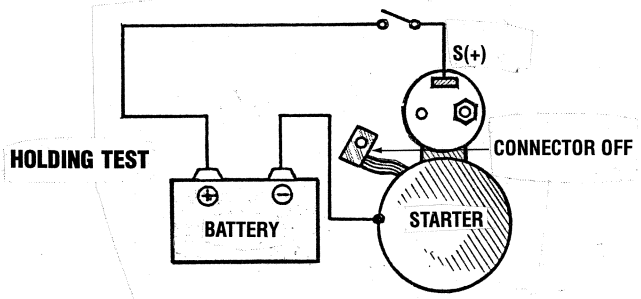
2. Connect a battery to the solenoid's terminal S for (+) and M for (-). Have a switch in the + lead and close it. The pinion drive should extend fully out.

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

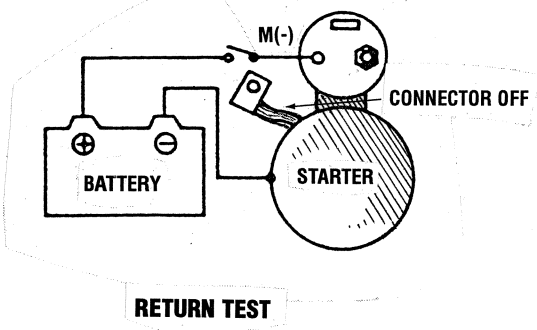
STARTER MOTOR



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.

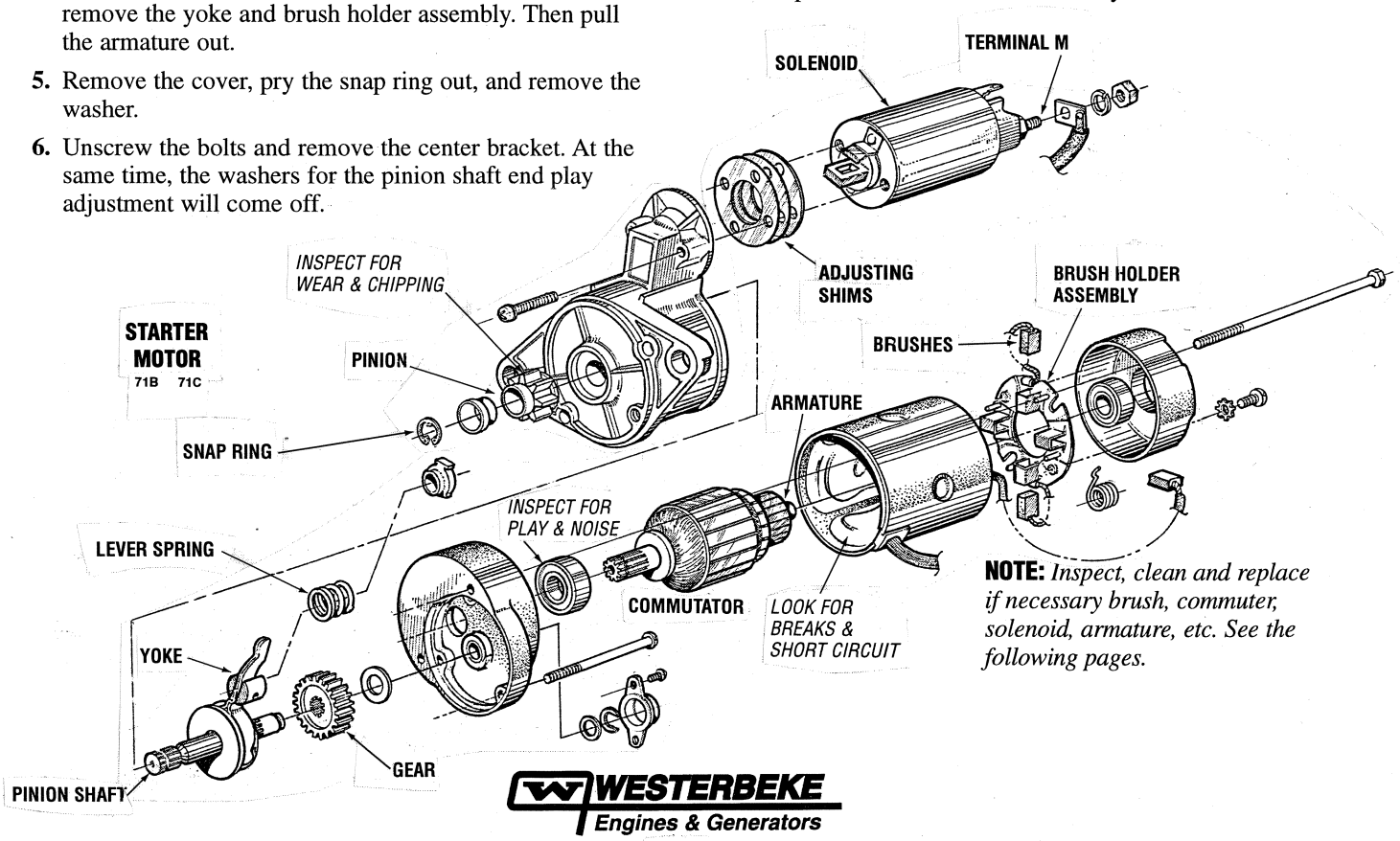


4. *Return test:*. With a battery connected to the solenoid terminal M (-) and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.



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.



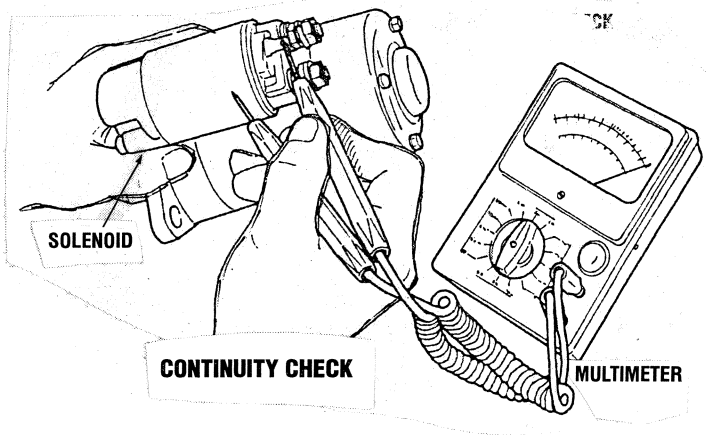
NOTE: *Inspect, clean and replace if necessary brush, commuter, solenoid, armature, etc. See the following pages.*

STARTER MOTOR

STARTER INSPECTION

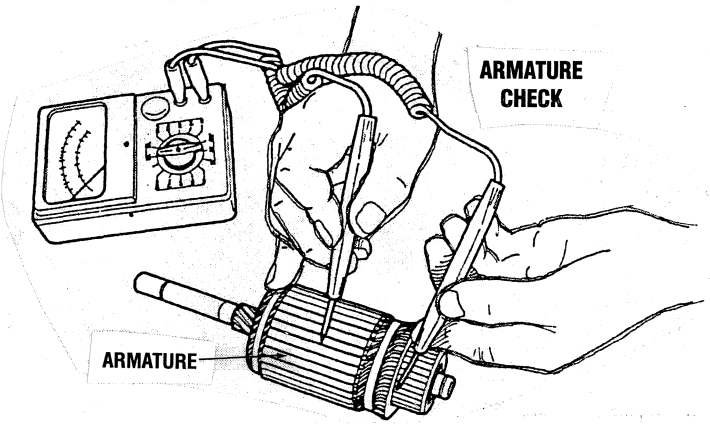
Solenoid

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.

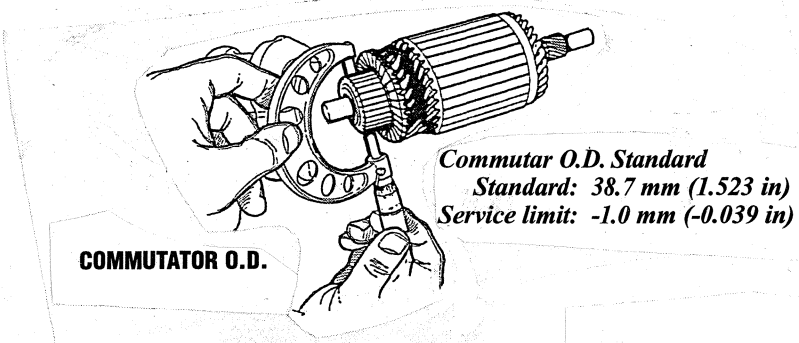


Inspecting The Armature

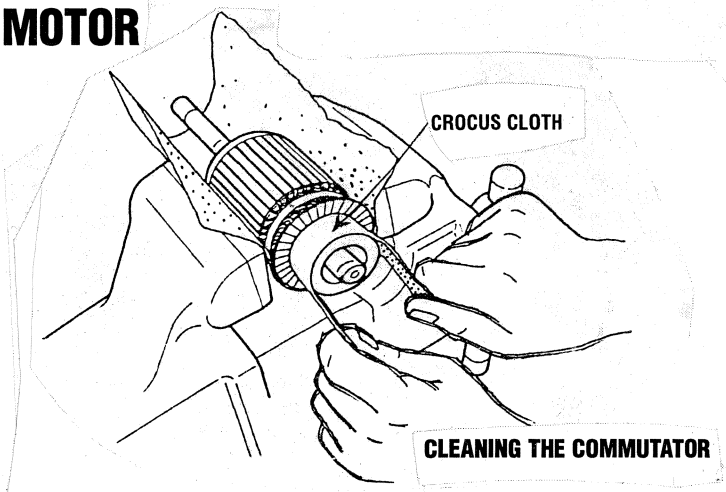
1. Check the armature with a growler tester. If it's short circuited, replace the armature. Also check for insulation between the communicator and its shaft. If poorly insulated, replace the armature.



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.



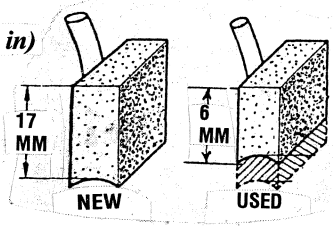
Commutar O.D. Standard
Standard: 38.7 mm (1.523 in)
Service limit: -1.0 mm (-0.039 in)



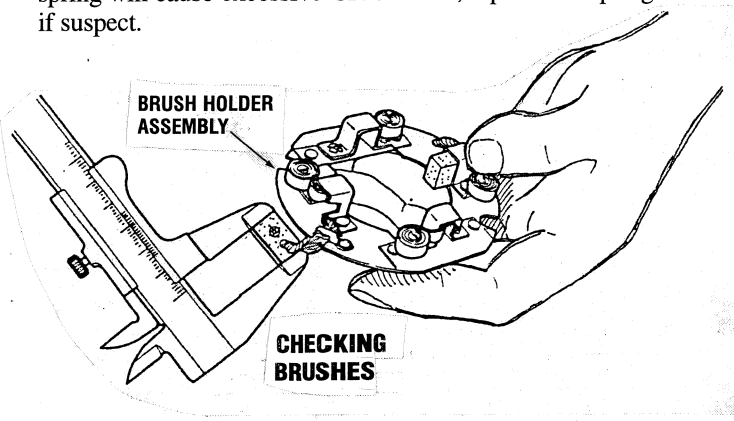
Brush and Brush Holder Inspection

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

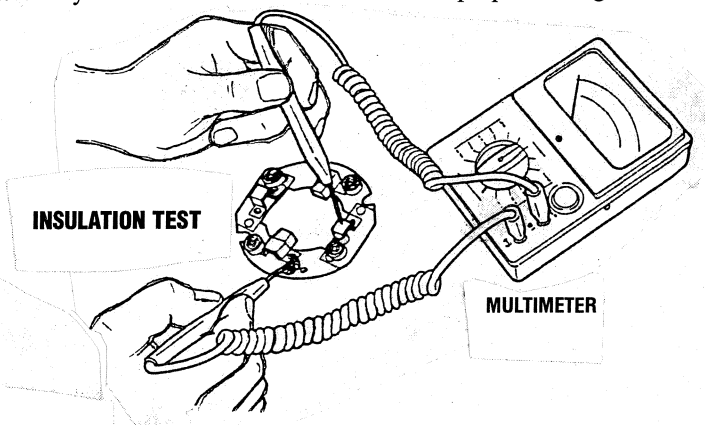
Brush Height
Standard 17 mm (o.669 in)
Limit 6 mm (0.236 in)



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



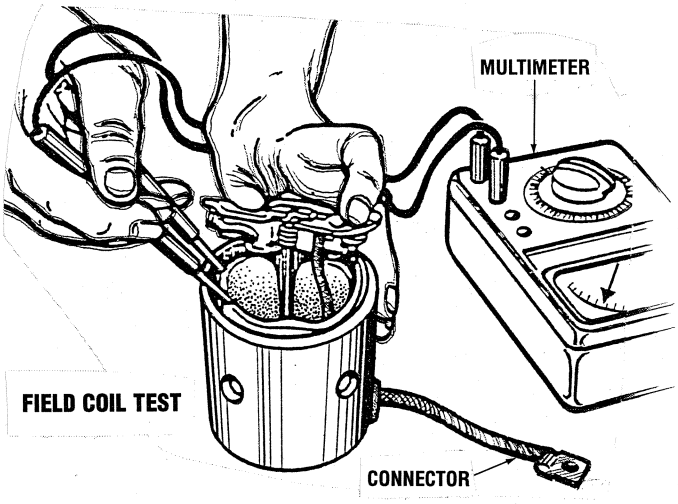
3. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also check the brush holders for proper staking.



STARTER MOTOR

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

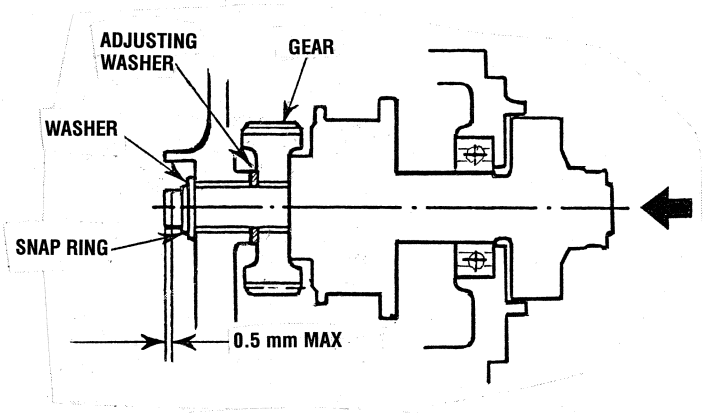
> ⚠ **CAUTION:** ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all oil, old paint, and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.***

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

TACHOMETER

TACHOMETER/HOURMETER

The tachometer/hourmeter used in propulsion engine instrument panels contains two separate electrical circuits with a common ground. One circuit operates the hourmeter and the other the tachometer. The hourmeter 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/hourmeter.

Hourmeter Inoperative

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

a. Voltage present - meter is defective - repair or replace.

b. 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.

a. Voltage present - attempt adjusting meter through calibration access hole. No results, repair or replace meter.

b. AC voltage not present - check for proper alternator DC output voltage.

c. Check for AC voltage at tach terminal on alternator to ground.

d. Check electrical connections from tachometer input terminal to alternator connection.

Tachometer Sticking

a. Check for proper AC voltage between "tach inp." terminal and (-) terminal.

b. Check for good ground connection between meter (-) terminal and alternator.

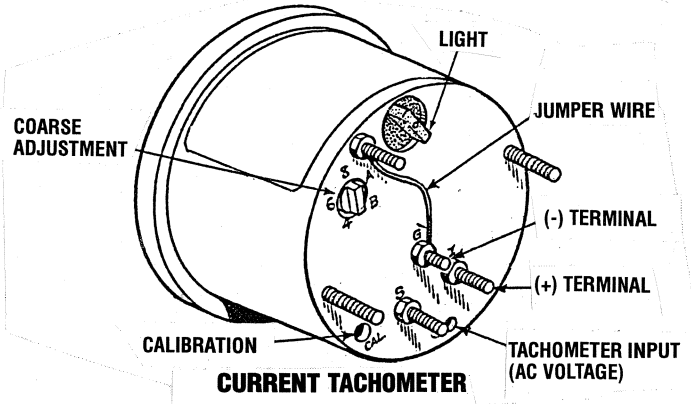
c. Check that alternator is well grounded to engine block at alternator pivot bolt.

Tachometer Inaccurate

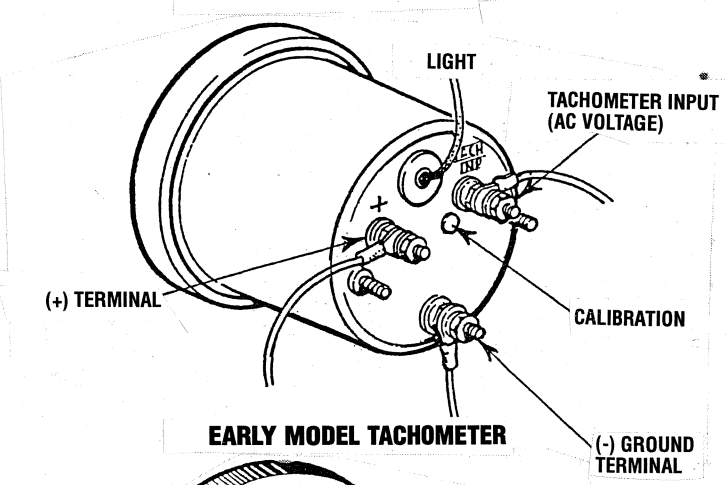
a. With a hand-held tach on the front of the crankshaft pulley retaining nut or with a strobe-type tach, read the front crankshaft pulley rpm. Set the engine with a hand or strobe tach at 1500-1800 rpm.

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 set by the strobe or hand tach. (Verify the rpm at idle and at high speed 2500-3000 rpm). (Adjust the tach as needed.)

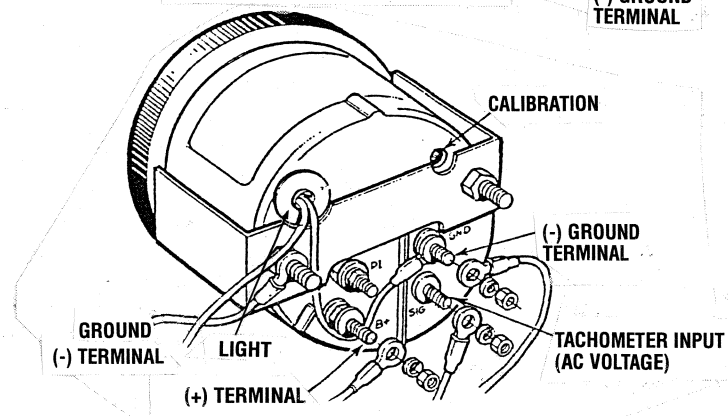
NOTE: *Current model tachometers use a coarse adjustment dial to set the tachometer to the crankshaft pulley rpms. The calibrating screw is then used for fine tuning.*



CURRENT TACHOMETER



EARLY MODEL TACHOMETER

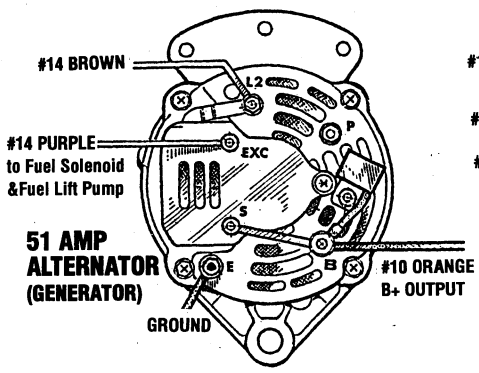


EARLY MODEL TACHOMETER

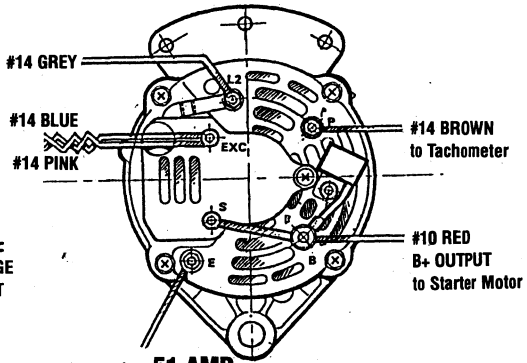
ALTERNATOR TESTING

DESCRIPTION

The charging system consists of an alternator with a voltage regulator, an engine DC wiring harness, a mounted DC circuit breaker and a battery with connecting cables. Because of the use of integrated circuits (IC's) the electronic voltage regulator is very compact and is mounted internally or on the back of the alternator.



51 AMP ALTERNATOR (GENERATOR)



51 AMP ALTERNATOR (ENGINE)

TROUBLESHOOTING

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

This troubleshooting section is to determine if a problem exists with the charging circuit or with the alternator. If it is determined that the alternator or voltage regulator is bad, it is best to have a qualified technician check it out.

The alternator charging circuit charges the starting battery and the service battery. An isolator with a diode, a solenoid, or a battery selector switch is usually mounted in the circuit to isolate the batteries so the service battery is not discharged along with the service battery. If the alternator is charging the starting battery but not the service battery, the problem is in the service battery charging circuit and not with the alternator.

Testing the Alternator

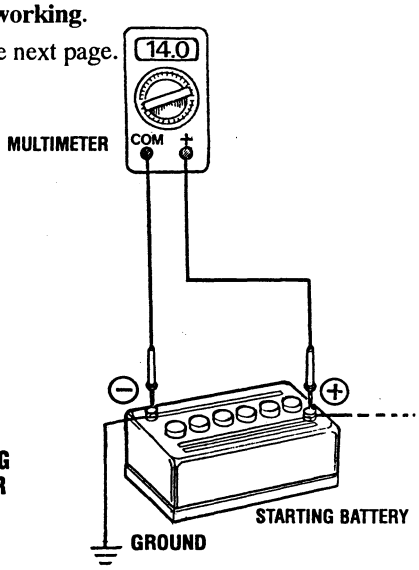
> ⚠ **WARNING:** ***Before starting the engine make certain that everyone is clear of moving parts! Keep away from sheaves and belts during test procedures.***

NOTE: *Multimeters and DC Circuits*

DC and AC circuits are often 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.

1. **Start the Engine**
2. After a few minutes of running measure the starting battery voltage at the battery terminals using a multi-meter set on DC volts.

   The voltage should be increasing toward 14 volts. If it is, **your alternator is working.**
3. Turn to step 5 on the next page.



TESTING THE STARTING BATTERY-ALTERNATOR (ENGINE RUNNING)

4. If the starting battery voltage remains around 12 volts after the engine is started and run for a few minutes, a problem exists with the alternator or the charging circuit.

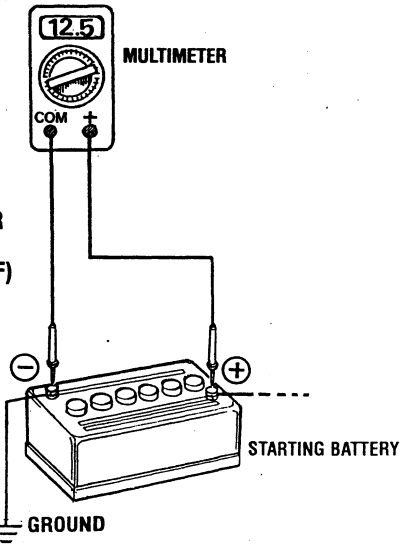
   A. Turn off the engine. Inspect all wiring and connections. Insure that the battery terminals and the engine ground connections are tight and clean.

> ⚠ **CAUTION:** ***To avoid damage to the battery charging circuit, never shut off the engine battery switch when the engine is running!***

   B. If a battery selector switch is in the charging circuit, insure that it is on the correct setting.

   C. Turn on the ignition switch, but do not start the engine.

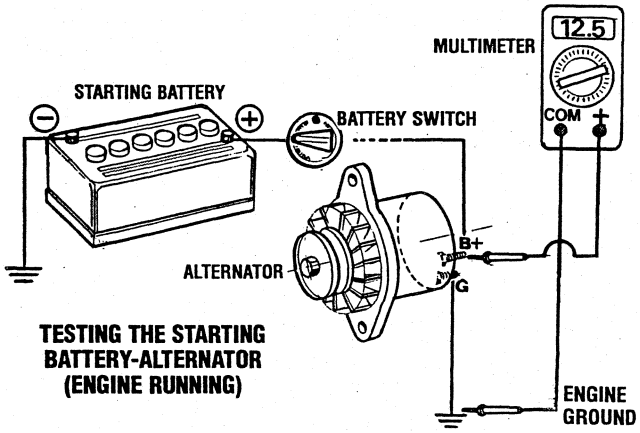
   D. Check the battery voltage. If your battery is in good condition the reading should be 12 to 13 volts.



TESTING THE ALTERNATOR VOLTAGE (IGNITION ON – ENGINE OFF)

ALTERNATOR TESTING

e. Now check the voltage between the alternator output terminal (B+) and ground. If the circuit is good, the voltage at the alternator should be the same as the battery, or if an isolator is in the circuit the alternator voltage will be zero. If not, a problem exists in the circuit between the alternator and the battery. Check all the connections - look for an opening in the charging circuit.



TESTING THE STARTING BATTERY-ALTERNATOR (ENGINE RUNNING)

f. Start the engine again. Check the voltage between the alternator output and ground.

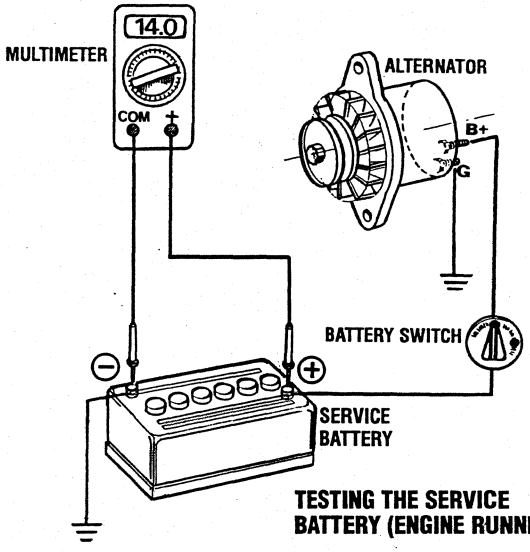
The voltage reading for a properly operating alternator should be between13.5 and 14.5 volts. If your alternator is over- or under-charging, have it repaired at a reliable service shop.

NOTE: *Before removing the alternator for repair, use a voltmeter to ensure that 12 volts DC excitation is present at the EXC terminal if the previous test showed only battery voltage at the B output terminal.*

If 12 volts are not present at the EXC terminal, trace the wiring looking for breaks and poor connections.

Alternator is Working

5. Check the voltage of the service battery. This battery should have a voltage between 13 and 14 volts when the engine is running. If not, there is a problem in the service battery charging circuit. Troubleshoot the service battery charging circuit by checking the wiring and connections, the solenoid, isolator, battery switch and the battery itself.



TESTING THE SERVICE BATTERY (ENGINE RUNNING)

> ⚠ **CAUTION:** ***When performing tests on the alternator charging circuit do not use a high voltage tester (i.e. Megger). You can damage the alternator diodes.***

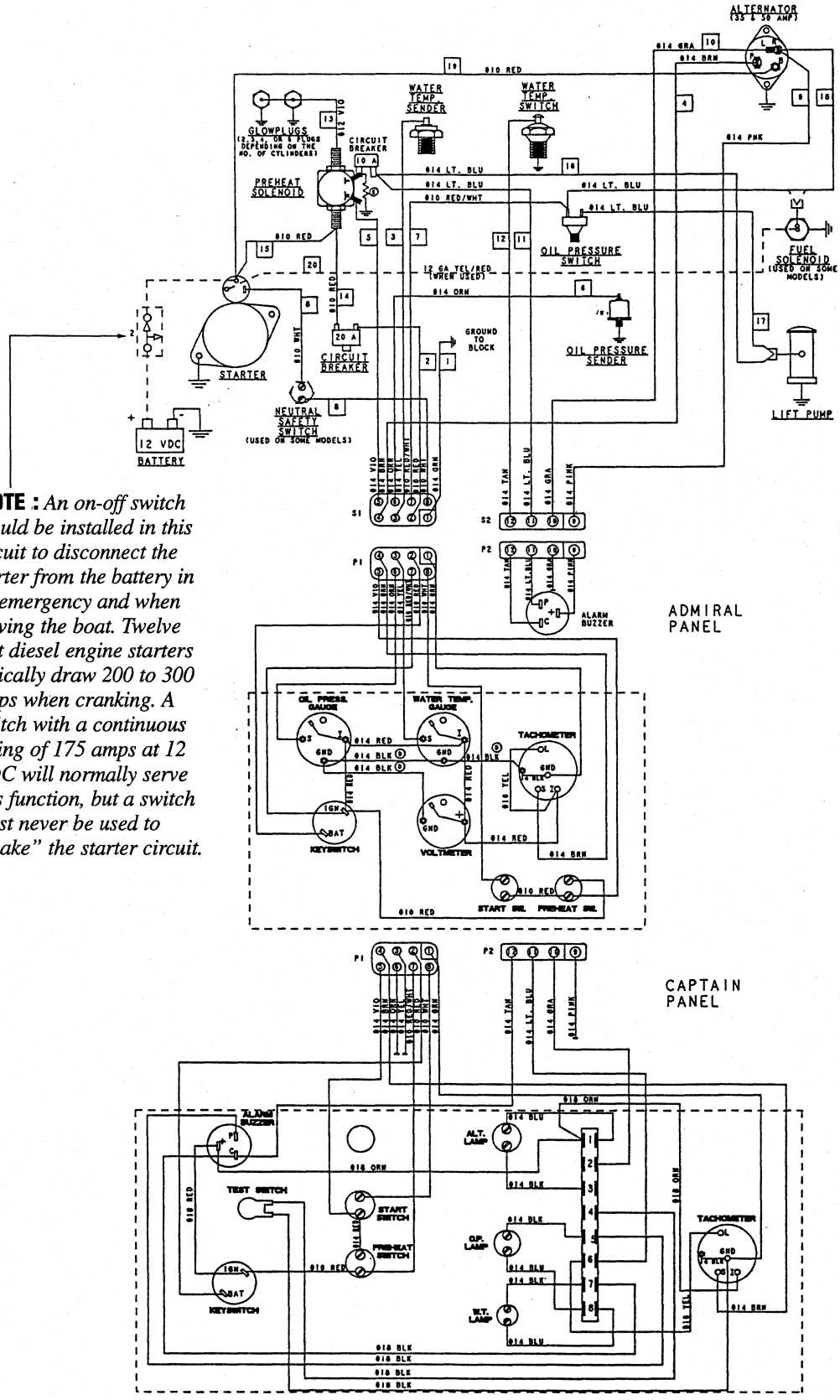
ALTERNATOR INSPECTION

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 those studs are tight. Also clean the wiring connections that connect to the wiring harness.

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

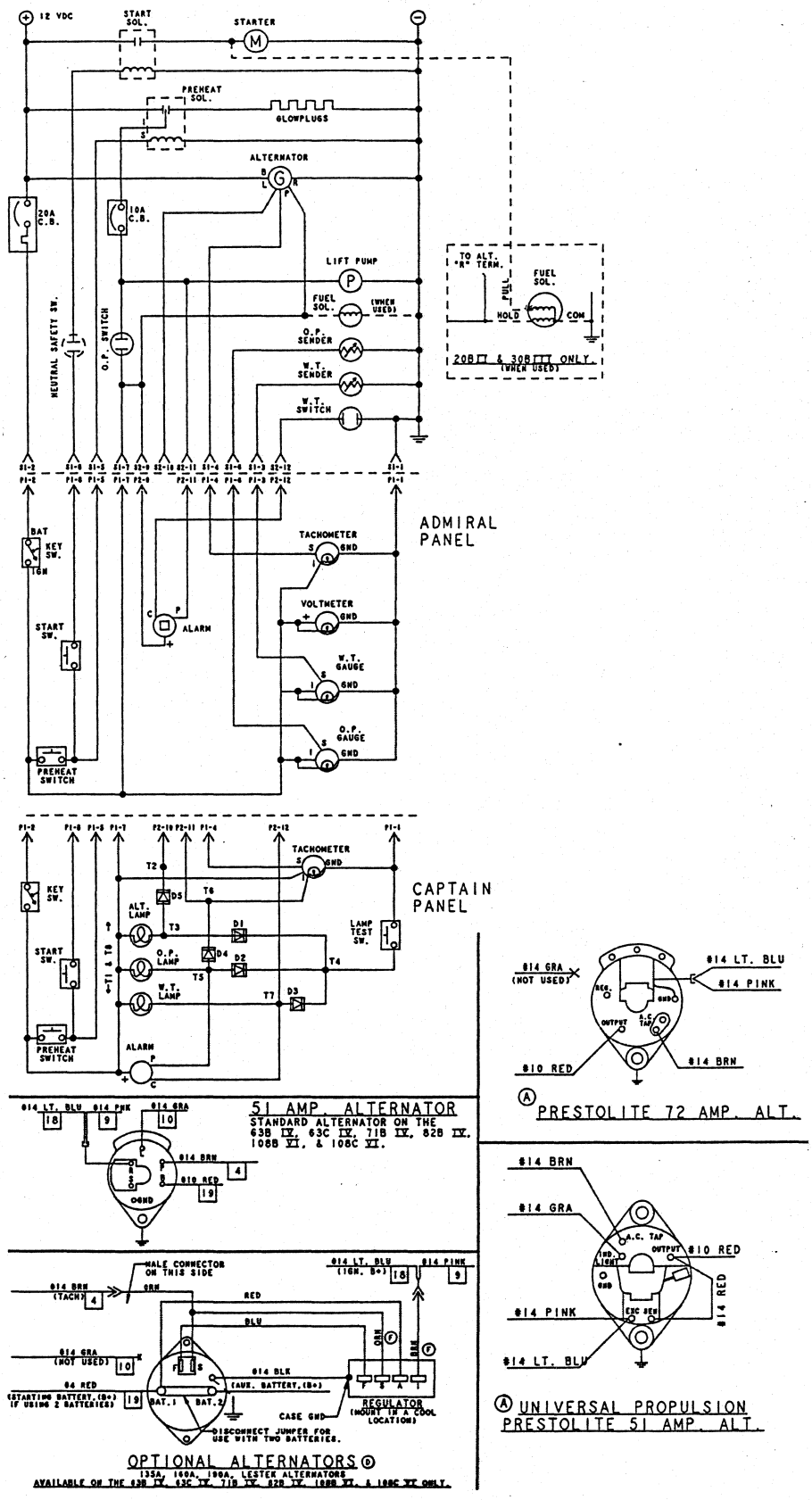
Depending on when the alternator was last serviced, the brushes may need replacing. If the alternator is at all suspect, send it to a service shop for testing and overhaul.

PROPULSION ENGINE
WIRING DIAGRAM #039144



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 diesel 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.*

PROPULSION ENGINE
WIRING SCHEMATIC #039144



GENERATOR INFORMATION

USE OF ELECTRIC MOTORS

The power required to start an electric motor is considerably more than is required to keep it running after it is started. Some motors require much more current to start them than others. Split-phase (AC) motors require more current to start, under similar circumstances, than other types. They are commonly used on easy-starting loads, such as washing machines, or where loads are applied after the motor is started, such as small power tools. Because they require 5 to 7 times as much current to start as to run, their use should be avoided, whenever possible, if the electric motor is to be driven by a small generator. Capacitor and repulsion-induction motors require from 2 to 4 times as much current to start as to run. The current required to start any motor varies with the load connected to it. An electric motor connected to an air compressor, for example, will require more current than a motor to which no load is connected.

In general, the current required to start 115-Volt motors connected to medium starting loads will be approximately as follows:

MOTOR SIZE (HP)	AMPS FOR RUNNING (AMPERES)	AMPS FOR STARTING (AMPERES)
1/6	3.2	6.4 to 22.4*
1/4	4.6	9.2 to 32.2*
1/3	5.2	10.4 to 72.8*
1/2	7.2	14.4 to 29.2*
3/4	10.2	20.4 to 40.8*
1	13	26 to 52

***NOTE:** *In the above table the maximum* Amps for Starting *is more for some small motors than for larger ones. The reason for this is that the hardest starting types (split-phase) are not made in larger sizes.*

Because the heavy surge of current needed for starting motors is required for only an instant, the generator will not be damaged if it can bring the motor up to speed in a few seconds. If difficulty is experienced in starting motors, turn off all other electrical loads and, if possible, reduce the load on the electric motor.

Required Operating Speed

Run the generator first with no load applied, then at half the generator's capacity, and finally loaded to its full capacity as indicted on the generator's data plate. The output voltage should be checked periodically to ensure proper operation of the generating plant and the appliances it supplies. If an AC voltmeter or ampere meter is not installed to monitor voltage and load, check it with a portable meter and amp probe.

NOTE: *When the vessel in which the generator is installed contains AC equipment of 120 volts only, it is recommended that the generator's AC terminal block be configured to provide one 120 volt AC hot leg for the vessel's distribution panel. This will ensure good motor starting response from the generator.*

Generator Frequency Adjustment

Frequency is a direct result of engine/generator speed, as indicated by the following:

- ☐ When the generator is run at 1800 RPM, the AC voltage output frequency is 60 Hertz.
- ☐ When the generator is run at 1500 RPM, the AC voltage output frequency is 50 Hertz.

Therefore, to change the generator's frequency, the generator's drive engine's speed must be changed. A reconfiguration of the AC output connections at the generator is also necessary.

Generator Maintenance

- ☐ Maintaining reasonable cleanliness is important. Connections of terminal boards and rectifiers may become corroded, and insulation surfaces may start conducting if salts, dust, engine exhaust, carbon, etc. are allowed to build up. Clogged ventilation openings may cause excessive heating and reduced life of windings.
- ☐ For unusually severe conditions, thin rust-inhibiting petroleum-base coatings, should be sprayed or brushed over all surfaces to reduce rusting and corrosion. Typical materials suggested are Daubert Chemical Co. "Non-Rust AC-410" and Ashland "Tectyle 506" or equivalent.
- ☐ In addition to periodic cleaning, the generator should be inspected for (a) tightness of all connections, (b) evidence of overheated terminals and (c) loose or damaged wires.
- ☐ The drive discs on single bearing generators should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.
- ☐ The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.
- ☐ Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. if side motion is detectable, bearings are wearing or wear on shaft of bearing socket outside bearing has occurred. Repair must be made quickly or major components will rub and cause major damage to generator.

THE BE GENERATOR
SINGLE AND THREE PHASE

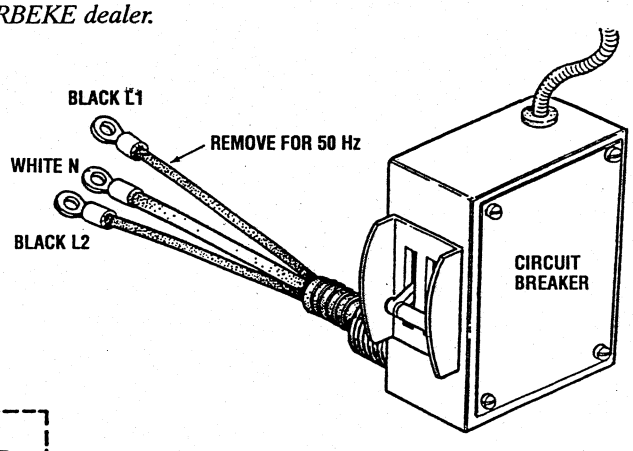
DESCRIPTION

This generator is a four-pole, brushless, self-excited generator which requires only the driving force of the engine to produce AC output. The copper and laminated iron in the exciter stator are responsible for the self-exciting feature of this generator. The magnetic field produced causes an AC voltage to be induced into the related excitor rotor windings during rotation. Diodes located in the exciter rotor rectify this voltage to DÇ and supply it to the windings of the rotating field. This creates an electromagnetic field which rotates through the windings of the main stator, inducing an AC voltage which is supplied to a load. An AC voltage is produced in the auxiliary windings of the main stator and is, in turn, supplied to a voltage regulator. The regulator produces a DC voltage to further excite the exciter stator windings, enabling the generator to produce a rated AC output. The voltage regulator senses AC voltage output and adjusts DC excitation to the exciter stator winding according to amperage load the generator is furnishing. To maintain a constant voltage output.

CIRCUIT BREAKER

A circuit breaker is installed on all WESTERBEKE generators. This circuit breaker will automatically disconnect generator power in case of an electrical overload. The circuit breaker can be manually shut off when servicing the generator to ensure that no power is coming into the boat.

NOTE: *This circuit breaker is available as a WESTERBEKE add-on kit for earlier model generators; contact your WESTERBEKE dealer.*



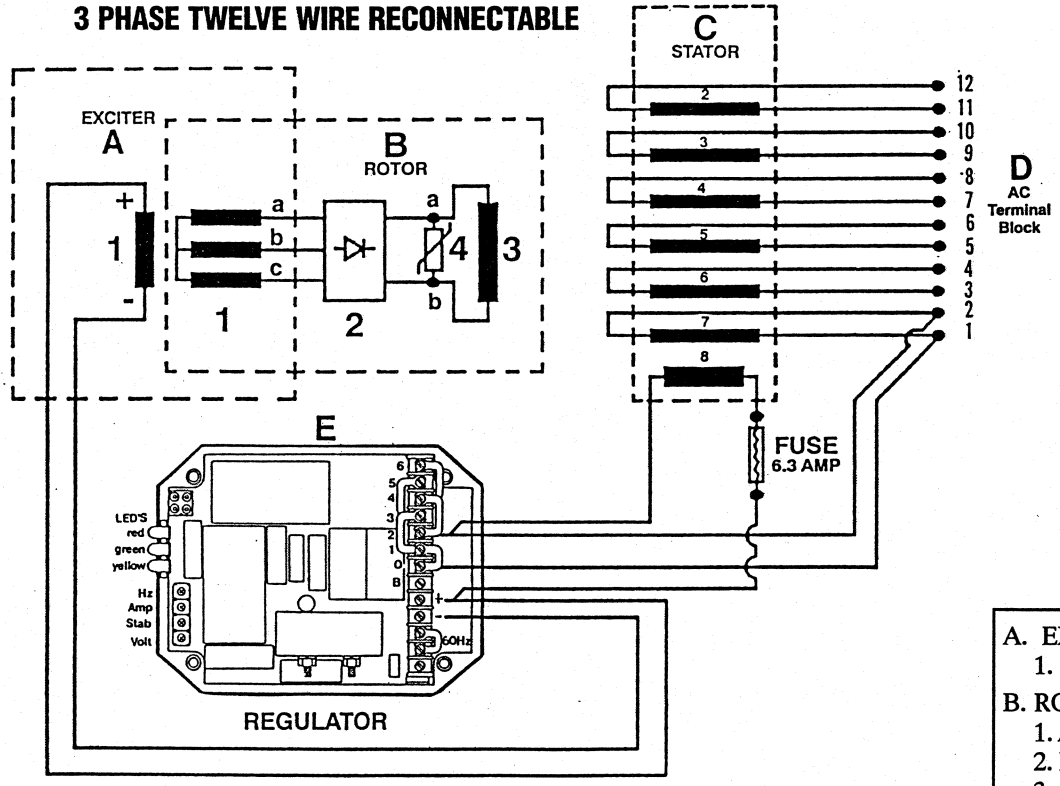
CIRCUIT BREAKER PART NUMBERS

20 KW – 60 Hz NO. 42701
[16 KW – 50 Hz NO. 42718]

25 KW – 60 Hz NO. 42702
[20 KW – 50 Hz NO. 42711]

32 KW – 60 Hz NO. 42703
[25 KW – 50 Hz NO. T D B]

INTERNAL WIRING SCHEMATIC
3 PHASE TWELVE WIRE RECONNECTABLE



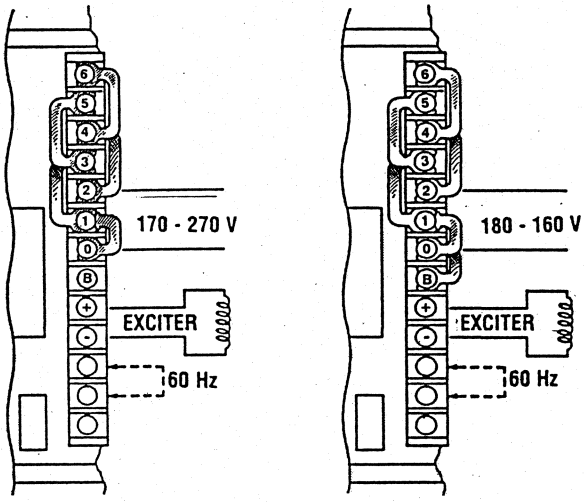
A. EXCITOR
   1. Exciter Stator Windings
B. ROTOR
   1. Auxiliary Windings a.b.c.
   2. Diodes
   3. Main Rotor Windings
   4. Pozi Resistor
C. MAIN STATOR
   1. Auxiliary Windings
   2. – 7 Main Stator Windings
   3. Auxiliary Windings (AC to Regulator)
D. AC TERMINAL BOARD
E. REGULATOR

GENERATOR AC VOLTAGE CONNECTIONS

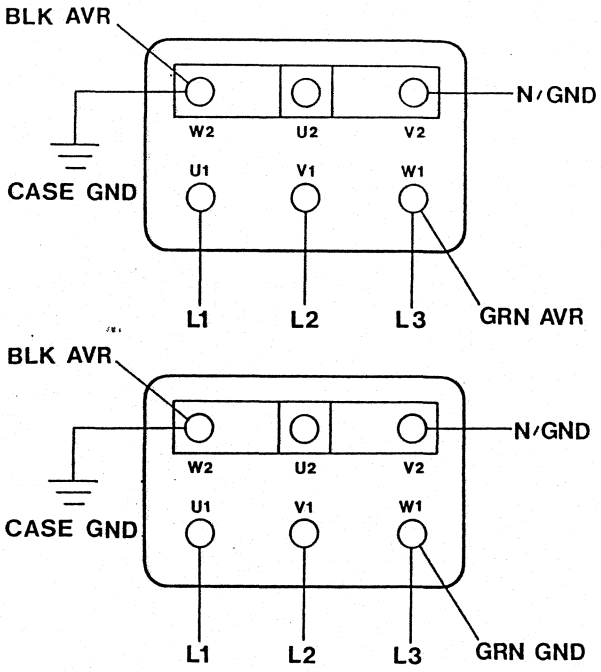
DESCRIPTION

The regulator is equipped with seven numbered terminals (0 to 6) and their related brass jumpers. The illustrations show connection points and jumpers for the 3 phase configuration of the generator. The sensing leads connect between pin #1 and pin #2 on the AC terminal block and connection #2 and #0 on the voltage regulator board.

NOTE: *Series Delta requires the installation of a jumper on the regulator board between terminal B and 10.*

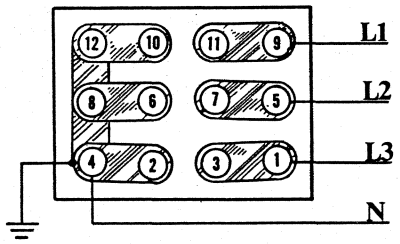


3 PHASE VOLTAGE REGULATOR



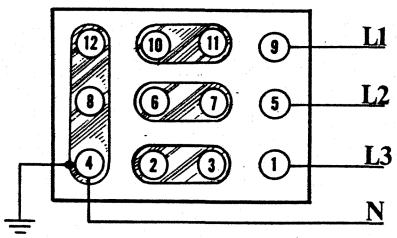
BE THREE PHASE (SIX WIRE)

PARALLEL WYE (STAR)



L-L – 208 VAC 3Ø 50 Hz
L-N – 120 VAC 1Ø 60 Hz
L-L – 190 VAC 3Ø 50 Hz
L-N – 110 VAC 1Ø 60 Hz

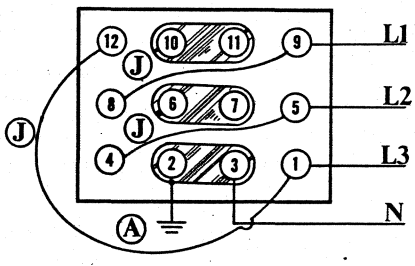
SERIES WYE (STAR)



L-L – 450 VAC 3Ø 60 Hz
L-N – 265 VAC 1Ø 60 Hz
L-L – 380 VAC 3Ø 50 Hz
L-N – 230 VAC 1Ø 50 Hz

BE THREE PHASE (TWELVE WIRE)

SERIES DELTA



L-L – 240 VAC 3Ø 60 Hz
L2, L3-N – 120 VAC 1Ø 60 Hz
L-L – 230 VAC 3Ø 50 Hz
L2, L3-N – 110 VAC 1Ø 50 Hz

A. SERIES DELTA – Note the repositioning of the ground lead from neutral to generator housing.

J. Jumper using #10 AWG Wire.

GENERATOR AC VOLTAGE CONNECTIONS

AC VOLTAGE CONNECTIONS

NOTE: The frame ground wire (white/green) must be properly positioned when changing the AC output configuration of the AC terminal block. For making connections to the AC terminal block, use terminal ends for 1/4 inch studs that will accept multi strand copper wire sized for the amperage rating from the hot lead connection. The frame ground wire is white or white with a green strip. It connects between the neutral stud and the generator frame.

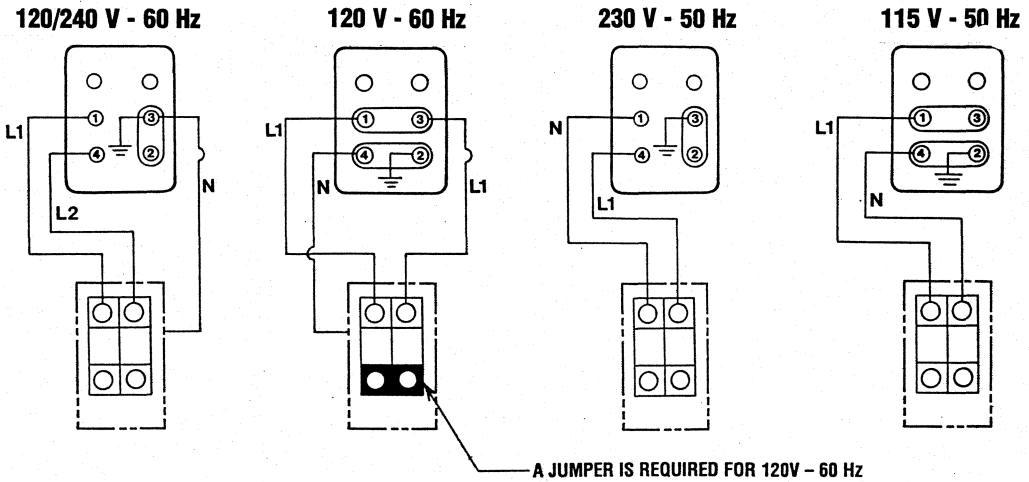
Generator Frequency

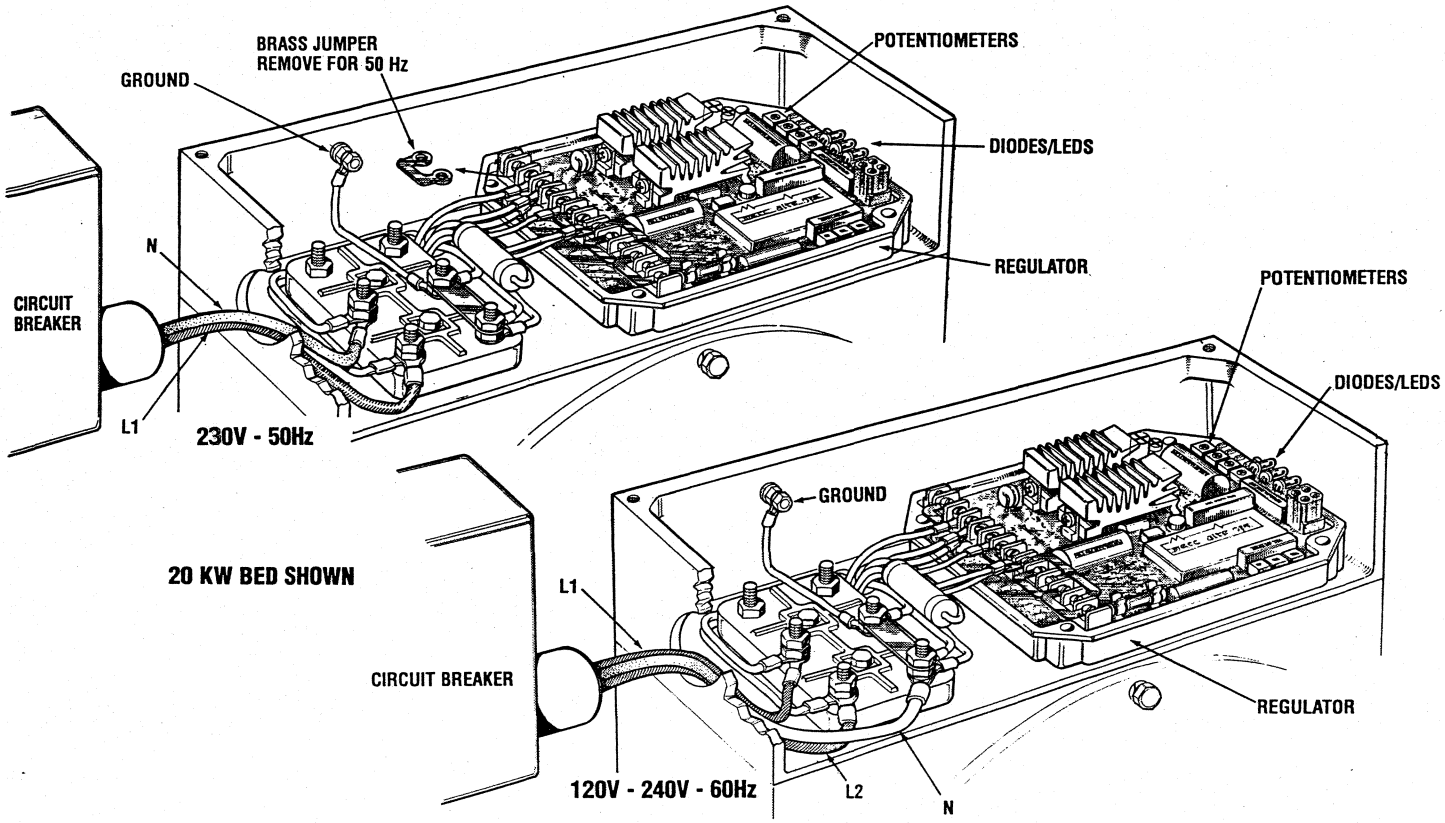
1. Frequency is a direct result of engine/generator speed: 1800 rpm = 60 hertz; 1500 rmp = 50 hertz.
2. To change generator frequency, follow the steps below:

   Configure the AC terminal block for the desired voltage frequency as shown above. Ensure that the case ground wire is connected to the correct terminal block neutral ground stud.

NOTE: *The white/green ground wire may be removed in those installations where the AC circuit has a separate neutral and ground circuit. This will prevent the unit from being a ground source in the vessel.*

BE SINGLE PHASE

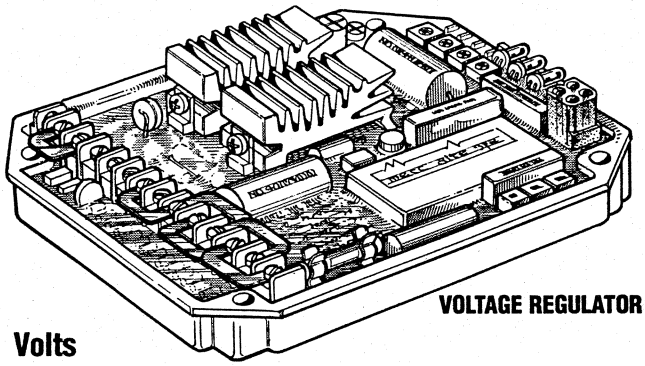




VOLTAGE REGULATOR ADJUSTMENTS

Description

The voltage regulator is an advanced design which ensures optimum AC alternator performance. It is equipped with complete protection circuitry to guard against operating conditions that could be detrimental to the AC alternator.



VOLTAGE REGULATOR

Volts

This potentiometer is used to adjust output voltage. At proper engine operating speed the output voltage should be held at ±1% from a no-load condition to a full rated generator output and from power factor 1.0 - 0.8 with engine drive speed variations up to -6%.

Prior to starting the engine, turn the VOLT and STAB trimmers (using a mini phillips screwdriver) fully in a counter clockwise (Minimum) direction until you feel them hit their stops.

Turn the AMP and HERTZ trimmers completely clockwise (Maximum) in the same manner.

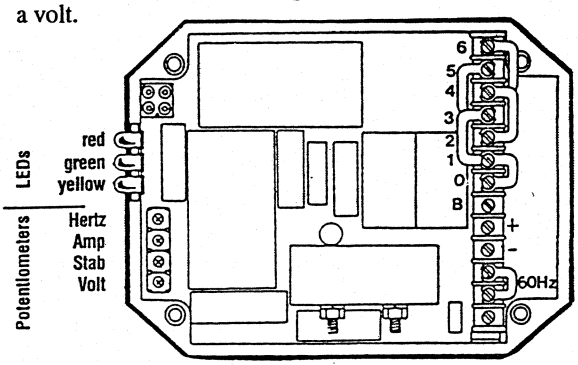
With the alternator running at no-load, at normal speed, and with VOLT adjust at minimum, it is possible that output voltage will oscillate. Slowly rotate the VOLT adjust clockwise. The voltage output of the alternator will increase and stabilize. Increase the voltage to the desired value. In this situation, only the green LED will stay lit.

Stability

This potentiometer permits variation of the regulator's response to generator load changes so as to limit overcompensation and obtain a minimum recovery time to the normal voltage output.

In order to adjust the regulator stability the alternator must be running at no-load and the output must be monitored.

Turn the STAB adjust slowly clockwise until the voltage starts to fluctuate. At this point rotate the STAB adjust counterclockwise until the voltage is stable within 1 or 2 tenths of a volt.



VOLTAGE REGULATOR DIAGRAM

Amp-Hertz

These two adjustments are used in conjunction with the two protection circuits in the voltage regulator that are indicated by the illumination of a colored LED lights.

1. Delayed overload protection (yellow LED).
2. Low speed protection (red LED).

Both systems have an intervention threshold which can be adjusted using the respective potentiometer. Each of the two circuits are able to cause an adequate reduction in excitor voltage to safeguard the excitor windings and prevent their overheating.

The overload protection system has a delay which permits temporary overloading of the generator during times such as motor start-up or other similar load surge demands. The regulator also has a third LED (green), that glows during generator operation to indicate correct operation of the regulator with the generator.

Setting the Overload Protection

In order to set the AMP overload protection, the alternator must be loaded to its full output rating.

1. Load the alternator to its rating, then decrease the speed of the engine by 10.10% (54 Hertz on 60 hertz units, 45 hertz on 50 hertz units).
2. Rotate the AMP adjustment counterclockwise until it hits its stop. Wait about 15-20 seconds after which the AC output of the alternator should drop and the yellow LED light should come on.
3. Slowly rotate the AMP adjustment clockwise until the output voltage increases to approximately 97% of the voltage output at the start of the adjustment. At this point the yellow LED light should come on.
4. Return to nominal speed, the yellow LED will turn off and the alternator voltage will rise to its normal value. Should this not happen, repeat the adjustment.

NOTE: *When changing from 60 hertz to 50 hertz operation, remove the 60 hertz jumper bar from the regulator board.*

Setting the Underspeed Protection

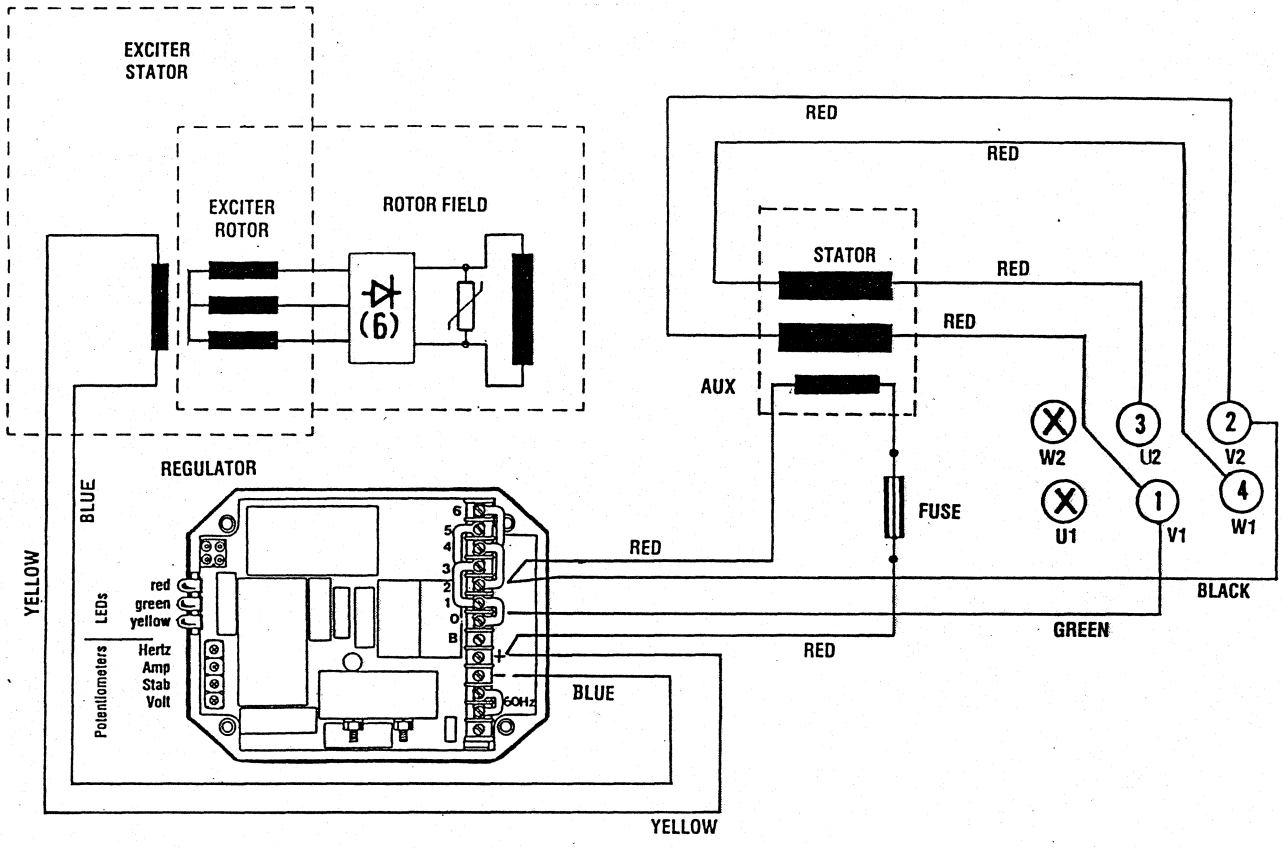
NOTE: *If the unit is operating at 60 Hertz ensure that the jumper strap is in place on the regulator board between the two 60 Hertz terminals. In order to adjust the underspeed setting, the alternator should be running at no-load.*

1. To adjust the underspeed (low frequency) protection circuit, lower the engine speed at 90% of its normal running speed (54 hertz on 60 hertz units, 45 hertz on 50 hertz units.
2. Rotate the Hertz adjustment counterclockwise slowly until the alternator's AC output voltage starts to decrease and at the same time the red "LED" light comes on.
3. Increase the engine speed to its normal speed (frequency). The red "LED" light will go out and the AC voltage output will return to normal.

With the above adjustments made, the regulator should function normally.

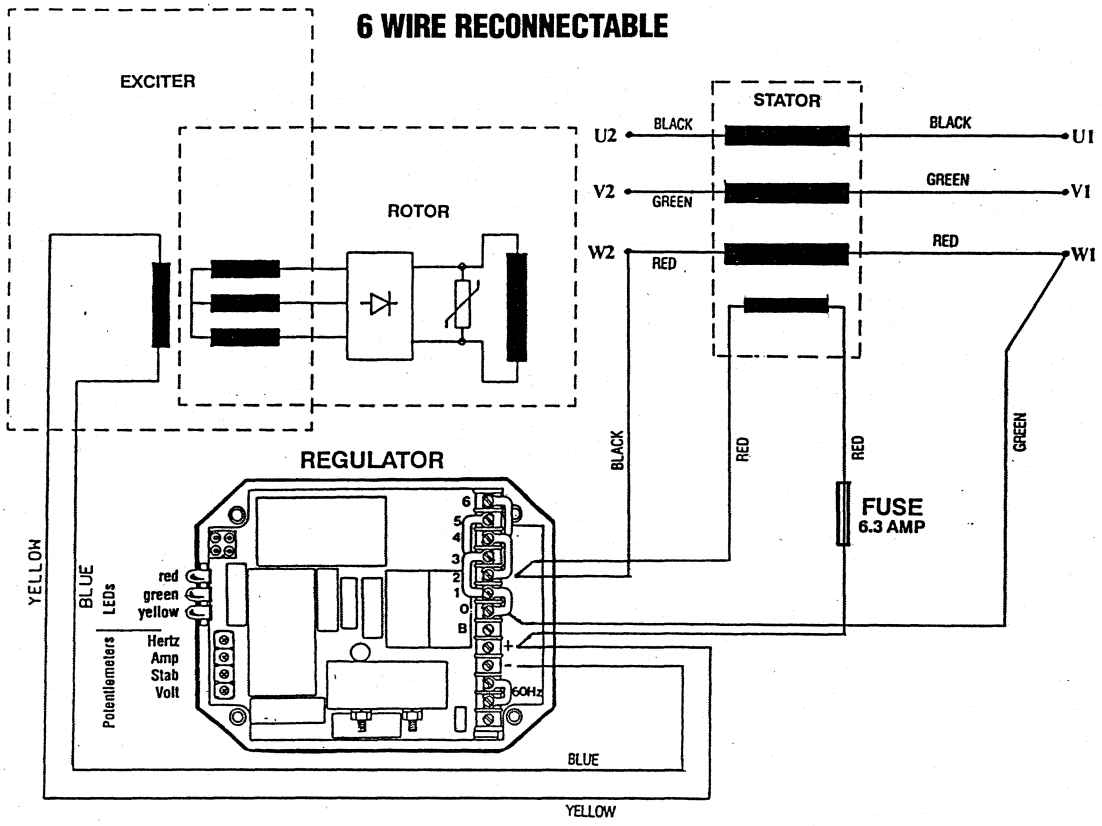
INTERNAL WIRING SCHEMATICS

SINGLE PHASE



THREE PHASE

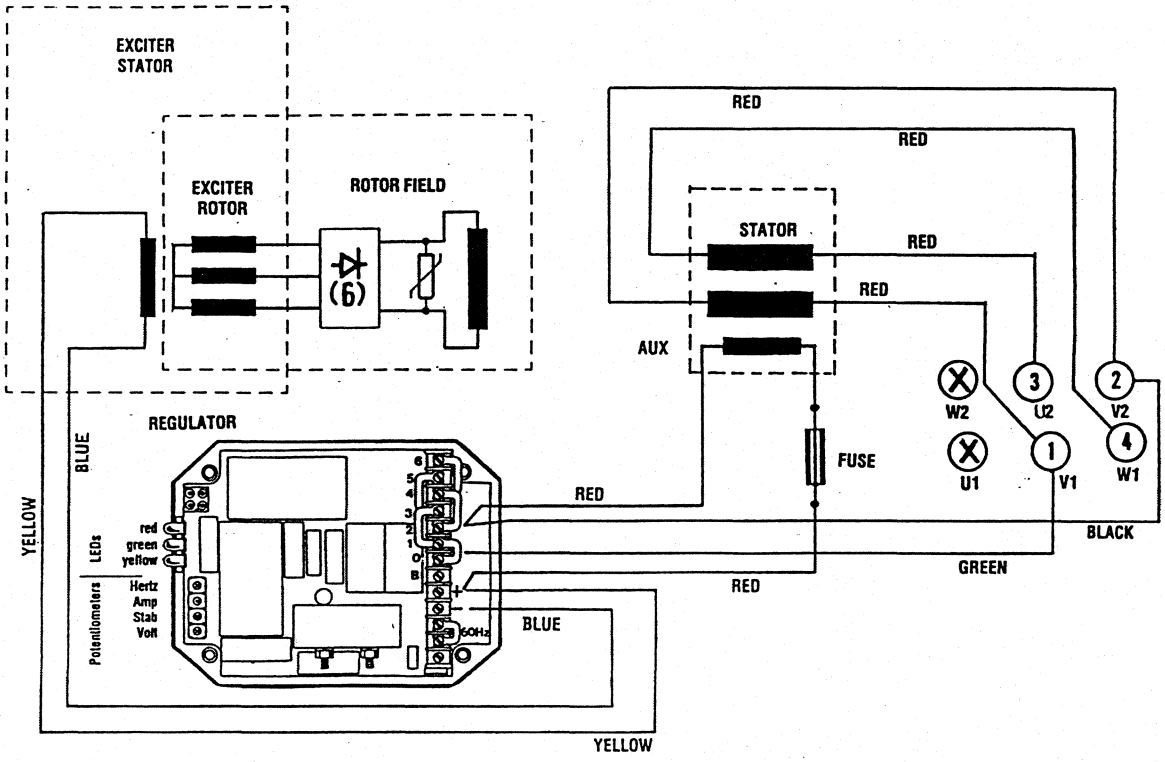
6 WIRE RECONNECTABLE



BE TROUBLESHOOTING

NOTE: *AC GENERATOR TROUBLESHOOTING MUST BE PERFORMED WITH ENGINE OPERATING AT 60 HERTZ.*

FAULT	PROBABLE CAUSE
No AC voltage output at no load.	**1.** Short or open in the main stator winding. **2.** Shorted pozi-resistor on exciter rotor. **3.** Four or more shorted or open diodes on exciter rotor. **4.** Short or open in exciter stator winding. **5.** Short or open in rotating field winding.
Residual voltage produced at no load 15 - 20 volts AC.	**1.** Blown 6 AMP buse fuse auxiliary circuit feed to AVR. **2.** Faulty voltage regulator. **3.** Shorted or open main stator auxiliary winding.
Low AC voltage output at no load 60 - 100 VAC.	**1.** Open or shorted diodes in exciter rotor 1 to 3 diodes. **2.** Open or shorted exciter rotor winding. **3.** Faulty voltage regulator.
High AC output voltage 150 VAC or higher.	**1.** Faulty voltage regulator.
Unstable voltage output.	**1.** STB pod on regulator needs adjustment. **2.** Faulty voltage regulator.
AC voltage drop under load 60 - 100 volts AC.	**1.** Diode(s) on exciter rotor breaking down when load is applied (inductive) 1-3 diodes.



ELECTRONIC GOVERNOR

ELECTRONIC GOVERNING SYSTEM

The system is composed of three basic components:

1. Controller – Mounted inside the instrument panel box.
2. Sensor - Installed on the generator stator housing over the flywheel ring gear.
3. Actuator - Mounted at the front of the engine and attached with linkage to the throttle arm of the injection pump.

Controller Adjustments

1. Speed. - This adjustment is used to raise or lower engine speed to the desired hertz.
2. Gain - This adjustment affects the reaction time of the actuator to the generator/engine load changes.

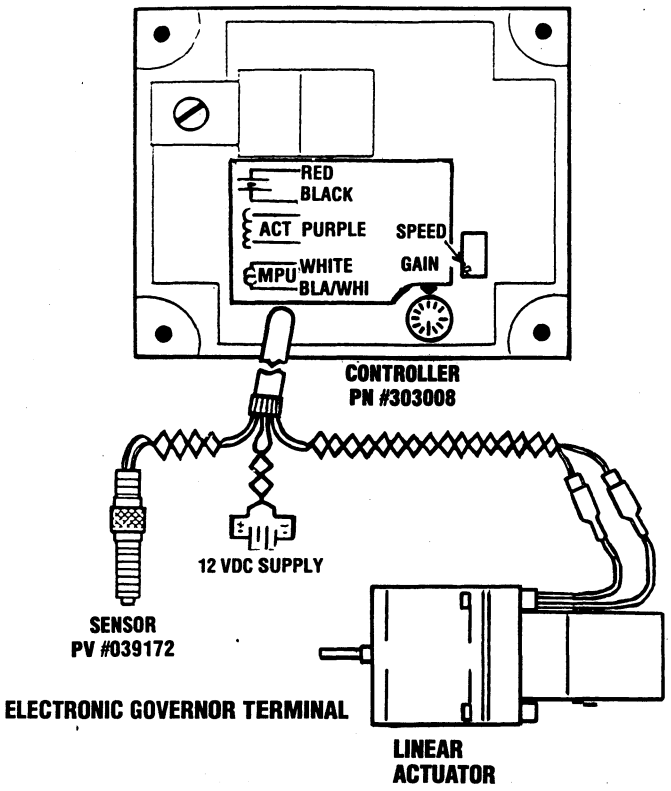
NOTE: *A high gain adjustment can induce an oscillating of the actuator producing a hunting mode. In such cases, lessen the gain adjustment.*

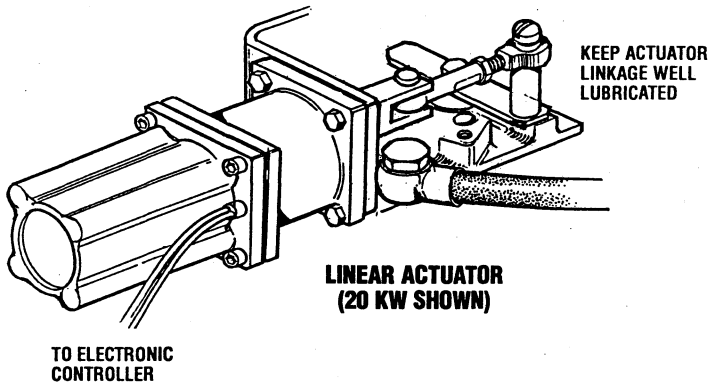
Calibration

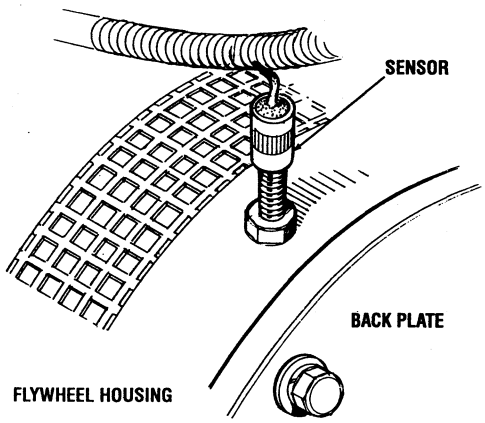
1. With no power to the governor (engine not running) adjust the GAIN potentiometer to 9:00 o'clock.
2. Start the engine and adjust the speed by turning the SPEED potentiometer clockwise to desired speed.

NOTE: *Controllers are factory adjusted to minimum rpm. However, for safety, one should be capable of disabling the engine if an overspeed should exist.*

3. At no load, turn the GAIN potentiometer clockwise until the engine begins to hunt. If the engine does not hunt, physically upset the governor linkage.
4. Turn the gain potentiometer counterclockwise until the engine runs stable.





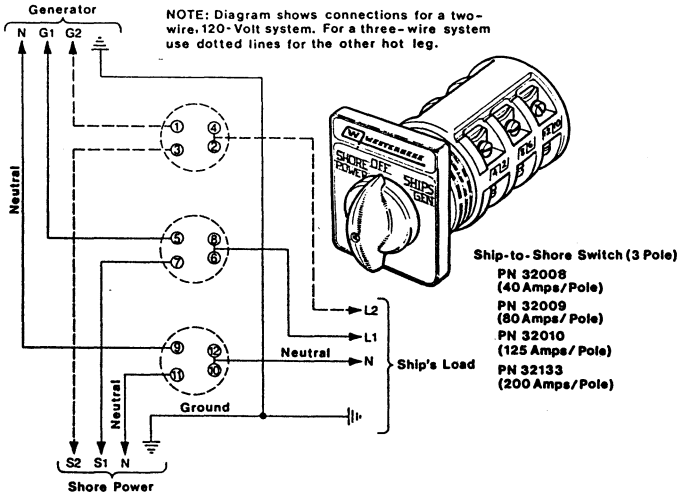


TROUBLESHOOTING THE ELECTRONIC GOVERNOR

Problem	Probable Cause	Verification/Remedy
System appears dead (Engine runs at idle.)	**1.** Low battery voltage at controller.	**1.** Check wiring for cause. Check battery state of charge.
	2. Stuck linkage.	**2.** Lubricate, free up linkage between controller and throttle arm.
	3. No signal or weak signal from sensor. (Measure AC voltage from sensor while engine is running at idle. Voltage should be 2.5 volts or greater.	**3.** Check for improperly installed or damaged sensor in flywheel housing. Replace or adjust.
	4. Check Actuator – depress PREHEAT and check for battery voltage between negative black lead at terminal block.	
	a. Purple lead to black.	**4.** Replace controller if battery voltage is not present at both leads.
	b. Second purple to black.	
	5. Perform the following check between terminals at the actuator and the negative DC lead at the controller terminal block. (Preheat depressed).	
	a. Low voltage (1.20-2.0 VDC) at either actuator connection.	**a.** Broken actuator lead.
	b. Battery voltage at both actuator connections.	**b.** Broken actuator lead.
	c. Battery voltage at one actuator lead but not the other.	**c.** Replace the actuator.
Actuator fully extends when PREHEAT is depressed and stays extended.	**1.** Check controller. Lift one of the purple actuator leads from the terminal block. Depress PREHEAT.	
	a. Actuator fully extends.	**a.** Short in lead to actuator.
	b. Actuator does not fully extend and connections.	**b.** Replace controller.
	NOTE: *Release* PREHEAT *and reconnect the purple lead.*	
Actuator hunts (oscillates) and engine running.	**1.** Linkage between actuator and throttle binding.	**1.** Lubricate/free-up.
	2. Improper adjustment of GAIN on controller.	**2.** Lessen GAIN adjustment (Recalibrate the Controller).
	3. Inadequate DC power supply to controller, complete the following tests:	
	Connect a DC voltmeter across the plus and negative leads at the controller terminal block.	
	Lift both purple leads from the terminal block.	
	Connect one purple lead to the C plus terminal and the other to the DC negative.	
	Momentarily depress PREHEAT. The actuator should fully extend.	**3.** If actuator does not fully extend, check the actuator leads. If the voltage is less than specified, check for loose or poor connections, low battery voltage, voltage drop in DC circuit due to remote panel installation and small wire sizes making connections.
		DC voltage registering on the meter should be: 12 VDC System – 9.6 VDC or higher 24 VDC System – 19.2 VDC or higher
		NOTE: *Reconnect actuator leads properly after making this test.*
	3a. Sensor positioned marginally too far away from flywheel teeth giving erratic signal voltage to controller.	**3a.** Check the position of the sensor.

SHORE POWER TRANSFER SWITCH

SHORE POWER CONNECTIONS (60 HERTZ)

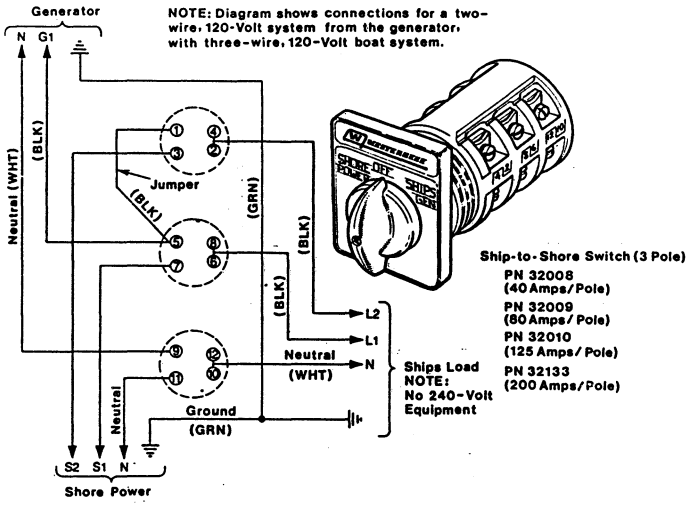


If the installer connects shore power to the vessel's AC circuit, this must be done by means of the Shore Power Transfer Switch. Set the transfer switch shown in the diagrams to the OFF position. This switch prevents simultaneous connection of shore power to generator output.

> **⚠ CAUTION:** ***Damage to the generator can result if utility shore power and generator output are connected at the same time. This type of generator damage is not covered under the warranty; it is the installer's responsibility to make sure all AC connections are correct.***

120 VOLT/60 HERTZ THREE WIRE CONFIGURATION

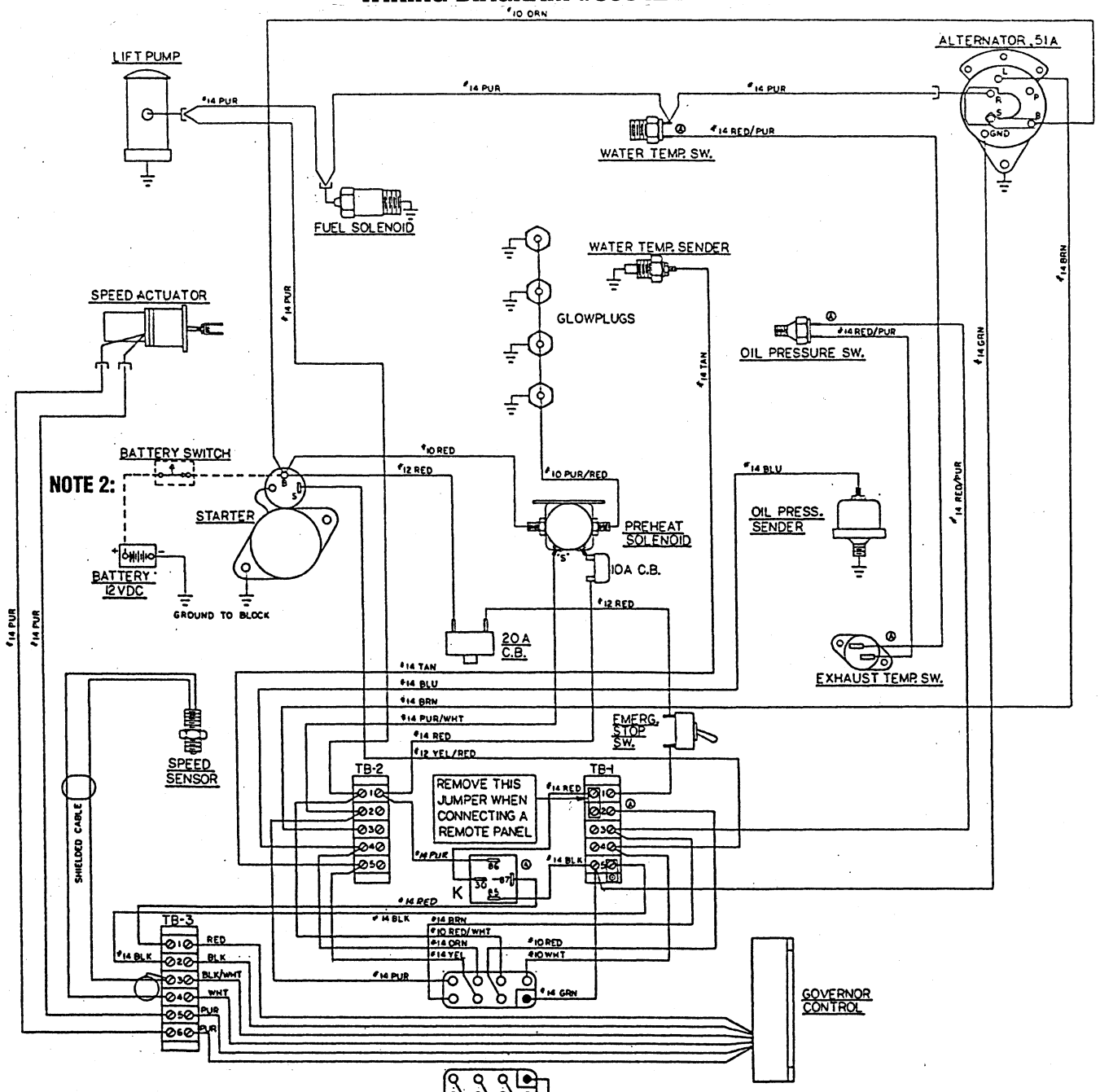
Notice the repositioning of the white wire ground load on the terminal block to the generator case.



Switching Shore Power to Generator Power

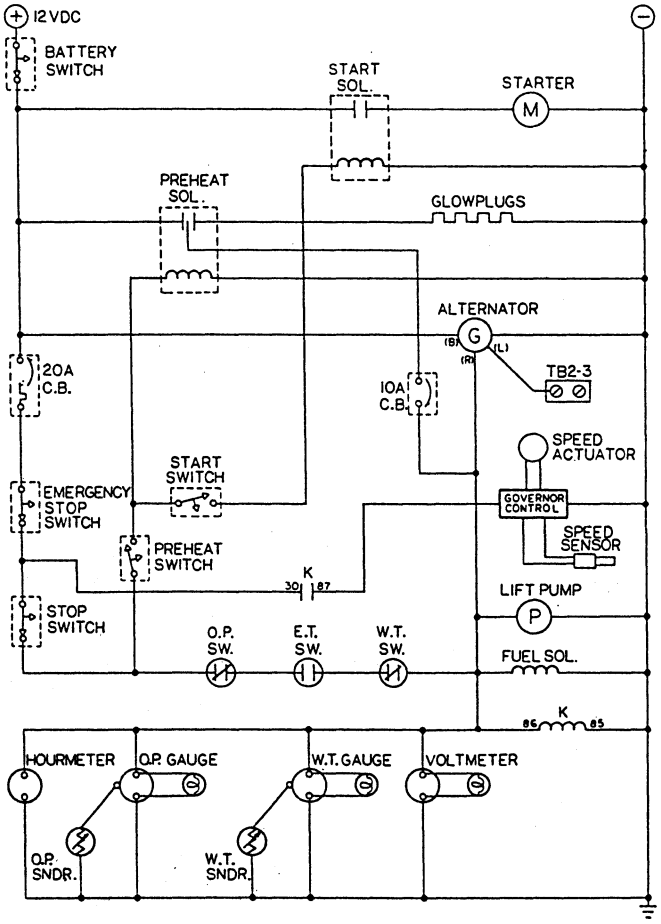
> **⚠ CAUTION:** ***Heavy motor leads should be shut off before switching shore power to generator power or vice-versa because voltage surges induced by switching with heavy AC loads on the vessel being operated may cause damage to the exciter circuit components in the generator.***

GENERATOR
WIRING DIAGRAM #039422

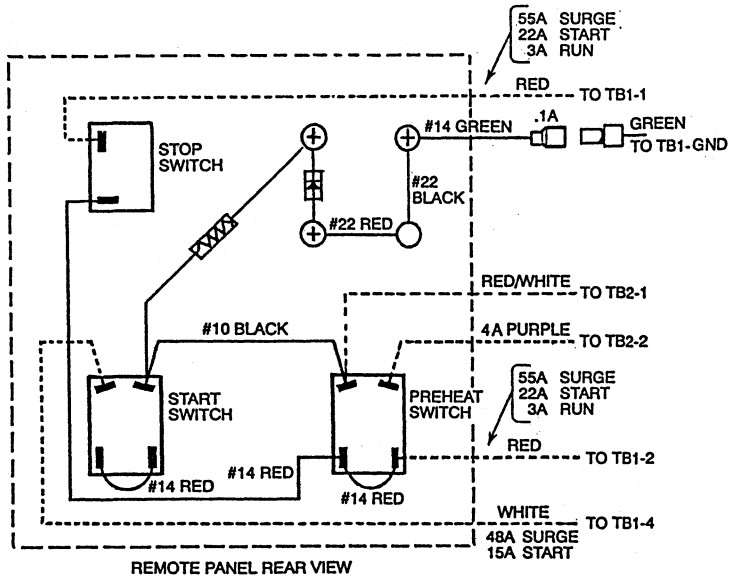


NOTE 2: *An on-off switch should be installed in this circuit to disconnect the starter from the battery in an emergency and when leaving the boat. Twelve volt diesel engine starters typically draw 200 to 300 amps when cranking. A switch with a continuous rating of 175 amps at 12 VDC will normally serve this function, but a switch must never be used to "make" the starter circuit.*

GENERATOR
WIRING SCHEMATIC #039422



REMOTE START/STOP PANEL



REMOTE PANEL REAR VIEW

SPECIFICATIONS
WESTERBEKE 20 KW BEDA GENERATOR

SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled Vertical, in-line overhead valve mechanism (33 hp at 1800 rpm maximum).
Aspiration	Naturally aspirated.
Governor	Electronic Governing
Combustion Chamber	Swirl type
Bore & Stroke	3.50 x 4.0 inches (88.9 x 101.6 mm)
Piston Displacement	154 cubic inches (2.5 liters)
Firing Order	1 - 3 - 4 - 2
Direction of Rotation	Clockwise, when viewed from the front
Maximum Torque (at 1800 rpm)	117 lb-ft (16.18 kg-m)
Compression Ratio	21:1
Dimensions	Height: 28.50 inches (723.9 mm) Width: 22.00 inches (546.1 mm) Length: 45.79 inches (1163.3 mm)
Weight	943 lbs (431.7 kgs)
Fuel Consumption (approximate)	2.0 gph (7.57 lph) at full rated output
Inclination	Continuous 15° Temporary 20° (not to exceed 20 min.)
Generator Power Take off	30 Horsepower (maximum)

TUNE-UP SPECIFICATIONS

Compression Pressure (Limit of difference between cylinders)	427 psi (30 kg/cm²) at 200 rpm (47.2 psi {3.0 kg/cm²})
Valve Timing	Intake Opens 17° BTDC Intake Closes 47° ABDC Exhaust Opens 51° BBDC Exhaust Closes 13° ATDC
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance (engine cold)	Intake 0.012 inches (0.3 mm) Exhaust 0.012 inches (0.3 mm)
Engine Speed	1800 RPM 60 Hertz 1500 RPM 50 Hertz
Injector Pressure	1920 + 71-0 psi (135 + 5-0 kg/cm²)
Engine Timing	Static timed - drop valve method 0.205 ± .005 inches BTDC

FUEL SYSTEM

General	Open flow, self priming - 1 bleed point
Fuel	No. 2 diesel oil (cetane rating of 45 or higher)
Fuel Injection Pump	ZEXEL Model VE Distributor
Fuel Injection Timing	0° TDC (Top Dead Center)
Nozzle	Throttle type
Fuel Filter (on engine)	Spin-on type, full flow
Air cleaner	Metal screen type
Air Flow (engine combustion)	81.0 cfm (2.29 cmm)

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, belt driven.
Raw Water Flow, at 1800 rpm	14.0 gpm (52.9 lpm) (measured before discharging into exhaust elbow).
System Capacity (fresh water)	11.5 qts (10.88 liters)

LUBRICATION SYSTEM

General	Pressure fed system
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (not including filter)	6.5 U.S. qts (6.15 liters) plus filter/cooler assembly
Operating Oil Pressure (engine hot)	50-60 psi (3.5 - 4.2 kg/cm²)
Oil Grade	API Specification of CF or CG-4, SAE 30, 10W-30, 15W-40

SPECIFICATIONS
WESTERBEKE 20 KW BEDA GENERATOR

ELECTRICAL SYSTEM

Starting Battery	12-Volt, (-) negative ground
Battery Capacity	400 - 600 Cold Cranking Amps (CCA)
DC Charging Alternator	51 Amp rated, belt-driven
Starter	12-Volt, Reduction Gear, 3 KW
Starting Aid	Glow plugs, sheathed type
DC No-Load Current	± 2% of rated Amps
DC Cranking Current	250 - 300 Amps (engine cold)

AC GENERATOR (SINGLE PHASE)

General - Single Phase	Brushless, four-pole, revolving field Sealed lubricated single bearing design. Reconnectable single phase for 120/240 volts with solid state voltage regulator.
Voltage - Single Phase	120 or 120/240 Volts - 60 Hertz 230 Volts - 50 Hertz
Voltage regulation:	± 2% no load to full load.
Frequency regulation:	0.30 Hertz no load to full load.
Rating (Volts AC)	20 KW - 60 Hertz (1800 rpm) 120 Volts 166 Amps 120/240 Volts 166/83 Amps 16 KW - 50 Hertz (1500 rpm) 230 Volts 72.7 Amps

AC GENERATOR (3 Phase)

General - 3 Phase 20.0 KW - 60 Hertz 16.0 KW - 50 Hertz	Brushless six pole, revolving field. Sealed lubricated single bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid State voltage regulator with protection circuitry.	
Voltage - 3 Phase (60 Hertz)	Low voltage WYE High voltage WYE DELTA	208 volts 480 volts 240 volts
Voltage - 3 Phase (50 Hertz)	High voltage WYE DELTA	380 volts 230 Volts
Amperage - 3 Phase (60 Hertz)	Low voltage WYE High voltage WYE DELTA	70 Amps 35 Amps 60 Amps
Amperage - 3 Phase (50 Hertz)	High voltage WYE DELTA	30.4 Amps 52.5 Amps

GENERATOR COOLING

Air Requirements (60 Hertz at 1800 RPM)	425 cfm (12.74 cmm)
Note: Increase air supply 15% for 50 Hertz operation 1500 rpm	
Engine Combustion Air Requirements (60 Hertz at 1800 RPM)	81.0 cfm (2.29 cmm)

SERVICE DATA / TOLERANCES AND LIMITS

20 KW 60Hz Generator/16KW 50 Hz Generator

	71B-FOUR	71C-FOUR
VALVE TIMING		
Intake Valve *Opens BTDC*	17°	17°
Closes ABDC	47°	47°
Exhaust Valve *Opens BBDC*	51°	51°
Closes ATDC	13°	13°
Compression Pressure *Standard*	30.0 kg/cm² (427 lb/in²) 200 rpm	30.0 kg/cm² (427 lb/in²) 200 rpm
Limit	27.0 kg/cm² (384 lb/in²) 200 rpm	27.0 kg/cm² (384 lb/in²) 200 rpm
Limit Differences Between Cylinders	3.0 kg/cm² (43 lb/in²)	3.0 kg/cm² (43 lb/in²)
Valve Clearance (cold) *Intake*	0.3 (0.012)	0.3 (0.012)
Exhaust	0.3 (0.012)	0.3 (0.012)
CYLINDER HEAD and VALVE SEAT	**mm (in)**	**mm (in)**
Distortion Limit	0.10 (0.004) Positions 1 + 2 0.25 (0.010) Positions 3 + 6	0.10 (0.004) Positions 1 + 2 0.25 (0.010) Positions 3 + 6
Dimension L (Intake) *Standard*	48.0 (1.89)	48.0 (1.89)
Limit	49.55 (1.95)	49.55 (1.95)
(Exhaust) *Standard*	48.05 (1.89)	48.05 (1.89)
Limit	49.55 (1.95)	49.55 (1.95)
Seat Angle (Intake)	45°	45°
(Exhaust)	30°	30°
Contact Seat Width (Intake)	2.0 (0.079)	2.0 (0.079)
(Exhaust)	2.0 (0.079)	2.0 (0.079)
Valve Margin *Limit*	1.35 (0.053)	1.35 (0.053)
VALVE GUIDE, VALVE AND VALVE SPRINGS	**mm (in)**	**mm (in)**
Valve Stem to Guide Clearance (Intake) *Standard*	0.038 - 0.085 (0.001 - 0.003)	0.038 - 0.085 (0.001 - 0.003)
Limit	0.127 (0.005)	0.127 (0.005)
(Exhaust) *Standard*	0.058 - 0.105 (0.002 - 0.004)	0.058 - 0.105 (0.002 - 0.004)
Limit	0.127 (0.005)	0.127 (0.005)
Guide Inner Spring Diameter	9.018 - 9.040 (0.355 - 0.356	9.018 - 9.040 (0.355 - 0.356
Main Journal Diameter *Standard*	69.812 - 69.825 (2.748 - 2.749)	65.0 - 65.013 (2.5591 - 2.5596)
Wear Limit	0.05 (0.002)	0.05 (0.002)
Grinding Limit	69.05 (2.718)	69.05 (2.718)
Main Journal Bearing Clearance *Standard*	0.059 - 0.090 (0.002 - 0.004)	0.040 - 0.091 (0.0016 - 0.0036)
Wear Limit	0.12 (0.005)	0.12 (0.005)
Protrusion from Cylinder Head	16.5 (0.650)	48.0 (1.890)
Valve Stem Diameter (Intake) *Standard*	8.955 - 8.980 (0.353 - 0.354)	8.955 - 8.980 (0.353 - 0.354)
Limit	8.884 (0.350)	7.880 (0.3102)
(Exhaust) *Standard*	8.935 - 8.960 (0.352 - 0.353)	8.955 - 8.980 (0.353 - 0.354)
Limit	8.864 - (0.349)	7.867 (0.3097)
Valve Head Thickness (Intake) *Standard*	1.7 (0.067)	1.7 (0.067)
Limit	1.0 (0.039)	1.0 (0.039)
(Exhaust) *Standard*	1.5 (0.059)	1.5 (0.059)
Limit	1.0 (0.039)	1.0 (0.039)
Valve Head Diameter (Intake)	40.4 - 40.6 (1.59 - 1.60)	40.4 - 40.6 (1.59 - 1.60)
(Exhaust)	35.87 - 36.13 (1.41 - 1.42)	35.87 - 36.13 (1.41 - 1.42)
Valve Seat Width (Intake)	36.8 (1.45)	36.8 (1.45)
(Exhaust)	31.7 (1.25)	31.7 (1.25)

SERVICE DATA / TOLERANCES AND LIMITS

20 KW 60Hz Generator/16KW 50 Hz Generator

	71B-FOUR	71C-FOUR
VALVE GUIDE, VALVE AND VALVE SPRINGS	mm (in)	mm (in)
Valve Face Angle (Intake)	45°	45°
(Exhaust)	30°	30°
Rear Oil Seal Insert *Limit*	6.35 - 7.62 (0.250 - 0.300)	6.35 - 7.62 (0.250 - 0.300)
Valve Spring Squareness Limit (Inner)	1.25 (0.049)	1.25 (0.049)
(Outer)	1.37 (0.054)	1.37 (0.054)
Free length of Valve Spring (Inner) *Standard*	43.6 (1.717)	42.0 (1.654)
Limit	42.0 (1.654)	42.0 (1.654)
(Outer) *Standard*	55.7 (2.193)	43.6 (1.717)
Limit	52.9 (2.083)	43.6 (1.717)
Valve Spring Constant (Inner)	2.02kg/mm (113lb/in)	2.02kg/mm (113lb/in)
(Outer)	2.16kg/mm (121lb/in)	2.16kg/mm (121lb/in)
CONNECTING ROD/CONNECTING ROD BEARING	mm (in)	mm (in)
Length (Center to Center)	173.012 - 173.063 (6.811 - 6.813)	173.012 - 173.063 (6.811 - 6.813)
Maximum Allowable Twist	0.05 per 100 (0.002 per 3.94)	0.05 per 100 (0.002 per 3.94)
Small Bore End	28.012 - 28.033 (1.103 - 1.104)	28.012 - 28.033 (1.103 - 1.104)
Clearance between Piston Pin & Small Bore End		
Standard	0.012 - 0.031 (0.0005 - 0.0015)	0.014 - 0.041 (0.0006 - 0.0016)
Limit	0.05 (0.002)	0.05 (0.002)
Connecting Rod Side Clearance *Standard*	0.239 - 0.330 (0.009 - 0.013)	0.239 - 0.330 (0.009 - 0.013)
Limit	0.4 (0.016)	0.4 (0.016)
Crankpin Bearing Clearance *Standard*	0.012 - 0.031 (0.0005 - 0.0012)	0.012 - 0.031 (0.0005 - 0.0012)
Oil Clearance *Wear Limit*	0.05 (0.002)	0.05 (0.002)
Crank Pin Dia. Available Undersize Bearing		
0.254 (0.01)	56.868 - 56.871 (2.2389 - 2.2391)	64.746 - 64.733 (2.5485 - 2.5491)
0.508 (0.02)	56.604 - 56.617 (2.2285 - 2.2312)	64.479 - 64.492 (2.5385 - 2.5391)
0.762 (0.03)	56.350 - 56.363 (2.2185 - 2.2191)	64.225 - 64.238 (2.5285 - 2.5291)
CRANKSHAFT AND MAIN BEARING	mm (in)	mm (in)
Crankpin Diameter *Standard*	57.112 - 57.125 (2.248 - 2.249)	53.0 - 53.013 (2.0866 - 2.0861)
Wear Limit	0.05 (0.002)	0.05 (0.002)
Grinding Limit	56.35 (2.218)	56.35 (2.218)
Main Journal Dia. Available Undersize Bearing		
0.254 (0.01)	69.558 - 69.571(2.7385 - 2.7391)	52.733 - 52.746 (2.0761 - 2.0766)
0.508 (0.02)	69.304 - 69.317 (2.7182 - 2.7291)	52.479 - 52.492 (2.0661 - 2.0666)
0.762 (0.03)	69.050 - 69.063 (2.7185 - 2.7191)	52.225 - 52.238 (2.0561 - 2.0566)
Available Oversize Thrust Bearing	0.178 (0.007)	0.178 (0.007)
Crankshaft Run-Out	0.05 (0.002)	0.05 (0.002)
Crankshaft End Play *Standard*	0.140 - 0.390 (0.005 - 0.015)	0.140 - 0.390 (0.005 - 0.015)
Limit	0.4 (0.016)	0.4 (0.016)
CYLINDER BLOCK, PISTON AND PISTON PIN	mm (in)	mm (in)
Limit of Distortion of Cylinder Block	0.10 (0.004) Positions 1 + 2	0.10 (0.004) Positions 1 + 2
	0.25 (0.010) Positions 3 + 4	0.25 (0.010) Positions 3 + 4
Cylinder Liner Diameter	88.925 - 88.950 (3.501 - 3.502)	88.925 - 88.950 (3.501 - 3.502)
Wear Limit of Cylinder Liner	0.20 (0.008)	0.20 (0.008)
Liner Protrusion above Cylinder Block	0.101 0 (0.004 - 0)	0.659 - 0.790 (0.026 - 0.031)

SERVICE DATA / TOLERANCES AND LIMITS

20 KW 60Hz Generator/16KW 50 Hz Generator

		71B-FOUR	71C-FOUR
CYLINDER BLOCK, PISTON AND PISTON PIN		**mm (in)**	**mm (in)**
Piston Diameter *(Diameter measured at 90° to pin bore axis and 23m (0.91 in) up from bottom)*		88.872 - 88.898(3.499 - 3.500)	88.880 ± 0.013 (3.4989 ± 0.0005)
Piston and Liner Clearance		0.044 - 0.070 (0.0017 - 0.0028)	0.054 - 0.080 (0.0021 - 0.0031)
Ring Groove Width	*Top*	2.433 - 2.543 (0.096 - 0.100)	2.433 - 2.543 (0.096 - 0.100)
	Second	2.423 - 2.443 (0.095 - 0.096)	2.423 - 2.443 (0.095 - 0.096)
	Oil	4.793 - 4.813 (0.1887 - 0.1895)	4.793 - 4.813 (0.1887 - 0.1895)
Piston Ring Thickness	*Top*	2.363 - 2.383 (0.093 - 0.094)	2.363 - 2.383 (0.093 - 0.094)
	Second	2.363 - 2.383 (0.093 - 0.094)	2.363 - 2.383 (0.093 - 0.094)
	Oil	4.743 - 4.763 (0.187 - 0.188)	4.743 - 4.763 (0.187 - 0.188)
Clearance Between Piston Ring & Ring Groove	*Top*	0.05 - 0.18 (0.002 - 0.007)	0.05 - 0.18 (0.002 - 0.007)
	Second	0.04 - 0.08 (0.002 - 0.003)	0.04 - 0.08 (0.002 - 0.003)
	Oil	0.03 - 0.07 (0.001 - 0.003)	0.03 - 0.07 (0.001 - 0.003)
	Limit	0.3 (0.012)	0.3 (0.012)
Piston Ring End gap	*Top*	0.35 0.55 (0.014 - 0.022)	0.35 0.55 (0.014 - 0.022)
	Second	0.35 0.55 (0.014 - 0.022)	0.35 0.55 (0.014 - 0.022)
	Oil	0.35 0.55 (0.014 - 0.022)	0.35 0.55 (0.014 - 0.022)
	Limit	1.5 (0.059)	1.5 (0.059)
Piston Pin Diameter		27.994 - 28.000 (1.1021 - 1.1024)	27.994 - 28.000 (1.1021 - 1.1024)
Piston Pin Hole Bore		27.996 - 28.008 (1.1022 - 1.1027)	27.996 - 28.008 (1.1022 - 1.1027)
OIL PUMP			
Oil Pressure		more than 3.8 Kg/cm² (54lb/in²) at 3600 rpm	
Outer Rotor and Body Clearance	*Standard*	0.14 - 0.25 (0.006 - 0.010)	0.14 - 0.25 (0.006 - 0.010)
	Limit	0.3 (0.012)	0.3 (0.012)
Clearance Between Lobes	*Standard*	0.04 - 0.15 (0.002 - 0.006)	0.04 - 0.15 (0.002 - 0.006)
	Limit	0.25 0 (0.01)	0.25 0 (0.01)
Rotor End Float	*Standard*	0.04 - 0.10 (0.002 - 0.004)	0.04 - 0.10 (0.002 - 0.004)
	Limit	0.15 - (0.006)	0.15 - (0.006)
Pump Shaft and Body Clearance	*Standard*	0.06 - 0.15 (0.002 - 0.006)	0.06 - 0.15 (0.002 - 0.006)
	Limit	0.1 - (0.004)	0.1 - (0.004)
Free Length of Plunger Spring	*Limit*	40 (1.61)	40 (1.61)
OIL PUMP			
Oil Filter Relief Valve Opens at		0.8 - 1.2 Kg/cm² (11 - 17lb/in²)	0.8 - 1.2 Kg/cm² (11 - 17lb/in²)
Oil Capacity of the Oil Pan		6.0 liters (6.3 US quarts)	6.0 liters (6.3 US quarts)
Classification		API, CF, or CG-4 27° c (80° f), or over SAE 30 -1 - 27° c (30 - 80 ° f), SAE 20W-20 -18 - -1° c (0 - 30° f) SAE 10W	API, CF, or CG-4 27°c (80° f), or over SAE 30 -1 - 27° c (30 - 80 ° f), SAE 20W-20 -18 - -1° c (0 - 30° f) SAE 10W
STARTER MOTOR		**mm (in)**	**mm (in)**
Depth of Brush Under Cut	*Standard*	0.5 (0.019)	0.5 (0.019)
	Limit	0.2 (0.008)	0.2 (0.008)
Height of Brush	*Standard*	17 (0.669)	17 (0.669)
	Limit	6 (0.236)	6 (0.236)
Spring Pressure		3 Kg/cm² (43 lb/in²)	3 Kg/cm² (43 lb/in²)
Commutator O. D.	*Standard*	38.7 (1.523)	38.7 (1.523)
	Limit	-1.0 (-0.039)	-1.0 (-0.039)
Pinion Shaft End Play		0.5 (0.014)	0.5 (0.014)

SERVICE DATA / TOLERANCES AND LIMITS

20 KW 60Hz Generator/16KW 50 Hz Generator

	71B-FOUR	71C-FOUR
ROCKER ARM AND ROCKER ARM SHAFT	**mm (in)**	**mm (in)**
Bore in Rocker Arm	15.876 - 15.896 (0.625 - 0.626)	15.876 - 15.896 (0.625 - 0.626)
Rocker Arm Shaft Diameter	15.835 - 15.860 (0.623 - 0.624)	15.835 - 15.860 (0.623 - 0.624)
Clearance in Rocker Arm *Standard*	0.016 - 0.061 (0.0006 - 0.0024)	0.016 - 0.061 (0.0006 - 0.0024)
Limit	0.07 (0.003)	0.07 (0.003)
TAPPET	**mm (in)**	**mm (in)**
Outer Diameter	14.224 - 14.249 (0.560 - 0.561)	14.224 - 14.249 (0.560 - 0.561)
Bore in Cylinder Block	14.288 - 14.319 (0.563 - 0.564)	14.288 - 14.319 (0.563 - 0.564)
Clearance in Cylinder Block *Standard*	0.039 - 0.095 (0.002 - 0.004)	0.039 - 0.095 (0.002 - 0.004)
Limit	0.10 (0.004)	0.1 (0.004)
CAMSHAFT	**mm (in)**	**mm (in)**
Camshaft Run-Out	0.08 (0.003)	0.08 (0.003)
Camshaft End-Play *Standard*	0.020 - 0.180 (0.001 - 0.007)	0.020 - 0.180 (0.001 - 0.007)
Limit	0.3 (0.012)	0.3 (0.012)
Journal Diameter 1.	51.910 - 51.940 (2.044 - 2.045)	*Front* 52.06 - 52.09 (2.0497 - 2.0508)
2.	51.660 - 51.690 (2.034 - 2.035)	*Center* 51.81 - 51.84 (2.0398 - 2.0409)
3.	51.410 - 51.440 (2.024 - 2.025)	*Rear* 51.31 - 51.34 (2.0201 - 2.0212)
4.	51.160 - 51.190 (2.014 - 2.015)	
Wear Limit of Journal	0.008 (0.0003)	0.008 (0.0003)
Bore in Cylinder 1.	52.000 - 52.030 (2.047 - 2.049)	52.000 - 52.030 (2.047 - 2.049)
2.	51.750 - 51.780 (2.037 - 2.039)	51.750 - 51.780 (2.037 - 2.039)
3.	51.500 - 51.530- (2.028 - 2.029)	51.500 - 51.530- (2.028 - 2.029)
4.	51.250 - 51.280 (2.018 - 2.019)	51.250 - 51.280 (2.018 - 2.019)
Journal Oil Clearance *Standard*	0.06 - 0.12 (0.002 - 0.005)	0.06 - 0.12 (0.002 - 0.005)
Limit	0.145 (0.006)	0.145 (0.006)
Cam Lobe Height (Intake) *Standard*	42.580 (1.676)	42.580 (1.676)
Limit	42.478 (1.672)	42.478 (1.672)
Cam Lobe Height (Exhaust) *Standard*	42.580 (1.676)	42.580 (1.676)
Limit	42.478 (1.672)	42.478 (1.672)
TIMING GEAR	**mm (in)**	**mm (in)**
Backlash Between Gear *Standard*	0.10 - 0.17 (0.004 - 0.007)	0.10 - 0.17 (0.004 - 0.007)
Limit	0.3 (0.012)	0.3 (0.012)
Idle Gear End Play	0.15 - 0.30 (0.0059 - 0.0118)	0.20 - 0.030 (0.0079 - 0.0188)
Idle gear Bushing Inside Diameter	44.009 - 44.034 (1.733 - 1.734)	44.009 - 44.034 (1.733 - 1.734)
Idle gear Spindle Diameter	43.975 (1.730 - 1.731)	43.975 (1.730 - 1.731)
Clearance Between Bushing and Spindle		
Standard	0.034 - 0.084 (0.001 - 0.003)	0.034 - 0.084 (0.001 - 0.003)
Limit	0.15 (0.006)	0.15 (0.006)

TORQUE SPECIFICATIONS

20 KW 60Hz Generator/16KW 50 Hz Generator

	71B-FOUR	71C-FOUR
COMPONENT	**m-Kg (ft-lb)**	**m-Kg (ft-lb)**
Alternator Bracket	3.8 - 5.3 (27 - 38)	3.8 - 5.3 (27 - 38)
Back Plate	3.3 - 4.8 (24 - 35)	3.3 - 4.8 (24 - 35)
Camshaft Gear	6.4 - 9.5 (46 - 69)	6.2 - 7.0 (45 - 51)
Camshaft Thrust Plate	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)
Connecting Rod Cap	8.2 - 9.0 (59 - 65)	6.9 - 7.5 (50 - 54)
Coolant Pump	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)
Coolant Pump Pulley	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)
Coolant Temperature Sender	1.2 - 1.8 (9 - 13)	1.2 - 1.8 (9 - 13)
Coolant Temperature Switch	1.2 - 1.8 (9 - 13)	1.2 - 1.8 (9 - 13)
Crankshaft Pulley Nut	35 - 40 (253 - 289)	35 - 40 (253 - 289)
Cylinder Head Bolts	11.8 - 12.5 (85 - 90)	11.0 - 11.7 (80 - 85)
Cylinder Head Cover	0.3 - 0.45 (2 - 3)	0.3 - 0.45 (2 - 3)
Damper Plate	1.9 - 2.7 (14 - 20)	1.9 - 2.7 (14 - 20)
Engine Mounts	3.2 - 4.7 (23 - 34)	3.2 - 4.7 (23 - 34)
Exhaust Manifold	2.7 - 3.3 (20 - 24)	2.7 - 3.3 (20 - 24)
Flywheel bolts	15.5 - 16.3 (112 - 118)	15.5 - 16.3 (112 - 118)
Friction Gear	6.4 - 9.5 (46 - 69)	6.4 - 9.5 (46 - 69)
Glow Plug	1.0 - 1.5 (7 - 11)	1.0 - 1.5 (7 - 11)
Idler Gear Thrust Plate	2.2 - 3.2 (17 - 23)	2.3 - 3.2 (16.6 - 23.1)
Injection Nozzle to Body	6.0 - 8.0 (43 - 58)	8 - 10 (58 - 72)
Injection pipe Flare Nut	2.5 - 3.0 (18 - 22)	2.5 - 3.0 (18 - 22)
Injection Pump Drive Gear Lock Nut	4.0 - 7.0 (29 - 51)	4.0 - 7.0 (29 - 51)
Injector Hold Down Nuts	1.6 - 2.4 (11.6 - 17.4)	–
**Injectors	–	6.0 - 7.0 (43 - 51)
Intake Manifold	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)
Main Bearing Cap	11.0 - 11.7 (80 - 85)	11.0 - 11.7 (80 - 85)
Oil Pan Bolts	1.6 - 2.3 (12 - 17)	1.6 - 2.3 (12 - 17)
Oil Pan Upper block	–	1.6 - 2.3 (12 - 17)
Oil Pressure Sender	1.2 - 1.8 (9 - 13)	1.2 - 1.8 (9 - 13)
Oil Pressure Switch	1.2 - 1.8 (9 - 13)	1.2 - 1.8 (9 - 13)
Oil Pump Cover	0.8 - 1.2 (5.8 - 8.7)	0.8 - 1.2 (5.8 - 8.7)
Oil Pump Pipe	0.8 - 1.2 (5.8 - 8.7)	0.8 - 1.2 (5.8 - 8.7)
Rear Oil Seal Cap	1.5 - 2.0 (11 - 14)	1.5 - 2.0 (11 - 14)
Rocker Arm Assembly	11.0 - 11.7 (80 - 85)	11.0 - 11.7 (80 - 85)
Rocker Arm Cover	0.25 - 0.40 (1.8 - 2.9)	0.25 - 0.40 (1.8 - 2.9
Thermostat Housing	0.8 - 1.1 (6 - 8)	0.8 - 1.1 (6 - 8)
Thrust Plate	1.9 - 2.6 (14 - 19)	1.9 - 2.6 (14 - 19)
Timing Gear Case	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)
Timing Gear Cover	1.6 - 2.4 (12 - 17)	1.6 - 2.4 (12 - 17)

** *The* 71B-FOUR *engine uses injectors that are bolted to the head with a torque value of 1.6 - 2.4 m-Kg (11.6 - 17.4 ft-lb) per bolt, tightened evenly.*

** *The* 71C-FOUR *engine injectors are screwed directly into the head with a torque value of 6.0 - 7.0 m-Kg (43 - 51 ft-lb).*

71B/71C ENGINE SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism (71 Hp at 3600 rpm maximum).
Aspiration	Naturally aspirated
Governor	Electronic Governing
Combustion Chamber	Swirl type
Bore & Stroke	3.50 x 4.0 inches (88.9 x 101.6 mm)
Piston Displacement	154 cubic inches (2.5 liters)
Firing Order	1 - 3 - 4 - 2
Direction of Rotation	Clockwise, when viewed from the front
Maximum Torque (at 1800 rpm)	118 lb-ft (16.31 kg-m)
Compression Ratio	21:1
Dimensions	Height: 26.9 inches (684.2 mm) Width: 22.2 inches (563.6 mm) Length: 39.5 inches (1003.3 mm)
Weight	652 lbs (295.9 kgs)
Fuel Consumption (approximate)	1.4 US gph (5.2 lph) at 2500 rpm with the prop allowing 3600 rpm full throttle in forward gear
Inclination	Continuous 14° Temporary 25° (not to exceed 30 min.)
Generator Power Take Off	30 Horsepower (maximum)

TUNE-UP SPECIFICATIONS

Compression Pressure (Limit of Difference Between Cylinders)	427 psi (30 kg/cm²) at 200 rpm limit (47.2 psi (3.0 kg/cm²))
Valve Timing	Intake Opens 17° BTDC Intake Closes 47° ABDC Exhaust Opens 51° BBDC Exhaust Closes 13° ATDC
Valve Seat Angle	Intake 45° Exhaust 30°
Engine Speed	1800 rpm 60 Hertz 1500 rpm 50 Hertz
Valve Clearance (engine cold)	Intake 0.012 inches (0.3 mm) Exhaust 0.012 inches (0.3 mm)
Engine Speed	Idle speed: 750 - 1000 rpm Cruising speed: 2500 - 3000 rpm
Injector Pressure	1920 + 71 - 0 psi (135 + 5 - 0 kg/cm²)
Engine Timing	Static timed - drop valve method 0.205 ± .005 in BTDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt, (-) negative ground
Battery Capacity	400 - 600 Cold Cranking Amps (CCA)
DC Charging Alternator	51 Amp rated, belt driven
Starter	12-Volt, reduction gear, 3 KW
Starting Aid	Glow plugs, sheathed type
DC No-Load Current	± 2% of rated Amps
DC Cranking Current	250 - 300 Amps (engine cold)

FUEL SYSTEM

General	Open flow, self bleeding - 1 bleed point
Fuel	No. 2 diesel oil (cetane rating of 45 or higher)
Fuel Injection Pump	Bosch Model VE Distributor
Fuel Injection Timing (spill timing)	0° TDC (Top Dead Center)
Nozzle	Throttle type
Fuel Filter	Spin-on type, full flow
Air cleaner	Metal screen type
Air Flow (engine combustion)	160.4 cfm (4.5 cmm) at 3600 rpm

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
Raw Water Flow, at 3600 rpm	10 US gpm (37.8 lpm) (measured before discharging into exhaust elbow).
System Capacity (fresh water)	11.5 qts (10.88 liters)

TRANSMISSION

Standard	Hurth - case hardened helical gears, with servo-operated multiple disc clutch
Gear Ratio	2.7 : 1
Prop Shaft Rotation	Right hand
Prop Recommendations for this Gear	20D x 14P - 2 blade or 20D x 12P - 3 blade propeller should allow the engine to reach it's full rated rpm (3600 + 000 - 100) at full open throttle in forward gear.
Lubrication Fluid	ATF type A Dextron II or III
Sump Capacity	0.79 US quarts (o.75 liters)

LUBRICATION SYSTEM

General	Pressure fed system
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (not including filter)	6.5 U.S. qts (6.15 liters) plus filter/cooler assembly
Operating Oil Pressure (engine hot)	50 - 60 psi (3.5 - 4.2 kg/cm²)
Oil Grade	API Specification CF or CG-4, SAE 30, 10W-30, 15W-40

STANDARD HARDWARE TORQUES

NOTE: *Unless stated otherwise for a specific assembly, use the following torque values when tightening standard hardware.*

Grade 4	Pitch	lb-ft	kg-m
6mm bolt head/nut	1	2.9-5.1	0.4-0.7
8mm bolt head/nut	1.25	7.2-11.6	1.0-1.6
10mm bolt head/nut	1.25	13.7-22.4	1.9-3.1
10mm bolt head/nut	1.5	13.0-21.7	1.8-3.0
12mm bolt head/nut	1.25 (ISO)	25.3-39.8	3.5-5.5
12mm bolt head/nut	1.5	25.3-39.8	3.5-5.5
12mm bolt head/nut	1.75	21.7-36.2	3.0-5.0
13mm bolt head/nut	1.5	32.5-50.6	4.5-7.0
14mm bolt head/nut	1.5	36.2-57.9	5.0-8.0
14mm bolt head/nut	2	34.0-55.7	4.7-7.7
16mm bolt head/nut	1.5	54.2-79.6	7.5-11.0
16mm bolt head/nut	2	51.4-76.7	7.1-10.6
Grade 6T			
6mm bolt head/nut	1	4.3-6.5	0.6-0.9
8mm bolt head/nut	1.25	10.8-15.9	1.5-2.2
10mm bolt head/nut	1.25	21.7-32.5	3.0-4.5
10mm bolt head/nut	1.5	19.5-30.4	2.7-4.2
12mm bolt head/nut	1.25 (ISO)	36.2-57.9	5.0-8.0
12mm bolt head/nut	1.5	36.2-50.6	5.0-7.0
12mm bolt head/nut	1.75	34.7-49.2	4.8-6.8

Grade 7T, 8T and 8.8	Pitch	lb-ft	kg-m
6mm bolt head/nut	1	5.8-8.7	0.8-1.2
8mm bolt head/nut	1.25	14.5-21.7	2.0-3.0
10mm bolt head/nut	1.25	28.9-39.8	4.0-5.5
10mm bolt head/nut	1.5	26.8-37.6	3.7-5.2
12mm bolt head/nut	1.25 (ISO)	54.2-75.9	7.5-10.5
12mm bolt head/nut	1.5	50.6-65.1	7.0-9.0
12mm bolt head/nut	1.75	43.4-61.5	6.0-8.5
13mm bolt head/nut	1.5	57.9-86.8	8.0-12.0
14mm bolt head/nut	1.5	72.3-108.5	10.0-15.0
14mm bolt head/nut	2	68.7-101.3	9.5-14.0
16mm bolt head/nut	1.5	108.5-166.4	15.0-23.0
16mm bolt head/nut	2	101.3-159.1	14.0-22.0
Grade 5 Cap Screw			
1/4 UNC		9-11	1.2-1.5
1/4 UNF		11-13	1.5-1.8
5/16 UNC		18-20	2.5-2.8
5/16 UNF		21-23	2.9-3.2
3/8 UNC		28-33	3.7-4.6
3/8 UNF		30-35	4.1-4.8
7/16 UNC		44-49	6.1-6.8
7/16 UNF		50-55	6.9-7.6
1/2 UNC		68-73	9.4-10.1
1/2 UNF		73-80	10.1-11.1

GENERAL SCREWS

BOLT DIA.	BOLT HEAD MARK		
	4	7	10
M6	0.3 – 0.5	0.8 – 1.0	1.0 – 1.3
M8	1.0 – 1.3	1.5 – 2.2	2.5 – 3.5
M10	1.8 – 2.5	3.0 – 4.2	5.0 – 7.0
M12	3.0 – 4.2	5.5 – 7.5	9.5 – 12.0
M14	5.0 – 7.0	8.0 – 11.0	16.0 – 19.0

SEALANTS

PARTS REQUIRING SEALANT	SURFACES REQUIRING SEALANT (where to mount sealant coated parts)	SEALANT
Taper screw 1/2 ″	Thread portion (Gear case)	Liquid Teflon
Taper screw 1/4 ″	Thread portion (Cylinder block right side, pump cover)	Liquid Teflon
Taper screw 1/8 ″	Thread portion (Cylinder head rear surface)	Liquid Teflon
Water drain plug	Thread portion (Cylinder block right side, rear middle portion)	Liquid Teflon
Oil pressure switch	Thread portion (Cylinder block right side surface)	Liquid Teflon
Side seal	Periphery (Main bearing caps No. 1 and No. 5)	Permatex #6B
Bearing cap No. 1	Contact surface with cylinder block	Permatex #6B

METRIC CONVERSIONS

INCHES TO MILLIMETERS / MILLIMETERS TO INCHES

Inches	mm	Inches	mm	mm	Inches	mm	Inches
1	25.40	15	381.00	1	0.0394	15	0.5906
2	50.80	20	508.00	2	0.0787	20	0.7874
3	76.20	25	635.00	3	0.1181	25	0.9843
4	101.60	30	762.00	4	0.1575	30	1.1811
5	127.00	35	889.00	5	0.1969	35	1.3780
10	254.00	40	1016.00	10	0.3937	40	1.5748

10 MILLIMETERS = 1 CENTIMETER, 100 CENTIMETERS = 1 METER = 39.37 INCHES (3.3 FEET)

INCHES TO METERS / METERS TO INCHES

Inches	Meters	Inches	Meters	Meters	Inches	Meters	Inches
1	0.0254	7	0.1778	0.1	3.937	0.7	27.559
2	0.0508	8	0.2032	0.2	7.874	0.8	31.496
3	0.0762	9	0.2286	0.3	11.811	0.9	35.433
4	0.1016	10	0.2540	0.4	15.748	1.0	39.370
5	0.1270	11	0.2794	0.5	19.685	1.1	43.307
6	0.1524	12	0.3048	0.6	23.622	1.2	47.244

TO CONVERT METERS TO CENTIMETERS, MOVE DECIMAL POINT TWO PLACES TO THE RIGHT

YARDS TO METERS / METERS TO YARDS

Yards	Meters	Yards	Meters	Meters	Yards	Meters	Yards
1	0.91440	6	5.48640	1	1.09361	6	6.56168
2	1.82880	7	6.40080	2	2.18723	7	7.65529
3	2.74320	8	7.31520	3	3.28084	8	8.74891
4	3.65760	9	8.22960	4	4.37445	9	9.84252
5	4.57200	10	9.14400	5	5.46807	10	10.93614

MOVE DECIMAL POINT FOR HIGHER VALUES — e.g. 6,000 METERS = 6,561.68 YARDS

POUNDS TO KILOGRAMS / KILOGRAMS TO POUNDS

lb	kg	lb	kg	kg	lb	kg	lb
1	0.454	6	2.722	1	2.205	6	13.228
2	0.907	7	3.175	2	4.409	7	15.432
3	1.361	8	3.629	3	6.614	8	17.637
4	1.814	9	4.082	4	8.818	9	19.842
5	2.268	10	4.536	5	11.023	10	22.046

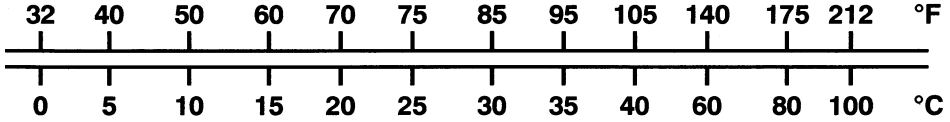
GALLONS TO LITERS / LITERS TO GALLONS

Gallons	Liters	Gallons	Liters	Liters	Gallons	Liters	Gallons
1	3.79	10	37.86	1	0.26	60	15.66
2	7.57	20	75.71	2	0.53	90	23.77
3	11.36	30	113.57	5	1.32	120	31.32
4	15.14	40	151.42	10	2.64	150	39.62
5	18.93	50	189.28	20	5.28	180	47.54

PINTS TO LITERS / LITERS TO PINTS

Pints	Liters	Pints	Liters	Liters	Pints	Liters	Pints
1	0.47	6	2.84	1	2.11	6	12.68
2	0.95	7	3.31	2	4.23	7	14.79
3	1.42	8	3.79	3	6.34	8	16.91
4	1.89	9	4.26	4	8.45	9	19.02
5	2.37	10	4.73	5	10.57	10	21.13

TEMPERATURE



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WESTERBEKE CORPORATION • AVON INDUSTRIAL PARK
AVON, MA 02322 • TEL: (508) 588-7700 • FAX: (508) 559-9323