SERVICE MANUAL

44A FOUR and 35C THREE MARINE DIESEL ENGINES

8.0KW-60Hz **6.0KW-50Hz BTDA**

10.0KW-60Hz **7.5KW-50Hz BTDA**

12.5KW-60Hz **9.4KW-50Hz BTDB**

15.0KW-60Hz **12.0KW-50Hz BTDC**

Single and Three Phase MARINE DIESEL GENERATORS

PUBLICATION NO.45100
FIRST EDITION
March 2001

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

Engine parts from Torrsen Marine - www.torresen.com - 231-759-8596

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	Muscular twitching
Dizziness	Intense headache
Throbbing in temples	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; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive 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 engine.

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

Order from:

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

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

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

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

Order from:

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

INSTALLATION

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

CODES AND REGULATIONS

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

SIPHON-BREAK

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

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

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

EXHAUST SYSTEM

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

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

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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.

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

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

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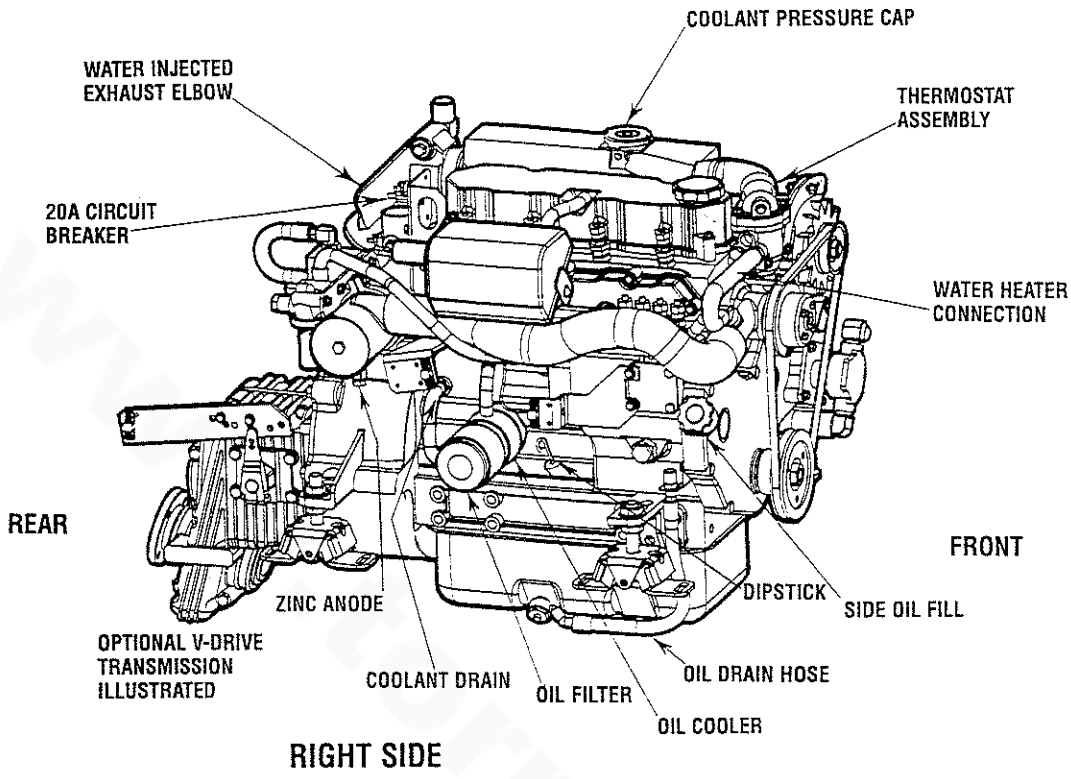

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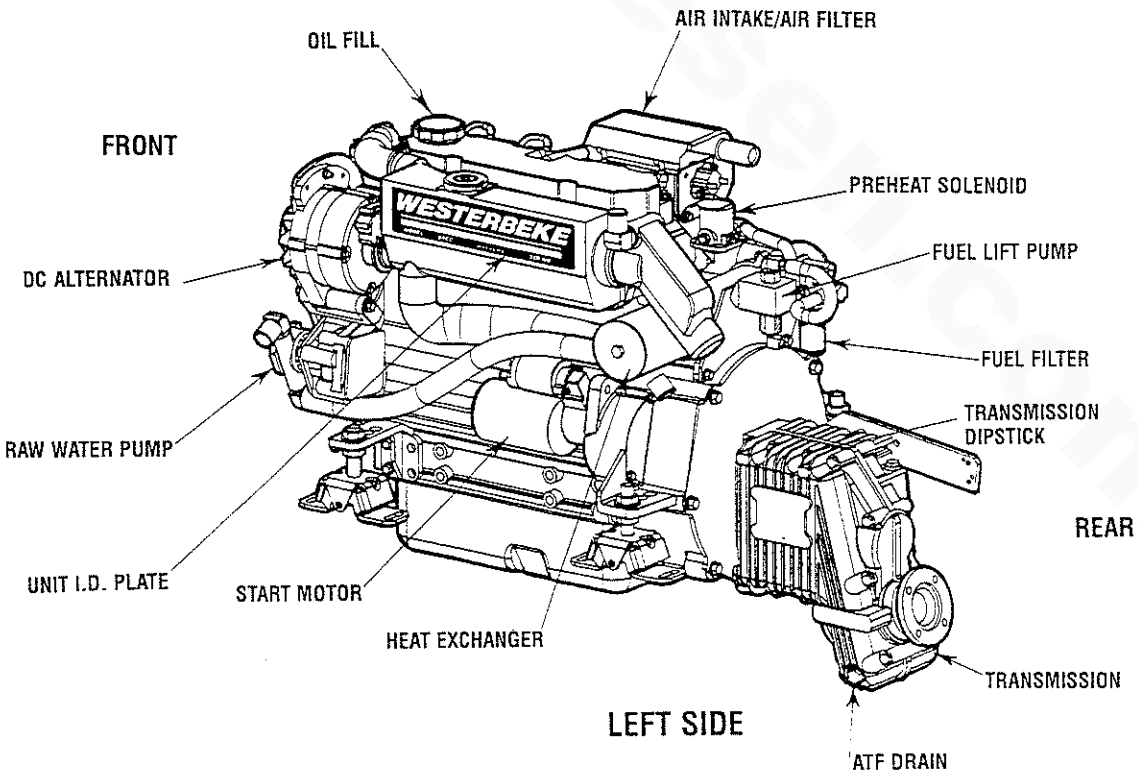

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WESTERBEKE Engines & Generators

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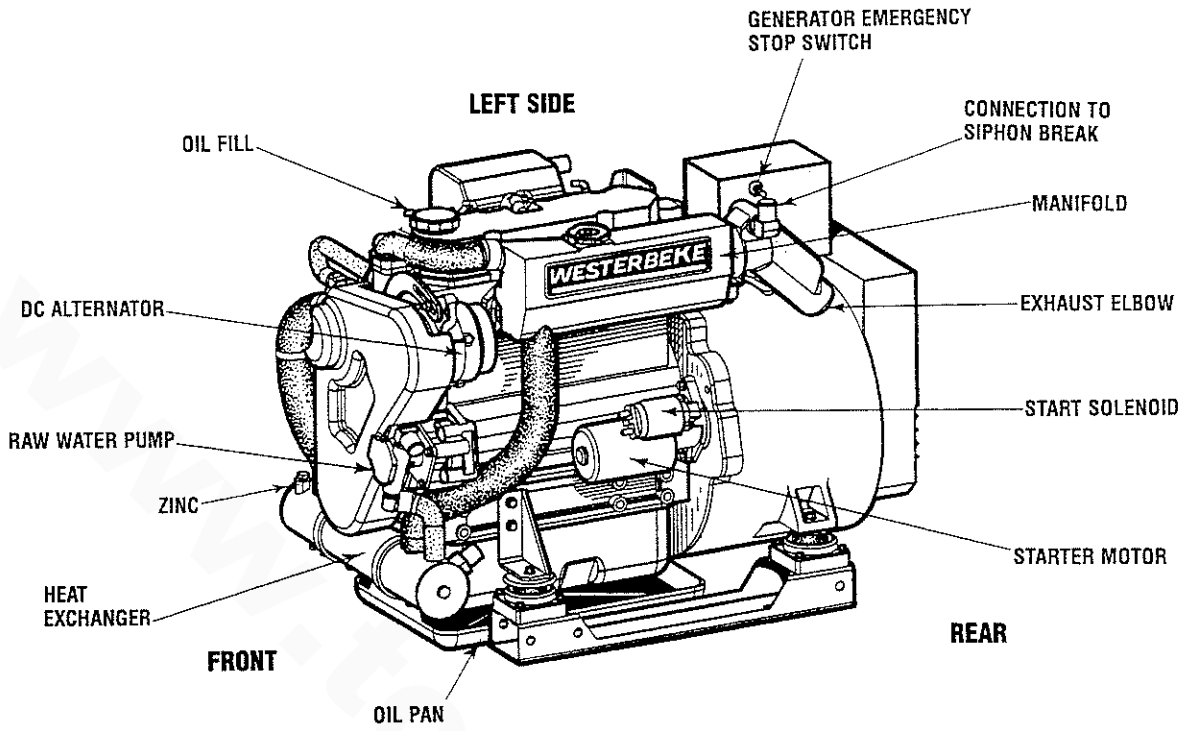
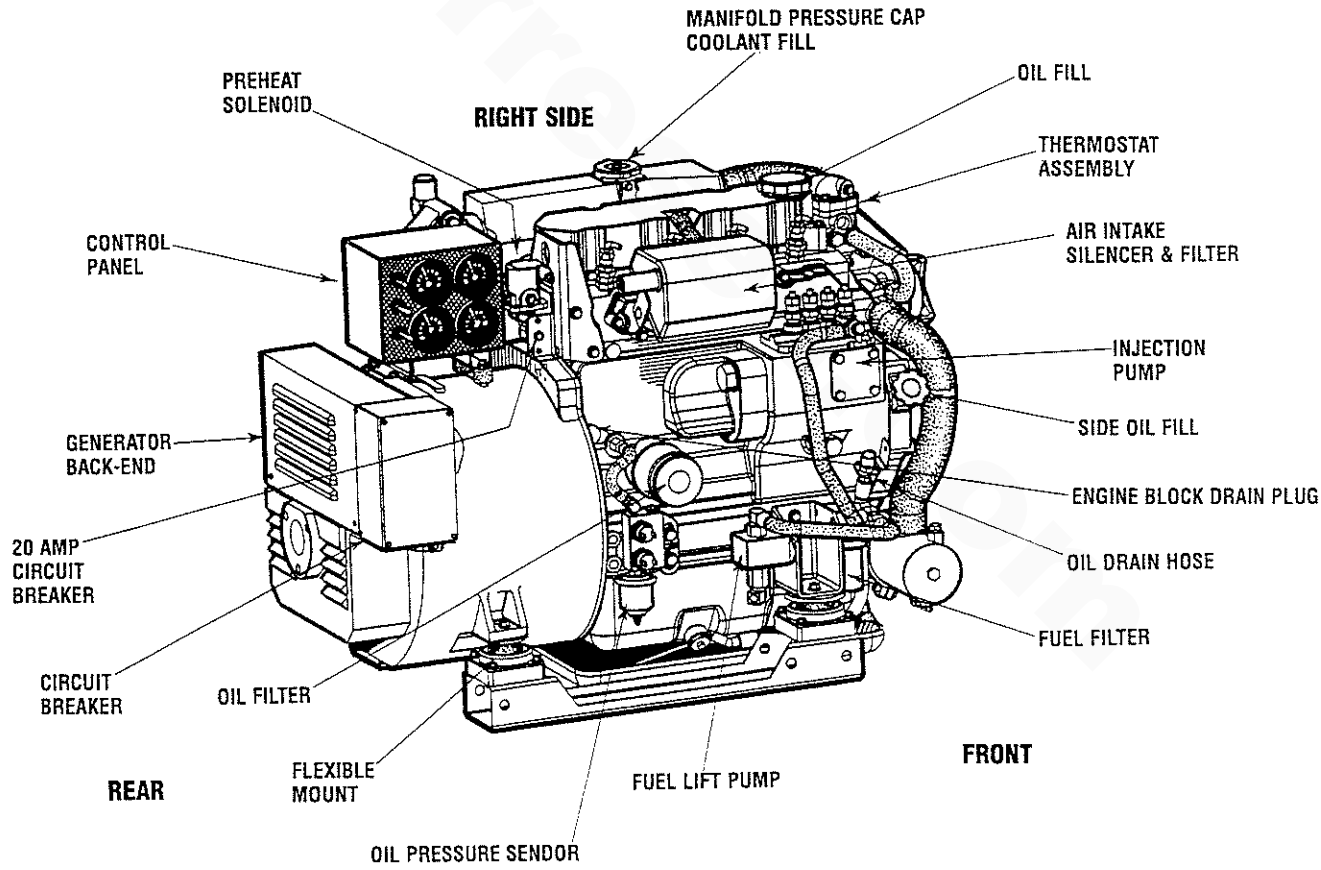




WESTERBEKE
Engines & Generators

INTRODUCTION

PRODUCT SOFTWARE

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

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

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

NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the operating procedures, maintenance schedules, and troubleshooting of your marine engine, 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.***

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

Customer Identification Card

WESTERBEKE Engines & Generators

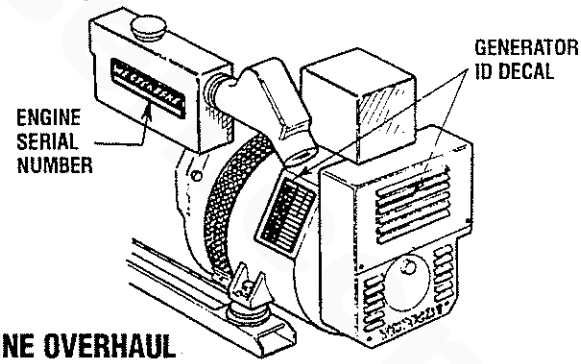
Customer Identification
MR. GENERATOR OWNER
MAIN STREET
HOMETOWN, USA
Model 44A Ser. #U0000-E102
Expires 2/5/2001

The WESTERBEKE serial number is an alphanumeric number that can assist in determining the date of manufacture of your WESTERBEKE engine or generator. The manufacturer's date code is placed at the end of the engine serial number and consists of a character followed by three numbers. The character indicates the decade (A=1960s, B=1970s, C=1980s, D=1990s E=2000s), the first number represents the year in the decade, and the second and third numbers represent the month of manufacture.

SERIAL NUMBER LOCATION

The engine's serial number can be found stamped into the engine block just out board of the injection pump. An identification plate on the engine manifold also displays the engine model and serial number.

The generator serial number is stamped on the left side of the generator housing and on the flat surface above the rotary carrier bearings.



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 taken 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.

ENGINE TROUBLESHOOTING

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

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

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
HARD STARTING	**LOW CRANKING SPEED** 1. Engine oil viscosity too high. 2. Run-down battery. 3. Worn battery. 4. Battery terminals loosely connected. 5. Defective starter. 6. Defective main drive section.	1. Replace engine oil with less viscous oil. 2. Recharge battery. 3. Replace battery. 4. Clean terminals and correct cables. 5. Repair or replace starter. 6. Check clutch for disengagement.
	DEFECTIVE INJECTION SYSTEM 1. Air trapped in fuel passage. 2. Clogged fuel filter. 3. Low injection pressure. 4. Inadequate spray. 5. Injection pump delivering insufficient fuel. 6. Injection too early.	1. Bleed air from fuel system. 2. Clean or replace filter. 3. Adjust injection pressure. 4. Clean or replace nozzle. 5. Repair or replace injection pump. 6. Adjust injection timing.
	MAIN ENGINE TROUBLES 1. Low compression. a. Incorrect valve clearance. b. Inadequate contact of valve seat. c. Valve stem seized. d. Broken valve spring. e. Compression leaks through cylinder head gasket. f. Piston ring seized. g. Worn piston ring and cylinder. 2. Burnt glow plug. 3. Faulty glow plug operation. 4. Incorrect governor lever position. 5. Governor spring out of POSITION	a. Adjust valve clearance. b. Lap valve. c. Replace valve and valve guide. d. Replace valve spring. e. Replace gasket. f. Replace piston and piston ring. g. Overhaul engine. 2. Replace glow plug. 3. Correct lead wire connection. 4. Set lever to starting position. 5. Correct spring
LOW OUTPUT	**LOW COMPRESSION**	See ***HARD STARTING***
	INJECTION SYSTEM OUT OF ADJUSTMENT 1. Incorrect injection timing. 2. Insufficient injection. 3. Low injection pressure.	1. Adjust injection timing. 2. Repair or replace injection pump. 3. Check injection nozzle and adjust pressure.
	INSUFFICIENT FUEL 1. Air trapped in fuel system. 2. Clogged filter. 3. Contaminated fuel tank.	1. Check and retighten connector. 2. Clean or replace filter. 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. Worn piston ring..	1. Replace ring.
	2. Worn piston or cylinder.	2. Replace piston and rebore cylinder.
	3. Incorrectly positioned piston ring gaps.	3. Correct ring gap positions.
	4. Displaced or twisted connecting rod.	4. Replace connecting rod.
	OIL LEVEL FALLING	
	1. Defective stem seal.	1. Replace stem seal.
	2. Worn valve and valve guide.	4. Replace a valve and valve guide.
EXCESSIVE FUEL CONSUMPTION	**ENGINE BODY TROUBLES**	
	1. Noisy knocking.	1. See *KNOCKING.*
	2. Smoky exhaust.	2. See *SMOKY EXHAUST.*
	3. Moving parts nearly seized or excessively worn.	3. Repair or replace.
	4. Poor compression.	4. See *LOW COMPRESSION; HARD STARTING.*
	5. Improper valve timing.	5. Adjust.
	6. Improper valve clearance.	6. Adjust.
	INSUFFICIENT INTAKE AIR	
	1. Air intake obstructed.	1. Remove obstruction.
	NOZZLE TROUBLES	
	1. Seized nozzle.	1. Replace.
	2. Worn nozzle.	2. Replace.
	IMPROPER FUEL	Replace with proper fuel.
	FUEL LEAKS	Find fuel leaks.
SMOKY EXHAUST	**WHITISH OR PURPLISH**	
	1. Excessive engine oil.	1. Correct oil level.
	2. Excessive rise of oil into combustion chamber.	
	a. Poor piston contact.	a. Check.
	b. Seized piston ring.	b. Replace or clean.
	c. Excessive piston-to-cylinder clearance.	c. Replace or correct.

(continued)

ENGINE TROUBLESHOOTING

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

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
KNOCKING	**ENGINE KNOCKS WITHOUT MUCH SMOKE**	
	1. Main engine troubles.	
	a. Overheated cylinder.	a. See *OVERHEATING; LOW OUTPUT.*
	b. Carbon deposits in cylinder.	b. Clean.
	2. Too early injection timing.	2. Correct.
	3. Too high injection pressure.	3. Correct.
	4. Improper fuel.	4. Replace with proper fuel.
	KNOCKING WITH DARK SMOKE	
	1. Poor compression.	1. See *LOW COMPRESSION; HARD STARTING.*
	2. Injection pump malfunctioning.	2. Adjust/Repair
	3. Improper nozzle.	
	a. Poor spray.	a. Clean or replace nozzle.
	b. Poor chattering.	b. Repair or replace nozzle.
	c. After-injection drip.	c. Repair or replace nozzle.
	d. Nozzle needle valve seized.	d. Replace.
INTERMITTENT EXHAUST SOUND	1. Fuel filter clogged.	1. Clean or replace.
	2. 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.

TESTING FOR OVERHAUL

HOW TO DETERMINE ENGINE OVERHAUL PERIOD

Cause of Low Compression

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

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

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

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

ASSEMBLY

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

OVERHAUL CONDITIONS

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

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

The engine requires overhaul when oil consumption is high, blowby evident, and compression values are at minimum or below. *Engine compression should be 30 kg/cm², 427 psi at 290 rpm. The maximum difference between cylinders must not exceed 10%.*

DISASSEMBLY

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

ALTERNATOR INSPECTION

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

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

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

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

ENGINE DISASSEMBLY

GENERATOR

Disconnect the AC wiring and unplug the engine's DC wiring harness at the generator control panel. Remove the battery cables from the engine and tape over the terminals.

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

Separate the exhaust hose at the water injected elbow and disconnect the fuel supply and return lines.

Drain the engine oil and the coolant from the engine.

Carefully support and then unbolt the generator backend from the engine. See *SPECIAL TOOLS* in this manual.

Additional generator information will be found in the *GENERATOR* section of this manual.

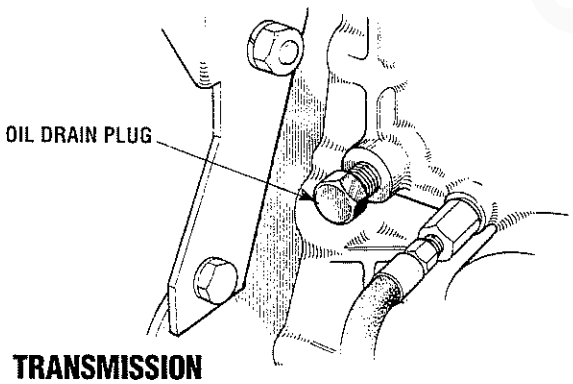
PROPULSION ENGINE

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

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

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

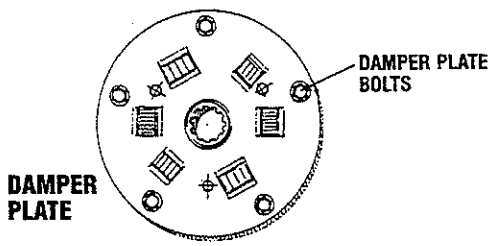
NOTE: *Label any lines, hoses or cables as you separate them.*



TRANSMISSION

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

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



ENGINE DISASSEMBLY

Take the following precautions:

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

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

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

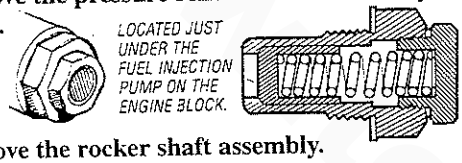
NOTE: *Put plugs or caps on the openings of the injection pump and nozzle connectors. Golf tees work well as plugs.*

14. **Remove the fuel injection nozzle..** Loosen the fuel injection nozzles with a wrench. Remove the nozzles and gaskets from the cylinder head.

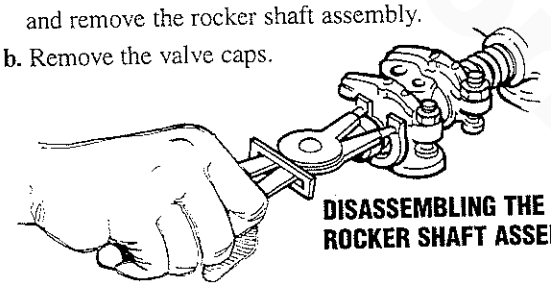
NOTE: *Remove the gaskets from the cylinder head with a gasket scraper. Discard the gaskets.*

ENGINE DISASSEMBLY

15. **Remove governor assembly.**
    a. Remove the tie rod cover.
    b. Remove the spring from the tie rod with pliers to disconnect the tie rod from the fuel injection pump.
    c. Remove the governor assembly.
16. **Remove governor weight.**
    a. Remove the sliding sleeve.
    b. Remove the sliding sleeve shaft and governor weights.
17. **Fuel injection pump removal.**
    a. Remove the tie rod cover.
    b. Remove the spring from the tie rod with pliers to disconnect the tie rod from the fuel injection pump.
18. **Remove the fuel injection pump.**
    NOTE: *Keep a record of the thickness of the shims for installation.*
19. **Remove the pressure relief valve from the cylinder block.**

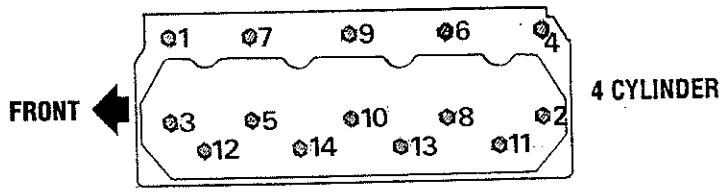


20. **Remove the rocker shaft assembly.**
    a. Remove the bolts that hold the rocker stays in position and remove the rocker shaft assembly.
    b. Remove the valve caps.

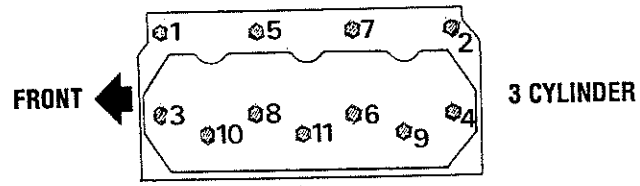


DISASSEMBLING THE ROCKER SHAFT ASSEMBLY

21. **Disassemble the rocker shaft assembly.** Put identification on each rocker arm as to its location on the rocker shaft.
22. **Remove the cylinder head bolt.** Loosen the cylinder head bolts in two or three steps in the sequence shown.
    NOTE: *If any parts on the cylinder head are faulty, check the cylinder head bolts for tightness with a torque wrench before loosening them.*



4 CYLINDER

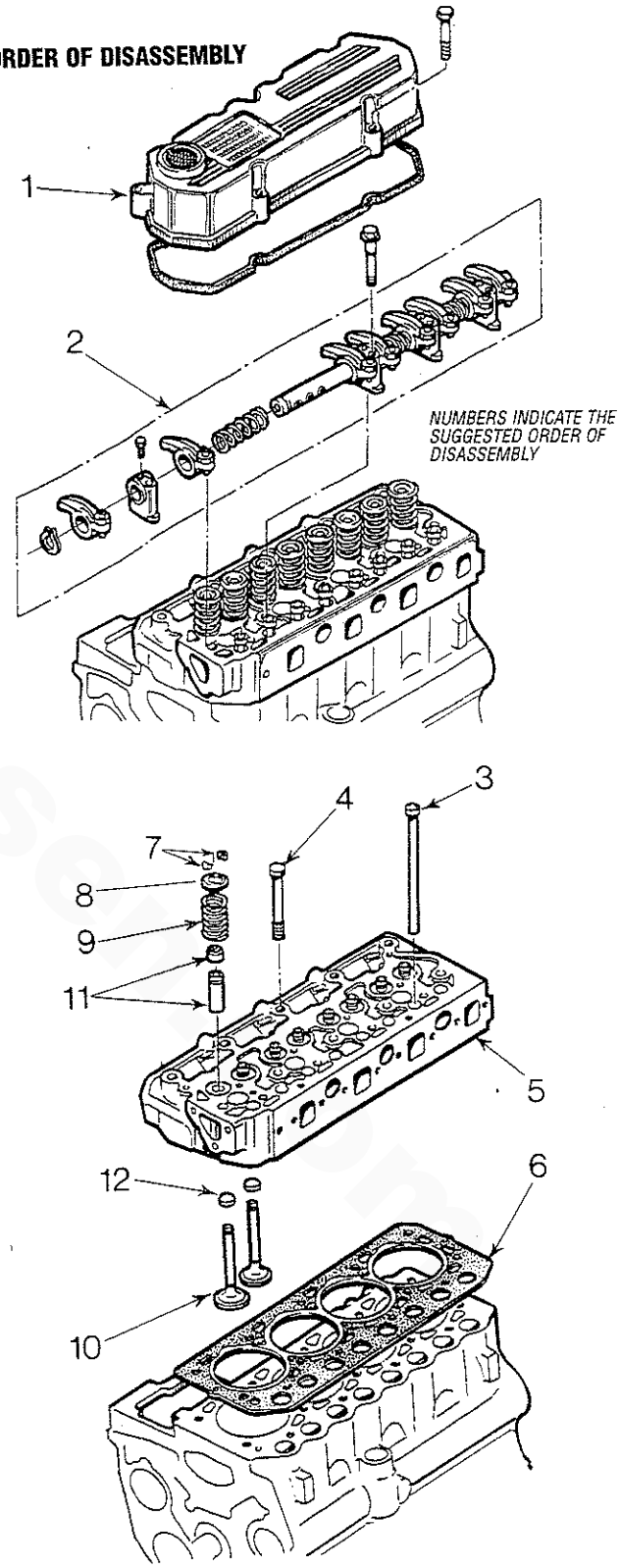


3 CYLINDER

CYLINDER HEAD BOLT LOOSENING SEQUENCE

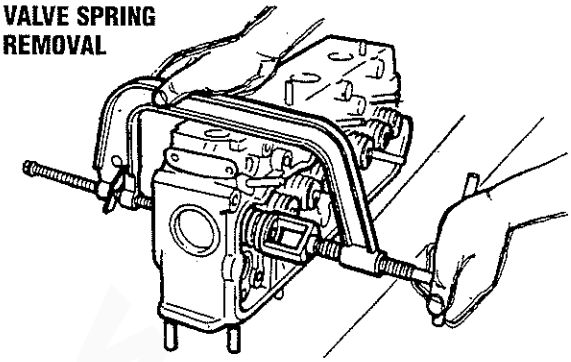
23. **Remove the cylinder head assembly.** Lift the cylinder head straight up with a hoist.
    NOTE: *If the gasket is seized and the cylinder head cannot be separated from the cylinder block, tap around the thick side portion of the cylinder head with a plastic hammer.*

ORDER OF DISASSEMBLY



ENGINE DISASSEMBLY

VALVE SPRING REMOVAL



24. **Remove the valve and valve spring.**
    a. Compress the valve spring with a valve lifter and remove the valve lock.
    b. Remove the retainer, spring and valve.

    NOTE: *The valves, retainers, springs and valve locks must be set aside separately in groups, each tagged for cylinder number, for correct installation.*

25. **Remove the valve stem seals with pliers.**

    NOTE: *Do not reuse the valve stem seals.*

26. **Remove the flywheel.**
    a. Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.
    b. Remove one of the bolts that hold the flywheel in position.
    c. Install a safety bar (M12 x 1.25) into the threaded hole in the flywheel from which the bolt was removed. Remove the remaining bolts.
    d. Hold the flywheel by hand and withdraw it from the crankshaft. Joggling the flywheel back and forth with facilitate removal.

27. **Remove the rear plate.** The rear plate is doweled in position. Pull the plate as straight as possible when removing it.

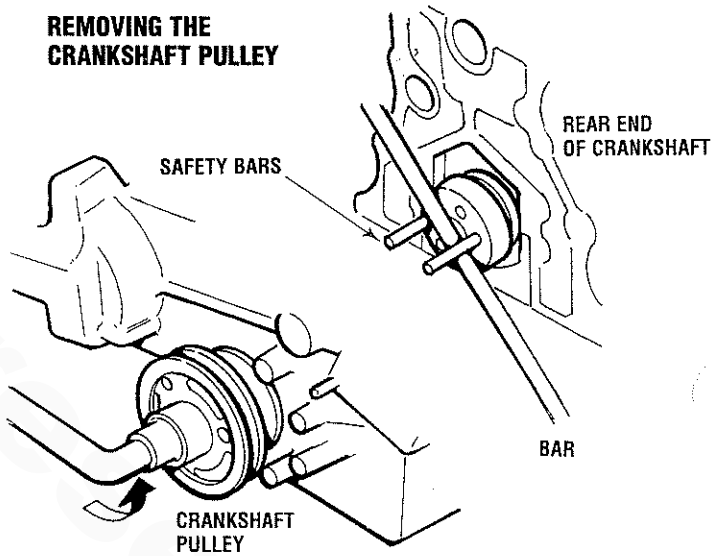
28. **Remove the oil seal case.** Remove the bolts that hold the oil seal case in position. Remove the case from the cylinder block with a screwdriver.

> ⚠ **CAUTION:** ***Do not cause damage to the oil seal.***

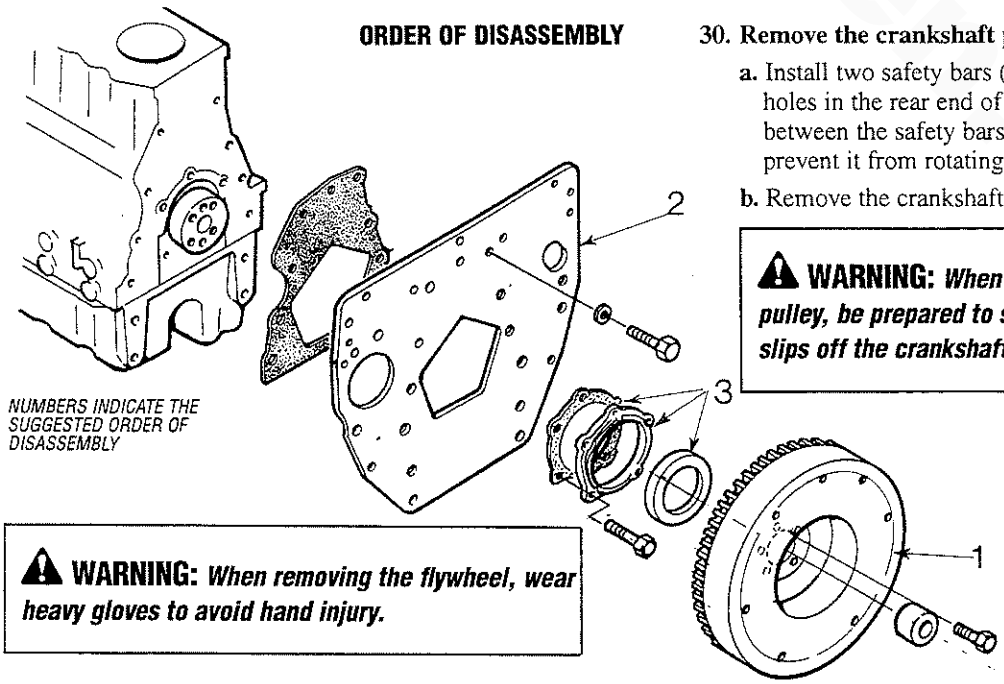
29. **Remove the tappet.** Remove the tappets from the cylinder block with a valve push rod.

    NOTE: *The tappets will fall into the oil pan if the camshaft is removed before the tappets are removed.*

REMOVING THE CRANKSHAFT PULLEY



ORDER OF DISASSEMBLY



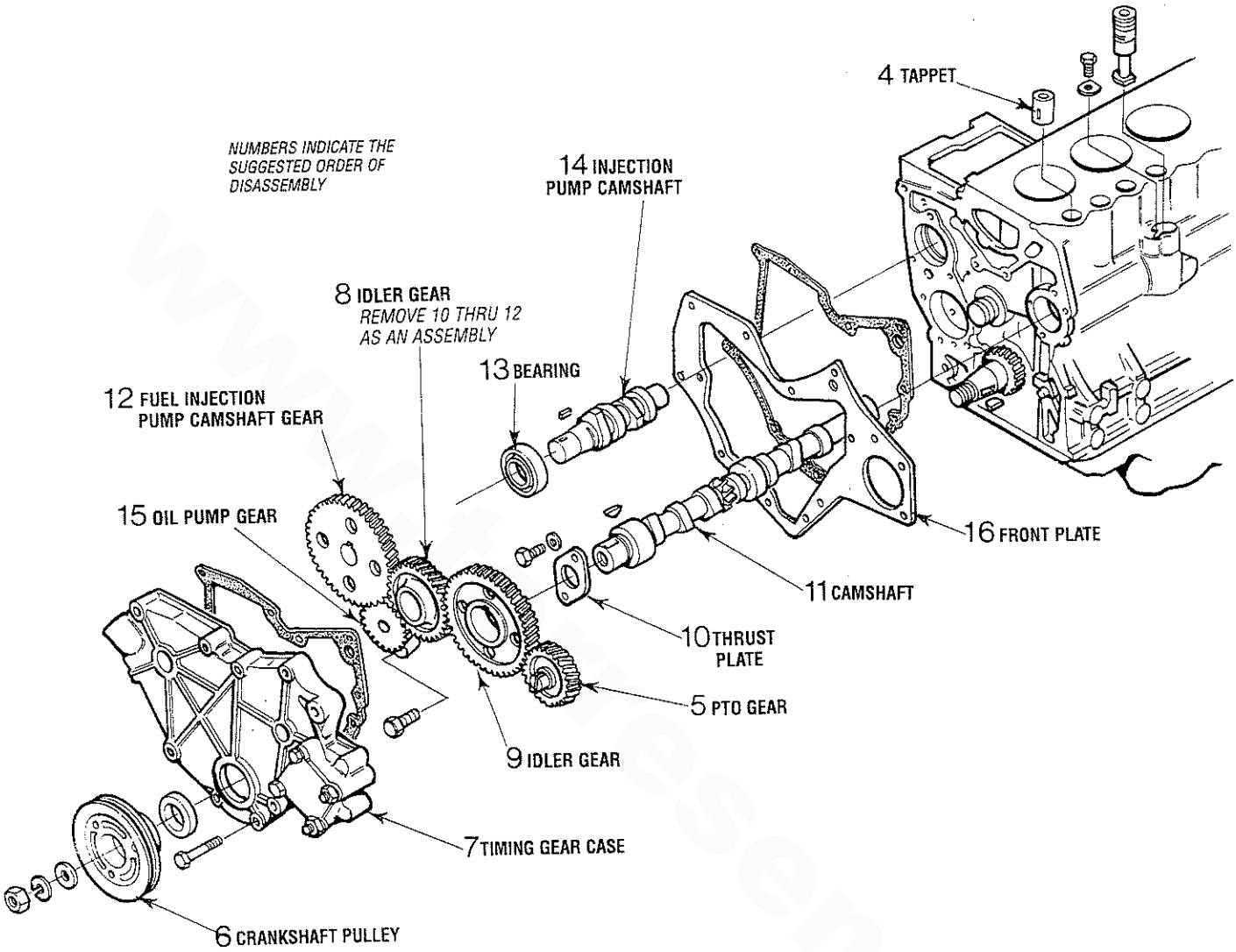
NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY

30. **Remove the crankshaft pulley.**
    a. Install two safety bars (M12 x 1.25) into the threaded holes in the rear end of the crankshaft. Put a bar between the safety bars to hold the crankshaft to prevent it from rotating.
    b. Remove the crankshaft pulley.

> ⚠ **WARNING:** ***When removing the crankshaft pulley, be prepared to stop the job in case the bar slips off the crankshaft to prevent injury.***

> ⚠ **WARNING:** ***When removing the flywheel, wear heavy gloves to avoid hand injury.***

ENGINE DISASSEMBLY
TIMING GEARS
ORDER OF DISASSEMBLY

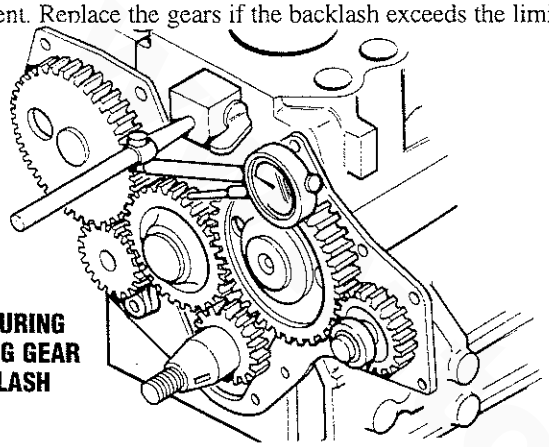


ENGINE DISASSEMBLY

31. **Remove the timing gear case.** Remove the bolts that hold the timing gear case in position and remove the case.

> ⚠ **WARNING:** ***The front plate is bolted inside the timing gear case. Do not attempt to remove this plate along with the timing gear case by tapping.***

32. **Timing gear backlash measurement.** Measure the backlash of each gear and keep a record for correct measurement. Replace the gears if the backlash exceeds the limit.



MEASURING TIMING GEAR BACKLASH

TIMING GEAR BACKLASH	STANDARD	LIMIT
CRANKSHAFT GEAR AND IDLER GEAR - IDLER GEAR AND CAMSHAFT GEAR - IDLER GEAR AND FUEL INJECTION PUMP CAMSHAFT GEAR	0.0016 - 0.0047 in (0.04 - 0.12mm)	0.0118 in (0.30mm)
CAMSHAFT GEAR/P.T.O. GEAR	0.0031 - 0.0075 in (0.08 - 0.19mm)	0.0118 in (0.30mm)
FUEL INJECTION PUMP CAMSHAFT GEAR AND OIL PUMP GEAR	0.0028 - 0.0079 in (0.07 - 0.20mm)	0.0118 in (0.30mm)

33. **Remove the idler gear.** To remove the idler gear, rotate the gear in a direction of the helix of the teeth to pull it out of mesh.

34. **Remove the camshaft.**

a. Remove the bolts that hold the thrust plate.

b. Pull the camshaft out of the cylinder block.

> ⚠ **CAUTION:** ***Do not cause damage to the lobes or bearing journals when removing the camshaft***

35. **Remove the fuel injection pump camshaft.**

a. Remove the stopper bolt.

b. Tap the rear end of the camshaft with a copper bar to push it out of the front side of the cylinder block.

36. **Remove the gear (when required).** To remove the gears from the camshaft and fuel injection pump camshaft, use an arbor press.

37. **Remove the oil pump.** Remove the bolts that hold the oil pump to the cylinder block and remove the pump.

38. **Remove the front plate.** Remove four bolts that hold the front plate in position. Tap the plate lightly with a plastic hammer to separate the gasket.

39. **Remove the oil pan.**

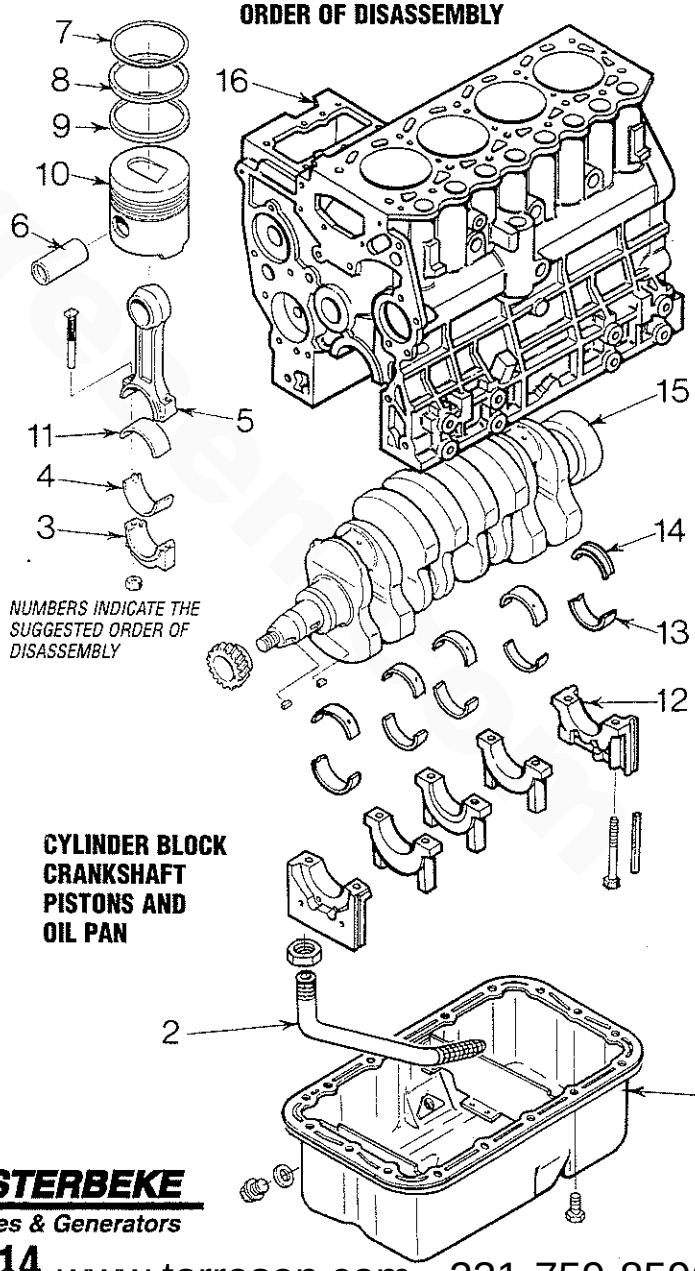
a. Turn the engine upside down.

b. Tap the bottom corners of the oil pan with a plastic hammer to remove the oil pan.

> ⚠ **CAUTION:** ***Do not attempt to pry off the oil pan by inserting a screwdriver or a chisel between the oil pan and the cylinder block. Damage to the oil pan can be the result.***

40. **Remove the oil screen.** Loosen the nut that holds the oil screen in position and remove the screen.

ORDER OF DISASSEMBLY



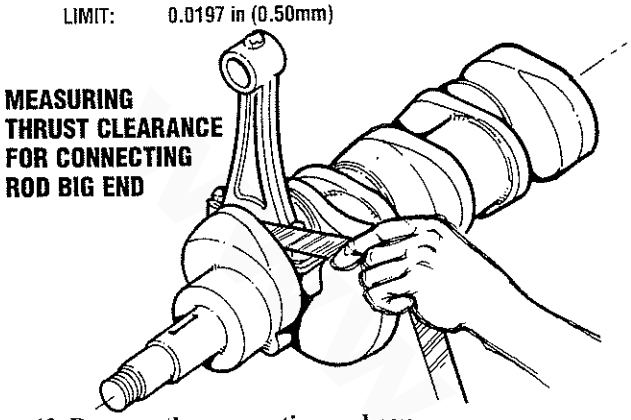
NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY

CYLINDER BLOCK CRANKSHAFT PISTONS AND OIL PAN

ENGINE DISASSEMBLY

41. Thrust clearance measurement for connecting rod big end. Install the connecting rod to its crankpin and tighten the cap nuts to the specified torque. Measure the thrust clearance with a feeler gauge. If the clearance exceeds the limit, replace the connecting rod.

THRUST CLEARANCE
STANDARD: 0.0039 - 0.0138 in (0.10 - 0.35mm)
LIMIT: 0.0197 in (0.50mm)



42. Remove the connecting rod cap.

a. Lay the cylinder block on its side.

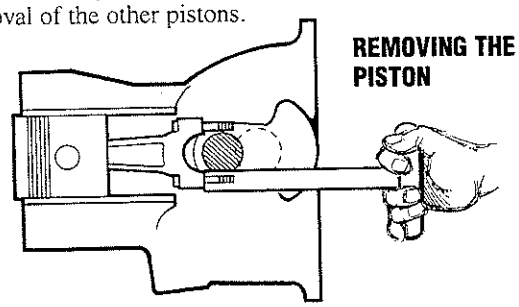
b. Put identification on each connecting rod and cap combination as to its location in the engine.

c. Remove the caps.

43. Remove the piston.

a. Turn the crankshaft until the piston is at top center.

b. Push the piston and connecting rod away from the crankshaft with the handle of a hammer until the piston rings are above the cylinder. Remove the piston and connecting rod. Repeat steps **a** and **b** for the removal of the other pistons.



44. Measuring the crankshaft end play. Set a dial indicator so that it will touch the end of the crankshaft and measure the end play. If the end play exceeds the limit, replace the flanged bearing.

CRANKSHAFT END PLAY
STANDARD: 0.00197 - 0.00689 in (0.050 - 0.175mm)
LIMIT: 0.01969 in (0.500 mm)

45. Remove the main bearing cap.

a. Lay the cylinder block with its bottom (oil pan) side up.

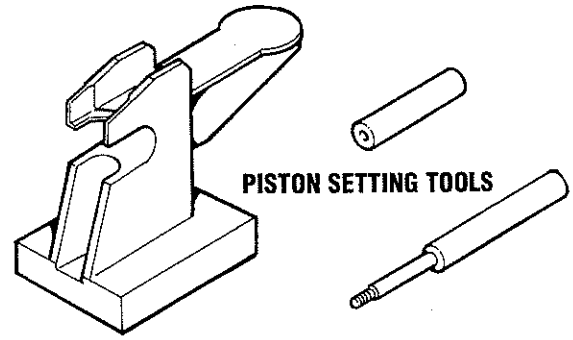
b. Remove the bolts that hold the main bearing caps in position. Remove the caps.

c. Remove the front and rear bearing caps with a sliding hammer.

46. Remove the crankshaft.

> ⚠ **CAUTION:** ***Do not cause damage to the bearings.***

NOTE: *Put identification on each main bearing as to its location in the engine.*



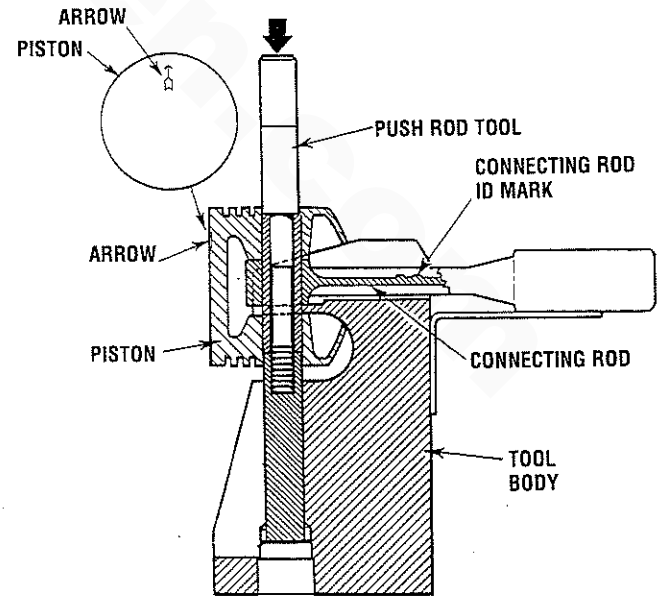
47. Separate the piston from the connecting rod.

a. Use Piston Pin Setting Tool to separate the piston from the connecting rod.

b. Insert the push rod of the tool into the bore in the piston for the piston pin and, using an arbor press, remove the piston pin.

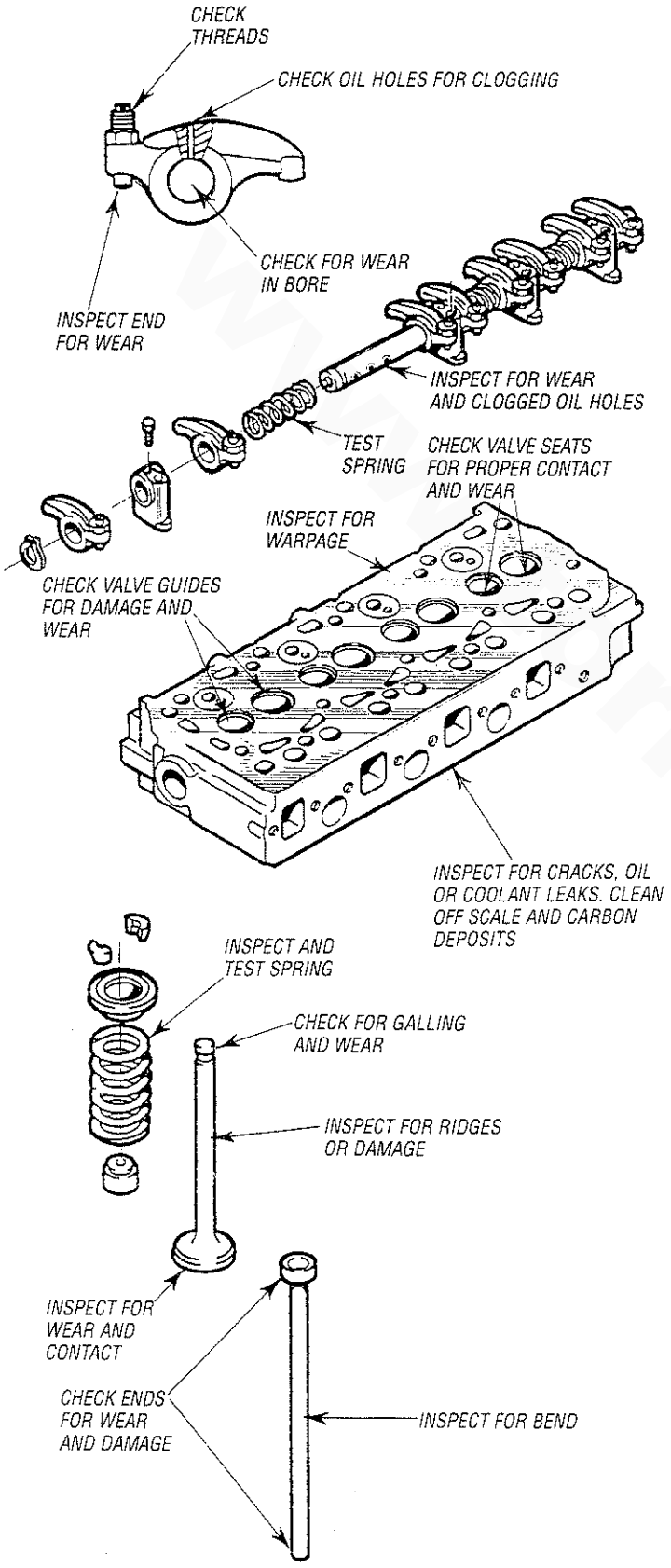
c. Also use the Piston Pin Setting Tool to install the connecting rod to the piston.

> ⚠ **CAUTION:** ***Do not attempt to remove the piston pin by tapping. Replace any piston pin which requires a greater force for removal.***



INSPECTION

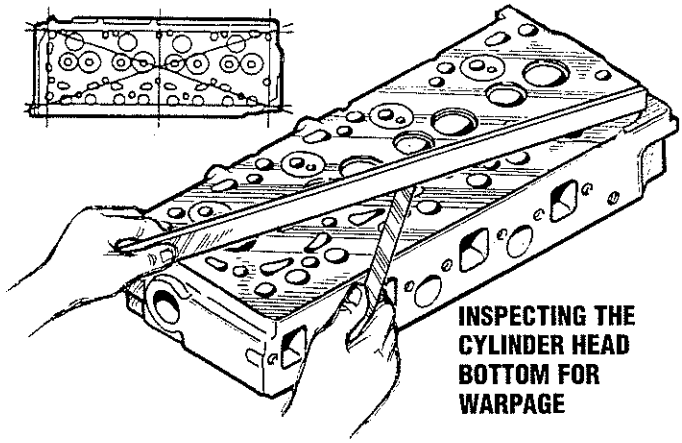
CYLINDER HEAD AND VALVE MECHANISM



1. **Cylinder head.** Using a heavy accurate straight edge and a feeler gauge, check the bottom face for warpage in three positions, lengthwise, two crosswise and two widthwise as shown in the illustration. If warpage exceeds the limit, reface the bottom face with a surface grinder.

WARPAGE - CYLINDER HEAD BOTTOM FACE

STANDARD	0.0020 in (0.05mm) MAXIMUM
LIMIT	0.0039in ((0.10mm)



INSPECTING THE CYLINDER HEAD BOTTOM FOR WARPAGE

2. **Rocker arms and rocker shaft.** Measure the bore in the rocker arm for the rocker shaft and the diameter of the rocker shaft to find the clearance between the arm and the shaft. If the clearance has reached the limit, replace the rocker arm. If it exceeds the limit, replace both arm and shaft.

BORE IN ROCKER ARM FOR SHAFT

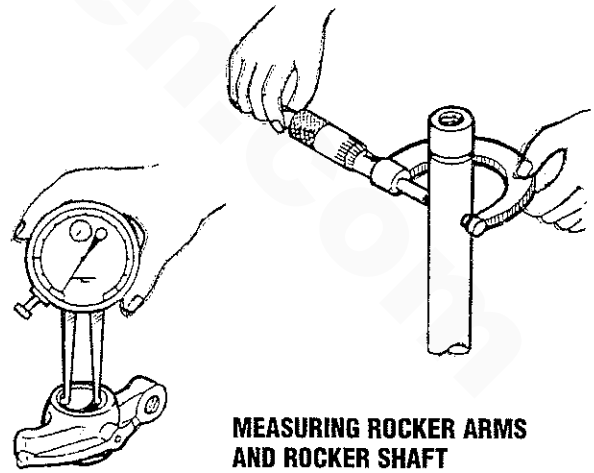
STANDARD	0.74449 - 0.74527 in (18.910 - 18.930mm)

DIAMETER OF SHAFT FOR ARM

STANDARD	0.74331 - 0.74401 in (18.880 - 18.898mm)

CLEARANCE BETWEEN ROCKER ARM AND SHAFT

STANDARD	0.00047 - 0.00197 in (0.012 - 0.050mm)
LIMIT	0.00787 (0.200mm)



MEASURING ROCKER ARMS AND ROCKER SHAFT

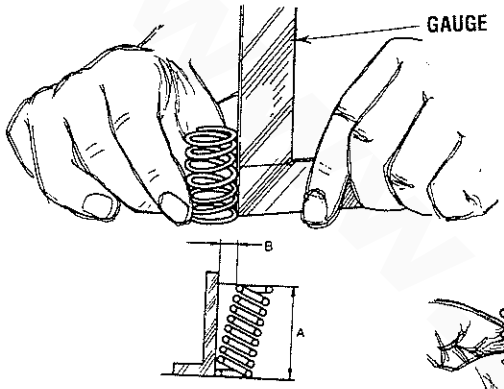
INSPECTION

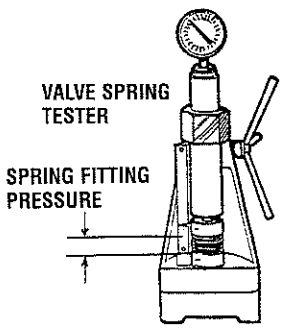
3. **Valve springs.** Check the squareness and free length. If the squareness and/or free length exceeds the limit, replace the spring.

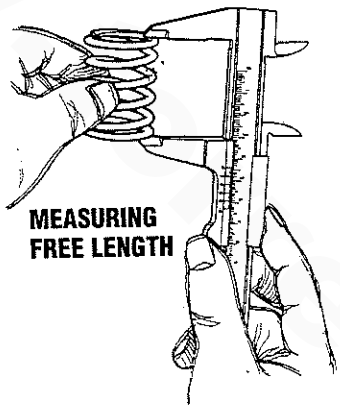
VALVE SPRING FREE LENGTH
STANDARD 1.85 in (47mm)
LIMIT 1.81 in (46mm)

SPRING SQUARENESS
STANDARD 1.5° MAXIMUM

SPRING TEST FORCE - LENGTH UNDER TEST FORCE (1.54 in (39.1mm)
STANDARD 30.6 ± 1.5 lb-ft
13.9 ± 0.7 Kg -f
LIMIT -15%



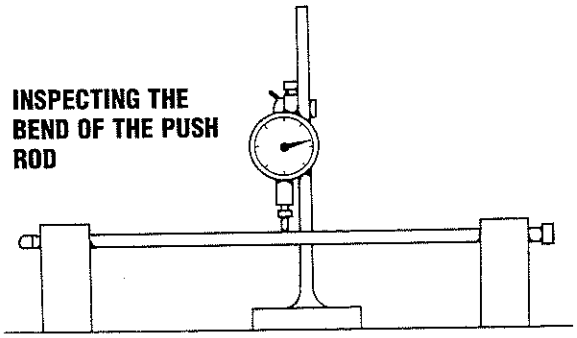




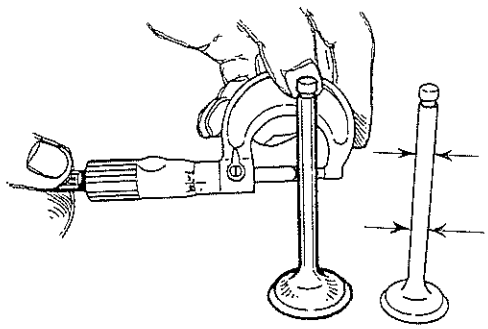
MEASURING FREE LENGTH

4. **Valve push rods.** Using V-blocks and a dial indicator, check for bend. If the bend exceeds the limit, replace the push rod.

BEND (DIAL INDICATOR READING) OF VALVE PUSH ROD
LIMIT 0.012 in (0.3mm) MAXIMUM



INSPECTING THE BEND OF THE PUSH ROD



MEASURING DIRECTIONS

CHECKING VALVE STEM WEAR

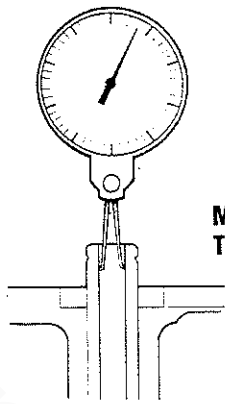
5. **Valves, valve guides and valve seats.**

a. Measure the diameter of the valve stem as shown in the illustration. If the stem is worn beyond the limit, or it is abnormally worn, replace the valve.

VALVE STEM DIAMETER (NORMAL SIZE 0.260 in (6.6mm) INLET AND EXHAUST)

INLET VALVE: STANDARD 0.25846 - 0.25905 in (6.565 - 6.580mm)
LIMIT 0.25591 in (6.500mm)

EXHAUST: STANDARD 0.25709 - 0.25787 in (6.530 - 6.550mm)
LIMIT 0.25591 in (6.500mm)



MEASURING I.D. OF THE VALVE GUIDE

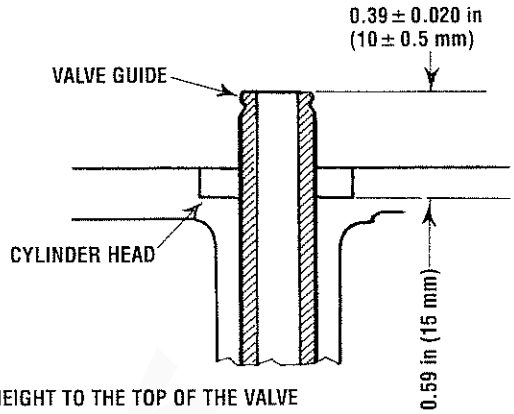
b. The valve guide wears more rapidly at its both ends than any other parts. Measure the bore in the guide for the stem at its ends with an inside micrometer caliper to find the clearance between the stem and guide. If the clearance exceeds the limit, replace the guide or valve whichever is badly worn.

CLEARANCE BETWEEN THE VALVE STEM AND VALVE GUIDE

INLET VALVE: STANDARD 0.008 - 0.0020 in (0.02 - 0.05mm)
LIMIT 0.0039 in (0.10mm)

EXHAUST VALVE: STANDARD 0.0020 - 0.00335 in (0.05 - 0.085mm)
LIMIT 0.0059 in (0.15mm)

INSPECTION



HEIGHT TO THE TOP OF THE VALVE
NORMAL SIZE 0.39 in (10mm)

c. Valve guide replacement.

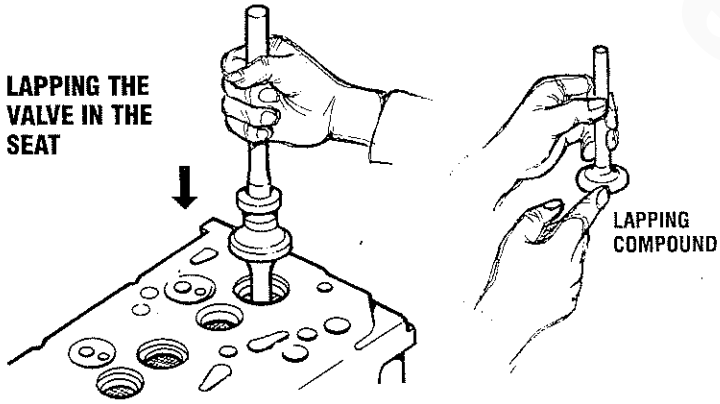
(1) Remove the guide from the cylinder head by pushing it with a tool and an arbor press from the bottom side of the head.

(2) Install a new guide into the cylinder head by pushing it with an arbor press from the upper side of the head until the specified height to the top of the guide is obtained.

(3) Insert a new valve into the guide and make sure the valve slides in the guide freely.

(4) After the valve guide has been replaced, check the valve contact with its seat.

(5) Put a small amount of Prussian blue or read lead on the valve face. Hold the valve with a valve lapping tool (commercially available) and press it against the seat to check its contact.



(6) The width of contact must be uniform all the way around both seat and valve. If the contact is bad, reface the valve and seat.

(7) If the valve margin (valve lip thickness) exceeds the limit, replace the valve.

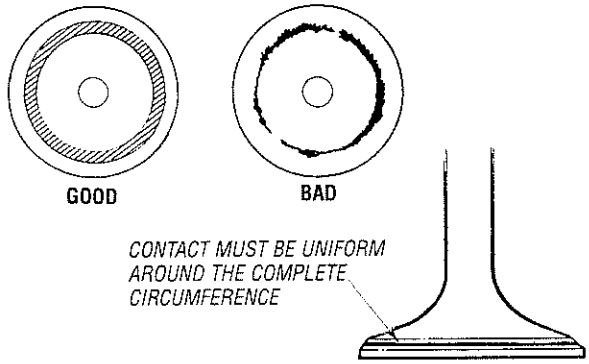
VALVE MARGIN (LIP) THICKNESS

STANDARD	0.039 in (1.0mm)
LIMIT	0.020 in (0.5mm)

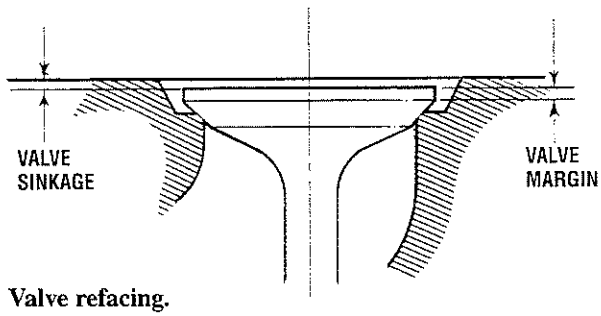
(8) If the valve sinkage (the dimension from the top of a closed valve to the face of cylinder head) exceeds the limit, recondition the valve seat or replace the cylinder head assembly.

VALVE SINKAGE

STANDARD	0.020 ± 0.0098in (0.5 ± 0.25mm)
LIMIT	0.059 in (1.5mm)



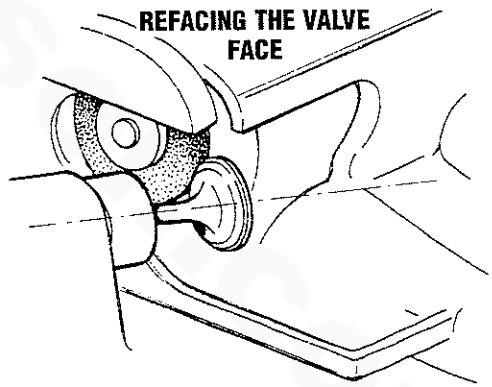
VALVE AND VALVE SEAT CONTACT



6. Valve refacing.

a. Set the valve refacer at an angle of 45° and grind the valve.

b. The valve margin must not be less than the limit. If the margin seems to be less than the limit when the valve is refaced, replace the valve.



7. Valve seat refacing.

a. Before refacing the valve seat, check the clearance between the valve and guide, and replace the guide if necessary.

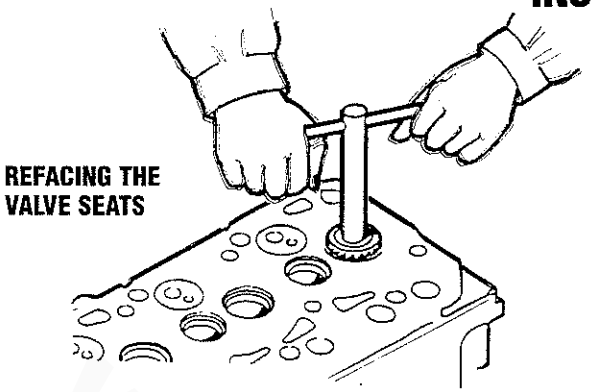
b. Cut the valve seat with a valve seat cutter (commercially available), or grind it with a valve seat grinder, and finish the width of valve seat and the angle of seat face to the correct values.

ANGLE OF SEAT FACE: STANDARD 45°

WIDTH OF VALVE SEAT

STANDARD	0.051 - 0.071 in (1.3 - 1.8mm)
LIMIT	0.098 in (2.5mm)

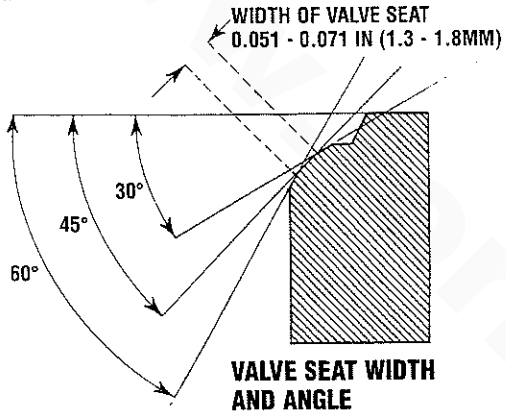
INSPECTION



c. After refacing the valve seat, put lapping compound on the valve face and lap the valve in the valve seat.

8. **Valve lapping.** Be sure to lap the valves in the seats after refacing or replacing the valves or valve seats.

   a. Put a small amount of lapping compound on the valve seat.



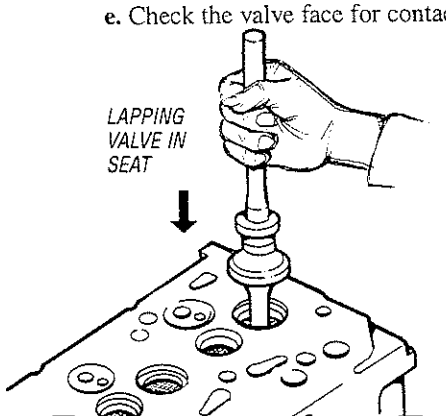
NOTE: *Do not put lapping compound on the valve stem. Use a lapping compound of 120 to 150 mesh for initial lapping and a compound of finer than 200 mesh for finish lapping.*
Mixing the compound with a small amount of engine oil will help put the compound on the valve face uniformly.

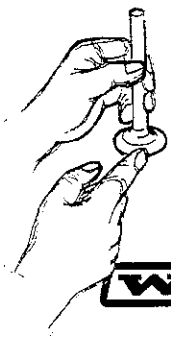
   b. Using a lapping tool, hold the valve against the seat and rotate it only a part of a turn, then raise the valve off its seat, rotating it to a new position. Press the valve against the seal for another part of a turn. Repeat this operation until the compound wears and loses its cutting property.

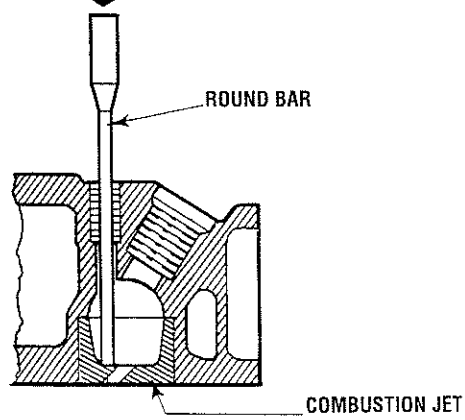
   c. Wash the valve and valve seat with dry cleaning solvent.

   d. Apply engine oil to the valve and lap it in the seat.

   e. Check the valve face for contact.



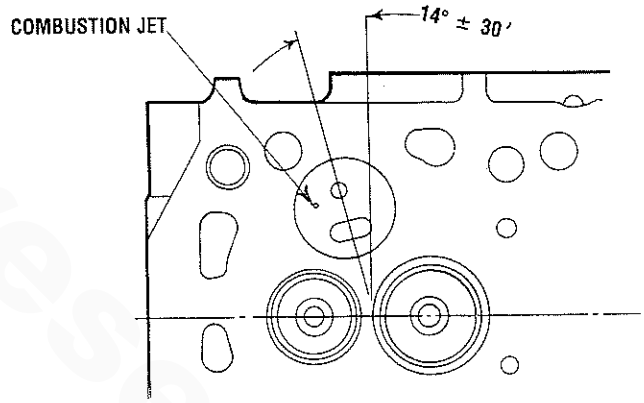




9. **Combustion jet replacement.** Replace the combustion jets only when they are cracked or defective.

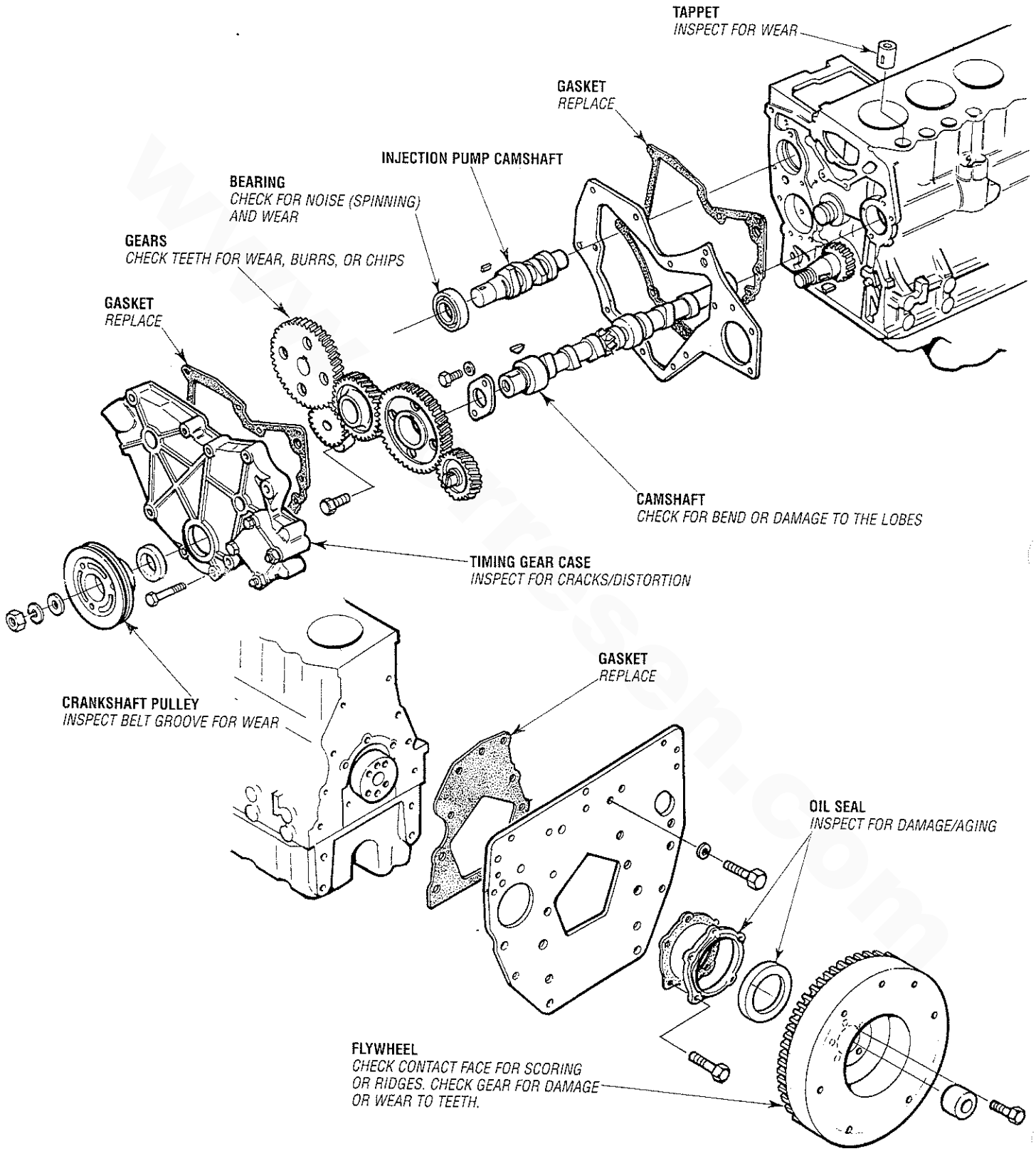
   a. To remove the jet, insert a 6mm (0.25in) diameter round bar through the bore in the cylinder head for the glow plug and tap around the jet.

   b. To install a new jet, put the jet in position in the head with its tangential orifice in alignment with the center of the main chamber and tap it with a plastic hammer.



ENGINE INSPECTION

TIMING GEARS AND FLYWHEEL - INSPECTION POINTS



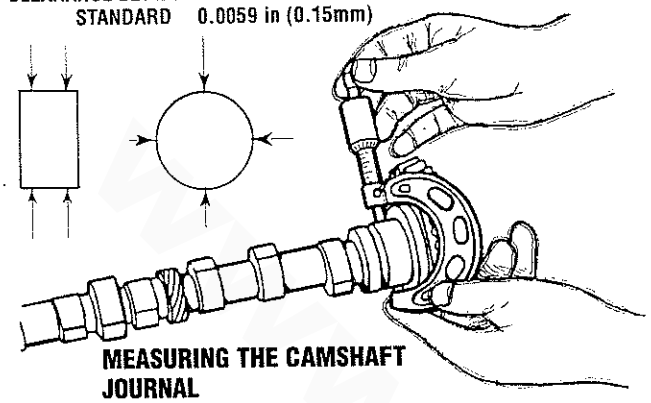
WESTERBEKE
Engines & Generators

INSPECTION

10. Camshaft

a. Measure the diameter of the journal and the bore in the bushing for the shaft to find the clearance as shown in the illustration. If the clearance exceeds the limit, replace the bushing.

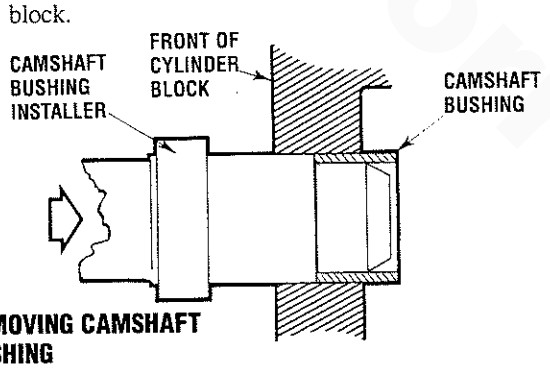
CLEARANCE BETWEEN THE CAMSHAFT JOURNAL AND BUSHING
STANDARD 0.0059 in (0.15mm)



MEASURING THE CAMSHAFT JOURNAL

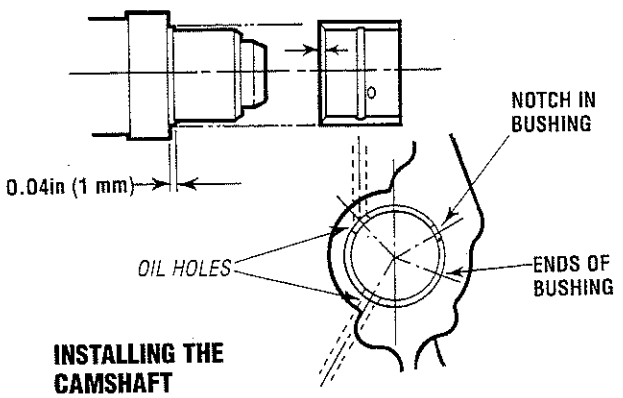
b. Use Camshaft Bushing Installer(special tool) for camshaft bushing replacement.

(1) Remove the oil pan. Using a "remover" end of the cylinder, push out the bushing into the cylinder block. Crush and take out the bushing from the block.



REMOVING CAMSHAFT BUSHING

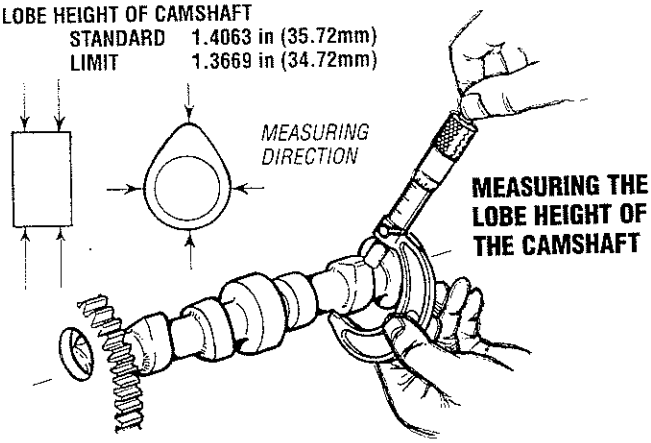
(2) Install a new bushing in position with its oil holes in alignment with those of the oil gallery.



INSTALLING THE CAMSHAFT BUSHING

(3) Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe lift . If the lobe lift exceeds the limit, replace the camshaft.

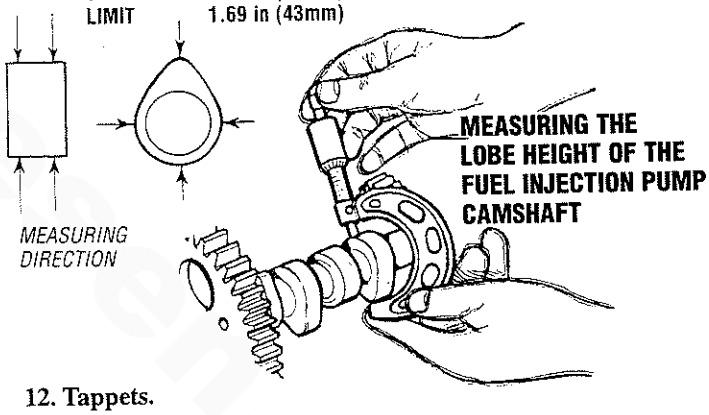
LOBE HEIGHT OF CAMSHAFT
STANDARD 1.4063 in (35.72mm)
LIMIT 1.3669 in (34.72mm)



MEASURING THE LOBE HEIGHT OF THE CAMSHAFT

11. Fuel injection pump camshaft. Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe lift . If the lobe lift exceeds the limit, replace the camshaft.

LOBE HEIGHT OF FUEL INJECTION PUMP CAMSHAFT
STANDARD 1.73 in (44mm)
LIMIT 1.69 in (43mm)



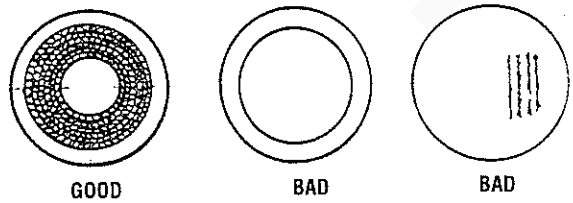
MEASURING THE LOBE HEIGHT OF THE FUEL INJECTION PUMP CAMSHAFT

12. Tappets.

a. Check the cam contact face of each tappet for abnormal wear. Replace the tappet if the face is defective.

b. Measure the diameter of the tappet and the bore in the cylinder block for the tappet to find the clearance. If the clearance exceeds the limit, replace the tappet.

CLEARANCE BETWEEN THE TAPPET AND THE CYLINDER BLOCK
STANDARD 0.0059 in (0.15mm)



CAM CONTACT FACE OF THE TAPPET

INSPECTION

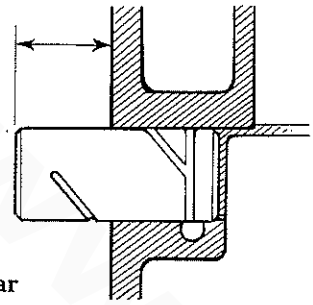
13. Idler gear.

a. Measure the bore in the idler gear for the shaft and the diameter of the shaft to find the clearance. If the clearance exceeds the limit, replace the gear or shaft whichever is badly worn.

CLEARANCE BETWEEN THE IDLER GEAR AND THE SHAFT

STANDARD	0.0012 - 0.0028 in (0.03 - 0.07mm)
LIMIT	0.0079 in (0.20mm)

b. Install a new idler shaft to the cylinder block so that its dimension from the face of the block is 1.043 ± 0.020 in (26.5 ± 0.5mm).



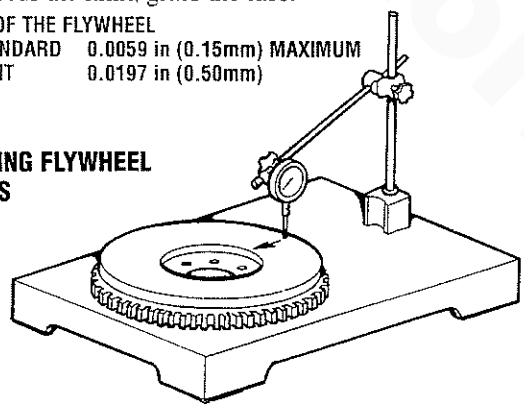
DIMENSION OF THE IDLER SHAFT FROM THE BLOCK FACE

14. Flywheel and ring gear

a. Put the flywheel on the surface plate. Set a dial indicator at one side of the friction (clutch contact) face and move it over to the opposite side of the face as shown in the illustration to find flatness. If flatness exceeds the limit, grind the face.

FLATNESS OF THE FLYWHEEL

STANDARD	0.0059 in (0.15mm) MAXIMUM
LIMIT	0.0197 in (0.50mm)



MEASURING FLYWHEEL FLATNESS

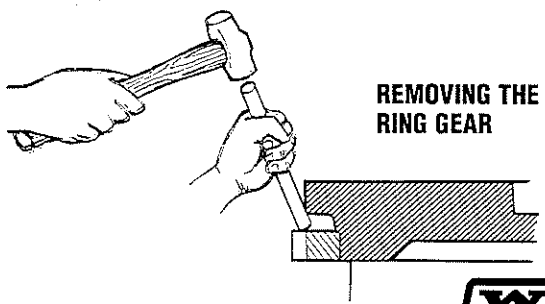
b. Check the ring gear and replace it if its teeth are abnormally worn or chipped.

(1) Removal

Heat the ring gear evenly with an acetylene torch. Tap the ring gear all the way around with a bar and a hammer as shown in the illustration to remove it from the flywheel.

(2) Installation

Heat a new ring up to a temperature of 302°F (150°C) with a piston heater and install it to the flywheel with its unchamfered side foremost.



REMOVING THE RING GEAR

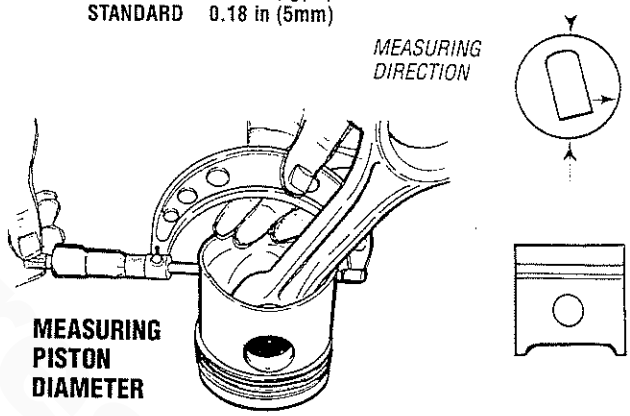
15. Pistons, piston rings and piston pins.

a. Measure the diameter of the piston at its skirt in a direction transverse to the piston pin with a micrometer as shown in the illustration. If the diameter exceeds the limit, replace the piston. Select a new piston so that the difference between average weight of all pistons in one engine does not exceed the standard.

DIAMETER OF PISTON	STANDARD	LIMIT
STANDARD (NOMINAL SIZE 3.0709 in (78.00mm)	3.0681 - 3.0689 in (77.93 - 77.95mm)	3.063 in (77.80mm)
OVERSIZE 0.0098 in (0.25mm) (NOMINAL SIZE 3.0807in 78.25mm)	3.0779 - 3.0787 in (78.18 - 78.20mm)	3.0728 in (78.05mm)
OVERSIZE 0.0197 in (0.50mm) (NOMINAL SIZE 3.0905in 78.50mm)	3.0878 - 3.0886 in (78.43 - 78.45mm)	3.0827 in (78.30mm)

MAXIMUM PERMISSIBLE DIFFERENCE BETWEEN AVERAGE WEIGHT OF ALL PISTONS IN ONE ENGINE, g(oz)

STANDARD	0.18 in (5mm)

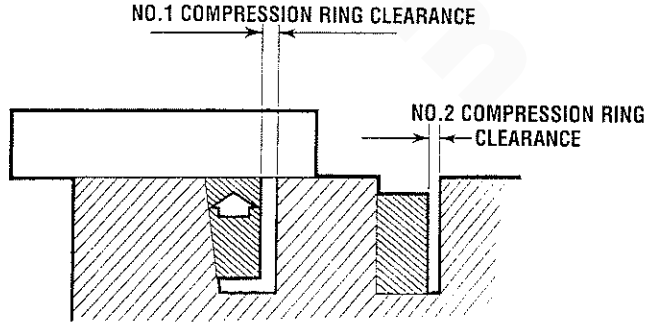


MEASURING PISTON DIAMETER

b. Measure the clearance between the groove and piston with a straight edge and a feeler gauge. If the clearance exceeds the limit, replace the ring.

COMPRESSION RING CLEARANCE	STANDARD	LIMIT
NO.1 COMPRESSION RING	0.0024 - 0.0039 in (0.06 - 0.10mm)	0.0118 in (0.30mm)
NO.2 COMPRESSION RING	0.0020 - 0.0035 in (0.05 - 0.9mm)	0.0079 in (0.20mm)
OIL RING	0.0012 - 0.0028 in (0.03 - 0.07mm)	0.0079 in (0.20mm)

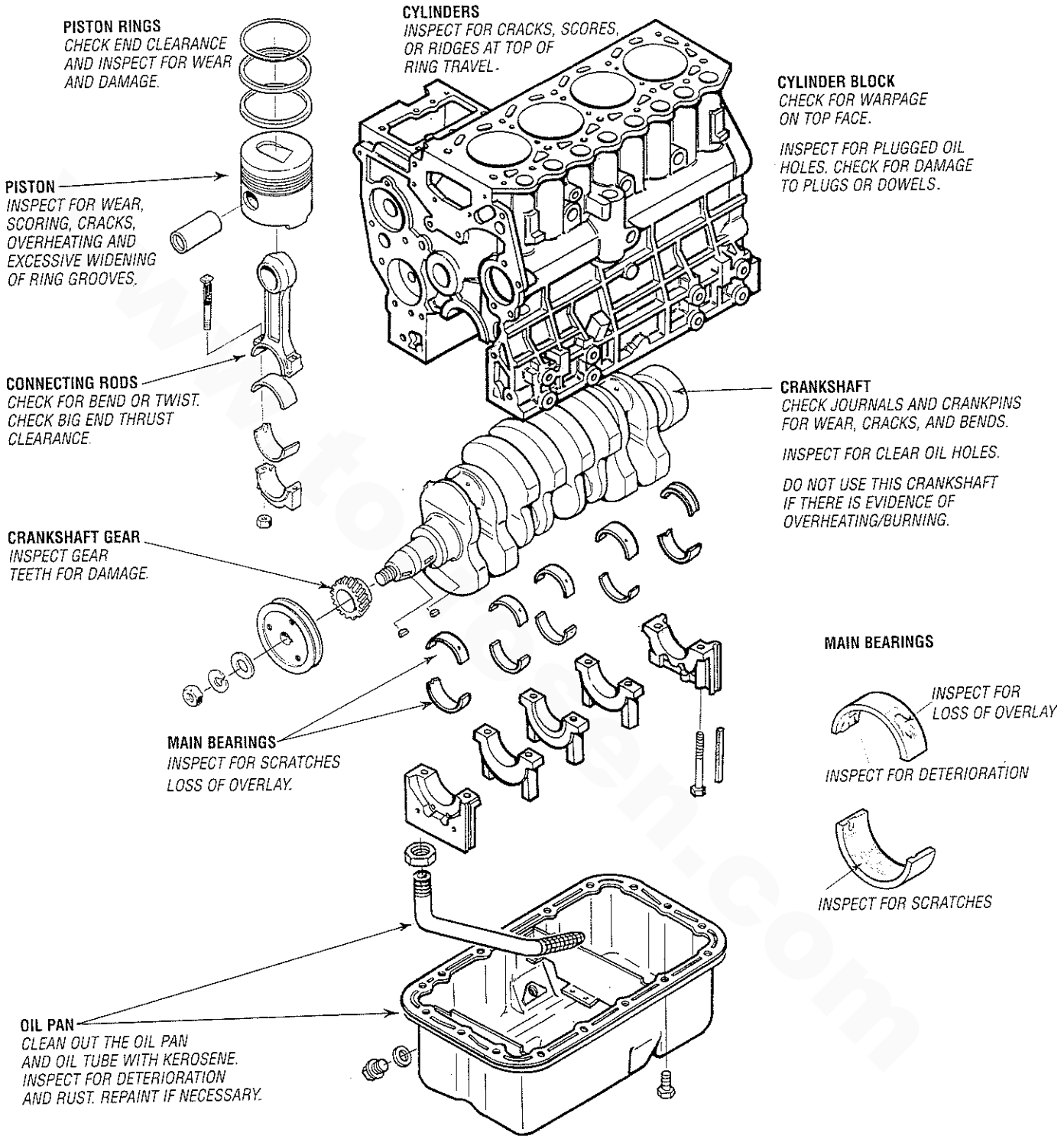
c. If the clearance still exceeds the limit after new piston rings have been installed, replace the piston.



MEASURING THE CLEARANCE BETWEEN THE PISTON RING AND GROOVE

ENGINE INSPECTION

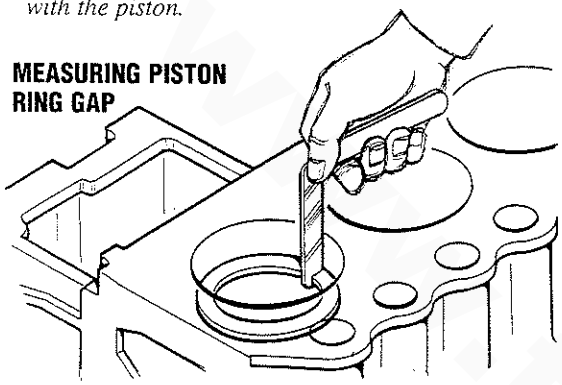
CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN - INSPECTION POINTS



d. Put the piston ring in a gauge or in the bore in a new cylinder block and measure the clearance between the ends of the ring with a feeler gauge as shown. If the clearance exceeds the limit, replace all the rings.

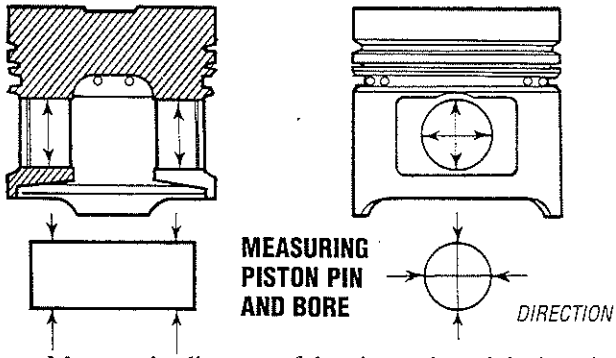
INSIDE DIAMETER OF GAUGE
STANDARD 3.07 $^{+0.0012}$ in (78 $^{+0.03}$ mm)
OVERSIZE 3.08 $^{+0.0012}$ in (78.25 $^{+0.03}$ mm)
(0.0098 in (0.25mm)
OVERSIZE 3.09 $^{+0.0012}$ in (78.50 $^{+0.03}$ mm)
0.0197 in (0.50mm)

NOTE: *Put the piston ring in the gauge or cylinder squarely with the piston.*



CLEARANCE BETWEEN THE ENDS OF THE PISTON RINGS

	STANDARD	LIMIT
NO.1 RING	0.0059 - 0.0118 in (0.15 - 0.30mm)	0.0591 in (1.50mm)
NO.2 RING	0.0059 - 0.0138 in (0.15 - 0.35mm)	0.00591 in (1.50mm)
OIL RING	0.0079 - 0.0157 in (0.20 - 0.40mm)	0.0591 in (1.50mm)



e. Measure the diameter of the piston pin and the bore in the piston for the pin to find the clearance. If the clearance exceeds the limit, replace the piston or pin, whichever is badly worn.

DIAMETER OF THE PISTON PIN (NOMINAL SIZE 0.91 in (23mm))
STANDARD 0.90527 - 0.90551 in (22.994 - 23.000mm)

CLEARANCE BETWEEN THE PISTON PIN AND PISTON
STANDARD 0.00024 - 0.0071 in (0.006 - 0.018mm)
LIMIT 0.00197 in (0.050mm)

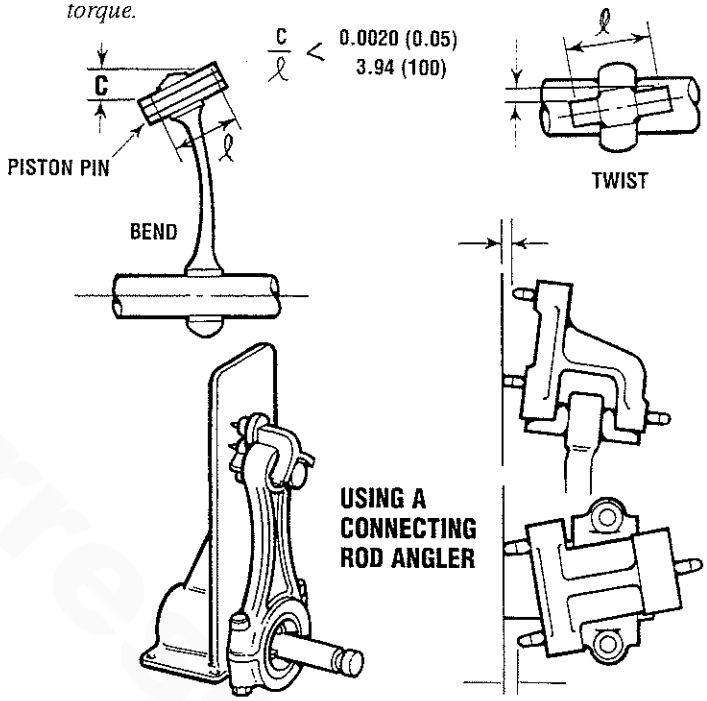
f. Check the connecting rod for bend or twist as follows:

(1) Measure "C" and "ℓ". If "C" exceed 0.0020 in (0.05mm) per 3.94 in (100mm) of "ℓ", straighten the connecting rod with a press.

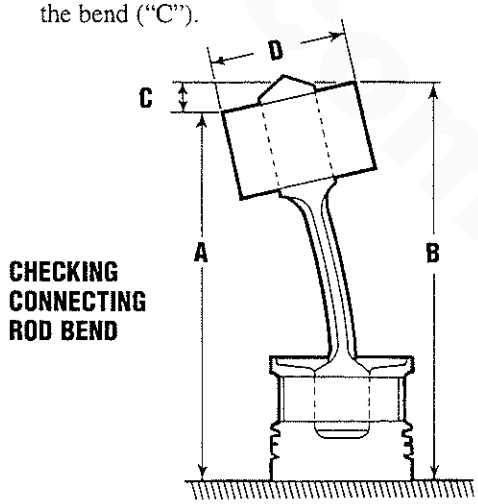
BENDING OR TWIST OF CONNECTING ROD
STANDARD 0.0020 in /3.94 maximum (0.05/100mm)
LIMIT 0.0059 in /3.94 maximum (0.15/100mm)

(2) Generally, a connecting rod aligner is used to check the connecting rod for bend or twist.

NOTE: *To check the rod for bend, install the cap to the connecting rod and tighten the cap nuts to the specified torque.*



(3) To check the connecting rod fitted to the piston for bend, put the connecting rod and piston on the surface plate as shown, insert a round bar having a diameter equal to that of the crankpin into the bore in the big end of the rod and measure "A" and "B" with a dial indicator. Subtract "A" from "B" to find the bend ("C").

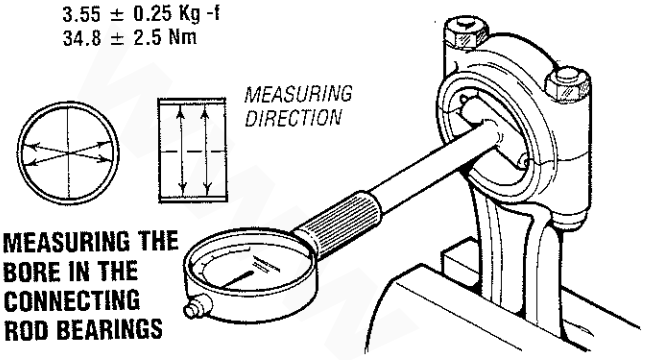


16. Crankshaft

a. Clearance between crankpin and connecting rod bearing.

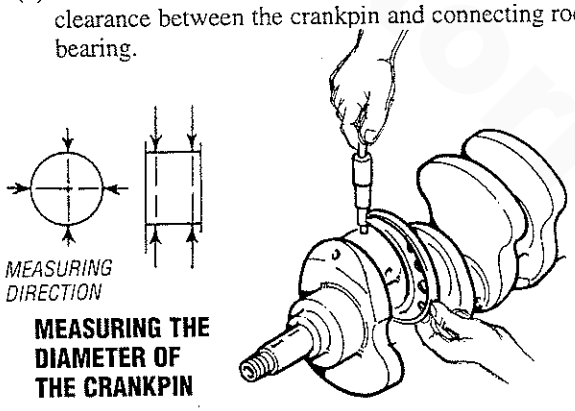
(1) Install the bearing (upper and lower halves) and cap to the big end of the connecting rod and tighten the cap nuts to the specified torque. Measure the bore in the bearing for crankpin as shown.

TIGHTENING TORQUE
25.7 ± 1.8 lb-ft
3.55 ± 0.25 Kg -f
34.8 ± 2.5 Nm



MEASURING THE BORE IN THE CONNECTING ROD BEARINGS

(2) Measure the diameter of the crankpin to find the clearance between the crankpin and connecting rod bearing.



MEASURING THE DIAMETER OF THE CRANKPIN

DIAMETER OF CRANKPIN (NORMAL SIZE 1.89 in (48mm)
STANDARD 1.88779 - 1.88838 in (47.950 - 47.965mm)

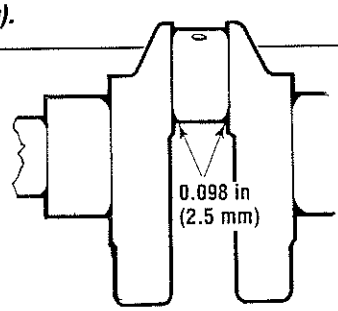
CLEARANCE BETWEEN THE CRANKPIN AND THE CONNECTING ROD BEARING
STANDARD 0.00098 - 0.00283 in (0.025 - 0.072mm)
LIMIT 0.00591 in (0.150mm)

(3) If the clearance exceeds the limit, install a new bearing and check the clearance again.

(4) If the clearance still exceeds the limit, grind the crankpin to 0.25mm (0.0098 in), 0.50mm (0.0197 in) or 0.75mm (0.0295 in) undersize and use a undersize connecting rod bearing.

CRANKPIN UNDERSIZES
0.25mm (0.0098 in)
FINISH 47.75 $^{-0.050}$ mm (1.8799 $^{-0.00197}$ in)
0.50mm (0.0197 in)
FINISH 47.50 $^{-0.050}$ mm (1.8701 $^{-0.00197}$ in)
0.75mm (0.0295 in)
FINISH 47.25 $^{-0.050}$ mm (1.8602 $^{-0.00197}$ in)

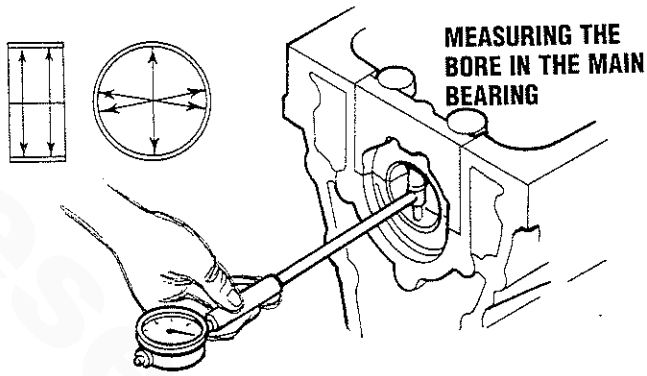
⚠ CAUTION: ***Grind all the crankpins of one crankshaft to the same undersize. Finish the crankpin fillets to a radius of 0.098 in (2.5mm).***



a. Inspect the clearance between the journal and the main bearing.

(1) Install the main bearing (upper and lower halves) and the cap to the cylinder block and tighten the cap bolts to the specified torque. Measure the bore in the bearing for the journal.

TIGHTENING TORQUE : 38 ± 1.8 lb-ft (5.25 ± 0.25 kg-m)

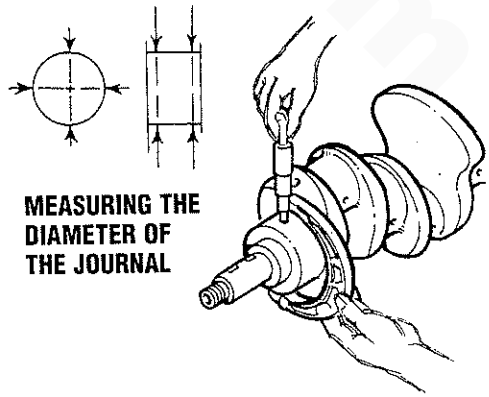


MEASURING THE BORE IN THE MAIN BEARING

(2) Measure the diameter of the journal as shown to find the clearance between the journal and main bearing.

DIAMETER OF JOURNAL (STANDARD)
NOMINAL SIZE 2.05 in (52mm)
STANDARD 2.04665 - 2.04724 in (51.985 - 52.000mm)

CLEARANCE BETWEEN JOURNAL AND MAIN BEARING
STANDARD 0.00118 - 0.00303 in (0.030 - 0.077mm)
LIMIT 0.00394 in (0.100mm)



MEASURING THE DIAMETER OF THE JOURNAL

(3) If the clearance exceeds the limit, install a new bearing and check the clearance again.

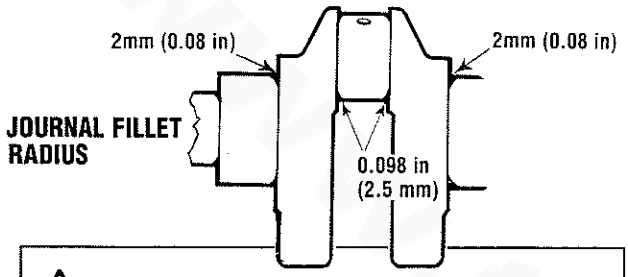
(4) If the clearance still exceeds the limit, grind the journal to 0.25mm (0.0098 in), 0.50mm (0.0197 in) or 0.75mm (0.0295 in) undersize and use undersize main bearing.

JOURNAL UNDERSIZES

0.25mm (0.0098 in)
FINISH 51.75 $^{-0.015}$ mm (2.0374 $^{-0.00059}$ in)

0.50mm (0.0197 in)
FINISH 51.50 $^{-0.015}$ mm (2.0276 $^{-0.00059}$ in)

0.75mm (0.0295 in)
FINISH 51.25 $^{-0.015}$ mm (2.0177 $^{-0.00059}$ in)

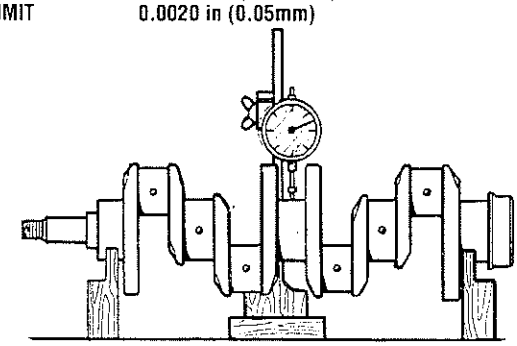


⚠ CAUTION: ***Grind all the crankpins of one crankshaft to the same undersize. Finish the crankpin fillets to a radius of 0.08 in (2.0mm).***

(5) Support the crankshaft on its front and rear journals in V-blocks or in a lathe and check the runout at the center journal with a dial indicator. Depending on the amount of runout, repair the crankshaft by grinding or by straightening with a press. If runout exceeds the limit, replace the crankshaft.

CRANKSHAFT RUNOUT

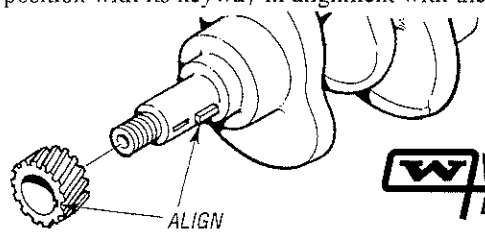
STANDARD	0.00098 in (0.025mm)
LIMIT	0.0020 in (0.05mm)



(6) Use a gear puller to remove the gear from the crankshaft.

NOTE: *Do not remove the gear unless the gear or crankshaft is defective.*

(7) Installation of the crankshaft gear. Install the key in position on the crankshaft. Install the gear in position with its keyway in alignment with the key.

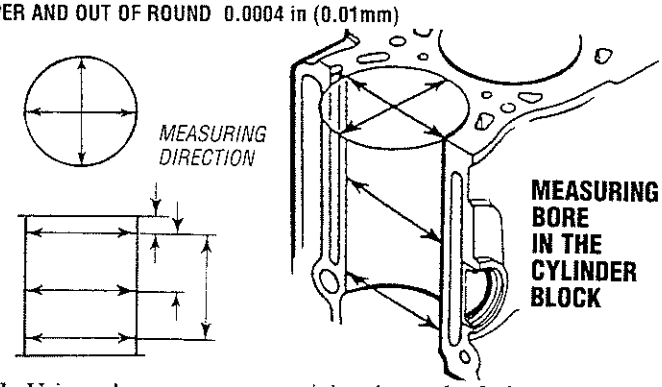


17. Cylinder Block

a. Measure the bore at the top, middle and bottom points on axes A and B with a cylinder bore gauge. If any one of the cylinders exceeds the limit, hone out all the bores for oversize pistons.

PISTON AND PISTON RING	BORE	LIMIT
STANDARD CODE: STD	3.07 in $^{+0.0012}$ (78mm $^{+0.03}$)	+0.0008 in (+0.2mm)
OVERSIZE 0.0098 in (0.25mm) CODE: 25	3.0807 in $^{+0.0012}$ (78.25mm $^{+0.03}$)	+0.0008 in (+0.2mm)
OVERSIZE 0.0197 in (0.50mm) CODE: 50	3.0905 in $^{+0.0012}$ (78.50mm $^{+0.03}$)	+0.0008 in (+0.2mm)

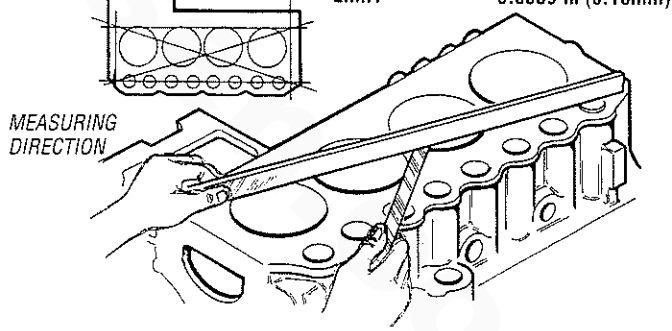
TAPER AND OUT OF ROUND 0.0004 in (0.01mm)



b. Using a heavy accurate straight edge and a feeler gauge, check the top face for warpage in two positions lengthwise, two crosswise and two widthwise. If warpage exceeds the limit, reface the top face with a surface grinder.

WARPAGE OF CYLINDER BLOCK TOP FACE

STANDARD	0.0020 in (0.05mm)
LIMIT	0.0039 in (0.10mm)

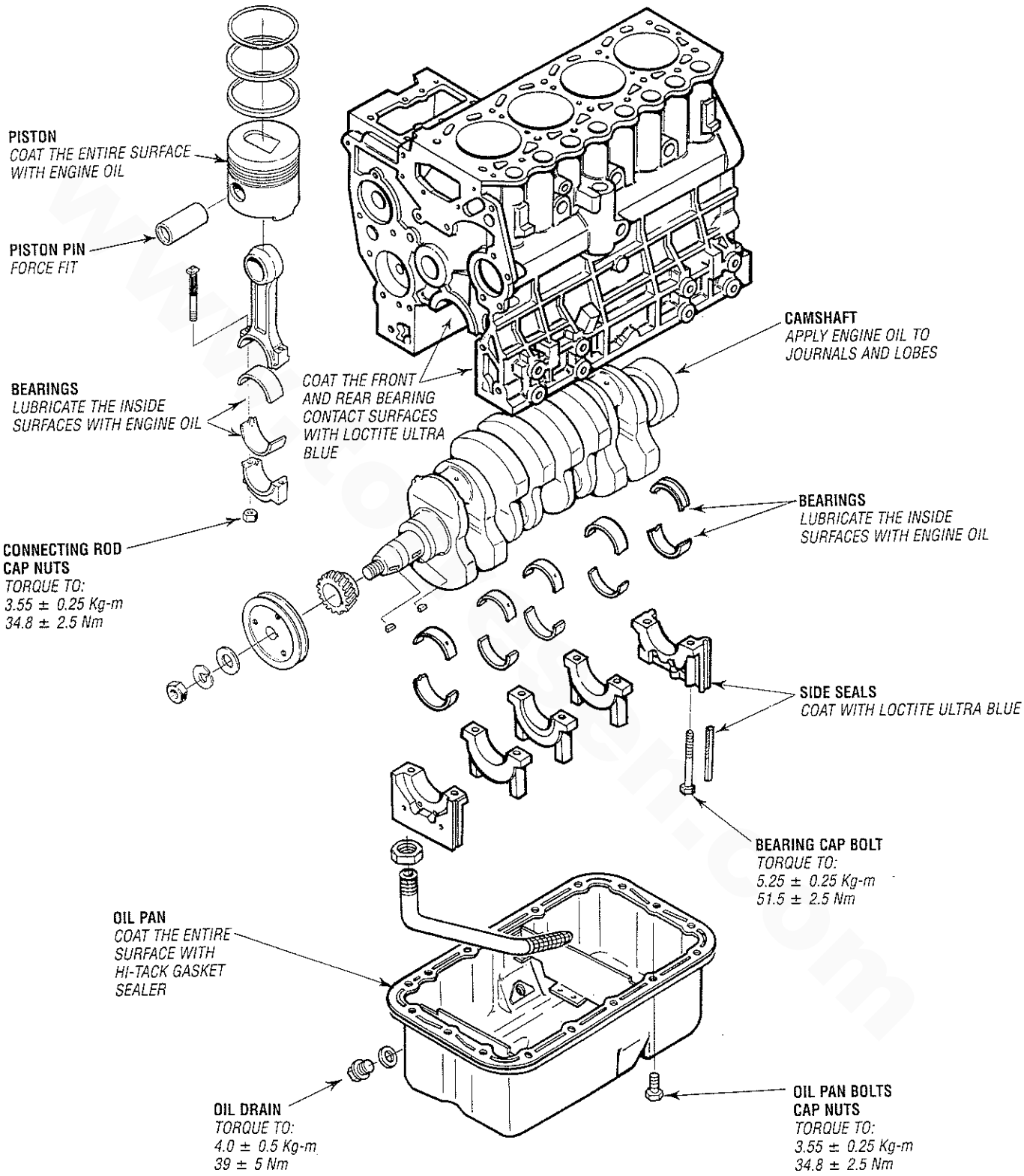


18. Manifold inspection. Using a straight edge and a feeler gauge, check the flange faces of the manifold for warpage. If warpage exceeds the limit, recondition or replace the manifold.

WARPAGE OF THE FLANGE: 0.0059 in (0.15mm)

ASSEMBLY

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN



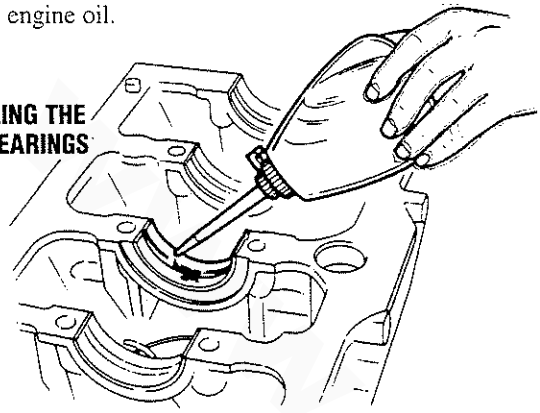
ASSEMBLY

1. Main bearing installation.

a. Install the upper halves of the main bearings in the cylinder block and the lower halves in the main bearing caps so their tabs fit into the notches in the cylinder block and the main bearing caps..

b. Install the flanged bearing in the No.3 journal.

c. Lightly lubricate the inside surfaces of the bearings with engine oil.



INSTALLING THE MAIN BEARINGS

2. Crankshaft installation.

a. Clean the crankshaft with cleaning solvent and blow dry with compressed air.

b. Fasten a hoist to the crankshaft and hold it in horizontal position. Carefully put the crankshaft in position in the cylinder block.

c. Lightly lubricate the crankshaft journals with engine oil.

3. Main bearing cap installation.

a. Coat the mating surfaces of the rear bearing cap and cylinder block with Loctite Ultra Blue.

b. Install the main bearing caps in position. Make sure the number (arrow head) on the main bearing cap is toward the front of the engine.

c. Tighten the main bearing cap bolts finger tight only.

> ⚠ **CAUTION:** ***Install the front and rear bearing caps in position so their end faces are even with the end faces of the cylinder block.***

d. Tighten the bolts holding the main bearing caps in steps to the specified torque.

TORQUE: 38 ± 2 lb-ft (5.25 ± 0.25 Kgf-m)

e. Make sure the crankshaft rotates freely without binding or catching.

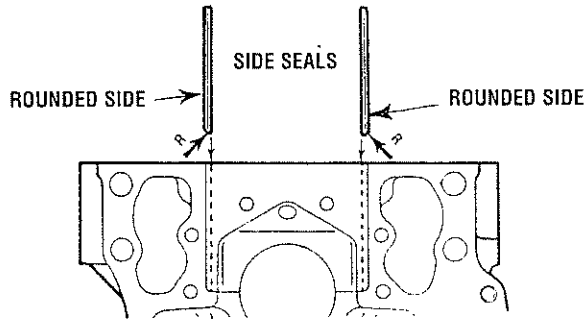
f. Measure the end play for the crankshaft. Make reference to *End play measurement* for crankshaft. If the end play is incorrect, loosen the bolts holding the main bearing caps once and tighten them again.

4. Side seal installation.

a. Coat the side seals with Loctite Ultra Blue.

b. Insert the side seals between the cylinder block and the front and rear caps and push them in by hand as far as possible, with their rounded side toward the outside of the cylinder block.

c. Using a flat plate, push the seals into position, taking care not to bend them.



5. Piston assembling to connecting rod.

a. Set Piston Setting Tool (special tool) in a hydraulic press.

b. Put the connecting rod on the Tool and lubricate the bore in the rod for the piston pin with engine oil.

c. Put the piston in position on the connecting rod, making sure the model identification on the rod is on the same side as the arrow head on the top of the piston. Put the piston pin in position.

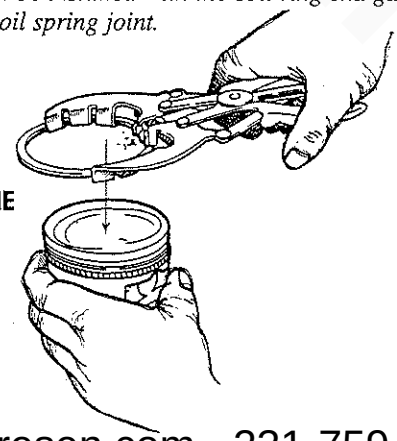
d. Insert the push rod of the Tool into the bore in the piston for the piston pin and press the pin with the press.

> ⚠ **CAUTION:** ***Observe the indicator of the press when pressing the piston pin. If the force of the press is ready to exceed 50kfg (110 lbf) [490N], stop pressing the pin and check the bores in the piston and connecting rod for alignment.***

e. After assembling the piston and connecting rod, make sure the connecting rod moves freely.

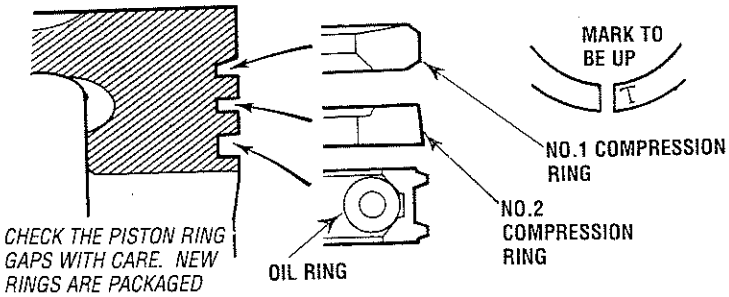
6. Using a piston ring pliers, install the piston rings on the piston.

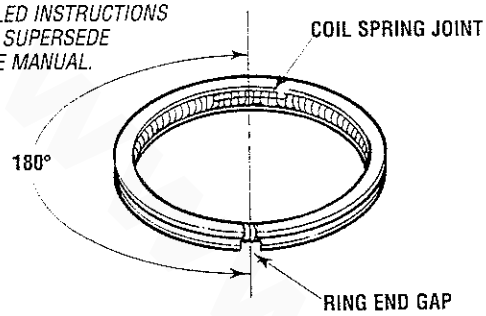
NOTE: *The piston rings must be installed with the side that has the mark "T" toward the top of the piston.*
The oil ring must be installed with the coil ring end gap 180° apart from the coil spring joint.

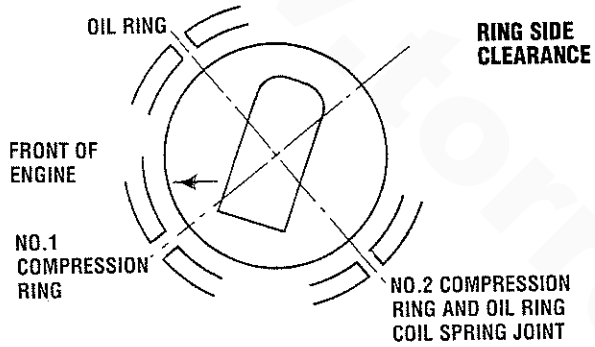


INSTALLING THE PISTON RINGS

ASSEMBLY







7. Piston and connecting rod installation.

a. Lubricate the piston and piston rings with engine oil.

b. Move the piston rings on the piston so that the end gaps are apart from a direction parallel to, or traverse to, the piston pin.

c. Install the connecting rod bearing (upper half) to the rod, making sure the tab in the back of the bearing is in the notch of the connecting rod.

d. Turn the crankshaft until the crankpin for the piston and connecting rod to be installed is at the top center.

e. Hold the piston and connecting rod with "FRONT" mark (arrow head) on the top of the piston toward the front (timing gear case side) of the engine.

f. Using a piston guide (commercially available), put the piston and connecting rod into the cylinder from the top of the cylinder block.

⚠ CAUTION: ***Do not use a hammer when installing the piston and connecting rod as this will damage the piston rings and crankpin.***

8. Connecting rod cap installation.

a. Push the piston into position until the big end of the connecting rod is put into position over the crankpin. Then turn the crankshaft 180° while pushing on the top of the piston.

b. Install the lower half of the connecting rod bearing in the connecting rod cap, making sure the tab in the back of the bearing is in the notch of the cap.

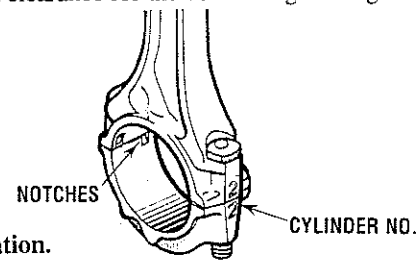
c. Install the bearing cap to the connecting rod.

NOTE: *Make sure the number on the cap is the same as the number on the connecting rod. In case of a new connecting rod having no cylinder number, install the cap to the rod with the notches on the same side.*

d. Tighten the connecting rod cap nuts in steps to the specified torque.

TORQUE: 25.7 ± 2 lb-ft (3.55 ± 0.25 Kgf-m)

e. Check the thrust clearance for the connecting rod big end.



9. Oil screen installation.

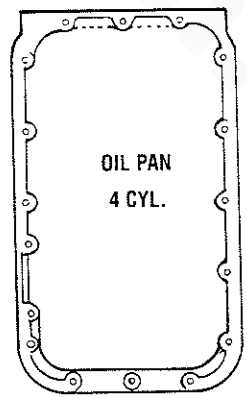
a. Lay the cylinder block with the bottom (oil pan side) up.

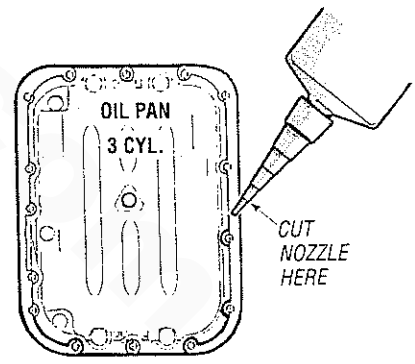
b. Install the oil screen in position.

NOTE: *The oil screen must be installed in position so that it is below the oil level line and away from the oil pan.*

10. Oil pan installation. Clean the mating surfaces of the oil pan and cylinder block and coat them with Hi-Tack Gasker Sealer. Tighten the bolts that hold the oil pan to the cylinder block in a crisscross pattern to the specified torque.

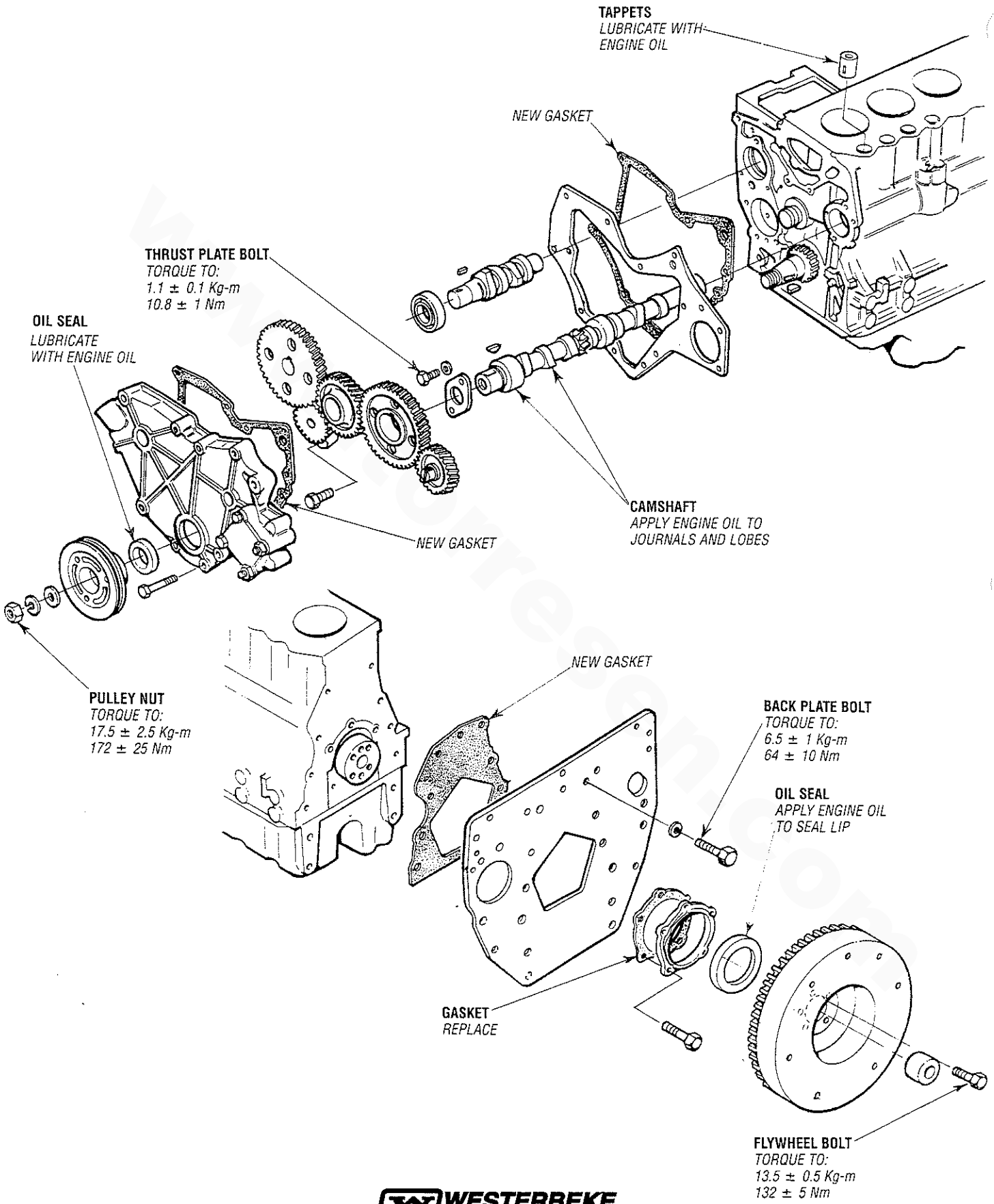
TORQUE: 8.3 ± 1.1 lb-ft (1.15 ± 0.15 Kgf-m)





NOTE: *Squeeze out a 4mm (0.2 in) thick bar of sealing compound* Hi-Tack Gasker sealer *from the tube and put it on the flange of the oil pan as shown. To squeeze out a 4mm (0.2 in) thick bar, cut the nozzle of the tube as shown.*

ASSEMBLY
TIMING GEARS AND FLYWHEEL



ASSEMBLY

11. Front plate installation.

a. Scrape the gasket from the cylinder block and front plate.

b. Coat the gasket contact surface of the cylinder block with adhesive and put a new gasket in position, making sure the holes in the gasket are all in alignment with the holes in the cylinder block.

c. Put the front plate in position. Install four bolts and tighten them.

12. Oil pump installation.

a. Make sure the packing has been put in position on the oil pump.

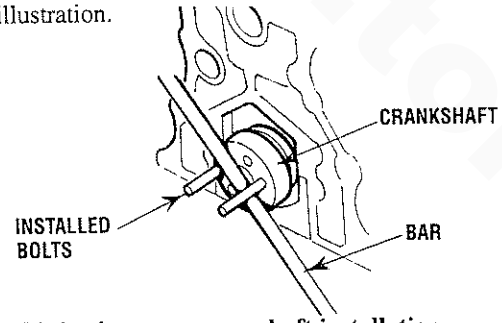
b. Put the oil pump in position on the cylinder block. Install the bolts and tighten them evenly.

c. Make sure the oil pump gear rotates freely.

13. Engine turning.

a. Install two bolts (M12 x 1.25) in the flywheel bolts holes in the crankshaft.

b. Put a bar between the bolts and turn the crankshaft to bring No.1 piston to the top center as shown in the illustration.



14. Fuel injection pump camshaft installation.

a. Put the camshaft (with bearing and gear) in position in the cylinder block.

b. Hit the gear with a plastic hammer to fit the bearing in position.

c. Make sure the camshaft rotates freely.

d. Tighten the stopper bolt.

15. Camshaft installation.

a. Lubricate the lobes and journals with engine oil.

b. Put the camshaft (with gear) in position in the cylinder block.

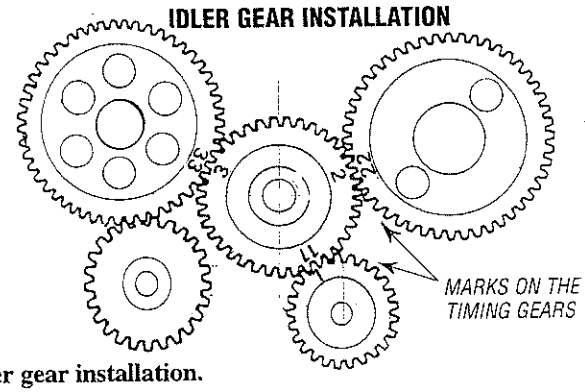
> ⚠ **CAUTION:** ***Do not cause damage to the lobes and journals when the camshaft is installed.***

c. Tighten the bolts that hold the thrust plate to the specified torque.

TORQUE: 8 ± 0.7 lb-ft (1.1 ± 0.1 Kgf-m)

d. Make sure the camshaft rotates freely, Check the end play for the camshaft.

IDLER GEAR INSTALLATION



16. Idler gear installation.

a. Lubricate the idler gear with engine oil.

b. Install the idler gear in position with its "3", "2" and "11" marks in alignment with the the "33" mark on the fuel injection pump camshaft gear, the "22" mark on the camshaft gear and the "1" mark on the crankshaft gear respectively.

c. Check the backlash of the gears. Make reference to *Timing gear backlash measurement.*

17. Timing gear case installation.

a. Coat the gasket with adhesive and put it in position on the front plate.

b. Lubricate the oil seal with engine oil.

c. Tighten the bolts that hold the timing gear case.

18. Crankshaft pulley nut tightening.

a. Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft and hold the crankshaft.

b. Tighten the crankshaft pulley nut to the specified torque.

TORQUE: 127 ± 18 lb-ft (17.5 ± 2.5 Kgf-m)

> ⚠ **WARNING:** ***Check the strength of the bolts and bar used for holding the crankshaft.***

19. P.T.O. gear installation. Install the P.T.O. gear in position in the timing gear case with the side that has no oil hole toward the rear of the engine.

20. Tappet installation. Lubricate the tappets with engine oil and put them in position in the cylinder block.

21. Oil seal case installation.

a. Put a new gasket in position on the oil seal case.

b. Lubricate the oil seal with engine oil and install the oil seal in position in the cylinder block.

22. Rear plate installation.

a. Put a new gasket in position on the rear plate.

b. Put the rear plate in position on the cylinder block with its dowel holes in alignment with the dowels. Tighten the bolts that hold the rear plate to the specified torque.

TORQUE: 47 ± 7 lb-ft (6.5 ± 1 Kgf-m)

NOTE: *Install the starter to the rear plate before installing the plate to the cylinder block for convenience of rear plate installation.*

ASSEMBLY

23. Flywheel installation.

a. Install a safety bar (M12x 1.25) in the rear end of the crankshaft.

b. Put the flywheel in position in alignment with the safety bar.

c. Install three of four bolts in the flywheel and tighten them finger tight only.

d. Remove the safety bar. Install the last bolt in the fly wheel and tighten it finger tight only.

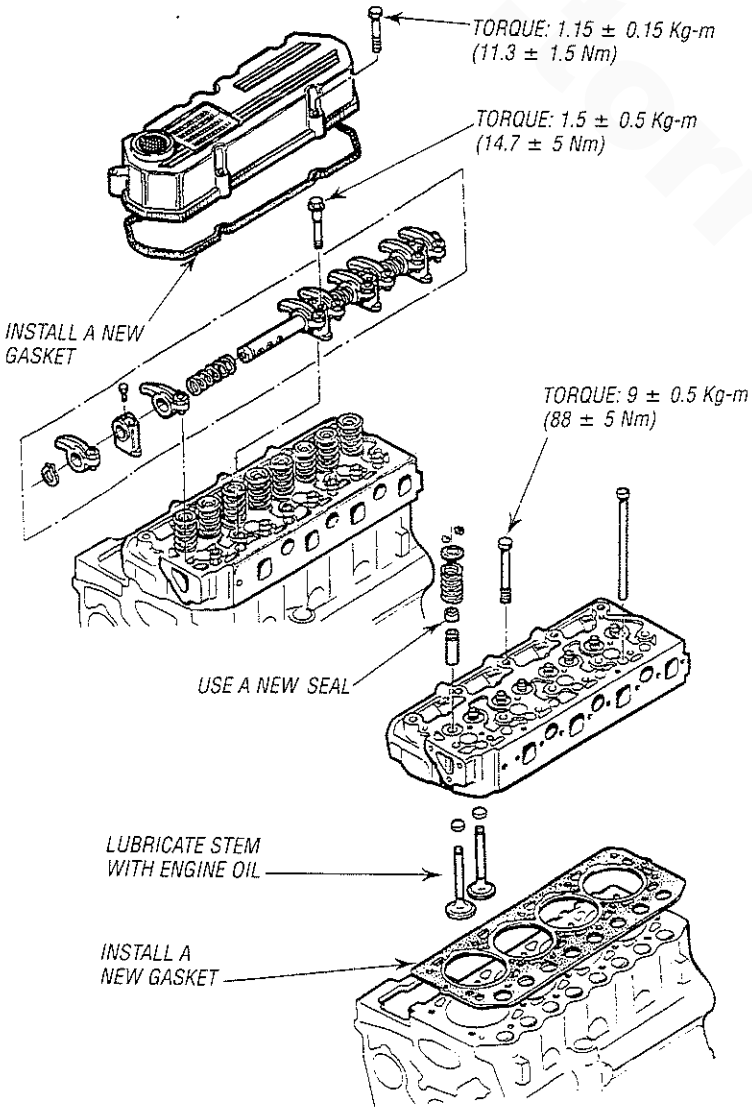
e. Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.

f. Tighten the four bolts that hold the flywheel to the specified torque.

TORQUE: 98 ± 4 lb-ft (13.5 ± 0.5 Kgf-m)

> **⚠ WARNING:** ***Always signal to each other to prevent possible personal injury.***

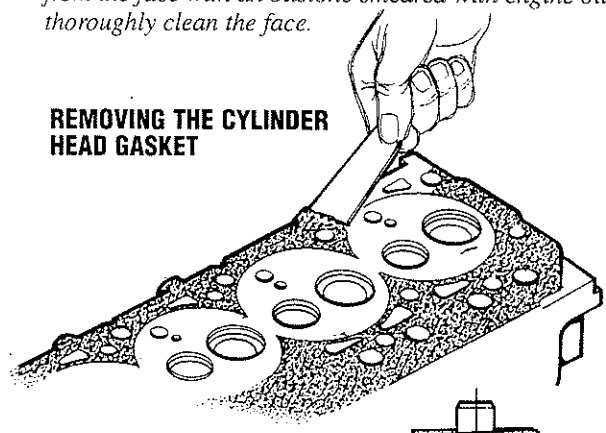
CYLINDER HEAD AND VALVE MECHANISM



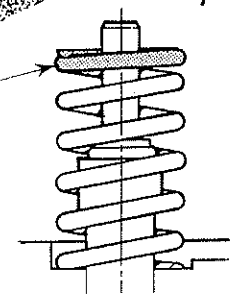
24. Cylinder head bottom face cleaning. Scrape the gasket from the bottom face of the cylinder head.

NOTE: *After scraping the gasket, rub off gasket remnants from the face with an oilstone smeared with engine oil and thoroughly clean the face.*

REMOVING THE CYLINDER HEAD GASKET



INSTALLING THE VALVE SPRING



25. Valve stem seal installation. Install the valve stem seal in position in the valve guide. After installation, make sure the seal is in its correct position.

NOTE: *Improper stem seal installation can cause a failure to seal against downward flow of oil along the stem.*

26. Install the valve spring with the white enameled end up.

27. Valve block installation. Put compression on the valve spring with a valve lifter and install the block in position on the valve top.

> **⚠ CAUTION:** ***Do not put excessive compression on the valve spring. This can cause the retainer to hit and damage the stem seal.***

28. Cylinder head gasket installation.

a. Thoroughly clean the top faces of the cylinder block and pistons,

b. Install two guide bolts (M10 x 1.25) in the bolt holes in the cylinder block.

c. Put a new cylinder head gasket in position on the cylinder block, making sure the guide bolts are all in alignment with their respective holes in the gasket..

> **⚠ CAUTION:** ***Do not use any gasket adhesive or other substances on the top face of the cylinder block.***

ASSEMBLY

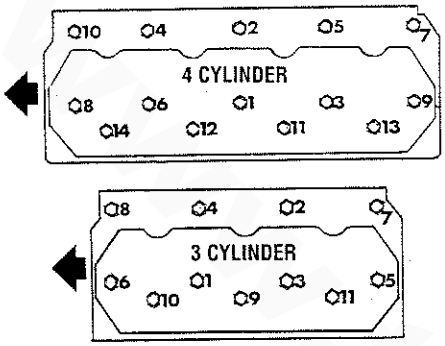
29. Installation of the cylinder head. Place the cylinder head in position on the cylinder block, making sure the guide bolts are all in alignment with their respective bolt holes in the head.

30. Cylinder head bolt tightening

a. Remove the guide bolts and install the bolts that hold the cylinder head to the cylinder block.

b. Tighten the bolts in number sequence in two or three steps to the specified torque.

TORQUE: 65 ± 4 lb-ft (9 ± 0.5 Kgf-m)



31. Valve push rod installation.

a. Put the valve push rod into position through the bore in the cylinder head.

b. Make sure the ball end of the push rod has been put into position over the top of the tappet.

32. Rocker shaft assembly.

a. Install the rocker arms, brackets and springs on the rocker shaft. Secure the brackets to the shaft by tightening the bolts.

b. Make sure the rocker arms move freely.

33. Rocker shaft assembly installation.

a. Install the valve caps in position on the top of the valves.

b. Put the rocker shaft assembly in position on the cylinder head. Tighten the bolts that hold the rocker shaft assembly to the specified torque.

TORQUE: 11 ± 4 lb-ft (1.5 ± 0.5 Kgf-m)

c. Adjust the valve clearance, see *VALVE CLEARANCE* in this manual.

34. Rocker cover installation.

a. Make sure the gasket is assembled to the rocker cover,

b. Tighten the bolts that hold the rocker cover to the specified torque.

TORQUE: 8.3 ± 1.1 lb-ft (11.5 ± 0.15 Kgf-m)

35. Tighten the bolts that hold the air intake to the specified torque.

TORQUE: 13.4 ± 2.5 lb-ft (1.85 ± 0.35 Kgf-m)

36. Tighten the bolts that hold the exhaust manifold to the specified torque.

TORQUE: 13.4 ± 2.5 lb-ft (1.85 ± 0.35 Kgf-m)

37. Fuel injection nozzle installation.

a. Put the gasket on the nozzle.

b. Put the nozzle assembly in position in the cylinder head and tighten it to the specified torque.

TORQUE: 40 ± 4 lb-ft (5.5 ± 0.5 Kgf-m)

38. Put the fuel injection pump in position on the cylinder block and tighten the bolts that hold the pump to the specified torque.

39. Put the flywheel assembly in position on the rear end of the fuel injection pump camshaft and tighten the sliding sleeve shaft to the specified torque.

TORQUE: 26 ± 4.3 lb-ft (3.6 ± 0.6 Kgf-m)

40. Install the sliding sleeve on the sliding sleeve shaft and make sure the sleeve moves freely.

41. Fuel injection nozzle installation.

a. Install the governor assembly in position while putting the tie rod and spring into position in the injection pump.

b. Install the tie rod to the pin of the control rack and secure it with the tie rod spring.

c. Install the tie rod cover in position.

42. Fuel injection line installation.

a. Put the fuel leak-off in position and connect it to the fuel injection nozzles.

b. Put the fuel injection lines in position and connect them to the fuel injection pump. Install the clamps.

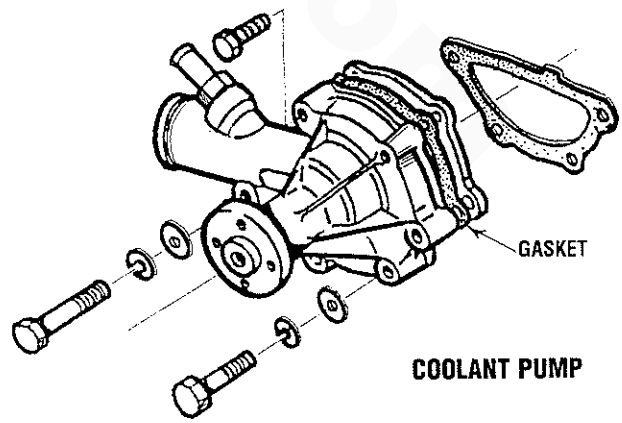
43. Pressure relief valve installation. Put the relief valve in position on the cylinder block and tighten it to the specified torque.

TORQUE: 36 ± 4 lb-ft (5 ± 0.5 Kgf-m)

44. Install the oil filter. Lightly lubricate the gasket with engine oil and install the new filter element by hand. When the gasket contacts the base, tighten one more turn.

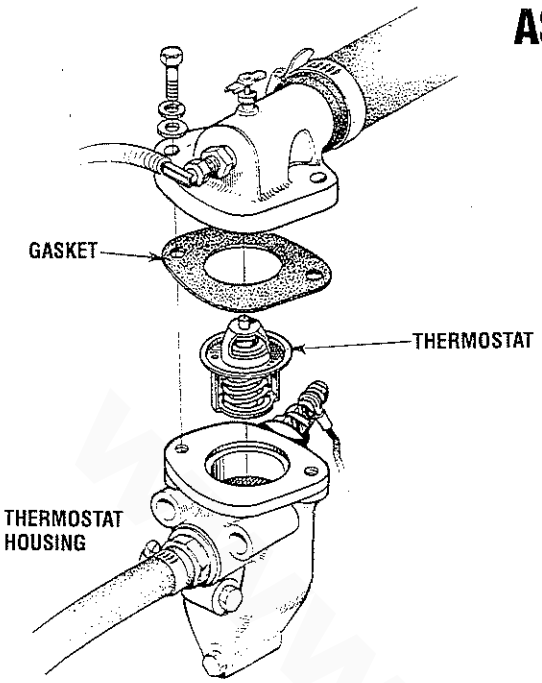
45. Coolant pump. Check the impeller and shaft for rotation. If they do not rotate freely or have noise, replace the coolant pump assembly.

46. Put a new gasket in position on the water pump flange. Install the water pump onto the cylinder block.



COOLANT PUMP

ASSEMBLY

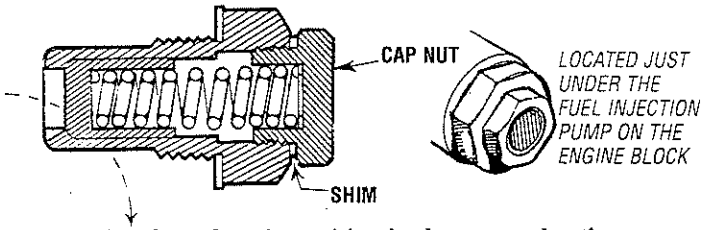


47. **Install the thermostat.** Put the thermostat in the thermostat housing with a new gasket and install the thermostat housing in position on the cylinder head.

48. **Oil pump. Visually check the pump for rough rotation or other defects.** Replace the pump assembly if defective.

49. **Oil pressure relief valve.** Check the valve seat for contact and check the spring for damage. Measure the oil pressure at which the relief valve opens (the oil pressure with the engine running at the rated rpm). If the pressure is not correct, remove the cap nut and increase or decrease the amount of shims. The engine oil pressure tap is located on the right side of the engine.

RELIEF VALVE OPENING PRESSURE: 50 ± 7 psi (3.5 ± 0.5 Kgf-m)



50. **Install the glow plugs in position in the precombustion chamber and tighten them to the specified torque. For testing, refer to *GLOW PLUGS* in this manual.**

TORQUE: 12.7 ± 1.8 psi (1.75 ± 0.25 Kgf-m)

51. **Alternator installation.**

a. Put the alternator in position. Install the adjusting bolt in position to hold the alternator in position.

b. Put the belt in position on the pulley. Move the alternator away from the engine to make an adjustment to the belt.

c. Tighten the bolts.

d. Make sure the tension of the belt is correct, about 1/2"deflection at the center with pressure.

52. **Fuel run solenoid installation [if applicable].**

a. Remove the tie rod cover.

b. Coat the threads of the stop solenoid with thread sealant (Three Bond 1212). Coat the length of the threads to be turned in the governor case.

c. Temporarily install the shutoff solenoid and nut in the governor case.

d. Move the injection pump control rack all the way to the non-injection (shutoff) position.

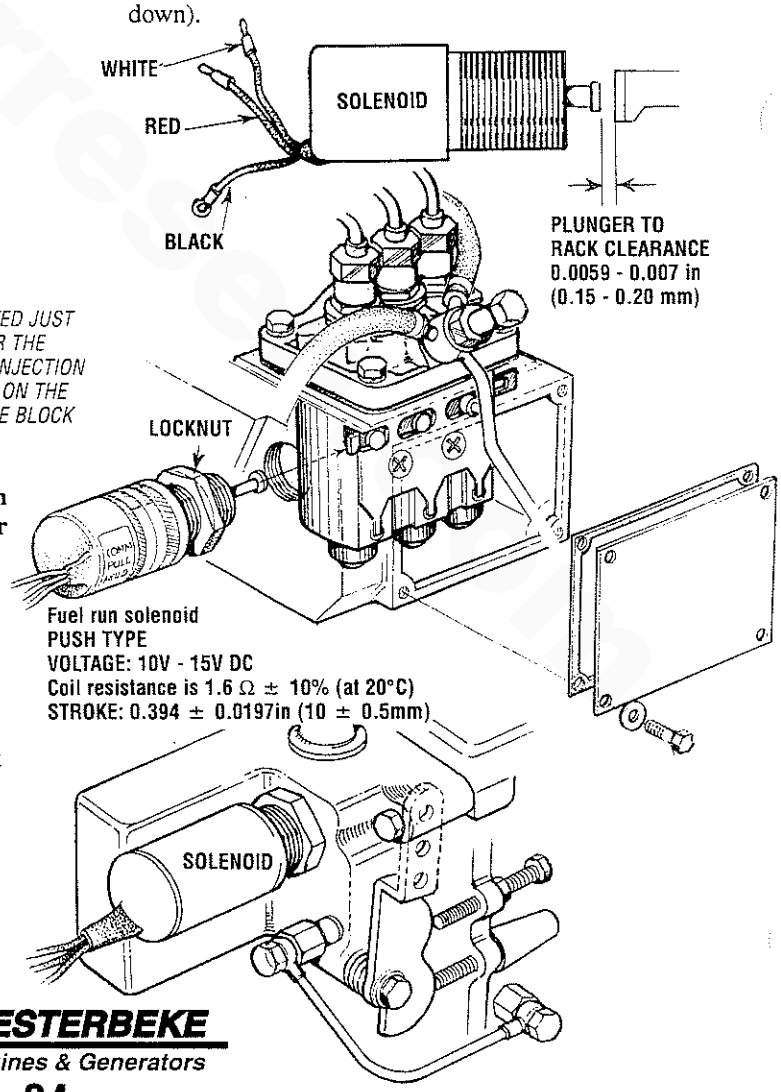
e. Turn the shutoff solenoid in the governor case while pushing the plunger toward the control rack until the shaft is in touch with the tie rod. At this time, clearance C must be 0 mm. (Under this condition, the plunger will be rotated by the shutoff solenoid being turned in).

f. Back off the shutoff solenoid 30° to 45° turn (the clearance between the control rack and plunger will be 0.15 to 0.20 mm (0.0059 to 0.0079in) and tighten the nut to the specified torque.

g. Start the engine and make sure the engine stops when the plunger is pushed all the way.

h. Stop the engine and make certain the engine stops when the start key is turned to the off position.

i. Install the rubber cap in position with the arrow head toward up (with the side that has a water drain hole down).



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. 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.

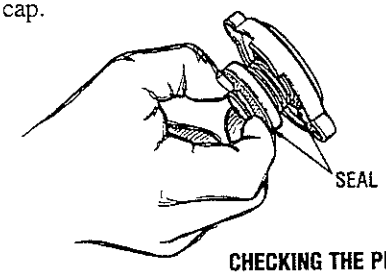
   Manifold Mounting Bolts Torque Values 20 - 24 ft-lb (2.7 - 3.3 m-kg)

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.

      Manifold Mounting Bolts Torque Values 20 - 24 ft-lb (2.7 - 3.3 m-kg)

   c. Reinstall the exhaust connections and plugs into the manifold using Loctite-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

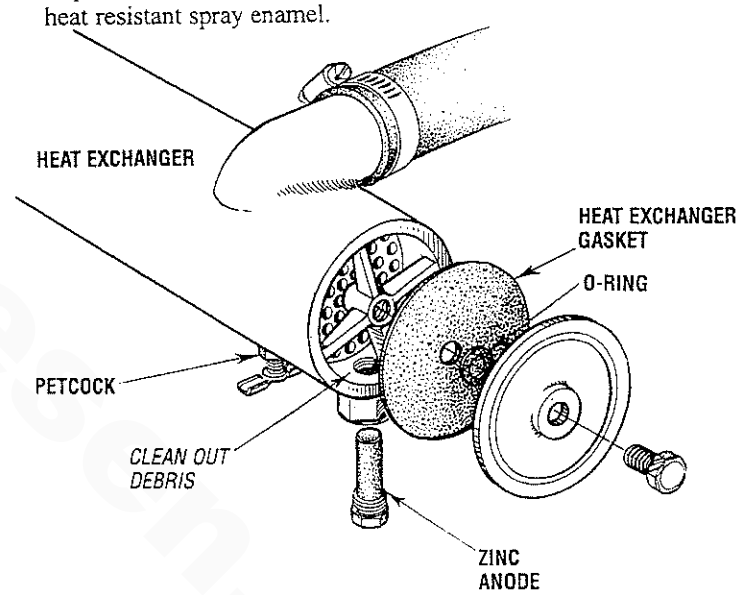
HEAT EXCHANGER

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

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

FUEL INJECTION PUMP

NOTE: *Injector pump servicing should be performed by a qualified injector shop.*

Disassembly Procedure

1. **Tappet removal.**
   - **a.** Hold the injection pump in a vise with the side that has the tappets up.
   - **b.** Straighten the lock plate away from the tappet guide pin with a screwdriver.
   - **c.** Rotate the tappet guide pin 180° to unlock it from the housing.
   - **d.** Remove the tappet guide pin with a needle-nose pliers while pushing down on the tappet. Remove the tappet.
   - **e.** Do Steps (b) through (d) again for the remainder of the tappets.

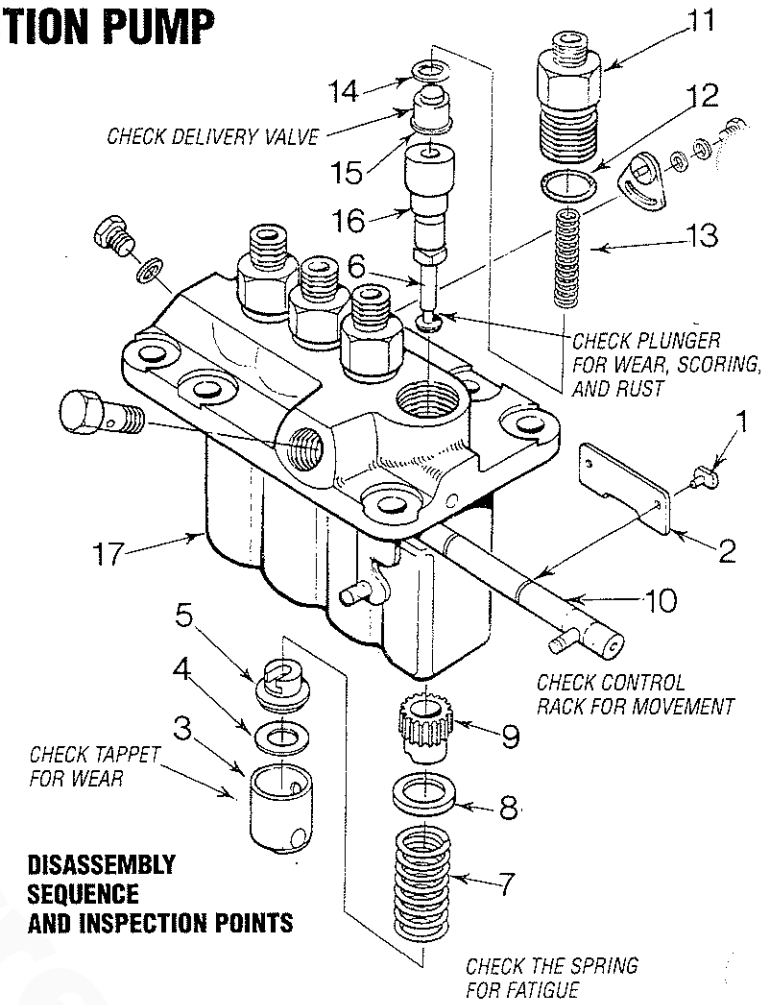
> ⚠ **CAUTION:** ***The tappet can be thrown from the housing when the tappet guide pin is removed. Hold the tappet to prevent it from falling.***

2. **Plunger removal.**
   - **a.** Remove the tappet adjusting shim.
   - **b.** Remove the lower spring seat and plunger with a tweezers.
   - **c.** Remove the plunger spring.
   - **d.** Remove the upper spring seat and control sleeve.
   - **e.** Do Steps (b) through (d) again for the remainder of the plungers.
   - **f.** Remove the control rack.
3. **Delivery valve removal.**
   - **a.** Turn the injection pump upside down and hold it in a vise.
   - **b.** Remove the delivery valve holder.
   - **c.** Remove the delivery valve spring.
   - **d.** Remove the delivery valve gasket.
   - **e.** Remove the delivery valve with a tweezers.
   - **f.** Do Steps (b) through (e) again for the remainder of the delivery valves.
   - **g.** Remove the barrels from the housing.

NOTE: *When replacing the plungers and barrels or delivery valves, do not loosen the adjusting plates between the pumping elements.*

After these parts have been replaced, the injection quantity must be measured. A Pump Tester Cam Box is needed for the measurement of the injection quantity.

Keep the disassembled injection pump parts in clean diesel fuel.



DISASSEMBLY SEQUENCE AND INSPECTION POINTS

> ⚠ **CAUTION:** ***The delivery valves, plungers and barrels are finely finished parts. Keep them as clean as possible.***
>
> ***Keep the plungers with their respective barrels for installation. Do not use plungers or barrels with other barrels or plungers.***

Assembly procedure

1. Put each barrel in position in the housing with its slot in alignment with the dowel of the housing and put it straight down into the bore.

NOTE: *If the slot in the barrel is not aligned with the dowel of the housing, the O-ring will not seat correctly (still visible) after the delivery valve holder has been installed.*

2. Install the delivery valve, gasket, spring and O-ring on the barrel and tighten the delivery valve holder finger tight. Do this step for the remainder of the delivery valves.

> ⚠ **CAUTION:** ***Anytime the injection pump is disassembled, a new O-ring must be installed.***
>
> ***Make sure the threads of the delivery valve holder do not cause damage to the O-rings.***

3. Install each control sleeve with the center tooth in alignment with the line mark of the control rack. Put the plungers in position in the barrels.

> ⚠ **CAUTION:** ***Make sure the notch in the plunger is toward the adjusting plate***

4. **Tappet installation.** Move the control rack back and forth while pushing down on each tappet to align the slot in the tappet with the hole in the housing for the tappet guide pin. Install the lock plates and tappet guide pins in position.

> ⚠ **CAUTION:** ***Anytime the injection pump is disassembled, new lock plates must be used.***

5. **Put the delivery valve holders in position and tighten them to the specified torque.**

> ⚠ **CAUTION:** ***Do not overtighten the delivery valve holders. This can put end force on the barrels, resulting in a failure of the plungers to move freely. If the holders are not tightened to the specified torque, engine oil would leak in the injection pump.***

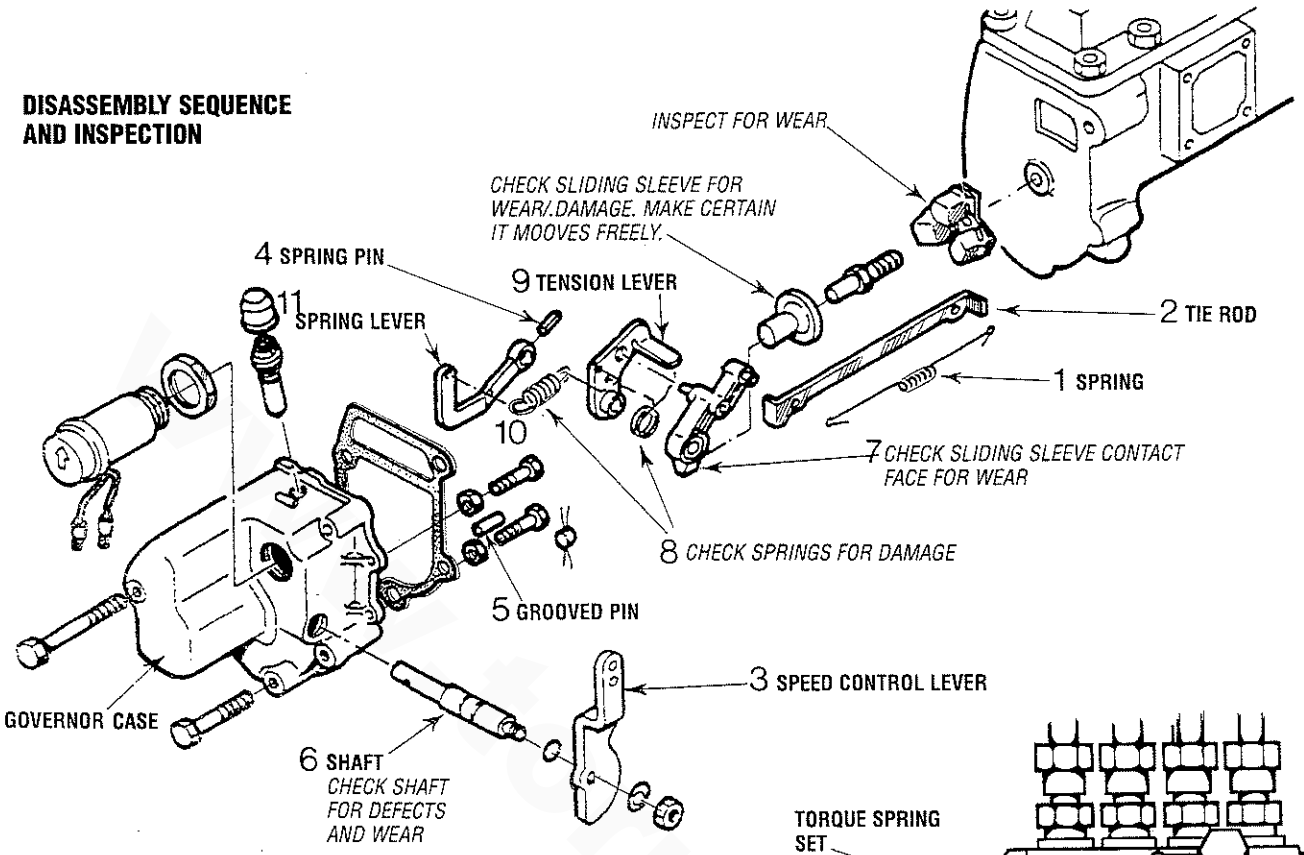
DELIVERY VALVE HOLDER TORQUE 4.5 ± 0.5 Kg-m (44 ± 5 Nm)

6. **Inspection after assembly.**
   - **a.** After the injection pump has been assembled, check to see if the control rack moves freely without any binding or catching.
   - **b.** If the control rack fails to move freely, the possible causes are:
     - ■ Pumping element(s) sticking.
     - ■ Foreign particles lodged between control rack and sleeves.
     - ■ Overtightening of delivery valve holder(s).

     Disassemble and check the injection pump to locate the cause of the trouble.
   - **c.** After the injection pump has been finally assembled, check the injection timing.

GOVERNOR

DISASSEMBLY SEQUENCE AND INSPECTION



1. Assembly.

a. Install the levers in position.

b. Put the O-ring on the governor shaft.

c. Put the governor shaft in position in the governor case and put the levers on the governor shaft.

d. Install the grooved pin and spring pin in position with a hammer.

e. Install the tie rod and tie rod spring in position.

2. Torque spring set installation.

The torque spring set is to be installed and adjusted after an adjustment is made to the low idle speed and high idle speed, with the engine at a standstill.

a. Remove the tie rod cover.

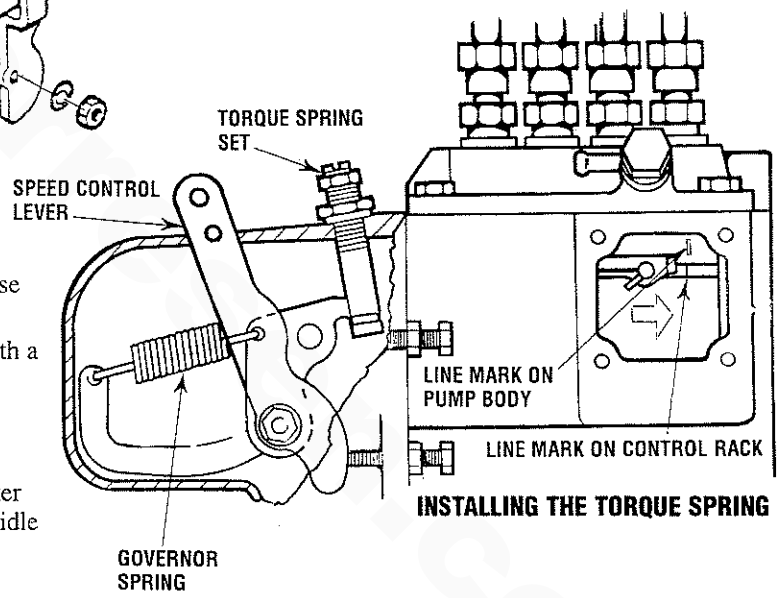
b. Move the speed control lever to the high idle position and hold it there.

c. Pull the tie rod in the direction of arrow head to the point where a slight resistance is encountered. In this position, the tie rod does not pull on the governor spring.

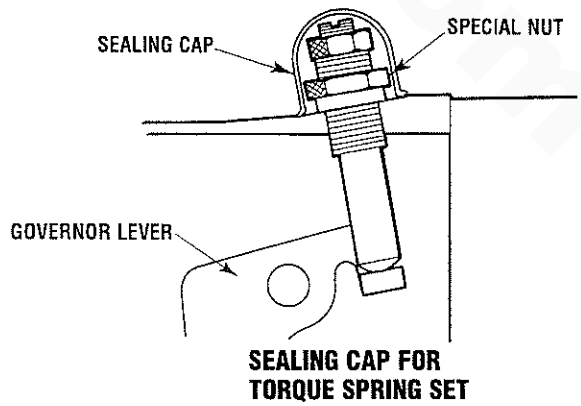
d. Turn in the torque spring set while lightly pulling the tie rod until the line mark on the control rack is aligned with the line mark on the pump body.

e. With these line marks aligned, lock the torque spring set in position by tightening the special nut.

f. Install the sealing cap over the torque spring set and stake the cap in position.



INSTALLING THE TORQUE SPRING



SEALING CAP FOR TORQUE SPRING SET

FUEL INJECTION TIMING

Preparation

a. Close the fuel shut-off valve.

b. Disconnect the No.1 fuel injection pipe from the cylinder head and injection pump.

c. Remove No.1 delivery valve holder from the injection pump. Remove the delivery valve and spring from the holder. Restore the delivery valve holder only to the injection pump.

d. Connect the fuel injection pipe to the injection pump.

e. Hold the speed control lever in the low speed position. (Generator) remove the fuel shut-off solenoid.

Inspection [fuel flow method]

a. Open the fuel shut-off valve. Turn the *key switch* to the ON position and press preheat.

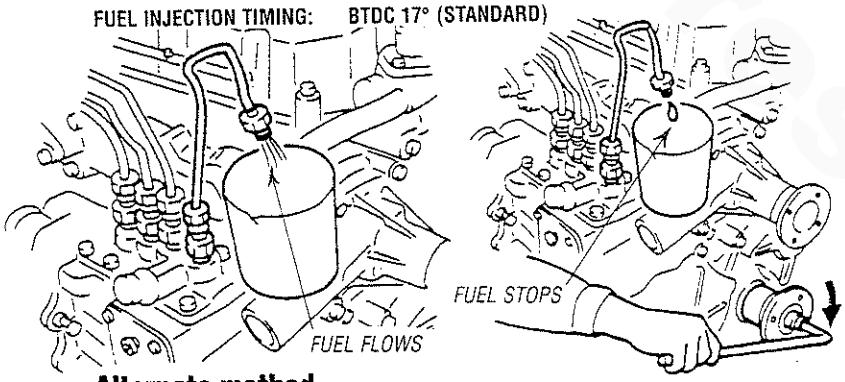
NOTE: *Fuel will come from the injection pipe with high pressure when the starter switch key is turned to ON position if the engine is equipped with an electric fuel pump. Direct fuel flow into the container.*

b. Slowly turn the crankshaft clockwise, looking at the open end of the injection pipe. The instant fuel stops coming out is the fuel injection timing.

NOTE: *Turn the crankshaft in reverse direction just a little and do step b again to verify the injection timing.*

c. The fuel injection timing is correct if the IT mark on the crankshaft pulley is aligned with the mark on the timing gear case when fuel stops from the injection pipe.

FUEL INJECTION TIMING: BTDC 17° (STANDARD)



Alternate method

In the fuel flow method, the delivery valve has to be removed. As a result, there is a good chance for dirt particles to get inside the fuel injection pump. In this alternate method, however, it is not necessary to remove the delivery valve.

a. Disconnect No.1 fuel injection pipe at the fuel injection nozzle (cylinder head).

b. Prime the fuel system.

c. Slowly turn the crankshaft clockwise until fuel just swells at the free end of the injection pipe and, at that instant, check the position of the IT mark with respect to the mark on the gear case. This timing is approximately 1° retarded. Take this 1° retardation into account when making a shim adjustment.

Adjustment

a. If the fuel injection timing is incorrect, change the thickness of shims under the fuel injection pump. An increase or decrease of the shims by 0.1mm (0.004 in) will vary the timing by 1°.

b. Increase the thickness of the shims to retard the timing or decrease it to advance the timing.

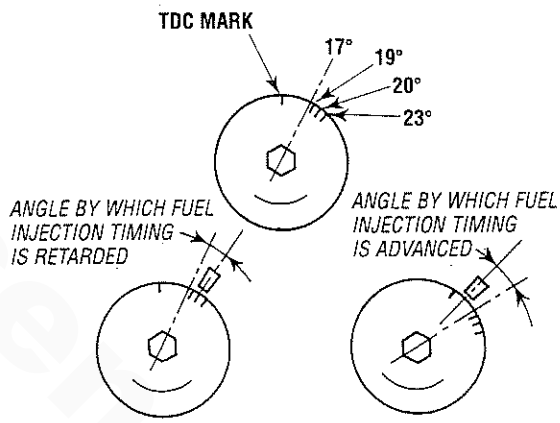
ADJUSTMENT RANGE: **STANDARD ± 1.5°**

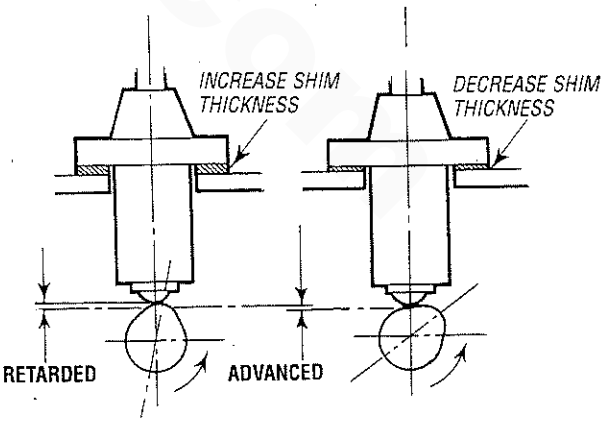
Four kinds of shims are available in thicknesses 0.2mmm (0.0079 in), 0.3mm (0.0118 in), 0.4mm (0.0157 in) and 0.8mm (0.0315 in). These shims have no identification, measure the thickness of each shim with calipers before using it.

> ⚠ **CAUTION:** ***Apply sealant to both faces of each shim to prevent oil leaks.***

c. After the timing has been adjusted, make sure it is correct.

d. Close the fuel filter valve and restore the delivery valve and injection pipe to the original state.





FUEL INJECTORS

REMOVING THE INJECTORS

NOTE: *Injector must be serviced in a "clean room" environment.*

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 sealing washers and banjo bolt that attaches the fuel return line to each injector.
3. Unscrew the injector from the cylinder head using a suitable deep socket.

   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 the socket wrench to free it and then lift it out.*

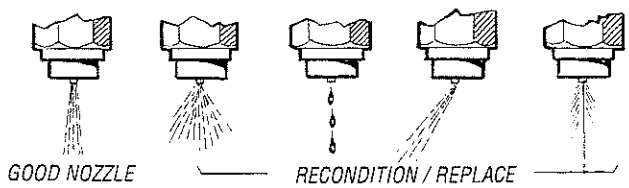
4. The injector seats in the cylinder head on a copper sealing washer. This washer should be removed with the injector and replaced with a new washer when the injector is reinstalled.

   NOTE: *Greatest possible care should be taken in handling the nozzles as they are precisely machined. The nozzle and the needle valve are matched parts. Do not mix their original combinations. Disassemble and wash each nozzle assembly separately.*
   Carbon deposits on the nozzle body must be removed with a piece of hard wood. However, it would be advisable not to clean the surrounding area of the nozzle orifice to avoid possible damage to the orifice.

INJECTION TESTING/ADJUSTMENT

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 discolored, replace it. At the same time, clean or replace the fuel filter.
   b. Mount the nozzle and nozzle holder on the nozzle tester.
   c. 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.

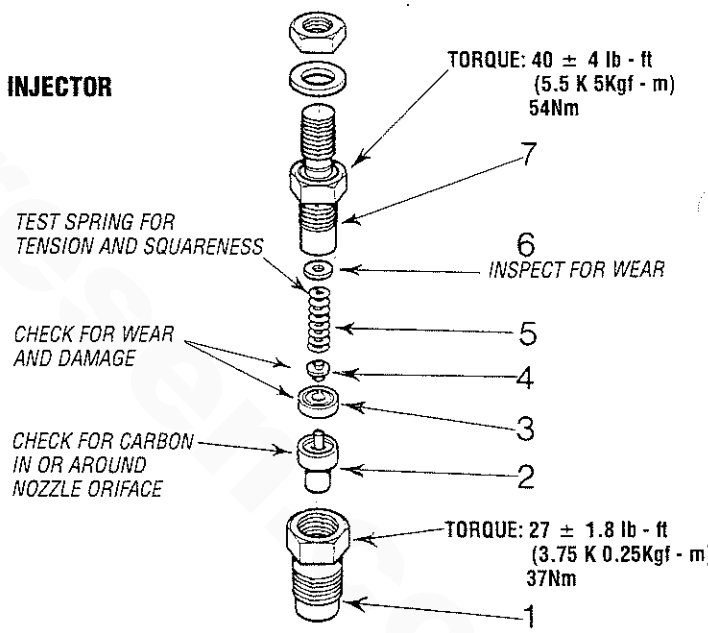
INJECTOR STARTING PRESSURE 1991 $^{+71}$ psi (140 $^{+5}$ kgf-cm)

   d. If the fuel injection starting pressure is not within the specification, it can be adjusted by removing or adding shims in the injector body to achieve proper pressure.

   NOTE: *An increase or decrease of shim thickness by 0.004 in (0.1mm) will vary the injection pressure by 142 psi (10 kgf-cm). Ten shims are available in thickness from 1.25 mm to 170 mm (0.0492 in to 0.0669 in) in increments of 0.0020 in (0.05 mm).*

   e. 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.

NOZZLE BODY TORQUE 27 ± 1.8 lb-ft (3.75 ± 0.25 kgf-m)



DISASSEMBLY AND INSPECTION

1. Clamp the nozzle holder in a vise, remove the nozzle nut and disassemble the nozzle body, spring,and needle.
2. Clean the disassembled parts with clean diesel fuel.

INSTALLING

1. Install in the reverse order of removal.

   NOTE: *The copper washers should not be reused. Replace with new washers.*

2. Tighten the nozzle on the cylinder head to the specified torque.

NOZZLE TORQUE 40 ± 4 lb-ft (5.5 ± 0.5 kgf-m)

GLOW PLUG TESTING

GLOW PLUGS

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

a. 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.

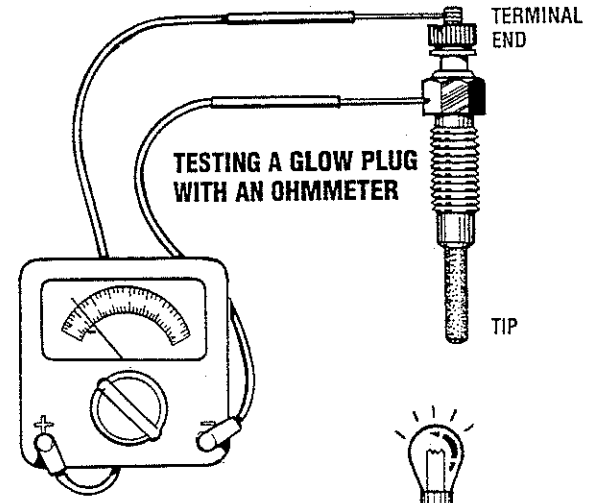
b. An accurate way to test glow plugs is with an ohmmeter. Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 0.4 - 0.6 ohm resistance. This method can be used with the plug in or out of the engine. You can also use an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

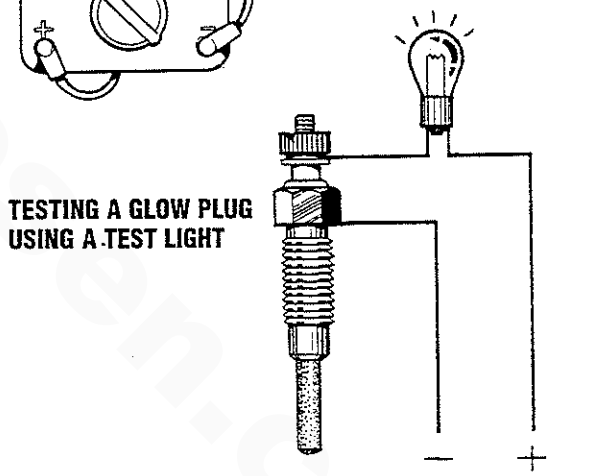
> ⚠ **WARNING:** ***These glow plugs will become very hot to the touch. Be careful not to burn your fingers when testing the plugs.***

c. Re-install the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) within 7 to 15 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 TIGHTENING TORQUE	7 - 11 ft-lb (1.0 - 1.5 m-kg)





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

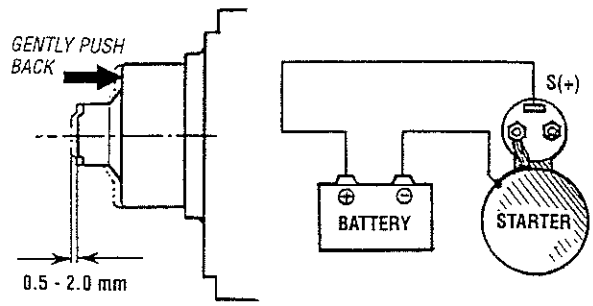
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

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.***

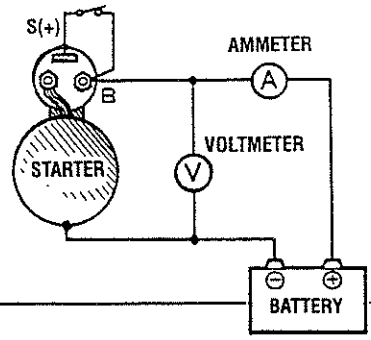
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, 0.0197 - 0.0788in (0.5 to 2.0mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



PINION GAP

No-Load Test

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

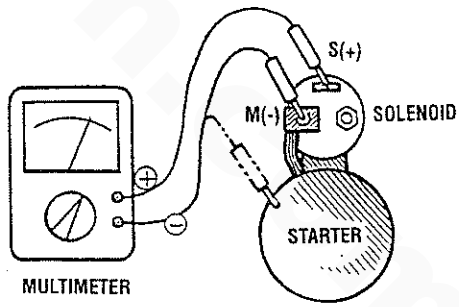


> ⚠ **CAUTION:** ***Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the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

SOLENOID

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

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

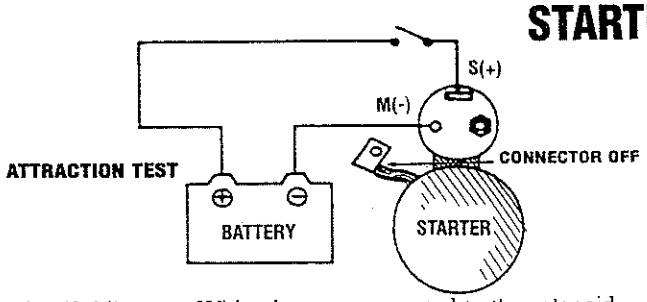


NOTE: *Disconnect the wire from terminal M.*

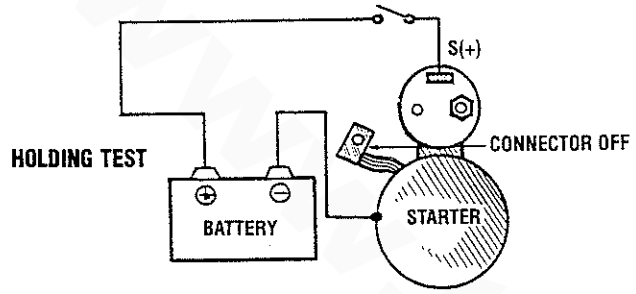
2. Connect a battery to the solenoid's terminal S for (+) and M for (-). Have a switch in the + lead and close it. The pinion drive should extend fully out.

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

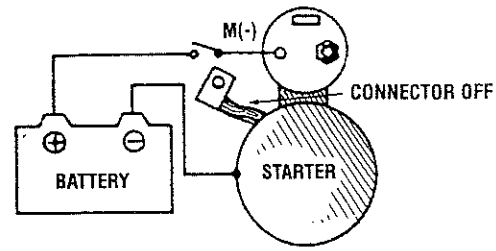
STARTER MOTOR



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



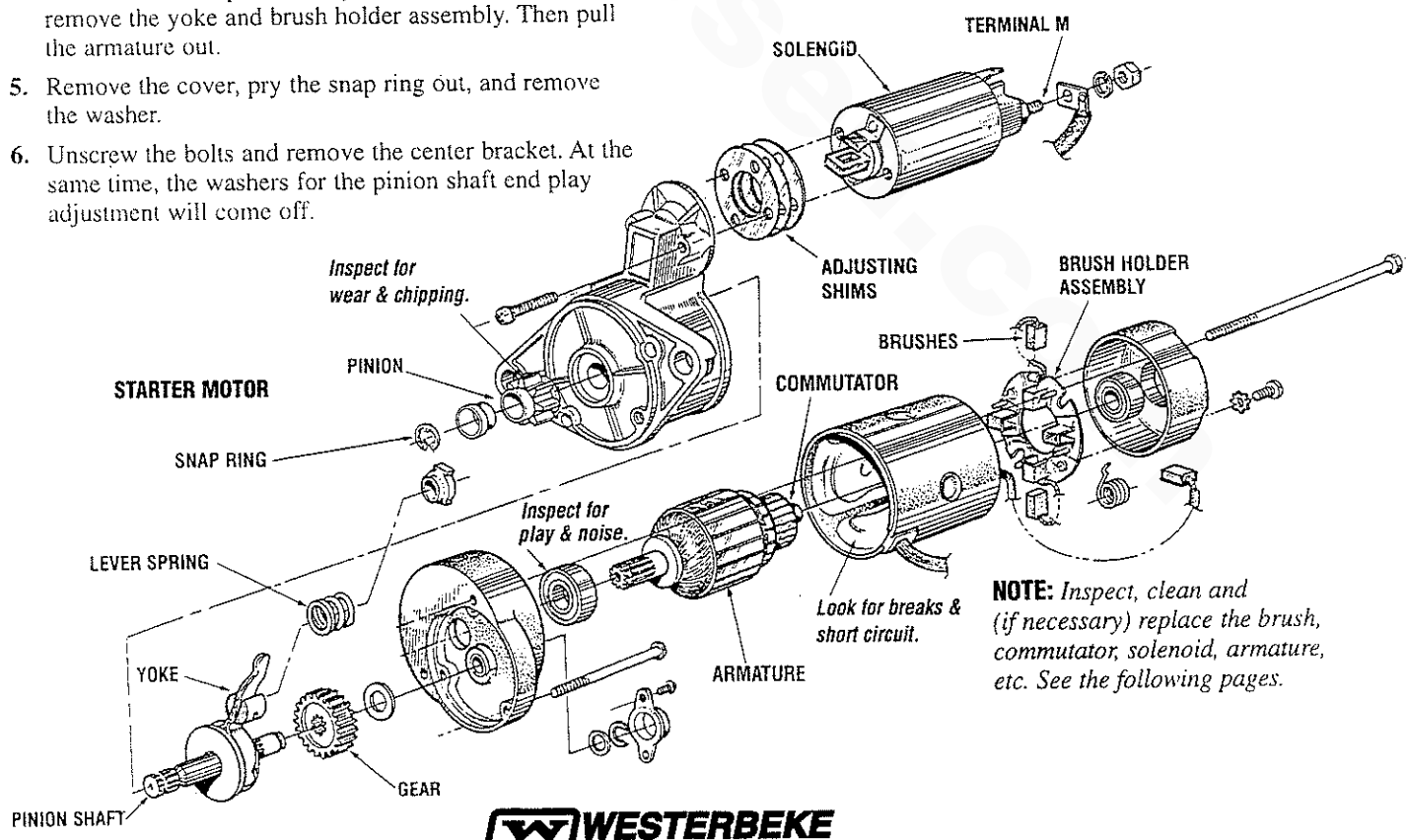
4. *Return test:* With a battery connected to the solenoid terminal M (-) and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.



RETURN TEST

STARTER ASSEMBLY

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.



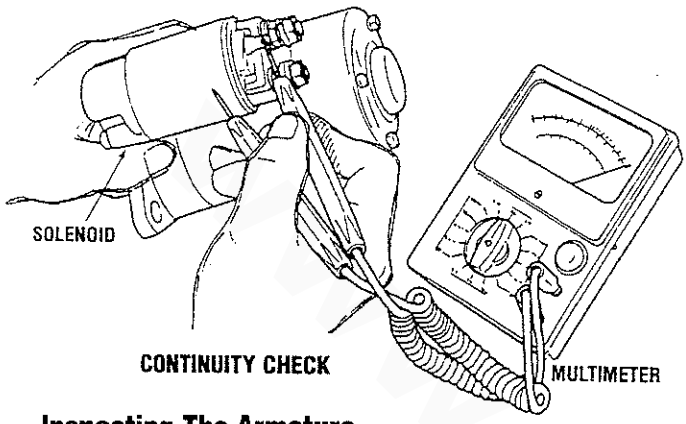
NOTE: *Inspect, clean and (if necessary) replace the brush, commutator, solenoid, armature, etc. See the following pages.*

STARTER MOTOR

STARTER INSPECTION

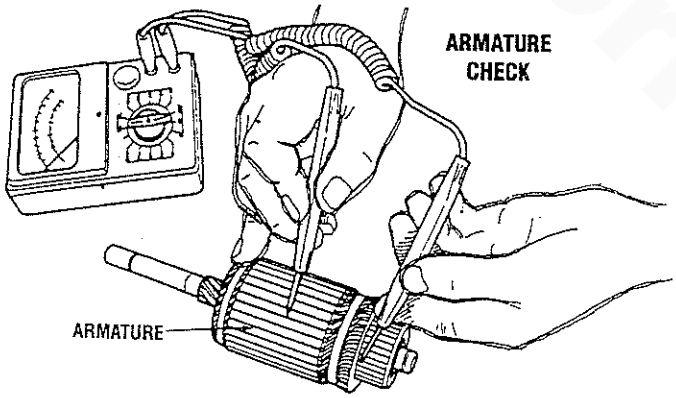
Solenoid

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.

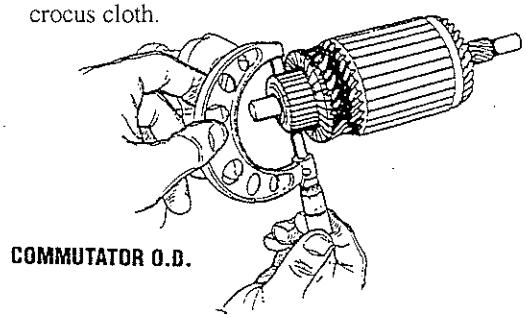


Inspecting The Armature

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

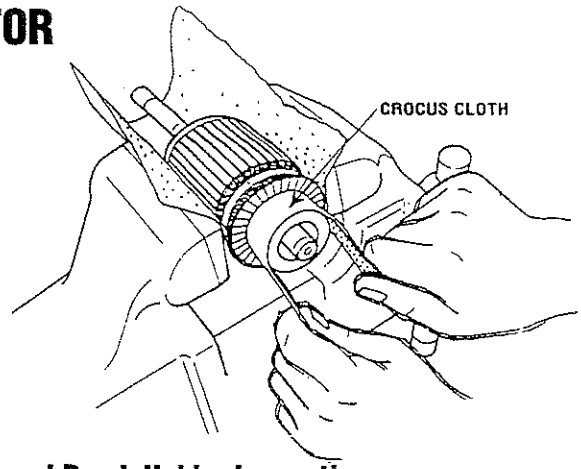


2. Measure the commutator O.D. and the depth of undercut. Repair or replace it if the service limit is exceeded. Also, check the commutator outside surface for dirtiness and roughness. If rough, polish the commutator with fine crocus cloth.



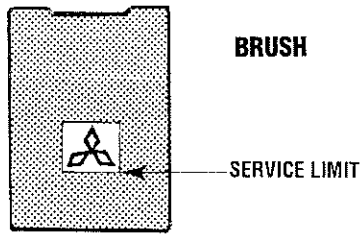
COMMUTATOR OUTSIDE DIAMETER

STANDARD	1.26 in (32 mm)
LIMIT	1.22 in (31 mm)



Brush and Brush Holder Inspection

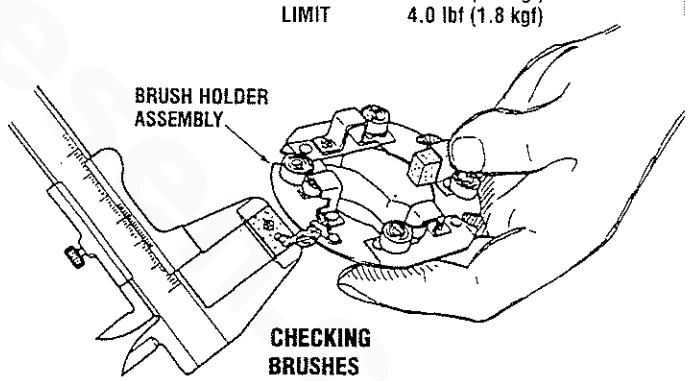
1. Check the brushes. If worn out beyond the service limit, replace the brushes.



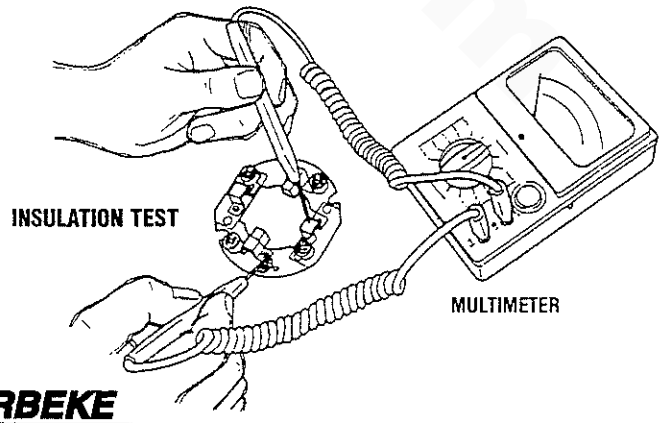
2. Check the brush spring tension. A weak or defective spring will cause excessive brush wear; replace the springs if suspect.

BRUSH HEIGHT

STANDARD	6.6 lbf (3.0 kgf)
LIMIT	4.0 lbf (1.8 kgf)



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.

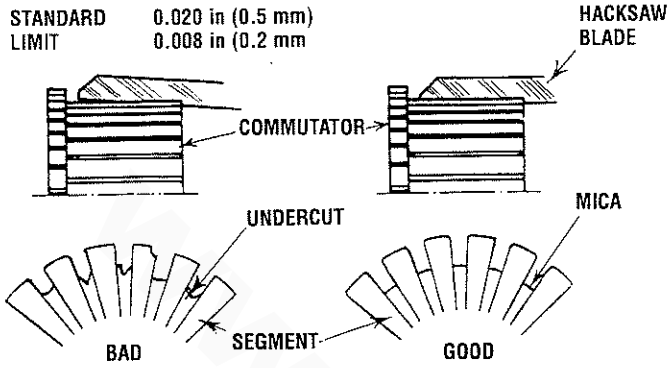


STARTER MOTOR

COMMUTATOR MICA UNDERCUT

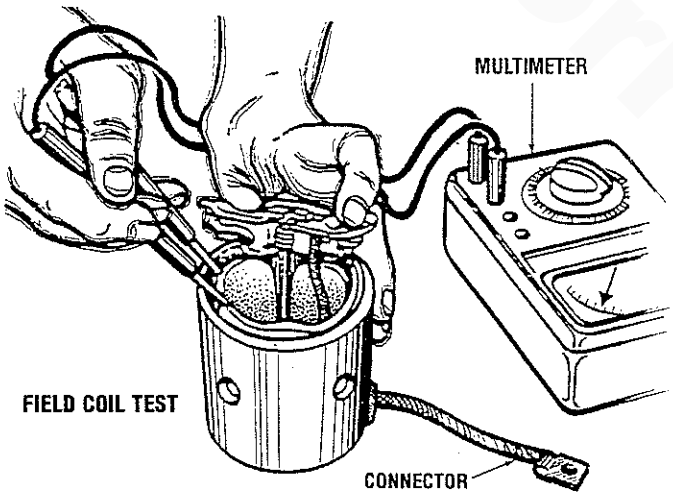
Measure the undercut of mica insulation between the adjacent segments. If undercut exceeds the limit, recondition the mica or replace the armature.

STANDARD	0.020 in (0.5 mm)
LIMIT	0.008 in (0.2 mm



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.

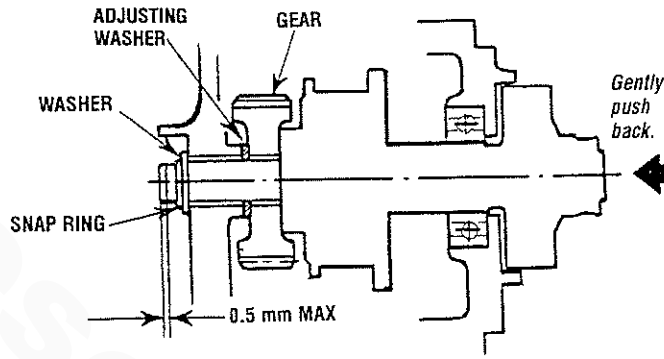


STARTER ADJUSTMENT AND REASSEMBLY

> ⚠ **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 2mm 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 0.5mm, 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.

RAW WATER PUMP

Disassembly

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

1. Remove the six cover plate screws, cover plate, and the cover plate gasket.

   NOTE: *Replacement of the cover plate gasket is recommended; however, if you are going to reuse it, keep the gasket submerged in water until the pump is reassembled. If it's allowed to dry, the gasket will shrink and not be reusable.*
2. Remove the impeller with its drive screw from the pump housing.
3. Remove the screw and sealing washer and remove the cam from the pump housing.
4. Remove the retaining ring.
5. Support the pump housing, at the mounting flange end, on an arbor press, and with a drift, press out the shaft and bearings from the pump housing.
6. With the pump housing supported, push the seals out of the pump housing. Push the impeller side seal out the impeller side, then lift the spacer out. Then push the bearing side seal out the bearing side.
7. Supporting the bearing's inner race, push the shaft out of the bearings.

Inspection

Inspect all parts and replace those showing wear or corrosion.

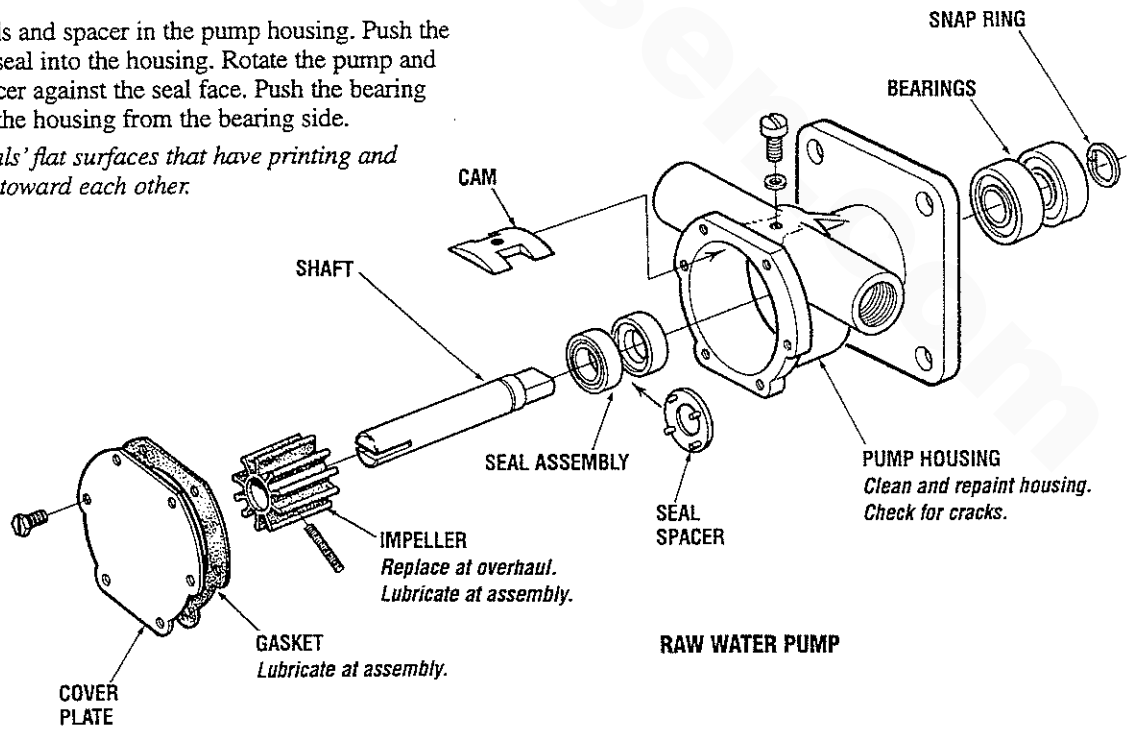
Reassembly

1. Install the seals and spacer in the pump housing. Push the impeller side seal into the housing. Rotate the pump and install the spacer against the seal face. Push the bearing side seal into the housing from the bearing side.

   NOTE: *The seals' flat surfaces that have printing and numbers face toward each other.*
2. Install the shaft into the bearings. Support the bearings at their center races. Push the shaft into the bearings, pushing at the impeller drive slot end using the base of the drive slot. Push the shaft through both of the bearings, flush against each other so the flat-sided end of the shaft extends beyond the second bearing center race 19/32 in (15 mm) ± 1/32 in (.5 mm).
3. Support the pump housing at the impeller side. Apply a small amount of petroleum jelly to the seal's inner lips and to the impeller shaft. Carefully install the shaft, rotating it through the seals until the bearings contact the housing from the bearing end. Use a pushing tool that will push this shaft and the bearing assembly into the pump housing by applying pressure against the outer bearing race. Push the assembly into the housing until the bearings seat fully in the housing. Install the retaining ring.
4. Position the cam in the housing and secure it in place with the screw and sealing washer.

   NOTE: *Use a small amount of Permatex #1 on the inner cam surface and screw threads. Remove any excess from the impeller housing.*
5. Apply a light film of silicone or petroleum jelly to the inner surface of the housing for the impeller.

   NOTE: *Coat only the surface, do not over-apply. Install the impeller with the drive screw. Push the assembly into the housing with the drive screw mating in the slot of the drive shaft.*
6. Install the cover gasket and cover, and secure them with the six cover screws.
7. Reposition and tighten the hose nipples. Assemble the pump to the engine, and attach the hoses.



RAW WATER PUMP

ENGINE ADJUSTMENTS

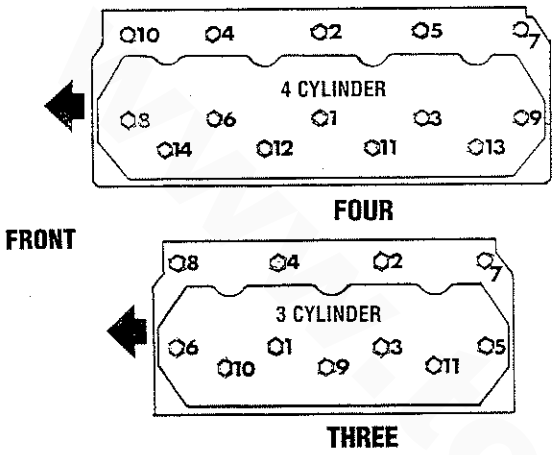
VALVE CLEARANCE ADJUSTMENT

Make the following adjustments when the engine is cold.

a. Remove the cylinder head cover.

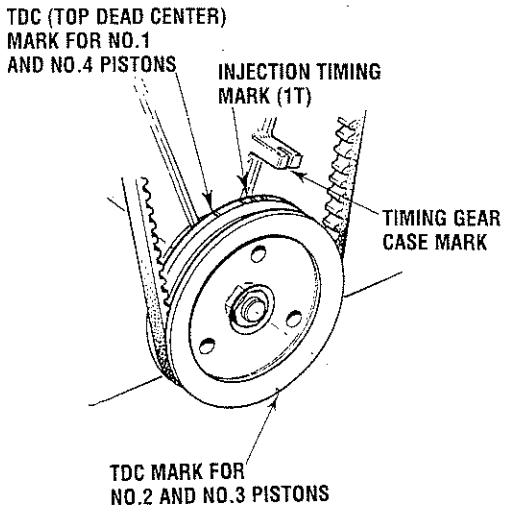
b. Slightly loosen the cylinder head bolts and retighten them to the specified torque in the number sequence shown below.

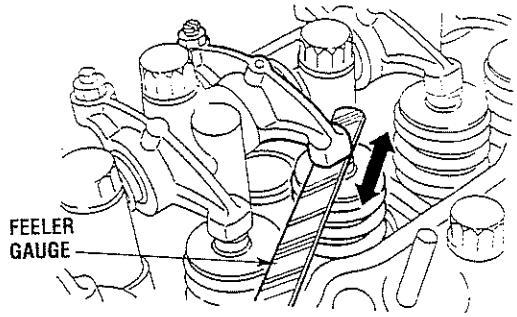
TIGHTENING TORQUE 65 ± 4 lb-ft (88 ± 5 Nm)



c. Find top dead center compression position for No.1 piston by using the procedure that follows:

d. Turn the crankshaft until TDC mark on the crankshaft pulley is aligned with the mark on the timing gear case.

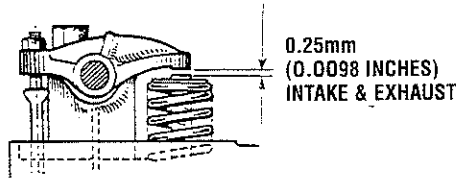




e. With No.1 piston at top dead center on the compression stroke, the rocker arms will not be moved when the crank shaft is turned approximately 20° in both directions.

f. If the rocker arms move, No.1 piston is at top dead center on the intake or exhaust stroke. In such a case, turn the crankshaft 360° in the direction of engine rotation again. No.1 piston is now at top dead center on the compression stroke.

g. Loosen the locknut for the adjusting screw. With a feeler gauge inserted between the rocker arm and valve cap, adjust the valve clearance by turning the adjusting screw. Make certain to adjust all the valves.



h. Hold the adjusting screw and tighten the locknut.

i. After the valve clearance on the valves for No.1 cylinder has been adjusted, turn the crankshaft 180° in the direction of engine rotation and adjust the valve clearance on the valves for the remainder of the cylinders in firing order (injection sequence).

INJECTION SEQUENCE:

3	1-3-2 240° CRANKSHAFT ROTATION
4	1-3-4-2 180° CRANKSHAFT ROTATION

j. After the valve clearance on the valves for all the cylinders have been adjusted, turn the crankshaft two or three times and make certain the clearance is correct.

k. Install the cylinder head cover.

HEAD COVER BOLT TORQUE 2 - 3 ft-lb (0.3 - 0.45 m-kg)

ENGINE ADJUSTMENTS

TESTING ENGINE COMPRESSION

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

a. Warm the engine to normal operating temperature.

b. Move the control lever to a position for shutting off the fuel. (Disconnect the wires if a fuel shutdown solenoid is used).

c. Remove all the glow plugs from the engine and install the compression gauge/adapter combination to the cylinder on which the compression is to be measured.

d. Close the raw water seacock (thru-hull).

e. Crank the engine and allow the gauge to reach a maximum reading, then record that reading.

f. Repeat this process for each cylinder.

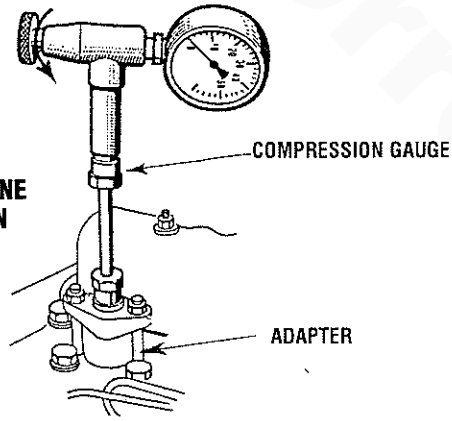
COMPRESSION PRESSURE 427 psi (30 kgf/cm2) at 290 rpm.

MAXIMUM PERMISSIBLE DIFFERENCE BETWEEN CYLINDERS 42.7 psi (3 kgf/cm2)

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

g. Re-install the glow plugs (use anti-seize compound on the threads) and reset the fuel shut-off to the run position.

h. **Open the raw water seacock (thru-hull).**



TESTING ENGINE COMPRESSION

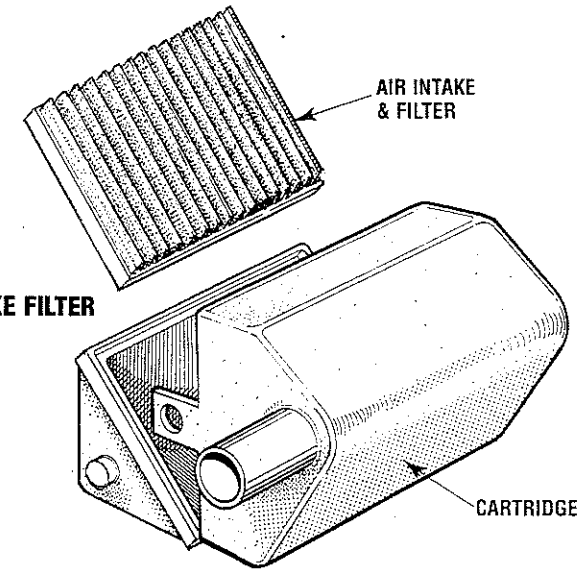
LOW COMPRESSION

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

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

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

AIR INTAKE FILTER/SILENCER



AIR INTAKE FILTER

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

ENGINE ADJUSTMENTS

GENERATOR FREQUENCY ADJUSTMENT (HERTZ)

Once the diesel generator set has been placed in operation, there may be adjustments required for engine speed (Hertz) during the engine's break-in period (first 50 hours) or after this period. A no-load voltage adjustment may also be required in conjunction with the engine's speed adjustment. These are not warrantable adjustments as they relate to normal break-in and maintenance.

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 engine speed *must* be changed. To accomplish the frequency change, perform the following:

1. With the engine stopped, connect the AC output leads to the AC terminal block in accordance with the AC voltage connections diagram specified for your generator set, and change the Hertz circuit connection to the capacitor. These connections are shown in the GENERATOR section of this manual.

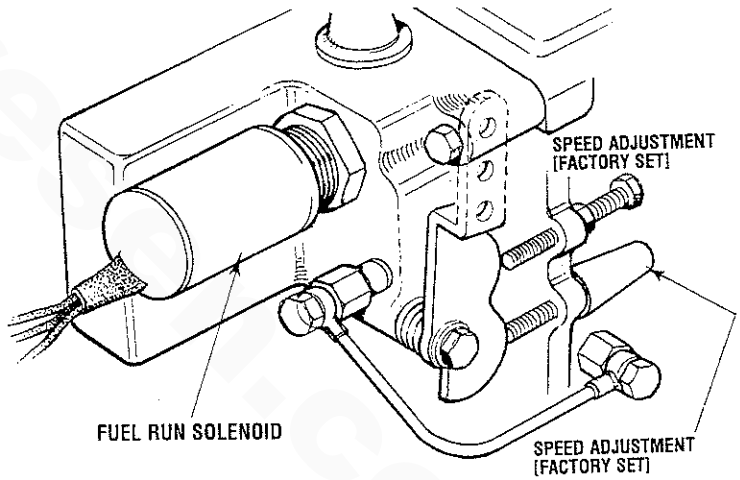
> ⚠ **WARNING:** ***Before starting the engine make certain that everyone is clear of moving parts! Keep away from pulleys and belts during test procedures.***

2. Start the engine and adjust the engine's speed to obtain the frequency corresponding to the voltage selected by adjusting the stop bolts and positioning the throttle arm against these stop bolts to either increase or decrease engine no-load speed to adjust the Hertz produced.
3. To arrive at the appropriate frequency, either monitor the speed of the engine/generator with a tachometer, or monitor the frequency with a frequency meter, the latter method being the more precise of the two.

FUEL RUN SOLENOID

The fuel run solenoid is mounted in a threaded hole on the engine's block just aft of and below the engine's fuel injection pump. Proceed as follows when installing a replacement or new fuel run solenoid.

1. Visual access to the fuel injection pump's fuel rack is needed. To obtain this, remove the small square side cover and gasket just below the fuel injection pump.
2. Thread the locknut onto the solenoid and then apply a small amount of Teflon sealant to the threads on the solenoid.
3. Thread the solenoid into the hole on the engine and observe the solenoid plunger through the cover opening. Allow the plunger to contact the fuel rack and move fully into the injection pump. Do not thread further so as to push the plunger into the solenoid.
4. Back the solenoid out 1/4 - 1/2 of a turn and secure it in position with the locknut.
   LOCKNUT TORQUE VALUE **28.9 - 36.2 ft-lb (4.0 - 5.0 m-kg)**
5. Properly connect the three electrical leads from the solenoid. Two of the connections plug into the engine harness and the third grounds to the engine block at an adjacent inboard threaded hole with an 8mm bolt.
6. Reassemble the cover and gasket and test run the unit. Make certain that the unit stops when the solenoid is de-energized.

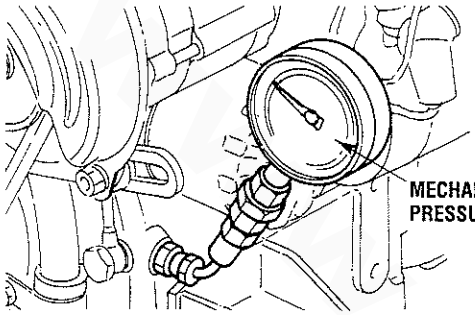


ENGINE ADJUSTMENTS

OIL PRESSURE

The engine's oil pressure, during operation, is indicated by the oil pressure gauge on the instrument panel. During normal operation, the oil pressure will range between 40 and 60 psi (2.8 and 4.2 kg/cm²).

NOTE: *A newly started, cold engine can have an oil pressure reading up to 60 psi (4.2 kg/cm²). A warmed engine can have an oil pressure reading as low as 35 psi (2.5 kg/cm²). These readings will vary depending upon the temperature of the engine and the rpms.*



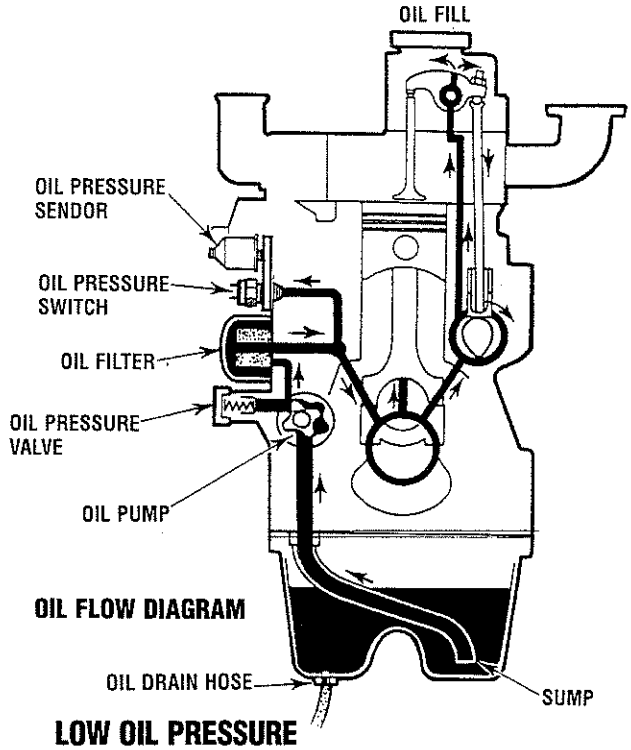
OIL PRESSURE [GENERATOR]

Oil pressure at 1800 (or 1500) rpm should maintain a reading of 50 psi.

TESTING OIL PRESSURE

To test the oil pressure, remove the oil pressure sender, then install a mechanical oil pressure gauge in it's place. After warming up the engine, set the engine speed at 1800 rpm and read the oil pressure gauge.

OIL PRESSURE	50 psi at 1800 rpm.
SENDER AND SWITCH TORQUE	9 - 13 ft-lb (1.2 - 1.8 m - kg).



OIL FLOW DIAGRAM

LOW OIL PRESSURE

The specified safe minimum oil pressure is 4.3 + 1.4 psi (0.3 + 0.1 kg/cm²). A gradual loss of oil pressure usually indicates a worn bearings. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

OIL PRESSURE RELIEF VALVE

An oil pressure relief valve is located on the engine block just below the injection pump. This valve opens at appoximately 50 psi [343 kpa] and maintains that pressure.

ENGINE ADJUSTMENTS

ADJUSTING THE IDLE SPEED

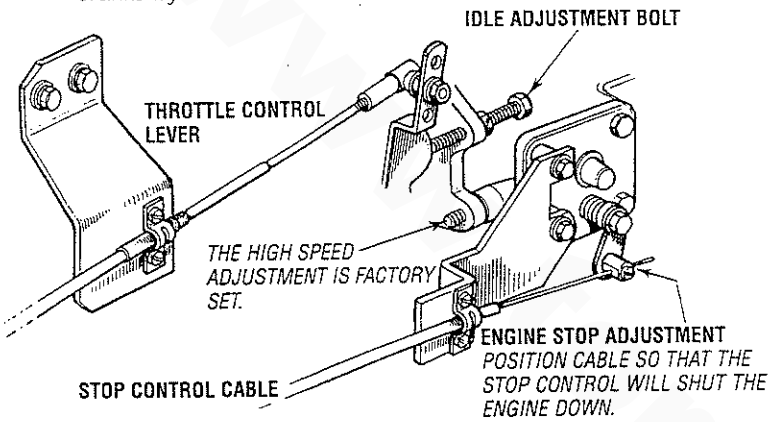
a. Loosen the locknut on the idle adjustment bolt on the fuel injection pump.

b. Adjust the bolt so that the throttle control lever will hold the engine at a quiet idle. [750 - 1000 RPM]

c. Tighten the locknut.

d. Race the engine several times to ensure the idle speed remains as set.

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



Fuel Shutoff Solenoid [Optional]

The optional fuel shutoff solenoid allows the engine to be shut down using the instrument panel key switch. The solenoid has been factory set and does not require adjustment. Refer to the assembly procedure of the fuel shutoff solenoid for the proper setting and clearance of the plunger. See *FUEL SHUTOFF SOLENOID INSTALLATION.*

Drive Belt Adjustment

Proper inspection, service and maintenance of the drive belts is important for the efficient operation of your engine.

Drive belts must be properly tensioned. Loose drive belts will not provide proper alternator charging and will eventually damage the alternator. Drive belts that are too tight will pull the alternator out of alignment and/or cause the alternator to wear out prematurely. Excessive drive belt tension can also cause rapid wear of the belt and reduce the service life of the coolant pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures and tachometer variations.

The drive belt is properly adjusted if the belt can be deflected no less than 3/8 inch (10mm) and no more than 1/2 inch (12mm) as the belt is depressed with the thumb at the midpoint between the two pulleys on the longest span of the belt. A spare belt or belts should always be carried on board.

> ⚠ **WARNING:** ***Never attempt to check or adjust the drive belt's tension while the engine is in operation.***

Adjusting Belt Tension

a. Loosen the alternator adjusting strap bolt and the base mounting bolt.

b. With the belt loose, inspect for wear, cracks and frayed edges.

c. Pivot the alternator on the base mounting bolt to the left or right as required, to loosen or tighten.

d. Tighten the base mounting bolt and the adjusting strap bolt.

e. Run the engine for about 5 minutes, then shut down and recheck the belt tensions.

SERVICE DATA - STANDARDS AND LIMITS

Component	Standard mm (inches)	Repair Limit mm (inches)
ENGINE COMPONENTS		
Compression pressure	427 psi at 290 rpm (30.0 kg/cm²) 2942 kPa	384 psi (27.0 kg/cm²) 2648 kPa
Maximum permissible difference between average compression pressure of all cylinders	42.7 psi (3.0kg/cm²) 294 kPa	
Injection timing at BTDC	17°	
Rocker arm bore for shaft	18.910 - 18.930 (0.74449 - 0.74527)	
Rocker arm shaft O.D.	18.880 - 18.898 (0.74331 - 0.7440)	
Clearance between rocker arm and shaft (oil clearance)	0.012 - 0.050 0.00047 - 0.00197	0.200 (0.00787)
Valve stem O.D.	0.260 (6.6)	
Height of valve guide	0.39 (10)	
Valve clearance	0.25 (0.0098)	
Stem to guide clearance		
Intake	0.02 - 0.05 (0.008 - 0.0020)	0.10 (0.0039)
Exhaust	0.05 - 0.085 (0.0020 - 0.00335)	0.15 (0.0059)
Valve margin (valve lip thickness)	1.0 (0.039)	0.5 (0.020)
Valve sinkage	0.5 ± 0.25 (0.020 ± 0.0098)	1.5 (0.059)
Valve seat		
Angle	45°	
Width	1.3 - 1.8 (0.051 - 0.071)	2.5 (0.098)
Valve spring		
Free length	47 (1.85)	46 (1.81)
Length under test force	39.1 (1.54) 30.5 (1.20)	
Test force 39.1 (1.54) [kgf (lbf)(N)]	13.9 ± 0.7 30.6 ± 1.5 136 ± 7	-15%
Test force 30.5 (1.20) [kgf (lbf)(N)]	29 ± 2 64 ± 4.4 284 ± 20	-15%
Warpage of cylinder head (bottom face)	0.05 (0.0020) max	0.10 (0.0039)
Bend (dial reading) of valve push rod	0.3 (0.012)	
Timing Gear Backlash		
Crankshaft gear/idler gear	0.04 - 0.12 (0.0016 - 0.0047)	0.30 (0.0118)
Idler gear/camshaft gear	0.04 - 0.12 (0.0016 - 0.0047)	0.30 (0.0118)
Idler gear/fuel injection pump camshaft gear	0.04 - 0.12 (0.0016 - 0.0047)	0.30 (0.0118)
Camshaft gear/P.T.O. gear	0.08 - 0.19 (0.0031 - 0.0075)	0.30 (0.0118)
Fuel injection pump camshaft gear and oil pump gear	0.07 - 0.20 (0.0028 - 0.0079)	0.30 (0.0118)
Lobe height of camshaft	35.72 (1.4063	34.72 (1.3669)

Component	Standard mm (inches)	Repair Limit mm (inches)
ENGINE COMPONENTS		
Lobe height of fuel injection pump camshaft	44 (1.73)	43 (1.3669)
Flatness of flywheel	0.15 (0.0059) max	0.50 (0.0197)
Clearance between tappet and cylinder block		0.15 (0.0059)
Clearance between camshaft journal and bushing		0.15 (0.0059)
Clearance between idler gear and shaft	0.03 - 0.07 (0.0012 - 0.0028)	0.20 (0.0079)
Warpage of cylinder block top face	0.05 (0.0020) max	0.10 (0.0039)
Bore in cylinder block	78.0 $^{+0.03}$ (3.07 $^{+0.0012}$)	78.2 (3.079)
Taper and out-of-round of cylinder	0.01 (0.0004)max	
Piston Pin O.D.	22.944 - 23.00 (0.90527 - 0.90551)	
Diameter of piston		
Standard	77.93 - 77.95 (3.0681 - 3.0689)	77.80 (3.0630)
0.25 (0.0098) Oversize	78.18 - 78.20 (3.0779 - 3.0787)	78.05 (3.0728)
0.50 (0.0197) Oversize	78.43 - 78.45 (3.0878 - 3.0886)	78.30 (3.0827)
Clearance between piston pin and piston	0.006 - 0.018 (0.00024 - 0.00071)	0.050 (0.00197)
Clearance between piston ring and groove		
No.1 Compression ring	0.06 - 0.10 (0.0024 - 0.0039)	0.30 (0.0118)
No.2 Compression ring	0.05 - 0.09 (0.0020 - 0.0035)	0.20 (0.0079)
Oil ring	0.03 - 0.7 (0.0012 - 0.0028)	0.20 (0.0079)
Clearance between ends of piston ring		
No.1 Compression ring	0.15 - 0.30 (0.0059 - 0.0118)	1.50 (0.059)
No.2 Compression ring	0.15 - 0.35 (0.0059 - 0.0138)	1.50 (0.059)
Oil ring	0.20 - 0.40 (0.0079 - 0.0157)	1.50 (0.059)
Clearance between piston and cylinder	0.035 - 0.086 (0.00138 - 0.00339)	0.300 (0.01181)
Clearance between crankpin and connecting rod bearing	0.025 - 0.072 (0.00098 - 0.00283)	0.150 (0.00591)
Thrust clearance for connecting rod big end	0.10 - 0.35 (0.0039 - 0.0138)	0.50 (0.0197)
Connecting rod bend/twist	0.05/100 (0.0020/3.94 max.) 0.15/100 (0.0059/3.94 max.)	

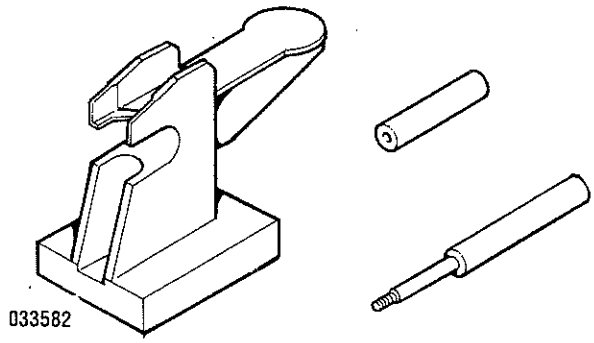
SERVICE DATA - STANDARDS AND LIMITS

Component	Specified Value / Standard inches(mm)	Repair Limit inches(mm)
ENGINE COMPONENTS		
Crankshaft		
Diameter of journal	51.985 - 52.000 (2.04665 - 2.04724)	
Diameter of crankpin	47.950 - 47.965 1.88779 - 1.88838)	
Runout	0.025 (0.00098)	0.05 (0.0020)
Clearance between journal and main bearing	0.030 - 0.077 (0.00118 - 0.00303)	0.100 (0.00394)
Clearance between crankpin and connecting rod bearing	0.025 - 0.072 (0.00098 - 0.00283)	0.150 (0.00591)
End play	0.050 - 0.175 (0.00197 - 0.00689)	0.500 (0.01969)
LUBRICATION SYSTEM		
Presure relief valve setting	50 ± 7 psi 3.5 ± 0.5 kgf/cm² 343 ± 49 kPa	
Presure difference at which oil pressure switch is closed	7 ± 1.4 psi 0.5 ± 0.1 kgf/cm² 49 ± 10 kPa	
FUEL SYSTEM		
Injection pressure (valve opening pressure)	1991 +71 psi 140 +5 kgf/cm² 13729 +490 kPa	
STARTER MOTOR		
Pinion clearance	0.5 - 2.0 (0.20 - 0.079)	
No-load characteristics 33C		
Terminal	11.5V	
Current draw	100A maximum	
Rpm	3000 minimum	
No-load characteristics 44A		
Terminal	11V	
Current draw	130A maximum	
Rpm	3850 minimum	
Brush length		wear limit line
Brush spring tension	3.0 kgf 6.6 lbf 29.4N	1.8 kgf 4.0 lbf 17.7N
Runout of commutator	0.03 (0.0012)	0.10 (0.0039)
Diameter of commutator	32 (1.26)	31 (1.22)
Undercut of mica	0.5 (0.020)	0.2 (0.008)

Component	Sealant	Mating Part
THREAD PARTS		
Stop solenoid	Loctite #587 Ultra Blue	Governor case
Water drain joint	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Cylinder block
Oil pressure switch	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Cylinder block
Torque spring set	Loctite #587 Ultra Blue	Governor case
PRESS FIT PARTS		
Sealing cap	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Cylinder block
Sealing cap	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Cylinder head
Sealing cap	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Cylinder head & block
Expansion plug	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	Governor block
Dipstick guide	Loctite Gasket Sealer #2 or High-Tack Gasket Sealer	
OTHERS		
Side seal	Loctite #587 Ultra Blue	Cylinder block and main bearing caps
Main bearing caps (front and rear)	Loctite #587 Ultra Blue	Cylinder block
Oil pan	Loctite #5699 Ultra Gray or High-Tack Gasket Sealer	Cylinder block

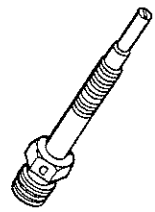
SPECIAL TOOLS - ENGINE

PIN SETTING TOOL [033582]
FOR PISTON PIN REMOVAL AND INSTALLATION



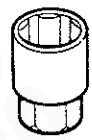
033582

COMPRESSION GAUGE ADAPTER [039254]
FOR COMPRESSION PRESSURE MEASUREMENT

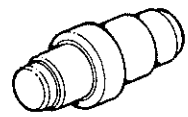


039254

OIL PRESSURE SWITCH SOCKET WRENCH
TO REMOVE THE OIL PRESSURE SWITCH



CAMSHAFT BUSHING INSTALLER [033583]
FOR REMOVING AND INSTALLING THE FRONT CAMSHAFT BUSHING



033583

THE ABOVE TOOLS ARE AVAILABLE FROM YOUR WESTERBEKE OR MITSUBISHI DEALER.

NOTE: IN ADDITION TO THESE TOOLS THE FOLLOWING ADDITIONAL TOOLS WOULD BE NEEDED:

BEARING PULLER, VALVE SEAT CUTTER TOOL, PROPER DIAL GAUGES, VALVE GUIDE INSTALLER TOOL, VALVE SPRING COMPRESSOR, SNAP RING PLIERS, ETC.

ALSO REFER TO SPECIAL TOOLS - GENERATOR IN THIS MANUAL

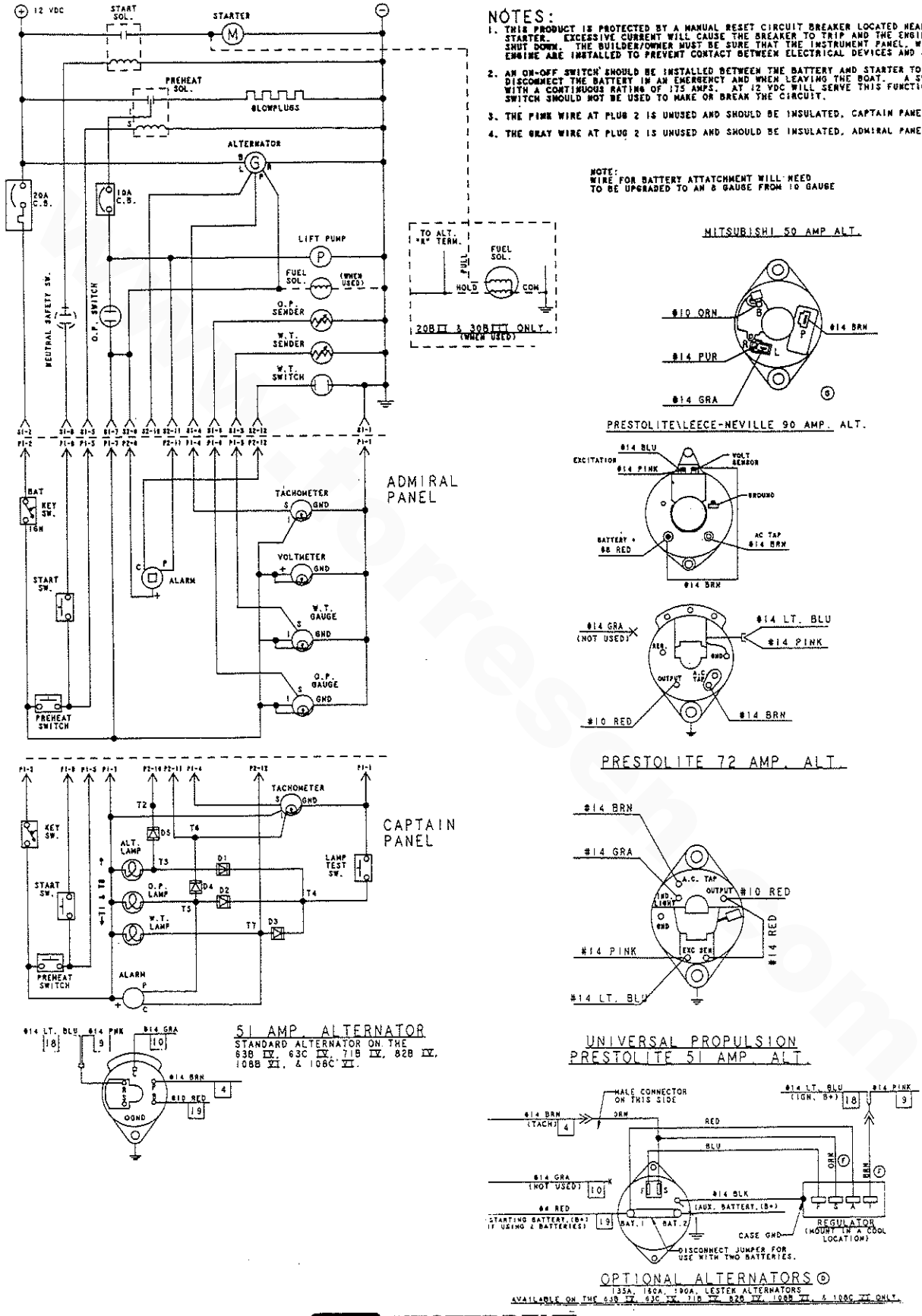
44A FOUR AND 35C THREE TORQUE SPECIFICATIONS

MAJOR BOLTS AND NUTS

Bolt or Nut	Diameter	Pitch	Width across flats	Clamp length	TORQUE kg -m	ft - lb	N -m
Alternator Bracket	---		---		3.8-5.3	27-38	36.6
Back Plate	---	---	---	---	3.3-4.8	24-35	32.5
Connecting Rod Cap	M9	1.0	14	---	3.55±0.25	27±7 2	34.8±2.5
Coolant Pump	---	---	---	---	1.6±2.4	12-17	17.2
Coolant Pump Pulley	---	---	---	---	1.6±2.4	12-17	17.2
Coolant Temperature Sender	---	---	---	---	1.2±1.8	9-13	12.2
Coolant Temperature Switch	---	---	---	---	1.2±1.8	9-13	12.2
Crankshaft Pulley Nut	M18	1.5	27	---	17.5±2.5	127±18	172±25
Cylinder Head Bolt	M10	1.25	14	87	9±0.5	65 ± 4	88± 5
Damper Plate	---	---	---	---	1.9± 2.7	14-20	8.9
Delivery Valve Holder	---	---	19	---	4.5±0.5	32±5 4	44± 5
Engine Mounts	---	---	---	---	3.2±4.7	23-34	31.1
Exhaust Manifold	---	---	---	---	1.6±2.4	12-17	7.2
Flywheel Bolt	M12	1.25	19	29	13.5±0.5	98±4	132±5
Fuel Filter Assembly	---	---	---	---	4.6±6.8	33-49	44.7
Fuel Injection Nozzle Holder	M20	1.5	21	---	5.5±0.5	40±4 4	54±5
Fuel Injection Pipe Nut	M12	1.5	---	---	3±0.5	22±4	29±5
Fuel Leak-Off Pipe Nut	M12	1.5	18	---	2.75±0.25	20± 2	27±2.5
Fuel Solenoid Locknut	---	---	---	---	4.0±0.5	28.9±36.2	39.18
Glow Plug	M10	1.25	12	60	1.75±0.25	12±7 2	17.2±2.5
Glow Plug Connection Plate	M4	0.7	8	---	0.125±0.025	0.9±0.2	1.2±0.2
Intake Manifold	---	---	---	---	1.6±2.4	12-17	16.2
Main Bearing Cap Bolt	M10	1.25	17	81	5.25±0.25	38±2	51.5±2.5
Oil Filter	M20	1.5	---	---	1.2±0.1	8.7± 0.7	12±1
Oil Pan Bolt	M8	1.25	12	25	2.8±0.3	20.3±2.2	27±5.3
Oil Pan Drain Plug	M14	1.5	22	10	4.0±0.5	29±4	39±5
Oil Pressure Sender	---	---	---	---	1.2±1.8	9-13	12.2
Oil Pressure Switch	PT1/8	---	26	11	1±0.2	7.2±1.4	10±2
Pressure Refief Valve	M22	1.5	22	33	5.0±0.5	36±4	49±5
Rear Plate Bolt (stamping)	M8	1.25	12	16	1.15±0.15	8.3±1.1	11.3±1.5
Rear Plate Bolt (standard)	M12	1.25	17	28	6.5±0.1	47±7	64±10
Retaining Nut for Delivery Valve Holder Body	M16	0.75	19	---	3.75±0.25	27±2	37±2.5
Rocker Cover Bolt	M8	1.25	12	40	1.15±0.15	8.3±1.1	11.3±1.5
Rocker Shaft Bracket Bolt	M8	1.25	12	581	1.5±0.5	11±4	14.7±5
Sliding Sleeve Shaft	M10	1.25	14	29.5	3.6±0.6	26±4	35±6
Special Nut for Torque Spring Set	M12	1.0	17	---	2±0.5	14±4	20±5
Starter B Terminal	M8	1.25	12	---	1.1±0.1	8 0±7	10.8±1
Stop Solenoid	M30	1.5	36	---	4.5±0.5	32±5 4	44±5
Thermostat Housing	---	---	---	---	0.3-0.45	2-3	2.7
Thermoswitch	M16	1.5	17	31.5	2.3±0.4	16.6 ± 3	22.6 ± 4

44A FOUR / 35C THREE MARINE ENGINE

WIRING SCHEMATIC #39144



NOTES:

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

NOTE:
WIRE FOR BATTERY ATTATCHMENT WILL NEED TO BE UPGRADED TO AN 8 GAUGE FROM 10 GAUGE

MITSUBISHI 50 AMP ALT.

PRESTOLITE\LEECE-NEVILLE 90 AMP. ALT.

PRESTOLITE 72 AMP. ALT.

51 AMP ALTERNATOR
STANDARD ALTERNATOR ON THE 638 IV, 63C IV, 71B IV, 82B IV, 108B VI, & 108C VI.

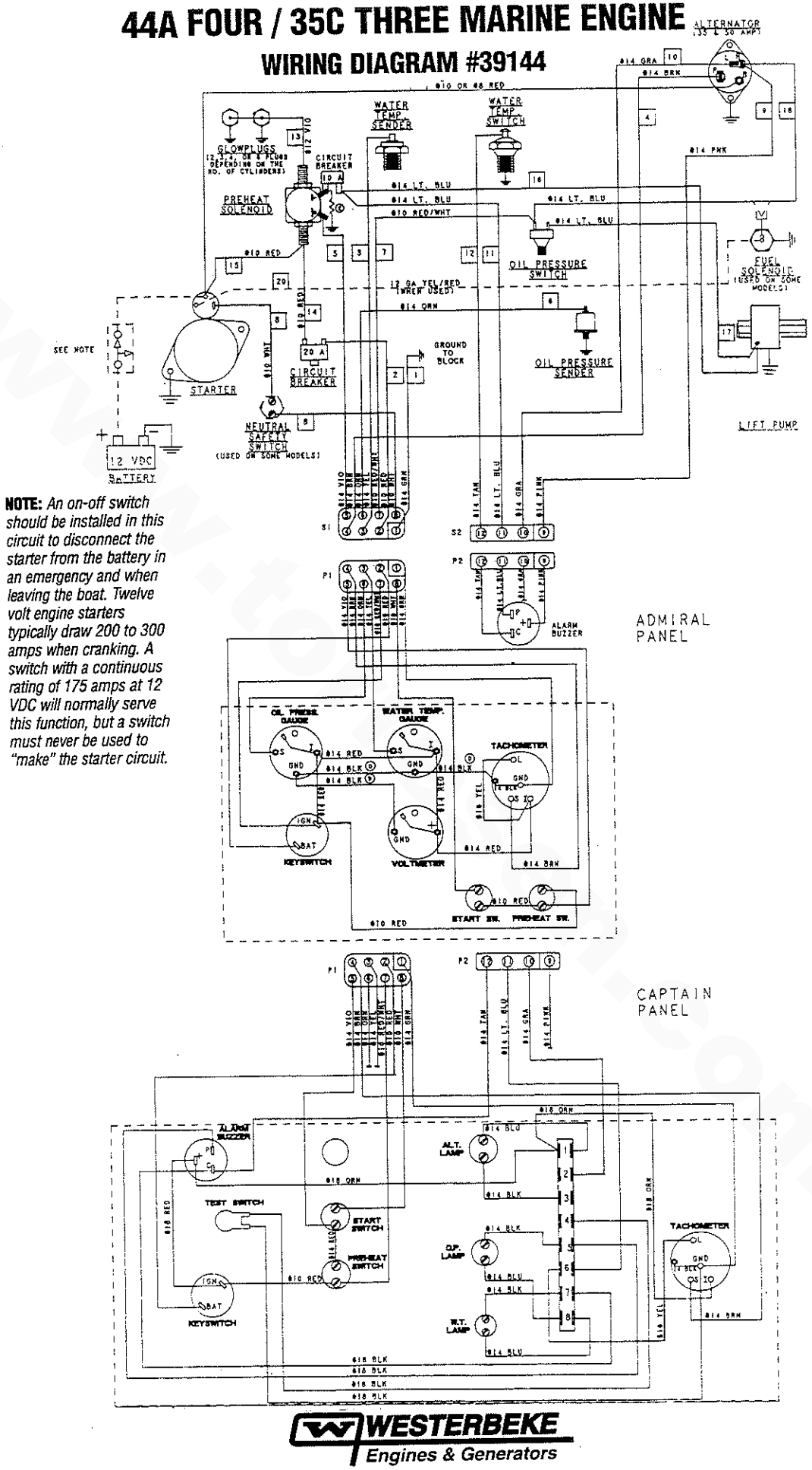
UNIVERSAL PROPULSION
PRESTOLITE 51 AMP. ALT.

OPTIONAL ALTERNATORS ⑥
135A, 160A, 190A, LESTER ALTERNATORS
AVAILABLE ON THE 63B IV, 63C IV, 71B IV, 82B IV, 108B VI, & 108C VI ONLY

WESTERBEKE
Engines & Generators

44A FOUR / 35C THREE MARINE ENGINE

WIRING DIAGRAM #39144



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

WESTERBEKE
Engines & Generators

SPECIFICATIONS 44A FOUR ENGINE

SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism..
Displacement	107.3 cubic inches (1.758 liter)
Aspiration	Naturally aspirated.
Combustion Chamber	Swirl type.
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)
Firing Order	1 - 3 - 4 -2
Direction of Rotation	Clockwise, when viewed from the front.
Compression Ratio	22:1
Dimensions - inches (mm) Engine Only	Height: 18.6 inches (472.4 mm) Width: 23.0 inches (584.2 mm) Length:25.6 inches (914.4 mm)
Weight	331 lbs (150 kgs) without transmission.
Fuel Consumption	2.5 g/hr (9.7 ltr/hr) at 3600 rpm
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Valve Timing	Intake Opens Intake Closes
Spilled Timing (Static)	17° (spill)
Valve Seat Angle	45°
Engine Speed	3600 rpm
Valve Seat Angle	Intake 45° Exhaust 30°
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Engine Timing	17° BTDC

FUEL SYSTEM

General	Open flow, self priming.
Fuel	No. 2 diesel oil (cetane rating of 45 or higher).
Fuel Injection Pump	In-line plunger type (BOSCH).
Fuel Injection Timing	0° TDC (Top Dead Center).
Nozzle	Throttle type.
Fuel Filter	Spin-on replaceable (PN#024363)..
Air cleaner	Replaceable paper filter cartridge.
Air Flow (engine combustion)	140 cfm (3.9 cmm) at 3600 rpm.
Fuel Lift Pump	12 volt DC lift capacity of 5' (1.5 mm) solid state

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	400 – 600 Cold Cranking Amps (CCA)
DC Charging Alternator	51 Amp rated, belt-driven
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear

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.
System Capacity (Fresh Water)	2.65 US qts (2.5 liters)

LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	4.5 U.S. qts (4.3 liters)
Operating Oil Pressure (engine hot)	50 – 60 psi (3.5 – 4.2 kg/cm²)
Oil Grade	API Specification CF or CG-4.

SPECIFICATIONS 35C THREE ENGINE

SPECIFICATIONS

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism..		
Displacement	80.4 cubic inches (1.318 liter)		
Aspiration	Naturally aspirated.		
Combustion Chamber	Swirl type.		
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)		
Firing Order	1 - 3 - 2		
Direction of Rotation	Clockwise, when viewed from the front.		
Compression Ratio	22:1		
Dimensions - inches (mm) Engine Only	Height:	21.6 inches	(540.6 mm)
	Width:	20.1 inches	(510.5 mm)
	Length:	22.4inches	(596 mm)
Weight	276 lbs (276 kgs) without transmission.		
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)		

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Valve Timing	Intake Opens Intake Closes
Spilled Timing (Static)	17° (spill)
Valve Seat Angle	45°
Engine Timing	17° BTDC
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Valve Seat Angle	Intake 45° Exhaust 30°

FUEL SYSTEM

General	Open flow, self priming.
Fuel	No. 2 diesel oil (cetane rating of 45 or higher).
Fuel Injection Pump	In-line plunger type (BOSCH).
Fuel Injection Timing	0° TDC (Top Dead Center).
Nozzle	Throttle type.
Fuel Filter	Spin-on replaceable (PN#024363)..
Air cleaner	Replaceable paper filter cartridge.
Air Flow (engine combustion)	140 cfm (3.9 cmm) at 3600 rpm.
Fuel Lift Pump	12 volt DC lift capacity of 5' (1.5 mm) solid state

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	400 – 600 Cold Cranking Amps (CCA)
DC Charging Alternator	51 Amp rated, belt-driven
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear

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.
System Capacity (Fresh Water)	1.9 US qts (1.8 liters)

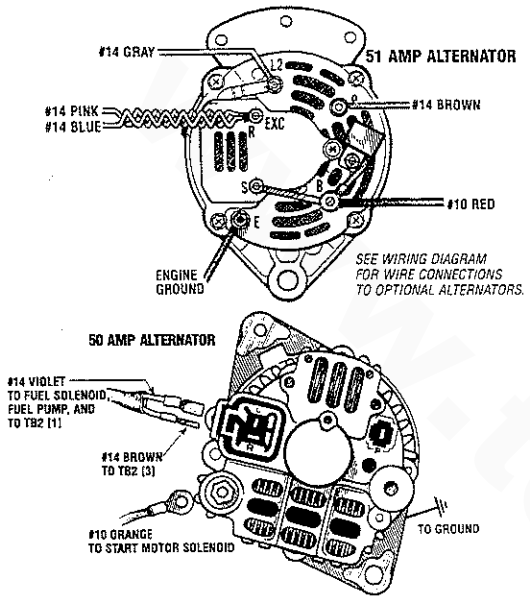
LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	3.9 U.S. qts (3.7 liters)
Operating Oil Pressure (engine hot)	50 – 60 psi (3.5 – 4.2 kg/cm²)
Oil Grade	API Specification CF or CG-4,

DC ELECTRICAL SYSTEM

ALTERNATOR

The charging system consists of a DC belt driven 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.



ALTERNATOR TROUBLESHOOTING

Use this troubleshooting section 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 faulty, have a qualified technician check it.

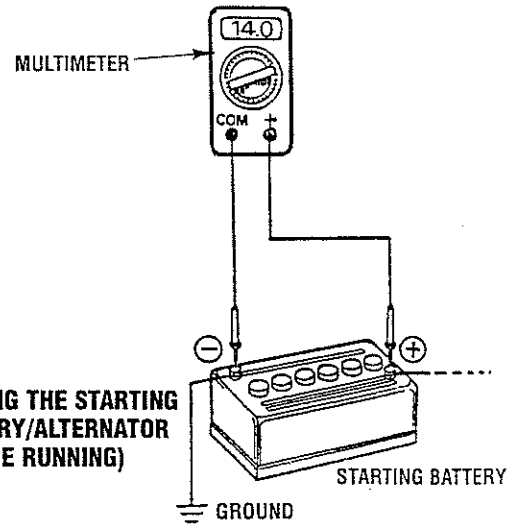
The alternator charging circuit charges the starting battery and the service battery. An isolator with a diode, a solenoid or a battery selector switch is usually mounted in the circuit to isolate the batteries so the starting battery is not discharged along with the service battery. If the alternator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

Testing the Alternator

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

> ⚠ **WARNING:** ***When testing with a multimeter: DC and AC circuits are often mixed together in marine applications. Always disconnect a shore power cord, isolate DC and AC converters, and shut down the engine before performing DC testing. No AC tests should be made without a proper knowledge of AC circuits.***

1. Start the engine.
2. After the engine has run for a few minutes, measure the starting battery voltage at the battery terminals using a multimeter set on DC volts.
   - **a.** If the voltage is increasing toward 14 volts, the alternator is working; omit Steps 3 through 8 and go directly to "Checking the Service Battery" on the next page.
   - **b.** If the voltage remains around 12 volts, a problem exists with either the alternator or the charging circuit; continue with Steps 3 through 8.

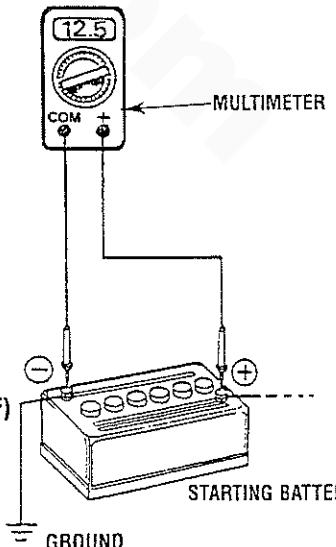


TESTING THE STARTING BATTERY/ALTERNATOR (ENGINE RUNNING)

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

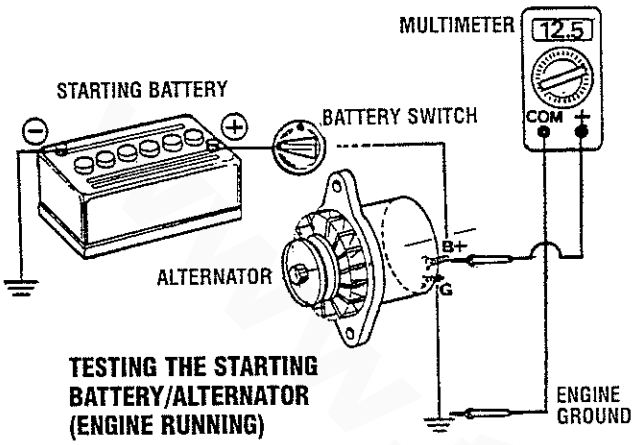
> ⚠ **CAUTION:** ***To avoid damage to the battery charging circuit, never shut off the engine battery switch when the engine is running!***

4. If a battery selector switch is in the charging circuit, ensure that it is on the correct setting.
5. Turn on the ignition switch, but do not start the engine.
6. Check the battery voltage. If the battery is in good condition, the reading should be 12 to 13 volts.



TESTING THE ALTERNATOR VOLTAGE (IGNITION ON - ENGINE OFF)

7. Now check the voltage between the alternator output terminal (B+) and ground. If the circuit is good, the voltage at the alternator will be the same as the battery, or if an isolator is in the circuit the alternator voltage will be zero. If neither of the above is true, 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)

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

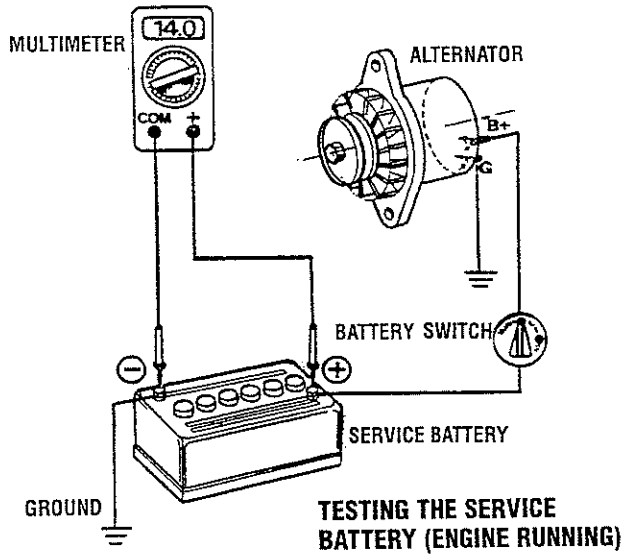
   The voltage reading for a properly operating alternator should be between 13.5 and 14.5 volts. If your alternator is over- or under-charging, have it repaired at a reliable service facility.

   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 is not present at the EXC terminal, trace the wiring and look for breaks and poor connections.

Checking the Service Battery

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:** ***To avoid damaging the alternator diodes, do not use a high voltage tester (i.e. a megger) when performing tests on the alternator charging circuit.***

12 VOLT DC CONTROL CIRCUIT

The engine has a 12 volt DC electrical control circuit that is shown on the wiring diagrams in this manual. Refer to these diagrams when troubleshooting or when servicing the DC electrical system.

> ⚠ **CAUTION:** ***To avoid damage to the battery charging circuit, never shut off the engine battery switch while the engine is running. Shut off the engine battery switch, however, to avoid electrical shorts when working on the engine's electrical circuit.***

BATTERY

The minimum recommended capacity of the battery used in the engine's 12 volt DC control circuit is 600 – 900 Cold Cranking Amps (CCA).

Battery Care

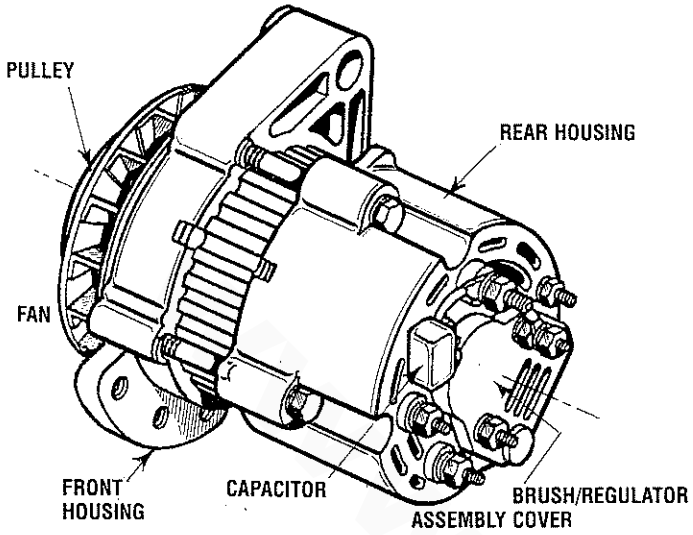
Review the manufacturer's recommendations and then establish a systematic maintenance schedule for your engine's starting batteries and house batteries.

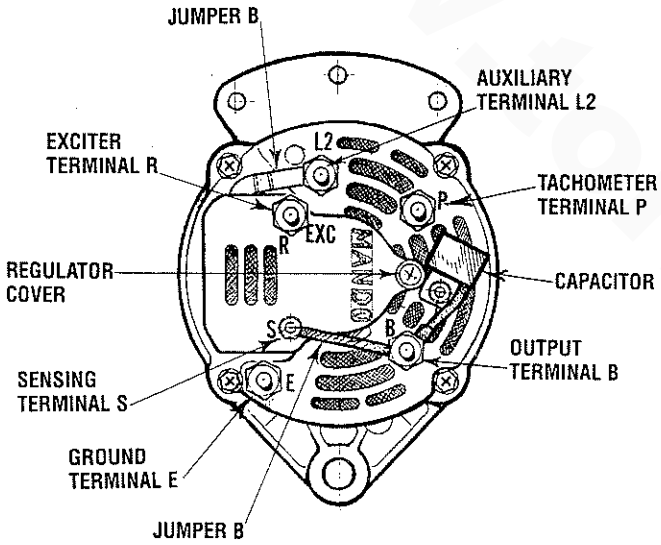
- ☐ Monitor your voltmeter for proper charging during engine operation.
- ☐ Check the electrolyte level and specific gravity with a hydrometer.
- ☐ Use only distilled water to bring electrolytes to a proper level.
- ☐ Make certain that battery cable connections are clean and tight to the battery posts (and to your engine).
- ☐ Keep your batteries clean and free of corrosion.

> ⚠ **WARNING:** ***Sulfuric acid in lead batteries can cause severe burns on skin and damage clothing. Wear protective gear.***

WESTERBEKE 51A MANDO ALTERNATOR

DISASSEMBLY AND TESTING

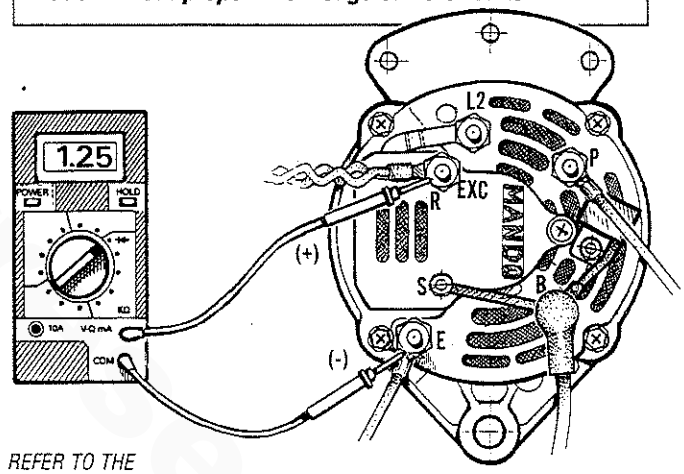




⚠ WARNING: ***A failed alternator can become very hot. Do not touch until the alternator has cooled down.***

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

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



REFER TO THE WIRING DIAGRAMS FOR THE ABOVE WIRING HARNESS CONNECTIONS

TESTING THE OUTPUT CIRCUIT

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

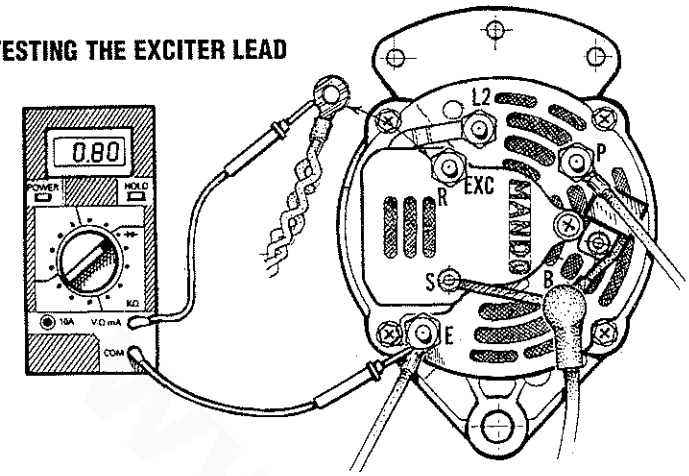
NOTE: *Prior to any alternator testing, inspect the entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly battery cable clamps and battery terminals. Inspect the alternator drive belt for excessive wear and replace if necessary. Also adjust for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

TESTING THE EXCITATION CIRCUIT

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

MANDO ALTERNATOR SERVICE

TESTING THE EXCITER LEAD



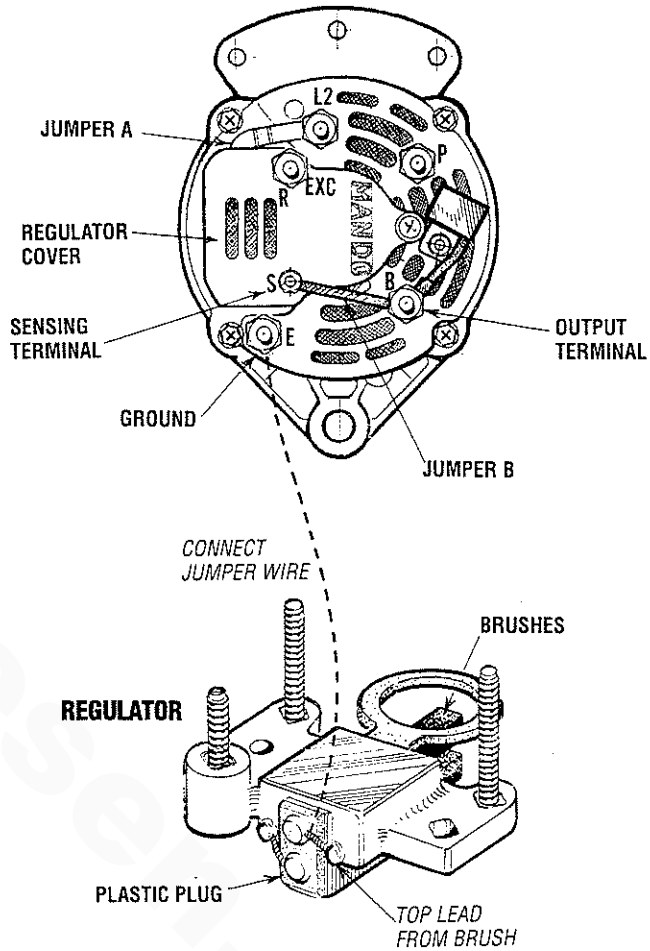
5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal R. Connect the positive voltmeter lead to the excitation lead and the negative voltmeter lead to ground terminal E. If the voltmeter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

TEST VOLTAGE REGULATOR

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

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

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



   i. Repeat steps **1** and **2**.

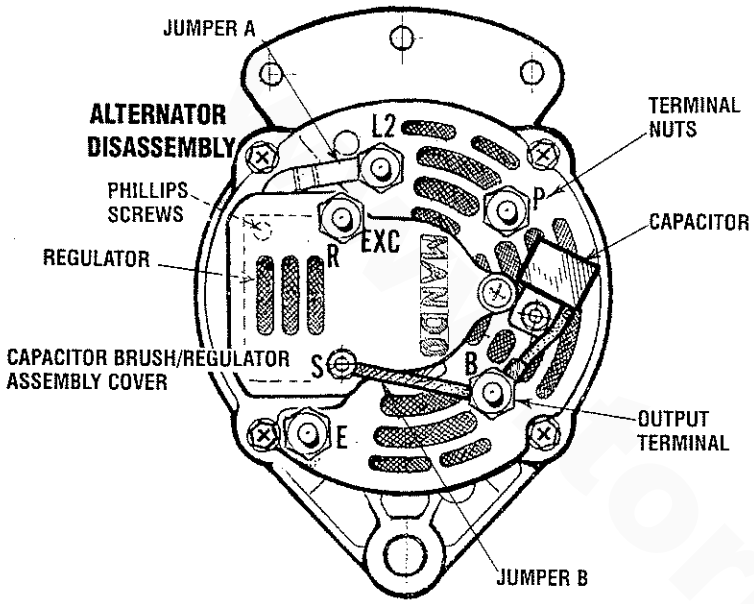
NOTE: *Do not let the voltage exceed 16 volts.*

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

MANDO ALTERNATOR SERVICE

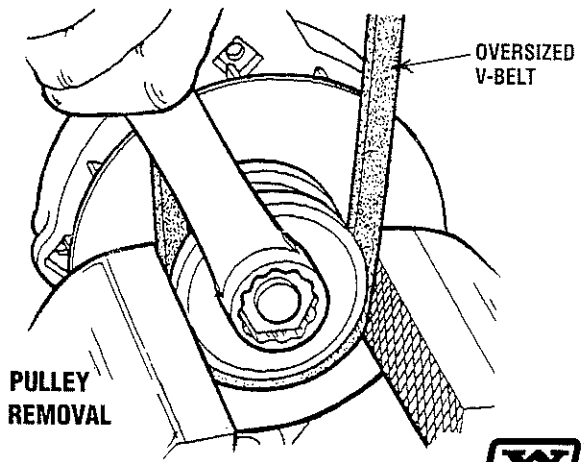
REMOVE ALTERNATOR

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

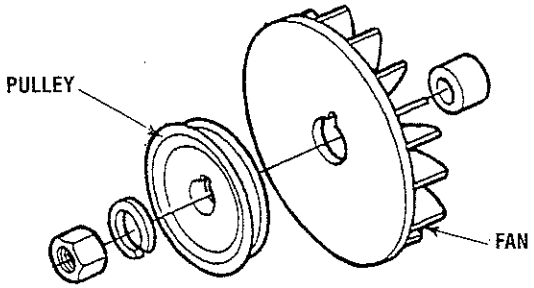


DISASSEMBLE ALTERNATOR

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



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

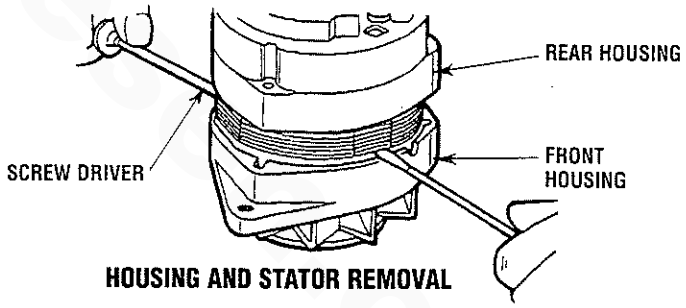


PULLEY AND FAN COMPONENTS

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

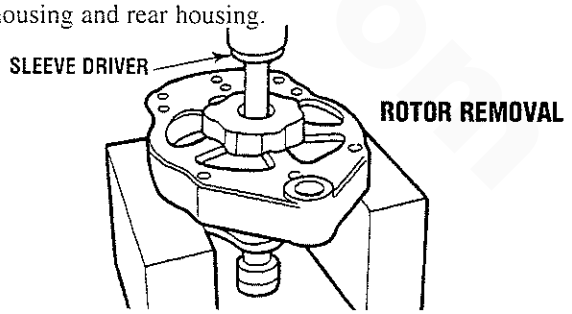
NOTE: *Score the stator, and the front and rear housings so the unit may be reassembled correctly.*

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



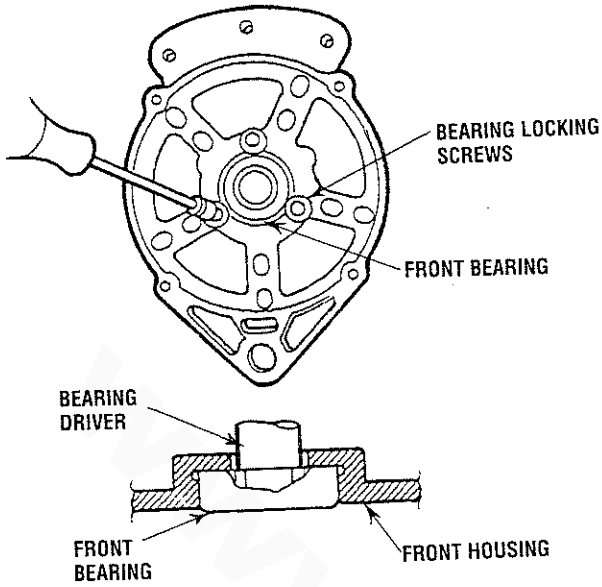
HOUSING AND STATOR REMOVAL

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

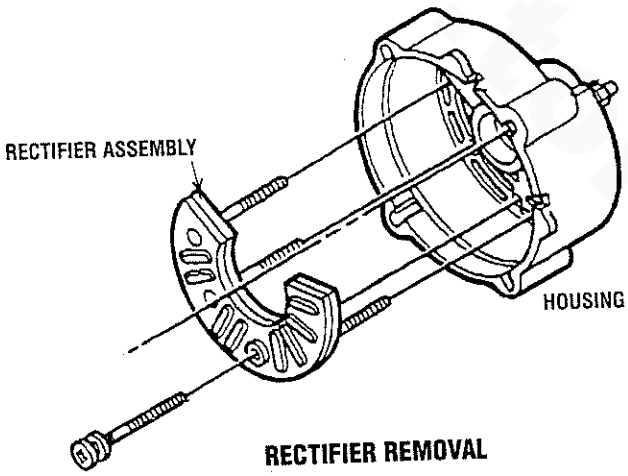


NOTE: *If the bearing is removed from the housing, a new bearing must be installed.*

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



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

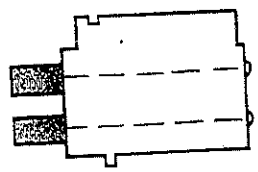


RECTIFIER REMOVAL

CLEAN AND TEST ALTERNATOR COMPONENTS

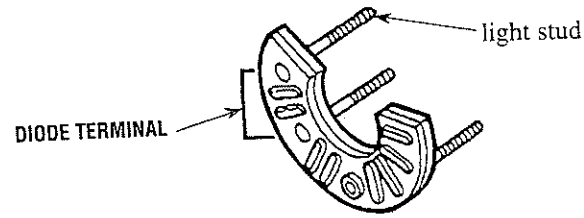
1. Inspect and test the brush/regulator assembly. The brush set may be reused if the brushes are 1/4 in. (6 mm) or longer. The brushes must not be oil soaked, cracked or grooved.

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



TESTING BRUSH ASSEMBLY

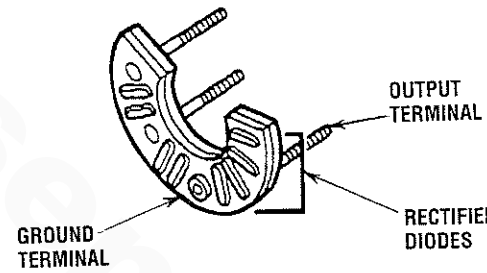
2. Inspect and test the diode-trio assembly:
   a. Using a commercial diode tester, a 12-volt DC test lamp or an ohmmeter, check the resistance between each of the three diode terminals and the indicator light stud.



DIODE TRIO ASSEMBLY

   b. Reverse the tester leads and repeat the resistance checks.
   c. A very low resistance should be indicated in one direction and a very high resistance should be indicated in the other direction if the diodes are normal.
   d. If any diode appears to be defective, replace the complete assembly. Do not attempt to replace an individual diode.

3. Test the diode-rectifier bridge as follows:
   a. Using a commercial diode tester, check for continuity from each of three terminals to the ouput terminal.

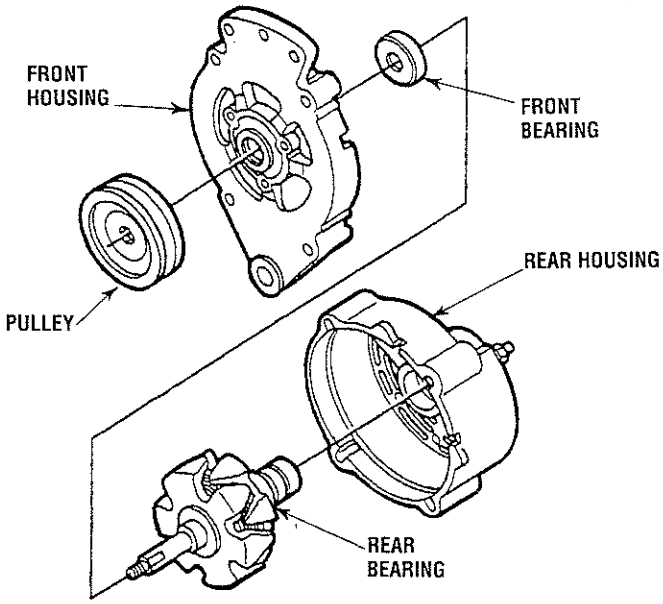


   b. Reverse the tester leads and repeat Step a.
   c. Continuity should exist in only one direction and all diodes should check alike.
   d. Perform the same continuity checks between the three terminals and strap ground terminal. This should show continuity in only one direction through the diodes and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

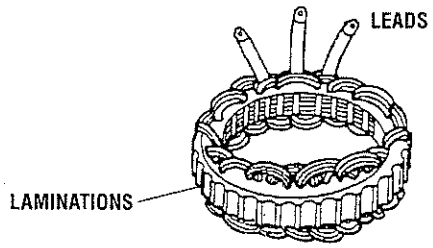
4. Clean and inspect the front and rear housings:
   a. Inspect the rear housing for cracks or breaks in the casting, stripped threads or a damaged bearing bore. Replace the housing if any of these conditions exist.
   b. Inspect the front housing for cracks, stripped or damaged threads in the adjusting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

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

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

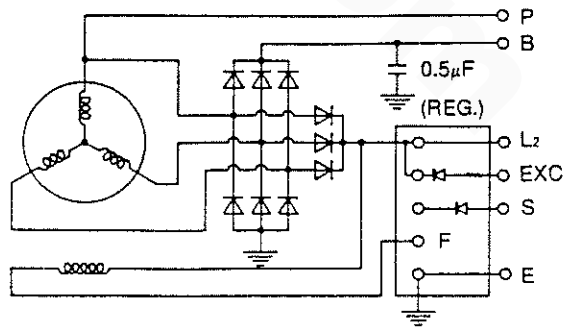


7. Test the stator windings as follows:
   a. Using an ohmmeter or test lamp, check for continuity between all three leads (1, 2, and 3). A low ohm reading or lit test lamp should be observed.



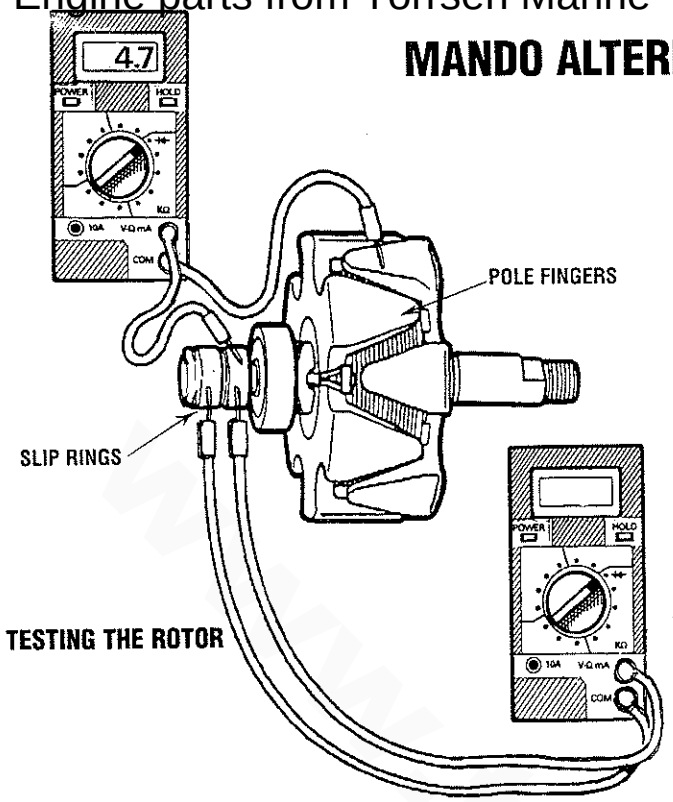
   b. Check the resistance from each lead (1, 2, and 3) to the laminations (4). There should be no continuity if the insulation is good.
   c. Inspect the stator windings for signs of discoloration. A discolored winding should be replaced.
   d. If a winding shows a high resistance or an open circuit between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

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



INTERNAL CIRCUIT WIRING

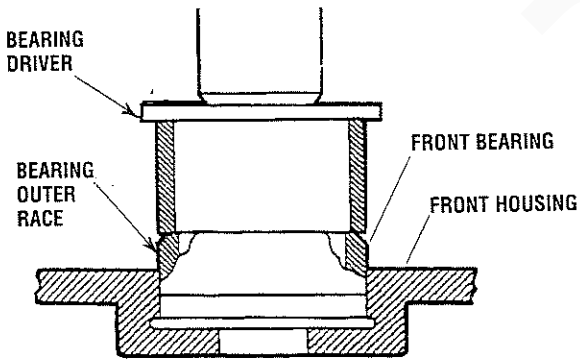
MANDO ALTERNATOR SERVICE



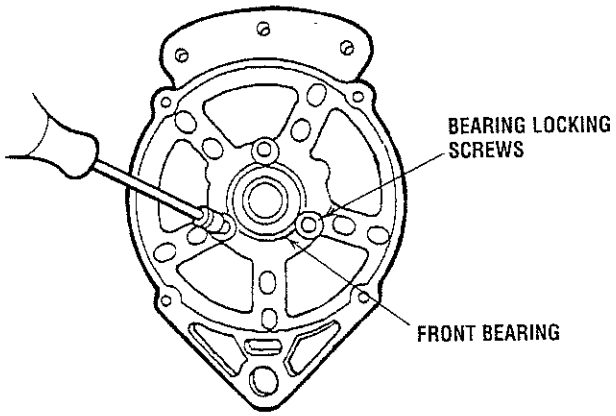
TESTING THE ROTOR

ASSEMBLE ALTERNATOR

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

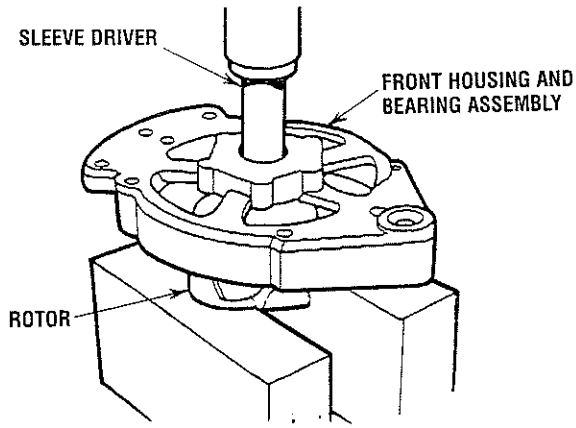


FRONT BEARING ASSEMBLY



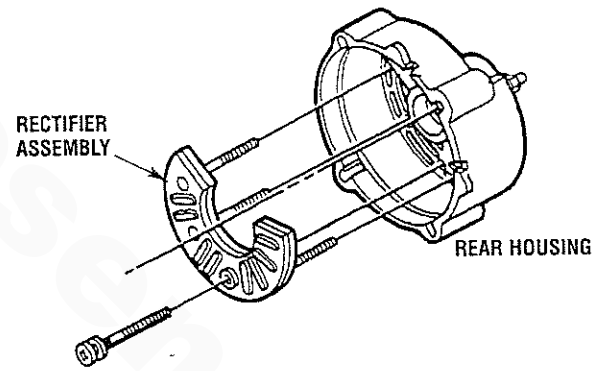
ASSEMBLING THE BEARINGS

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



INSTALLING THE FRONT HOUSING ON THE ROTOR ASSEMBLY

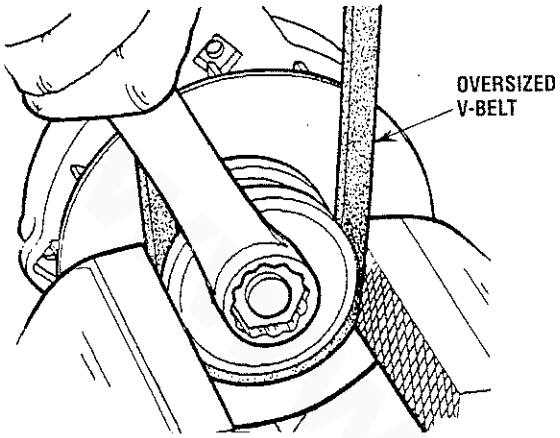
4. Install the rectifier assembly into the rear housing.
5. Insert the Phillips screw and tighten it.



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

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

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



INSTALLING THE PULLEY AND THE FAN NUT

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

INSTALL ALTERNATOR

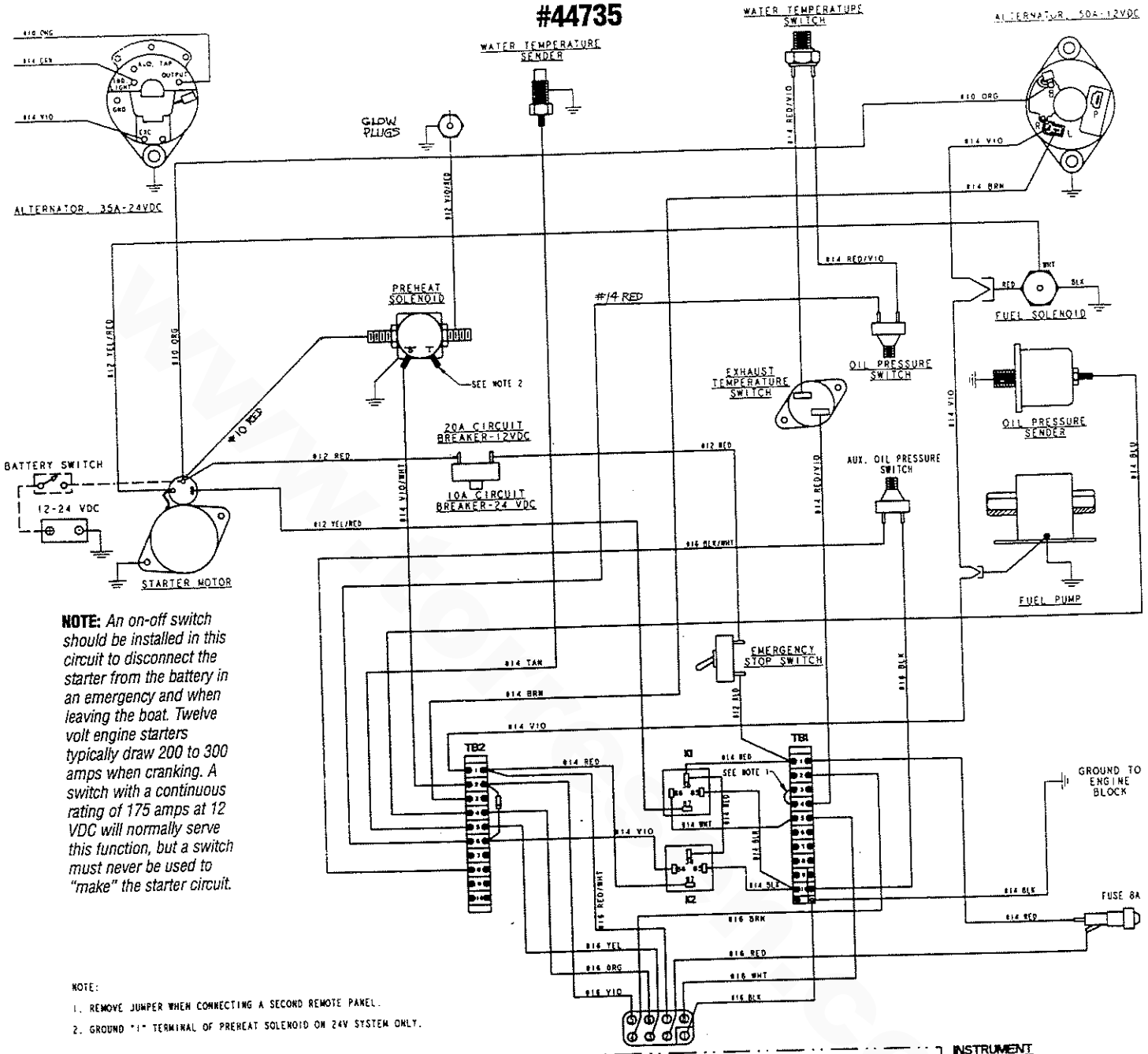
1. Install the alternator, screws and washers.
2. Connect the wiring leads.
3. Put the belt on the alternator, crankshaft and coolant pump pulleys.
4. Adjust the alternator belt's tension (see *DRIVE BELT ADJUSTMENT* under *ENGINE ADJUSTMENTS*).

MANDO ALTERNATOR SPECIFICATIONS

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

GENERATOR WIRING DIAGRAM

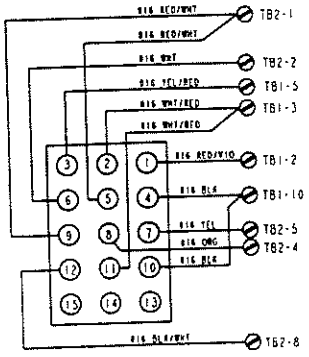
#44735

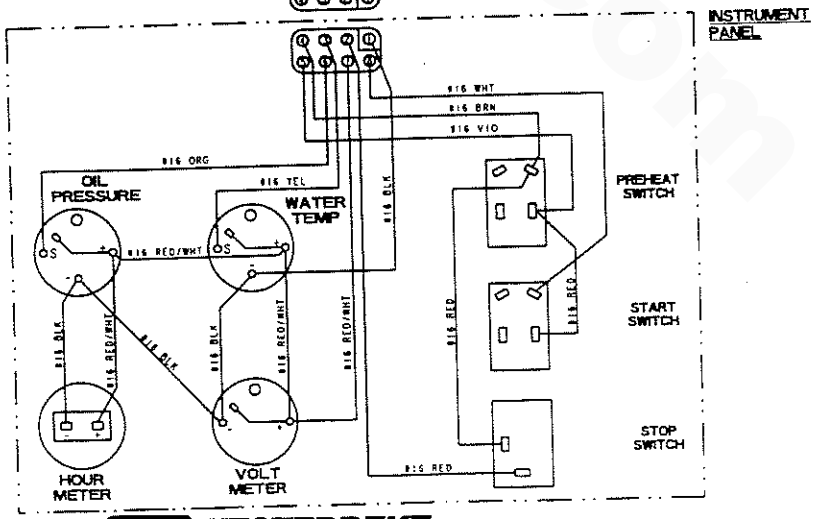


NOTE: *An on-off switch should be installed in this circuit to disconnect the starter from the battery in an emergency and when leaving the boat. Twelve volt engine starters typically draw 200 to 300 amps when cranking. A switch with a continuous rating of 175 amps at 12 VDC will normally serve this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

NOTE:

1. REMOVE JUMPER WHEN CONNECTING A SECOND REMOTE PANEL.
2. GROUND "I" TERMINAL OF PREHEAT SOLENOID ON 24V SYSTEM ONLY.





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GENERATOR WIRING SCHEMATIC

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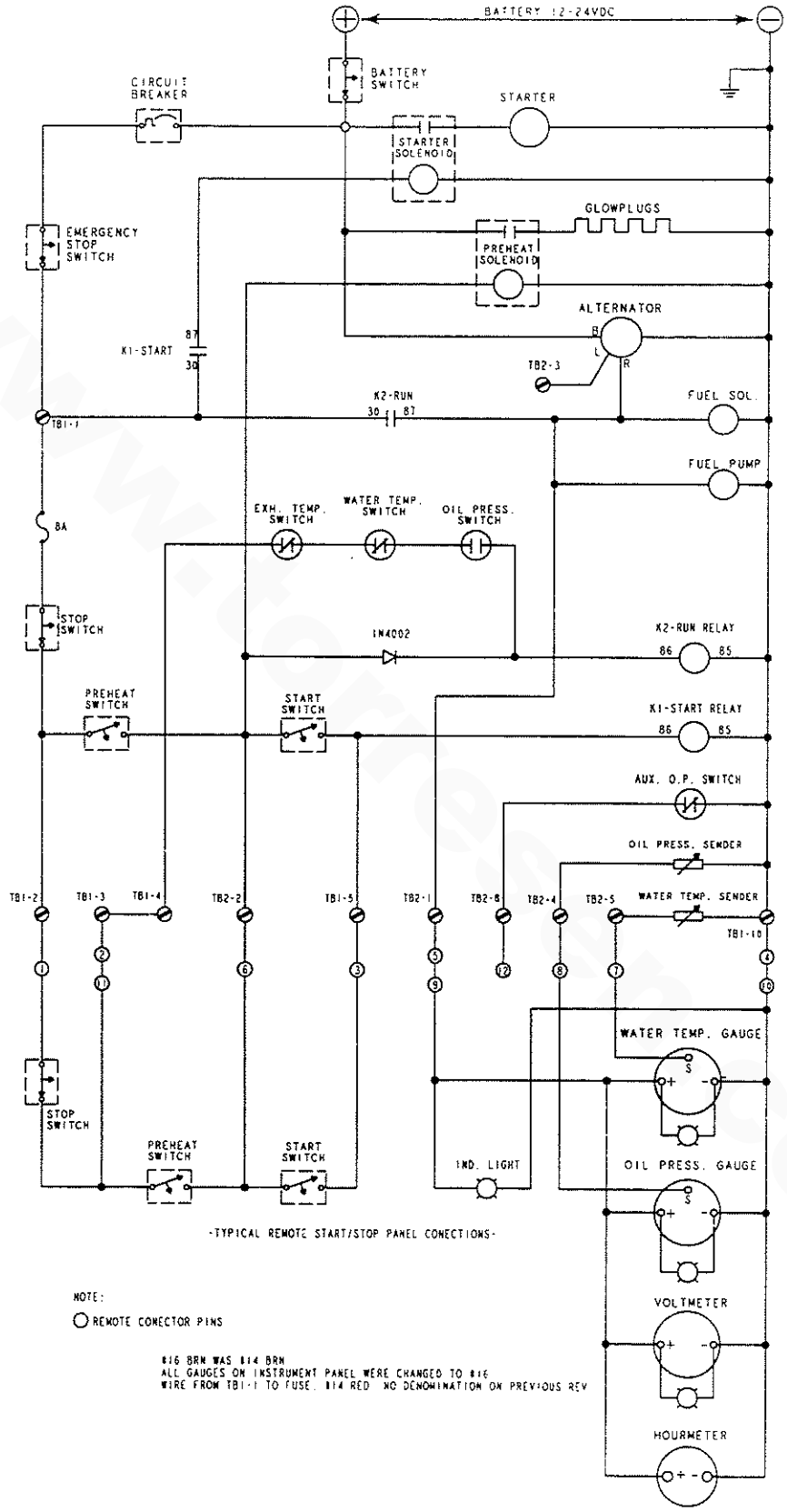

-TYPICAL REMOTE START/STOP PANEL CONECTIONS-

NOTE:

○ REMOTE CONECTOR PINS

#16 BRN WAS #14 BRN
ALL GAUGES ON INSTRUMENT PANEL WERE CHANGED TO #16
WIRE FROM TB1-1 TO FUSE, #14 RED NO DENOMINATION ON PREVIOUS REV

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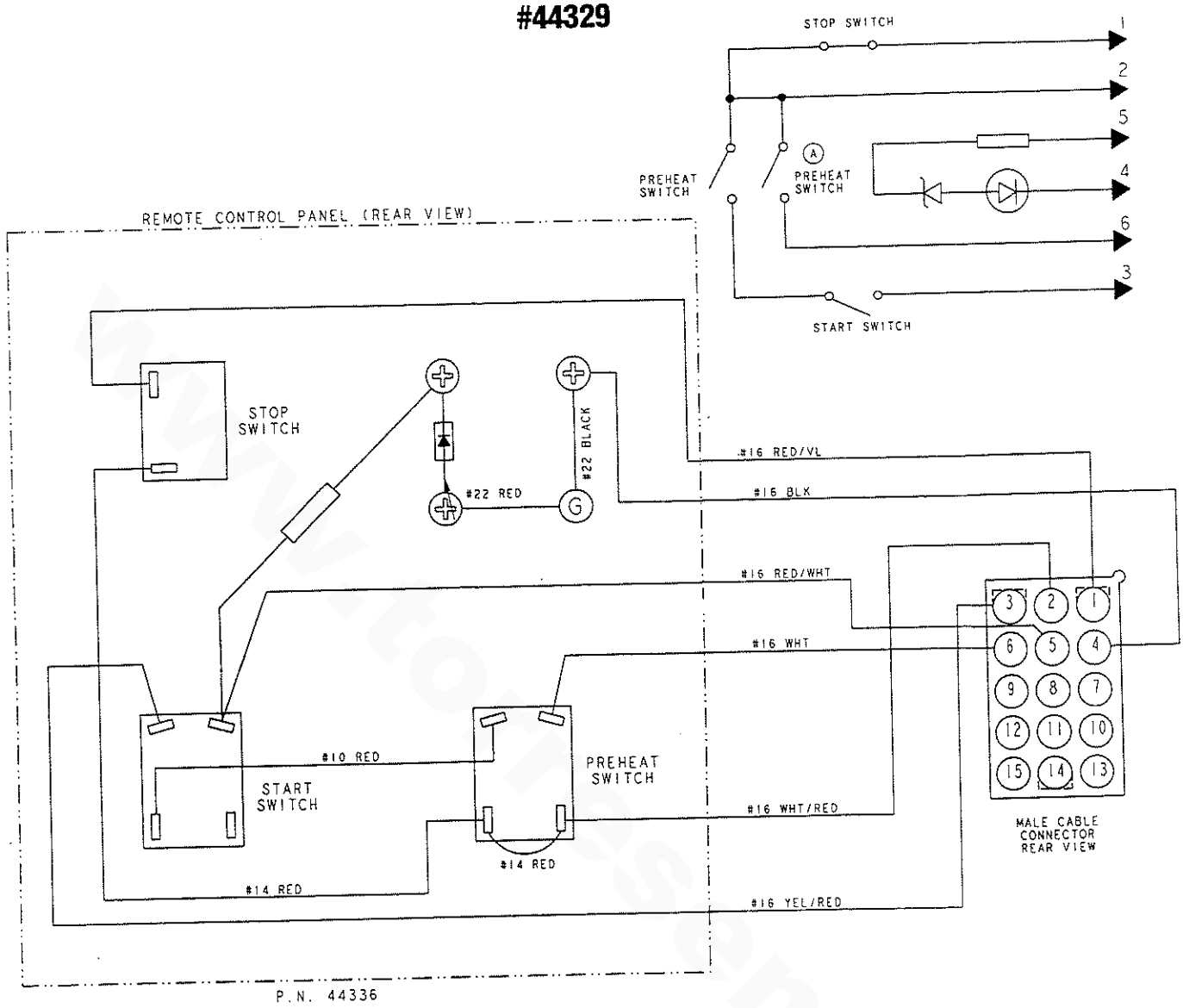
REMOTE INSTRUMENT PANEL

#44329



SPECIFICATIONS 10.0KW/8.0KW BTDA

GENERAL

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Displacement	80.4 cubic inches (1.318 liter)
Aspiration	Naturally aspirated.
Combustion Chamber	Swirl type.
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)
Firing Order	1 - 3 - 2
Direction of Rotation	Clockwise, when viewed from the front.
Compression Ratio	22:1
Weight (Engine Only)	276 lbs (276 kgs) without transmission.
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Spilled Timing (Static)	17° (spill)
Valve Seat Angle	45°
Engine Timing	17° BTDC
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance (engine cold)	0.25mm (0.0098in)

LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	3.9 U.S. qts (3.7 liters)
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

FUEL SYSTEM

General	Open flow, self priming.
Fuel	No. 2 diesel oil (cetane rating of 45 or higher).
Fuel Injection Pump	In-line plunger type (BOSCH).
Nozzle	Throttle type.
Fuel Filter	Spin-on replaceable (PN#024363).
Air cleaner	Replaceable paper filter cartridge.
Fuel Lift Pump	12 volt DC lift capacity of 5' (1.5 mm) solid state

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	400 – 600 Cold Cranking Amps (CCA)
DC Charging Alternator	51 Amp rated, belt-driven
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear
Engine Combustion Air Requirements @ 60Hz 1800 rpm	41 cfm (1.16 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. (Measured before discharging into exhaust elbow).	7-8 gpm (25.9 - 29.6 lpm).
System Capacity (Fresh Water)	5.0 US qts (4.7 liters)

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SPECIFICATIONS 10.0KW BTDA

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole, revolving field. Pre-lubricated, single-bearing design. Reconnectable, single-phase transformer regulation (optional solid-state voltage regulation)	
Voltage	120 or 120/240 Volts - 60 Hertz 220 Volts - 50 Hertz	
Voltage regulation:	±5% no load to full load	
Frequency regulation:	±3 Hertz (5%) no load to full load	
Rating (Volts AC) 60 Hertz (1800 rpm) 10.0KW 50 Hertz (1500 rpm) 7.5KW	120 Volts 120/240 Volts 220 Volts	83.3 Amps 83.3/41.6 Amps 34.1 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	225 - 250 cfm (5.66 - 6.37 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	

AC GENERATOR (3 Phase)

Three Phase 10.0 Kw - 60 Hertz 7.5 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 220 Volts
Amperage - 3 phase 60 Hertz	Low Voltage WYE High Voltage WYE DELTA	35 Amps 15 Amps 30 Amps
Amperage - 3 phase 50 Hertz	High Voltage WYE DELTA	14 Amps 24 Amps
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	32 cfm (.906 cmm)	
Engine Compartment Cooling Requirements	100-200 cfm (2.83-5.66 cmm)	

SPECIFICATIONS 8.0KW BTDA

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole, revolving field. Pre-lubricated, single-bearing design. Reconnectable, single-phase transformer regulation (optional solid-state voltage regulation)	
Voltage	120 or 120/240 Volts - 60 Hertz 220 Volts - 50 Hertz	
Voltage regulation:	±5% no load to full load	
Frequency regulation:	±3 Hertz (5%) no load to full load	
Rating (Volts AC) 60 Hertz (1800 rpm) 8.0KW 50 Hertz (1500 rpm) 6.0KW	120 Volts 120/240 Volts 220 Volts	66 Amps 66/33 Amps 27 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	175 - 200 cfm (4.95 - 5.66 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	32 cfm (.906 cmm)	
Engine Compartment Cooling Requirements	100-200 cfm (2.83-5.66 cmm)	

SPECIFICATIONS 15KW BTDC/12.5KW BTDB

GENERAL

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Displacement	107.3 cubic inches (1.758 liter)
Aspiration	Naturally aspirated.
Combustion Chamber	Swirl type.
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)
Firing Order	1 - 3 - 4 -2
Direction of Rotation	Clockwise, when viewed from the front.
Compression Ratio	22:1
Dimensions - inches (mm) Engine Only	Height: 24.0 inches (609.6 mm) Width: 19.0 inches (482.6 mm) Length: 34.6 inches (878.8 mm)
Weight (dry)	569 lbs (258.10 kgs)
Fuel Consumption	1.42 g/hr (5.38 ltr/hr) at 1800 rpm
HP @ 1800 RPM	25 HP

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Spilled Timing (Static)	17° (spill)
Valve Seat Angle	Intake 45° Exhaust 30°
Engine Speed	1800 rpm (60Hz) 1500 rpm (50Hz)
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance	0.25mm (0.0098in)
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Engine Timing	17° 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
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear

FUEL SYSTEM

General	Open flow, self priming.
Fuel	No. 2 diesel oil (cetane rating of 45 or higher).
Fuel Injection Pump	In-line plunger type (BOSCH).
Nozzle	Throttle type.
Fuel Filter	Spin-on replaceable (PN#024363)..
Air cleaner	Replaceable paper filter cartridge.
Fuel Lift Pump	12 volt DC lift capacity of 5' (1.5 mm) solid state

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.
System Capacity (Fresh Water)	8.0 US qts (7.6 liters)
Raw Water Flow at 1800 rpm. (Measured before discharging into exhaust elbow).	7-8 gpm (25.9 - 29.6 lpm).
Engine Combustion Air Requirements @ 60Hz 1800 rpm	41 cfm (1.16 cmm)

LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	4.5 U.S. qts (4.3 liters)
Operating Oil Pressure (engine hot)	50 – 60 psi (3.5 – 4.2 kg/cm²)
Oil Grade	API Specification CF or CG-4

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SPECIFICATIONS 15KW BTDC

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole, revolving field. Pre-lubricated, single-bearing design. Reconnectable, single-phase transformer regulation (optional solid-state voltage regulation)
Voltage	120 or 120/240 Volts - 60 Hertz 230 Volts - 50 Hertz
Voltage regulation:	±5% no load to full load
Frequency regulation:	3 Hertz (5%) no load to full load.(Electronic Governered) Non-Electronic ±3 Hertz
Rating (Volts AC)	60 Hertz (1800 rpm) 120 Volts 125 Amps 120/240 Volts 125/62.5 Amps 50 Hertz (1500 rpm) 230 Volts 60 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	225 - 250 cfm (6.37 - 7.08 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	70 cfm (1.89 cmm)
Generator Compartment Ambient Temperature Recommendations	104°F (40°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 104°F (40°C).*

AC GENERATOR (3 Phase)

Three Phase 15.0 Kw - 60 Hertz 12.0 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 50 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	52 Amps 22 Amps 45 Amps
Amperage - 3 phase 50 Hertz	High Voltage WYE DELTA	22 Amps 39 Amps
Generator Compartment Ambient Temperature Recommendations	104°F (40°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 104°F (40°C).*	

SPECIFICATIONS 12.5KW BTDB

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole, revolving field. Pre-lubricated, single-bearing design. Reconnectable, single-phase transformer regulation (optional solid-state voltage regulation)
Voltage	120 or 120/240 Volts - 60 Hertz 220 Volts - 50 Hertz
Voltage regulation:	±5% no load to full load
Frequency regulation:	±3 Hertz (5%) no load to full load
Rating (Volts AC) 60 Hertz (1800 rpm) 12.5KW 50 Hertz (1500 rpm) 9.3KW	120 Volts 104 Amps 120/240 Volts 104/52 Amps 220 Volts 42.3 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	200 - 225 cfm (6.37 - 7.08 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*

AC GENERATOR (3 Phase)

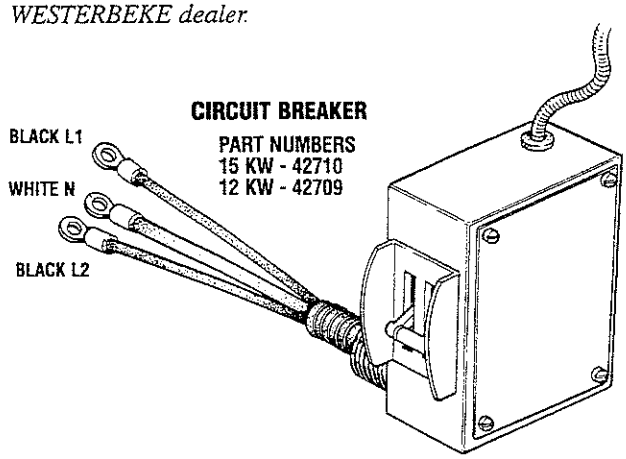
Three Phase 12.5 Kw - 60 Hertz 9.3 Kw - 50 Hertz	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase 60 Hertz	Low Voltage WYE High Voltage 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	43 Amps 18 Amps 37 Amps
Amperage - 3 phase 50 Hertz	High Voltage WYE DELTA	17 Amps 30 Amps
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	32 cfm (.906 cmm)	
Engine Compartment Cooling Requirements	100-200 cfm (2.83-5.66 cmm)	

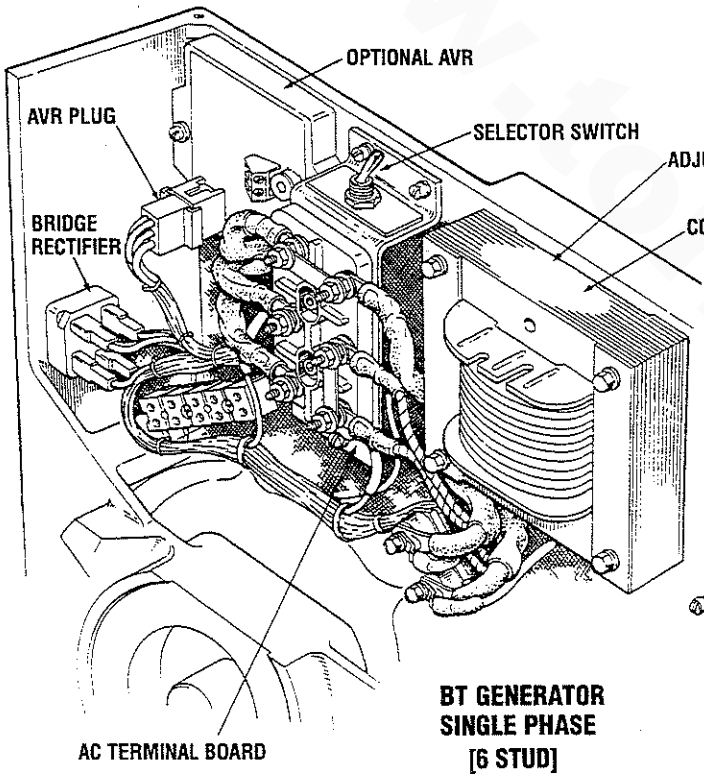
BT GENERATOR SINGLE/THREE PHASE

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 exciter rotor windings during rotation. Diodes located in the exciter rotor rectify this voltage to DC 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. A step down transformer is connected in parallel to the AC output of the main stator. An AC voltage is produced in the auxiliary windings of the transformer and the main stator and is, in turn, supplied to a full-wave bridge rectifier. The rectifier produces a DC voltage to further excite the exciter stator windings, enabling the generator to produce a rated AC output. An optional solid-state voltage regulator is available to work in tandem with the transformer regulator to produce a more stable AC output.

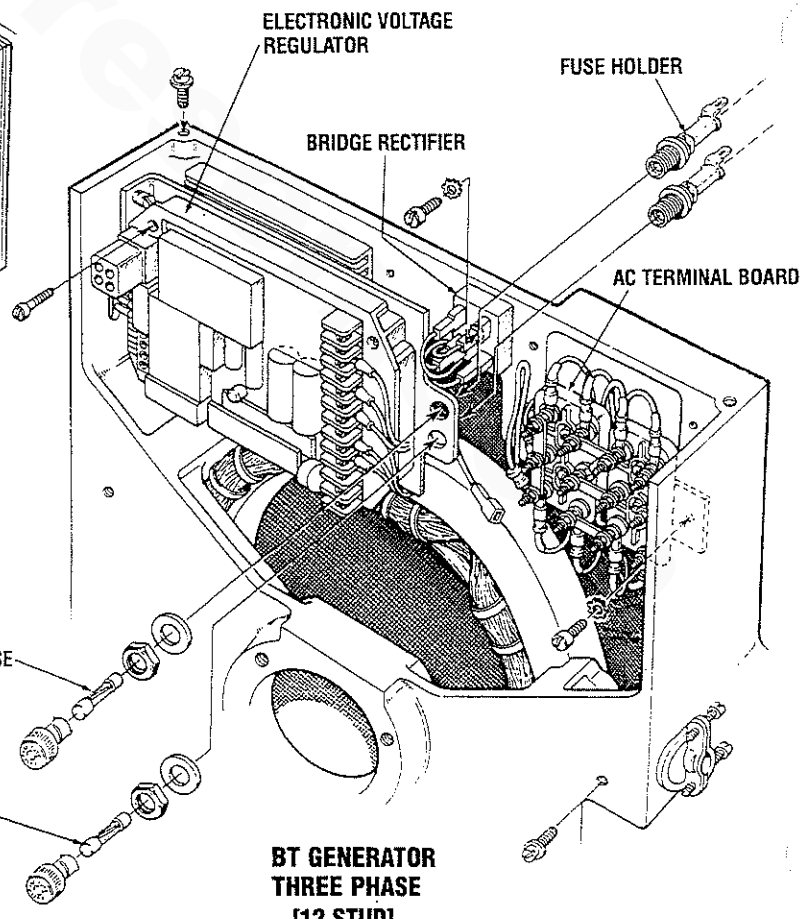
A circuit breaker is installed on all WESTERBEKE generators. This circuit breaker will automatically disconnect generator power in case of an electrical overload. The circuit breaker can be manually shut off when servicing the generator to ensure no power is coming into the boat.

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





BT GENERATOR SINGLE PHASE [6 STUD]

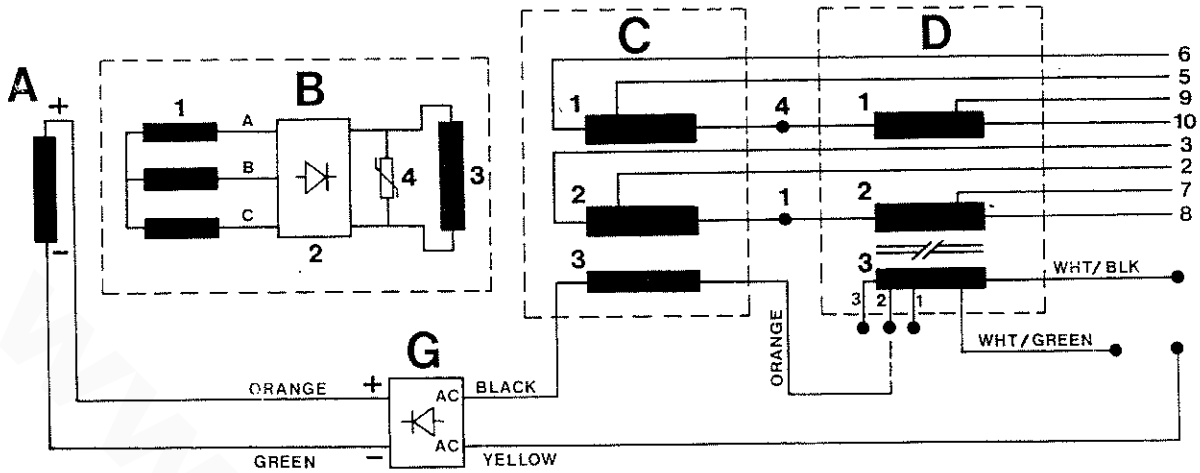


BT GENERATOR THREE PHASE [12 STUD]

WESTERBEKE Engines & Generators

BT GENERATOR 12 STUD INTERNAL WIRING SCHEMATIC

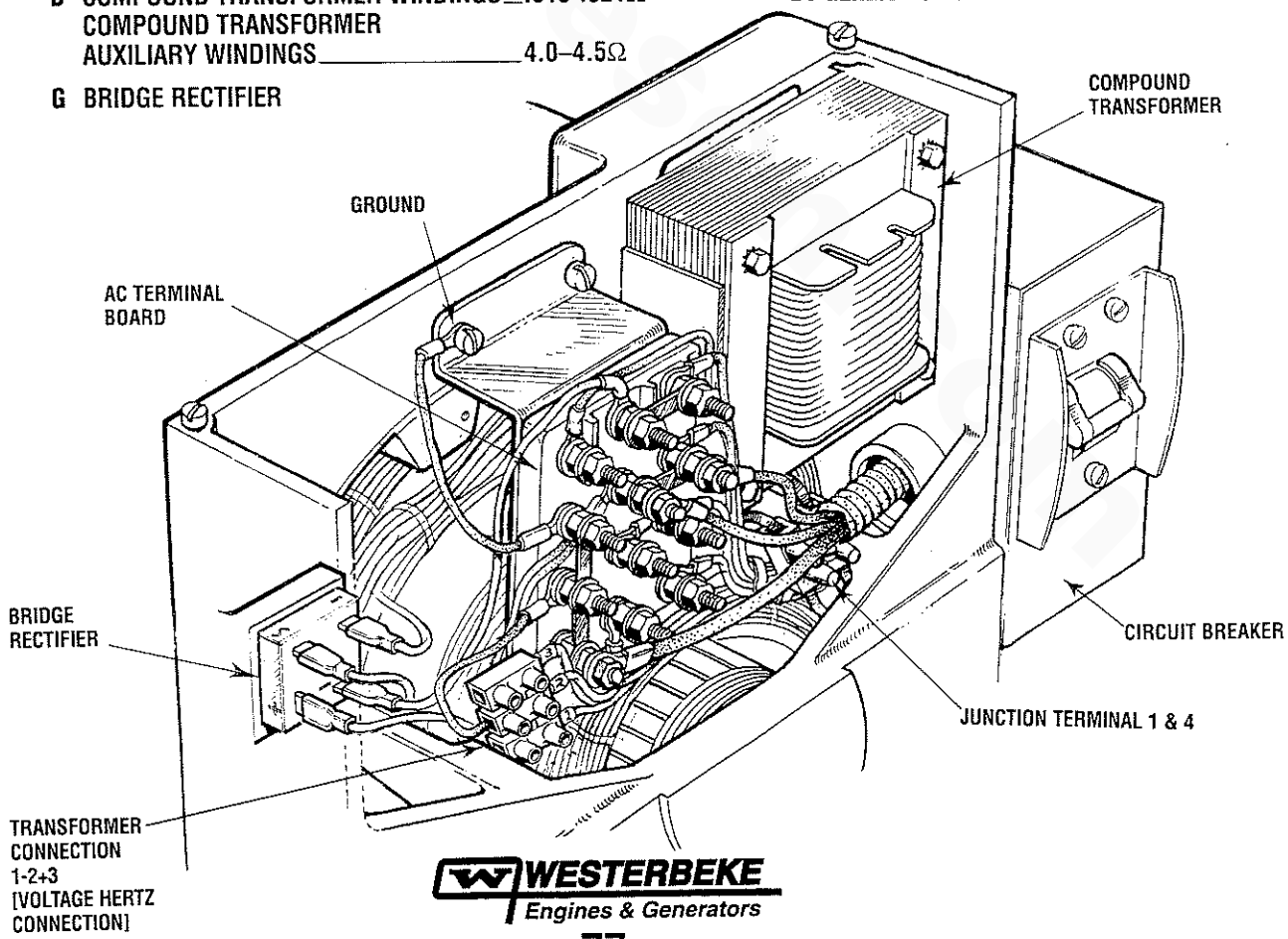
NOTE: *Refer to the text and diagrams for the proper method of testing for resistance and continuity.*



COMPONENT RESISTANCE VALUES [OHMS]

A	EXCITER STATOR WINDINGS	10.0Ω
B	AUXILIARY ROTOR WINDINGS (A,B,C)	1.0–1.2Ω
	DIODES (6)	11Ω/infinite
	ROTATING FIELD WINDINGS	7.0–8.0Ω
	POSI RESISTOR)	infinite
C	MAIN STATOR WINDINGS	20-22Ω
	MAIN STATOR AUXILIARY WINDINGS	1.5–1.8Ω
D	COMPOUND TRANSFORMER WINDINGS	.019-.021Ω
	COMPOUND TRANSFORMER AUXILIARY WINDINGS	4.0–4.5Ω
G	BRIDGE RECTIFIER	

BT GENERATOR SINGLE PHASE 12 STUD



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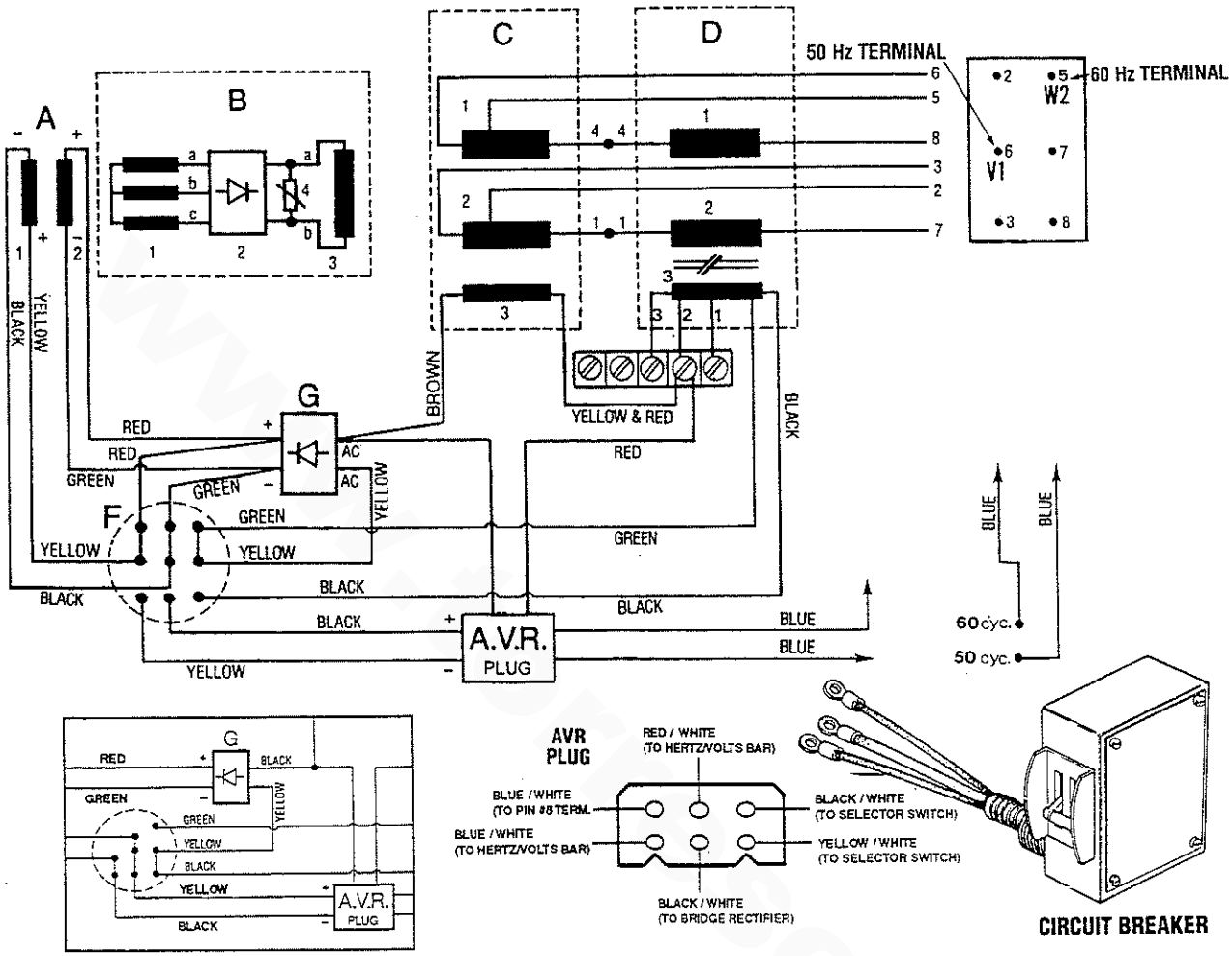
BT GENERATOR/SINGLE PHASE
10KW-15KW GENERATORS



BT GENERATOR/SINGLE PHASE
10KW-15KW GENERATORS

A. EXCITER STATOR WINDINGS 1& 2
A-1 and **A-2** Exciter Stator Windings (Selector in **COMP** position)

B. EXCITER ROTOR and FIELD
1. Auxiliary Windings **(a-b-c)**
2. Diodes (6)
3. Rotating Field Windings
4. Posi Resistor

C. MAIN STATOR
1. Main Stator Windings
2. Main Stator Windings
3. Main Stator Auxiliary Windings

D. COMPOUND TRANSFORMER
1. Compound Transformer Windings
2. Compound Transformer Windings
3. Compound Transformer Auxiliary Windings

Resistance readings and voltage checks can be accessed easily for the components in the exciter circuit **A**, **G**, **C-3** and **D-3** by locating the color coded wires at the connection points shown on the above schematic. When checking winding resistance values be sure to lift both of the component's electrical connections.

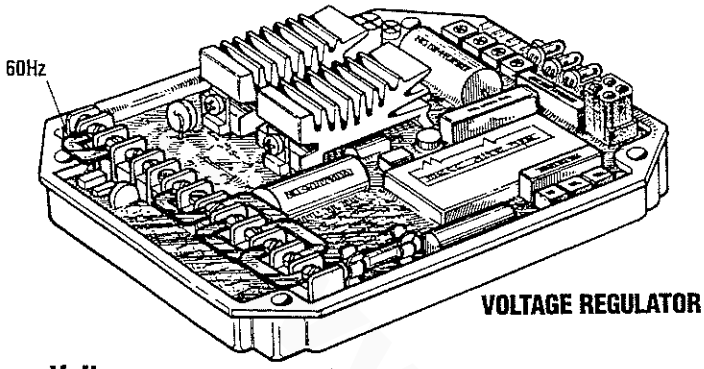
G. BRIDGE RECTIFIER

A.V.R. Optional Automatic Voltage Regulator Plug (6 Prong).

BT GENERATOR VOLTAGE REGULATOR ADJUSTMENTS

Description

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



VOLTAGE REGULATOR

Volts

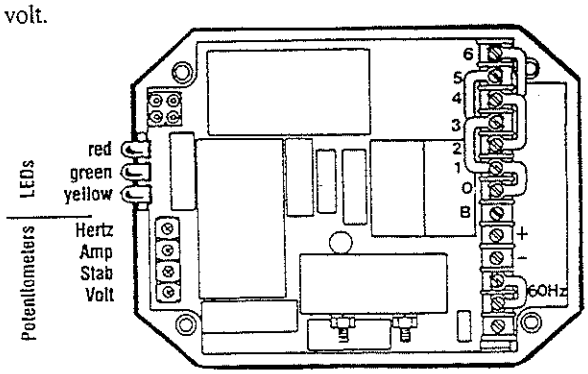
This potentiometer is used to adjust output voltage. At proper engine operating speed the output voltage should be held at ±1% from a no-load condition to a full rated generator output and from power factor 1.0 - 0.8 with engine drive speed variations up to -6%. Prior to starting the engine, turn the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

1. Load the generator 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 generator 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 generator 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 generator 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 generator'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.

BT GENERATOR TROUBLESHOOTING CHART

The following troubleshooting chart is designed to give insight into problems which may be encountered with the BT brushless generators operating on compound transformer regulation. Owing to the simplicity of the equipment and controls, troubleshooting is relatively easy, once the relationship between cause and effect is understood. Most potential problems are covered in the text of this manual

Keep in mind that a basic fundamental knowledge of electricity is required for this troubleshooting, and always remember that lethal voltages are present in the circuitry; therefore, extreme caution is essential when troubleshooting a generator.

Only a few basic tools are necessary for diagnosis and repair. These are hand tools: an ampprobe and a quality volt-ohmmeter capable of reading less than one ohm due to the precision required in reading component winding resistances.

Before attempting any repairs, get a clear an explanation of the problem as possible, preferably from an individual witnessing the problem. In some cases, this may bring to light a problem which is related to the method of operation rather than equipment fault. Bring basic repair tools with you on the initial trip to the problem equipment, such as: diodes and bridge rectifier, so that if the problem should be found in one of these easily replaceable parts, the problem can be remedied early and efficiently.

NOTE: *When fault finding, troubleshoot components in the order indicated below.*

COMPONENT CHECKS

REFER TO THE INTERNAL WIRING DIAGRAMS

1. LOW VOLTAGE 60-100 VOLTS AC

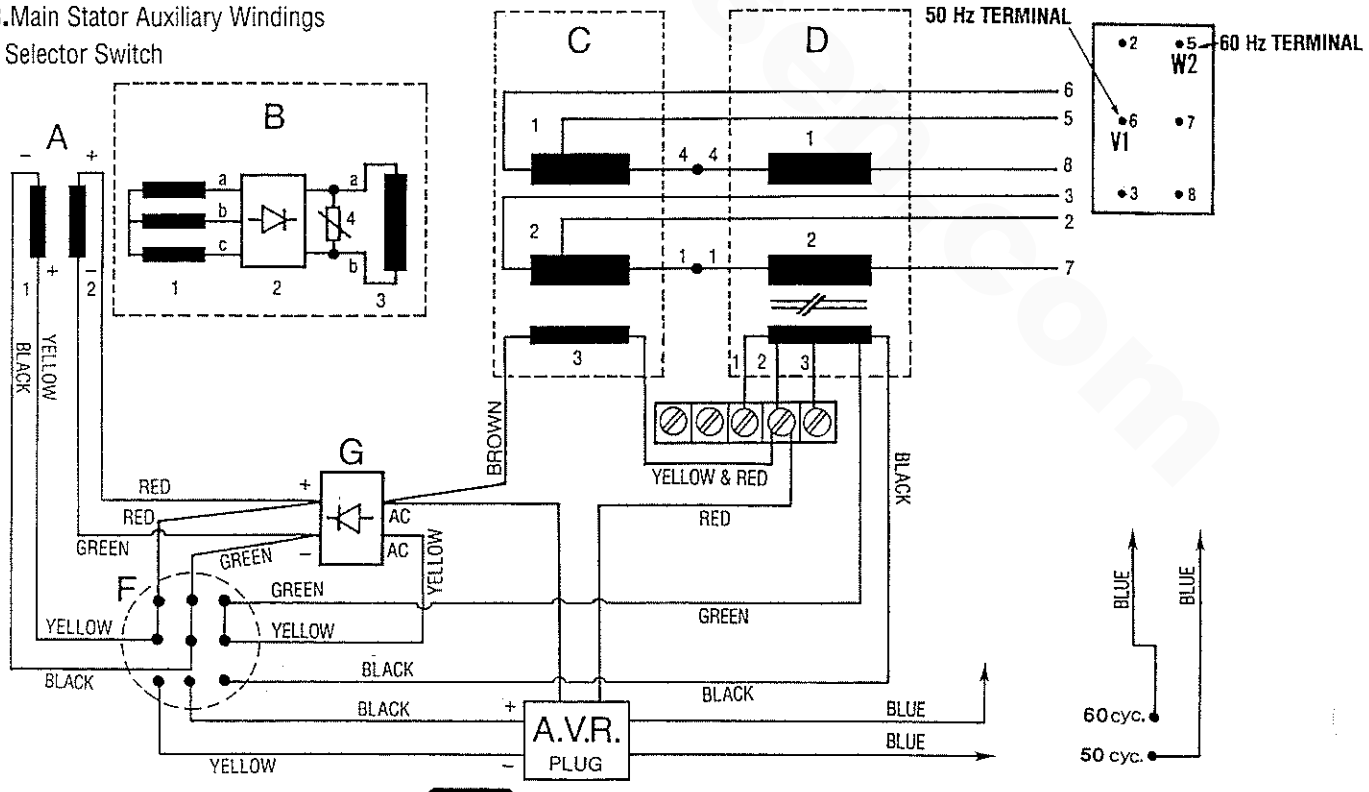
- **F.** Selector Switch
- **B.** Rotor Components
  - **B-2** Exciter Rotor Diodes
  - **B-3** Rotor Field Windings
  - **B-1** Exciteor Rotor Windings **a,b, c**
- **A.** (1-1+2) Exciter Stator Windings

2. RESIDUAL VOLTAGE - EXCITER CIRCUIT FAULTY

- **A.** (1-1+2) Exciter Stator Windings
- **G.** Bridge Rectifier
- **D-3.**Transformer Auxiliary Windings
- **C-3.**Main Stator Auxiliary Windings
- **F.** Selector Switch

3. NO AC VOLTAGE OUTPUT - MAIN STATOR/ROTOR COMPONENTS/TRANSFORMER

- **C.** (1+2) Exciter Stator Windings
- **B-4.**Posi Resistor
- **B-2.**Diodes (4-6 open/shortened)
- **D.** (1+2) Compound Transformer Windings
- **B-3.**Rotor Field Windings



BT GENERATOR TROUBLESHOOTING

Testing Residual Voltage

1. The amount of no-load voltage produced by the generator can be an indicator of where in the generator the problem/fault may lie.

Residual Voltage 10-14 volts AC

This voltage is the AC voltage produced by the generator from magnetism in the exciter stator field. This voltage is measured between the AC Neutral and Hot leg(s) with no-load on the generator running at 60 hertz.
The presence of residual voltage is an indication that the following generator components are OK. Refer to *INTERNAL WIRING SCHEMATICS*.

a. Exciter Rotor (B-1 a, b, & c) & (B-2);

b. Rotating Field (B-3);

c. Main Stator (C-1 & C-2); and

d. Compound Transformer (D-1 & D-2).

The fault lies in one or more of the following components in the exciter circuit:

a. Exciter Stator (A-1 & A-2)

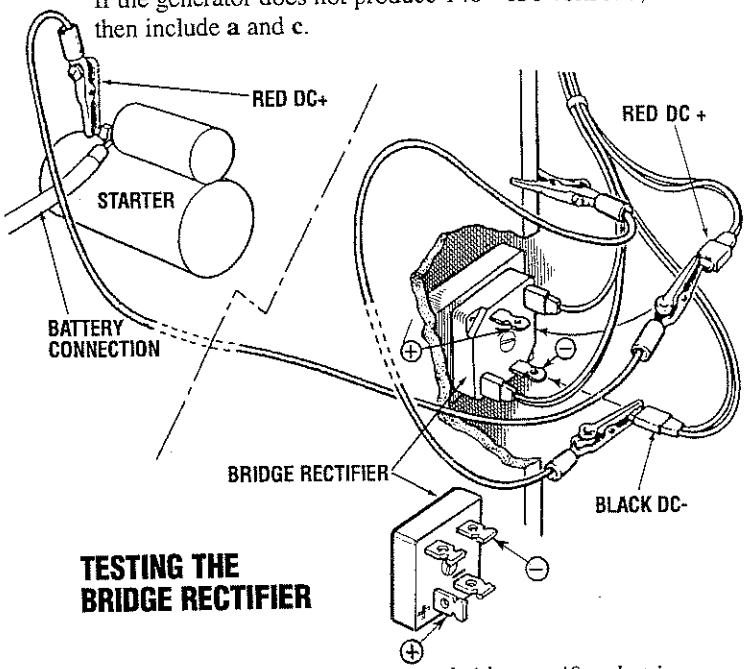
b. Bridge Rectifier (G)

c. Selector Switch (F)

d. Main Stator Auxiliary Windings (C-3)

e. Compound Transformer Auxiliary Winding (D-3)

2. Twelve (12) volt DC excitation of the exciter stator windings should cause the generator to produce between 140 - 150 volts AC between each hot lead and the neutral (12 volts DC is applied between the lifted (+) and (-) leads of the bridge rectifier, + to + and - to -).
Correct voltage produced with twelve volts DC excitation indicates the fault is in one or more of the above listed components **b**, **d** or **e**.
If the generator does not produce 140 - 150 volts AC, then include **a** and **c**.



TESTING THE BRIDGE RECTIFIER

NOTE: *Current BT Generators use a bridge rectifier that is configured differently, connections are the same.*

3. The absence of any voltage from the generator indicates a fault with the main stator windings C-1 and C-2 and/or the compound transformer windings D-1 and D-2.
Apply 12 volt DC excitation to the exciter stator windings as explained in paragraph 2. A fault in the main stator and/or compound transformer windings such as a short will cause the generator engine to load down and the shorted windings to eventually produce smoke as the excitation is continued.

4. Voltage output greater than residual and less than rated output (25 - 100 volts) indicates a fault in the exciter rotor/field B-1, B-2 or B-3. Excitation of the generator as explained in paragraph **2** should produce a partial rise in voltage output and, when removed, the voltage will return to the original low output.

BRIDGE RECTIFIER

The bridge rectifier is supplied AC voltage from the auxiliary windings in the generator stator (C-3) and the compound transformer (D-3). The AC voltage measured across the AC terminals of the rectifier during engine operation is as follows:

120 Volts	**120/240**
N/L F/L	N/L F/L
11 – 20 volts AC	11 – 20 volts AC

Diodes in the rectifier convert this AC voltage to DC and supply it to the windings of the exciter stator to induce a field through which the exciter rotor revolves. The DC voltage measured across the (+) and (–) terminals of the bridge rectifier during engine operation is as follows:

120 Volts	**120/240**
N/L F/L	N/L F/L
8 – 15 volts AC	8 – 15 volts AC

Failure of the bridge rectifier will result in a weak field being produced by the exciter stator windings. A weak field is present, due to the magnetism in the exciter stator, which will cause the generator to produce residual voltage.

Testing the Bridge Rectifier for Faults with an Ohmmeter

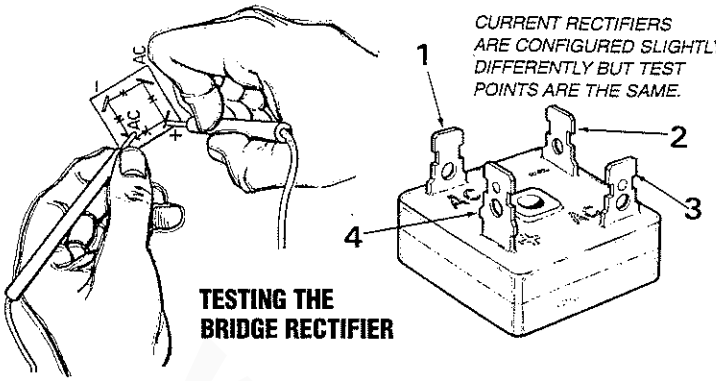
(Meter used: *Simpson 260* at 70°F (21°C)

1. Set the ohmmeter scale on RX1 (+ DC) and set the needle to zero.

2. Connect the positive (+) lead from the ohmmeter to point #4. Taking the ohmmeter's negative (-) lead, momentarily contact points #1, #2, #3, and #5. The ohmmeter should register no deflection for any of the points touched.

3. Remove the positive (+) lead from point #4 and connect the negative (-) lead to point #4 and, with the positive (+) lead, momentarily touch points #1, #2, and #3. The ohmmeter's needle should deflect when each point is touched, showing a passage of meter voltage through the diodes in the rectifier.

BT GENERATOR TROUBLESHOOTING/SINGLE PHASE



TESTING THE BRIDGE RECTIFIER

4. Leaving the negative (-) ohmmeter lead on point #4, touch point #5 with the positive (+) lead. No deflection of the needle should occur.
5. Place the positive (+) lead of the ohmmeter on point #1 and the negative (-) lead on point #3. The ohmmeter should not register any deflection of the needle (no deflection indicates infinite resistance). Reverse these connections and the ohmmeter should again register no deflection.
   If the rectifier fails any of the previous tests (1 - 4) it is defective and should be replaced.

NOTE: *Different style/model meters may produce opposite results from the above tests.*

Component Resistance Values

A. Exciter Stator
A-1 & A-2 11.5 ohm
A-1 49.4 ohm
A-2 12.9 ohm

B. Excitor Rotor/Field
B-1 1.05 ohm,
B-3 8.9 ohm

C. Main Stator
C-1 0.089 ohm
C-2 0.089 ohm
Auxiliary Windings
C-3 0.85 ohm

D. Compound Transformer
D-1 0.007 ohm
D-2 0.007 ohm
Auxiliary Windings
D-3 5.02 ohm

E. A.C. Terminal Board **F. Selector Switch**
H. Optional AVR

G. Bridge Rectifier

The model code number is found stamped in the generator housing on a flat surface above the rear generator carrier bearing.

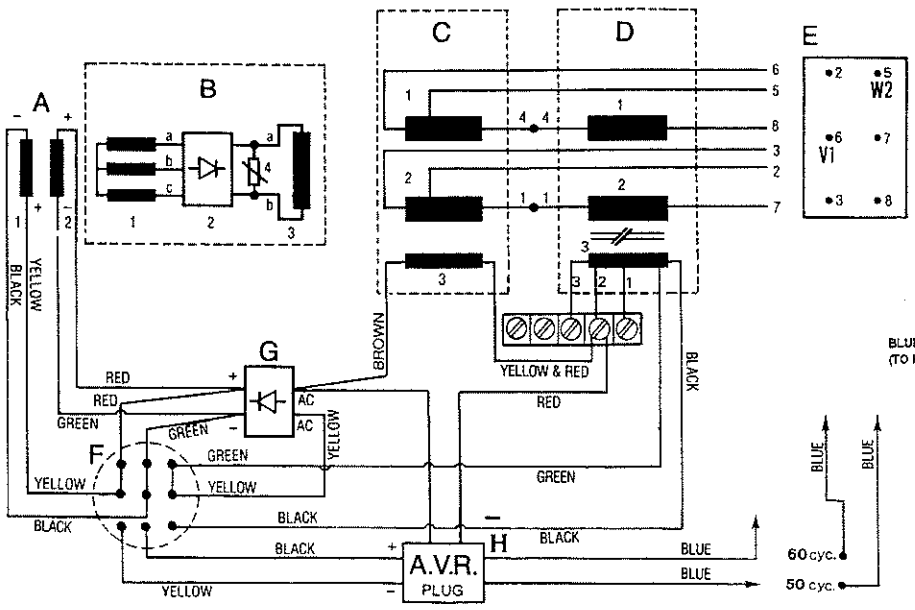
NOTE: *These two model BT generators are used on models rated lower than the capabilities of the generator. However, the generator is rated according to the capabilities of the drive engine since horsepower produces kilowatts.*

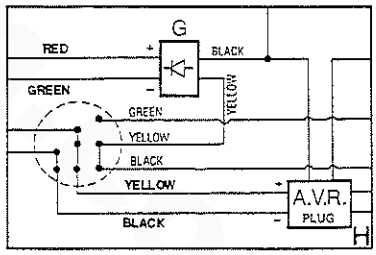
COMPONENT RESISTANCE CHECKS

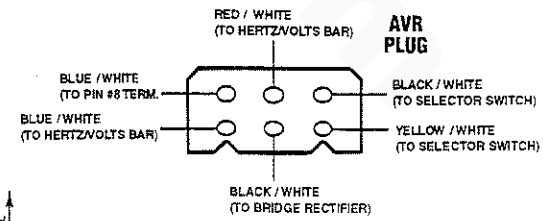
Exciter Stator Windings

1. **Windings A-1 and A-2**
   Resistance readings for exciter windings A-1 and A-2 with the selector switch in the COMP position are taken between the positive (+) and negative (-) leads lifted off the bridge rectifier (G). Neither of these two leads should have the continuity to the generator case/ground.
2. **Winding A-1**
   Resistance readings for exciter windings A-1 with the selector switch in the ELEC position is taken between the yellow wire and the black at the A.V.R. plug (G).
3. **Winding A-2**
   Resistance readings for exciter winding A-2 with the selector switch in the ELEC position is taken between the green wire lifted off the negative (-) terminal of the bridge rectifier (G) and the red wires lifted off the positive (+) terminal of the bridge rectifier (G).

NOTE: *The white striped wiring on earlier model generators has been changed to solid colors on current generators, the colors, however, remain the same.*







BT GENERATOR INTERNAL WIRING SCHEMATIC (W/OPTIONAL AVR)

BT GENERATOR TROUBLESHOOTING/SINGLE PHASE

Main Stator Windings

1. **Group #1.** The resistance value is measured between the lifted lead #4 from the insulated terminal below the transformer and lead #6 lifted from the AC terminal block. Lead #5 should be lifted from the terminal block in order to totally isolate the stator windings of group #1, .
2. **Group #2.** The resistance value is measured between the lifted lead #1 from the insulated terminal below the transformer and lead #3 lifted from the AC terminal block. In order to totally isolate the stator windings of group #2, lead #2 should be lifted from the terminal block.

   NOTE: *No continuity should be found between any of the lifted stator leads and the case ground or between the connections of the two groups.*
3. **Main Stator Auxiliary Windings.** The resistance values for these windings are measured between the black double lead connection lifted off the AC terminal of the bridge rectifier (G) and the red #3 lead lifted off the Voltage/Hertz connection bar.

   NOTE: *No continuity should be found between either of these winding groups or to the generator case.*

Compound Transformer

1. **Group 1.** Resistance value is measured between lifted lead #4 from the red insulated terminal stud below the transformer and lead #8 lifted off the AC terminal block.
2. **Group 2.** Resistance value is measured between lifted lead #1 from the red insulated terminal stud below the transformer and lead #7 lifted off the AC terminal block

   NOTE: *No continuity should be found between either of these lifted leads or to the generator case/ground.*
3. **Transformer Auxiliary Windings.** Resistance is measured between the yellow wire lifted off the AC terminal block of the bridge rectifier (G) with the selector switch in the ELEC position and the #1 red lead lifted off the Voltage/Hertz connection bar. Off this same bar, lift the #2 and #3 red leads that come from the auxiliary windings to totally isolate these windings. There should be no continuity found from either of these connections to the case/ground or to either of the transformer groups.

Selector Switch

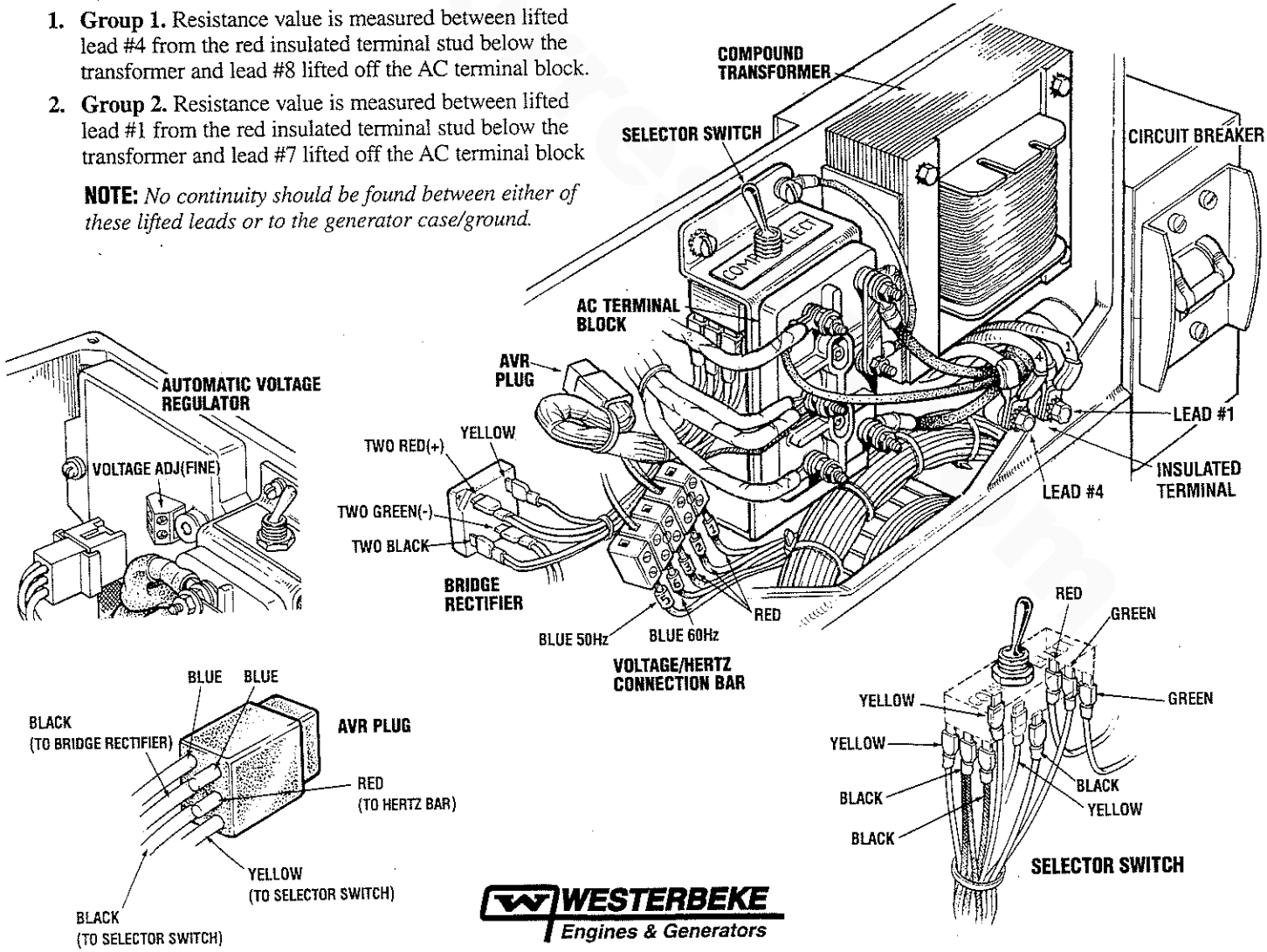
This switch is is normally set in the COMP position. If an optional AVR is installed, the switch is toggled to the ELEC position..

NOTE: *With the selector switch in ELEC position the exciter stator windings are divided, one group is excited through the bridge rectifier and the other group through the A.V.R.*

Bridge Rectifier Wiring

The illustration below shows the color coded wires at the two AC terminals and the color coded wires at the (+) and (-) DC terminals.

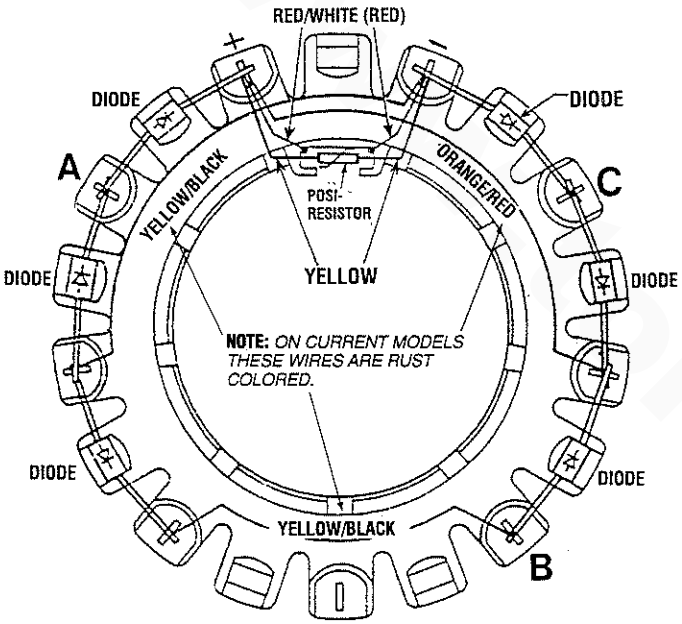
NOTE: *When removing or reinstalling connections, maintain correct polarity connection on the (+) and (-) DC terminals.*



BT GENERATOR TROUBLESHOOTING

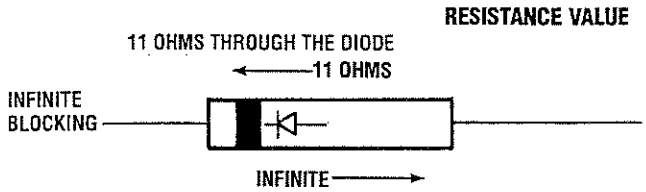
Exciter Rotor/Field

1. **Auxiliary windings group a, b and c.** Locate the three terminal points on the exciter rotor for these auxiliary winding groups. Position the exciter rotor as shown in the illustration and count off the porcelain knobs from the 12 o'clock point either left or right to locate terminal points a, b and c. Measure the resistance value between the pairs of terminal points A & B, B & C, and C & A. There is no need to unsolder these connections unless a faulty reading appears. If this occurs, unsolder and verify the winding fault. There should be no continuity found between any of the three terminal points and the rotor shaft/case ground.



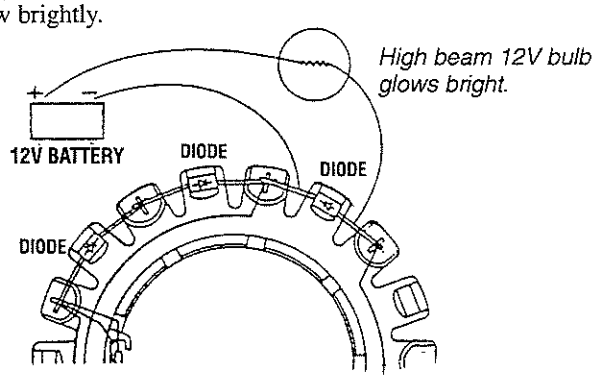
2. **Rotating Field Windings.** Refer to the illustration above of the exciter rotor. The field winding connections are noted as the (+) and (–) connections of the red & white striped wires. Measure the resistance value with your ohmmeter between these two connection points. These connections need not be unsoldered unless a faulty reading appears. If this occurs unsolder the connection and verify the resistance reading. With these connections lifted, there should be no continuity to the rotor shaft. This would indicate a short to ground with these field windings.

3. **Diodes.** Six diodes are mounted on the exciter rotor; they rectify the AC voltage produced by the three groups of auxiliary windings to DC voltages and supply this DC voltage to the rotating field windings.
The diodes can be easily checked in place with the use of a common automotive 12-volt high beam headlight bulb, some jumper leads and the generator's 12 volt starting battery.
A short or an open in a diode can easily be found with the above without having to unsolder and isolate each diode to check it with an ohmmeter.



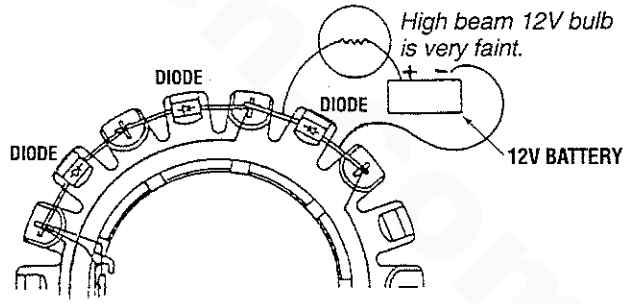
NOTE: *Attempting to check diodes in place with an ohmmeter will give erroneous readings on the diodes due to the auxiliary winding's connections.*

4. When leads are put across the diode, as illustrated, voltage passes through the diode allowing the headlight to glow brightly.



5. **Reverse the leads across the diode.** The diode should block voltage passing through it, and the headlight should not glow, or it may glow faintly.
   a. Should the bulb not glow with leads connected in both directions, the diode is open internally.
   b. Should the bulb glow with leads connected in both directions, the diode is shorted internally.

   In both **a** and **b** above, the diode should be replaced. Check the resistance values of the rotating field windings and the integrity of the resistors connected between the field windings.



6. **Rotating Field Windings** Readings taken between the two red & white wires connected to the (+) and (–) terminals of the exciter rotor as shown.
7. **Posi-resistor.** Infinite readings between both yellow leads lifted from the (+) and (–) terminals on the exciter rotor. A short in the posi-resistor will cause a loss of the rotating field. AC output voltage will drop to zero.

BT GENERATOR TROUBLESHOOTING/SINGLE PHASE

No-Load Voltage Adjustment

Voltage adjustment is made with the generator regulation being governed by the compound transformer.

1. The selector switch *must* be in the COMP position.
2. To confirm no-load voltage, start the generator and apply a momentary (moderate) load to excite the transformer. The voltage produced by the generator after the momentary load is removed is no-load voltage. Note the voltage output from the generators 120 volt leg(s) (230 volt 50 hertz). The no-load voltage should be between 121-124 volts at 61.5-62 hertz (232- 236 volts at 51.5-52 hertz).
3. To raise or lower the voltage, shims of varying thickness (non-conductive material) are placed or removed from under the steel laminated bar on top of the compound transformer. The material used for shimming should not soften at temperatures in the 176° F (80° C) range. A small reduction in no-load voltage (1 to 3 volts) can some times be accomplished by gently tapping the top of the laminated steel bar to reduce the gap between the exist ing shims and the transformer core.

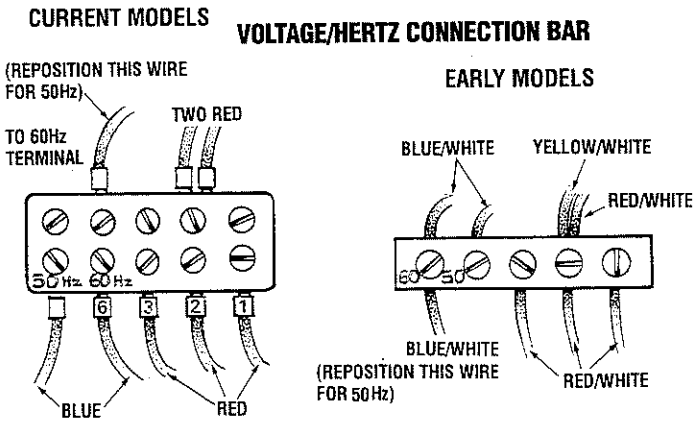
VOLTAGE/HERTZ CONNECTION BAR

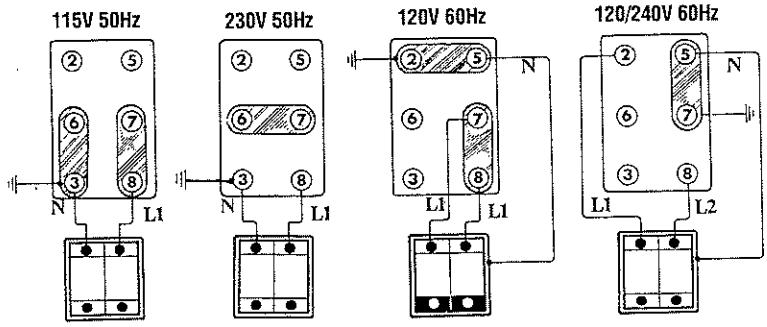
If there is no automatic voltage regulator (AVR) installed, do not change the wiring on the Voltage/Hertz Connection Bar. Simply reconfigure the AC voltage connections at the AC terminal for the hertz change.

The blue or blue/white lead should be connected to the Hertz terminal that the generator will be set to produce.

The order of the numbered connections on some Voltage/Hertz Connection Bars may be reversed (as in the diagrams below). To ensure a proper connection follow the blue/white or blue lead to the AC terminal block, it should connect to the correct terminal: stud 6(V1) for 50 Hz, 5(W2) for 60 Hz. See the *BT WIRING SCHEMATIC.*

NOTE: *When the optional voltage regulator is installed and if the Blue/White (Blue) lead is not correctly positioned to correspond to the Hertz the unit is operating at, the regulator will sense incorrect voltage and cause the generator to produce abnormally high output voltage.*





BT Generator Six Stud AC Voltage Connections

NOTE: *The frame ground wire must be moved when changing from 110 volts and 110/220 volts 50 hertz to 230 volts 50 hertz. For output leads from 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 connects between the neutral stud and the generator frame.*

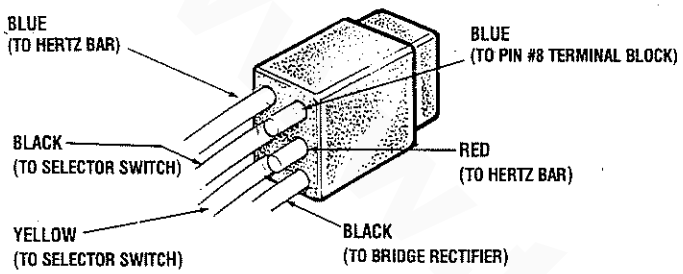
Generator Frequency

1. Frequency is a direct result of engine/generator speed:
   1800 rpm = 60 hertz;
   1500 rpm = 50 hertz.
2. To change generator frequency follow the steps below.
   a. Connect the AC output leads to the AC terminal block, following the correct diagram above..
   b. If an AVR is installed, reposition the blue or blue/white lead to correspond to the hertz selected on the Voltage/Hertz Connection Bar.
   c. Start the engine, monitor voltage and adjust engine no-load speed. Adjust diesel units by the linkage between the throttle arm and fuel solenoid or the throttle lever on the injection pump.
   60 hertz: no-load speed, 61.5-62.0 hertz.
   50 hertz: no-load speed, 51.5-52.0 hertz.
   d. After the no-load hertz adjustment is made, the no-load voltage may need to be readjusted. In most cases, if the generator was producing the correct no-load voltage at the previous hertz setting, it would be correct at the changed hertz setting.
   In the event it needs adjustment, adjust the shim thickness under the laminated steel bar of the transformer.
   60 hertz: no-load voltage, 121-124 volts
   50 hertz: no-load voltage, 232-236 volts,
   e. Load the generator to the rated amperage output corresponding to the hertz speed of the generator.
   Rated Loaded Speed
   60 hertz: loaded speed, 58.5-59.0 hertz
   50 hertz: loaded speed, 48.5-49.0 hertz
   The lowest acceptable voltage at full rated output (amps)
   60 hertz: 108-110 volts
   50 hertz: 205-210 volts

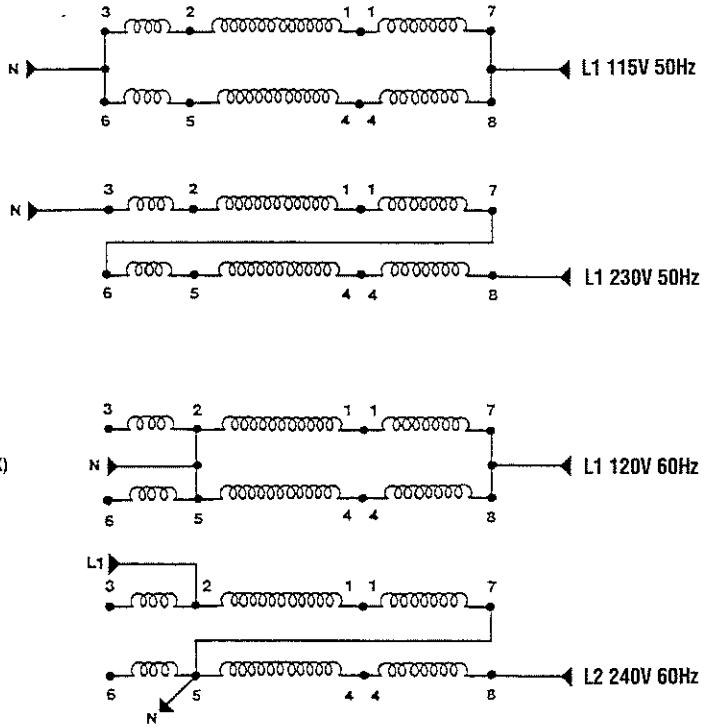
BT GENERATOR TROUBLESHOOTING

f. Should the voltage drop below the proper rate, loaded excitation can be increased to raise this voltage by repositioning connections on the Voltage/Hertz Connection Bar. Repositioning the two leads (red/white and yellow/white) from (1) to (2) or (3) terminals will increase the loaded voltage out progressively in that order.

NOTE: *No-load voltage may be effected needing readjustment with the compound transformer.* ***Do not*** *use these adjustments to compensate for overload conditions being placed on the generator/engine (inductive-motor type loads). Loss of generator hertz/speed, the result of overload, will cause a drop in voltage output.*



A.V.R. Plug and Connections



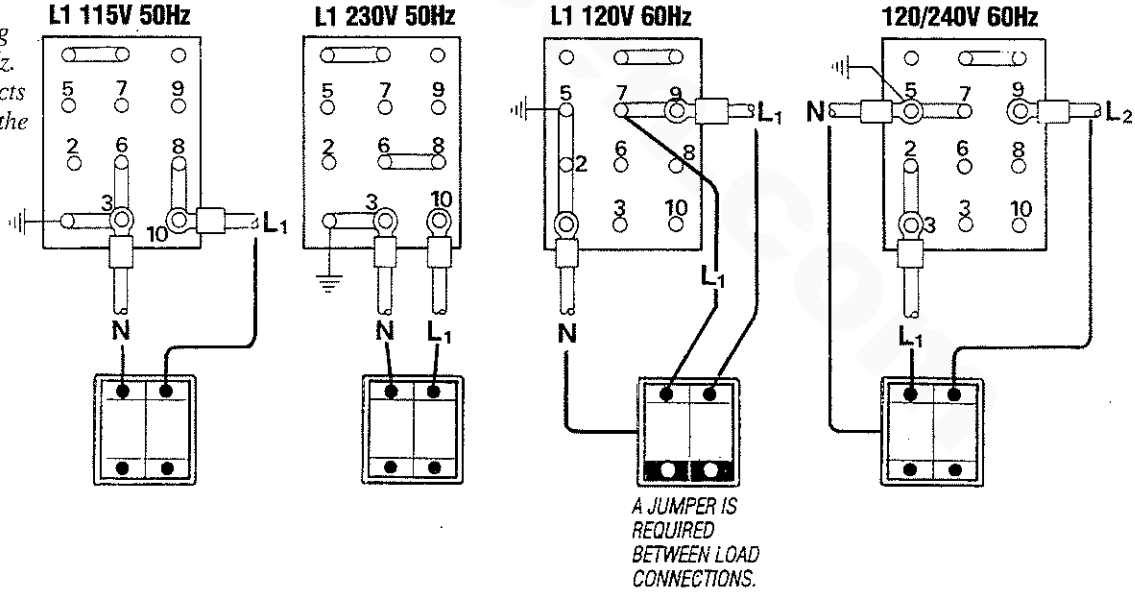
Terminal Block Wiring Connections

Wiring connections needed to obtain proper voltage and frequency are illustrated in the diagrams above.

NOTE: *Connections 1 and 4 are located on two red terminals below the compound transformer.*

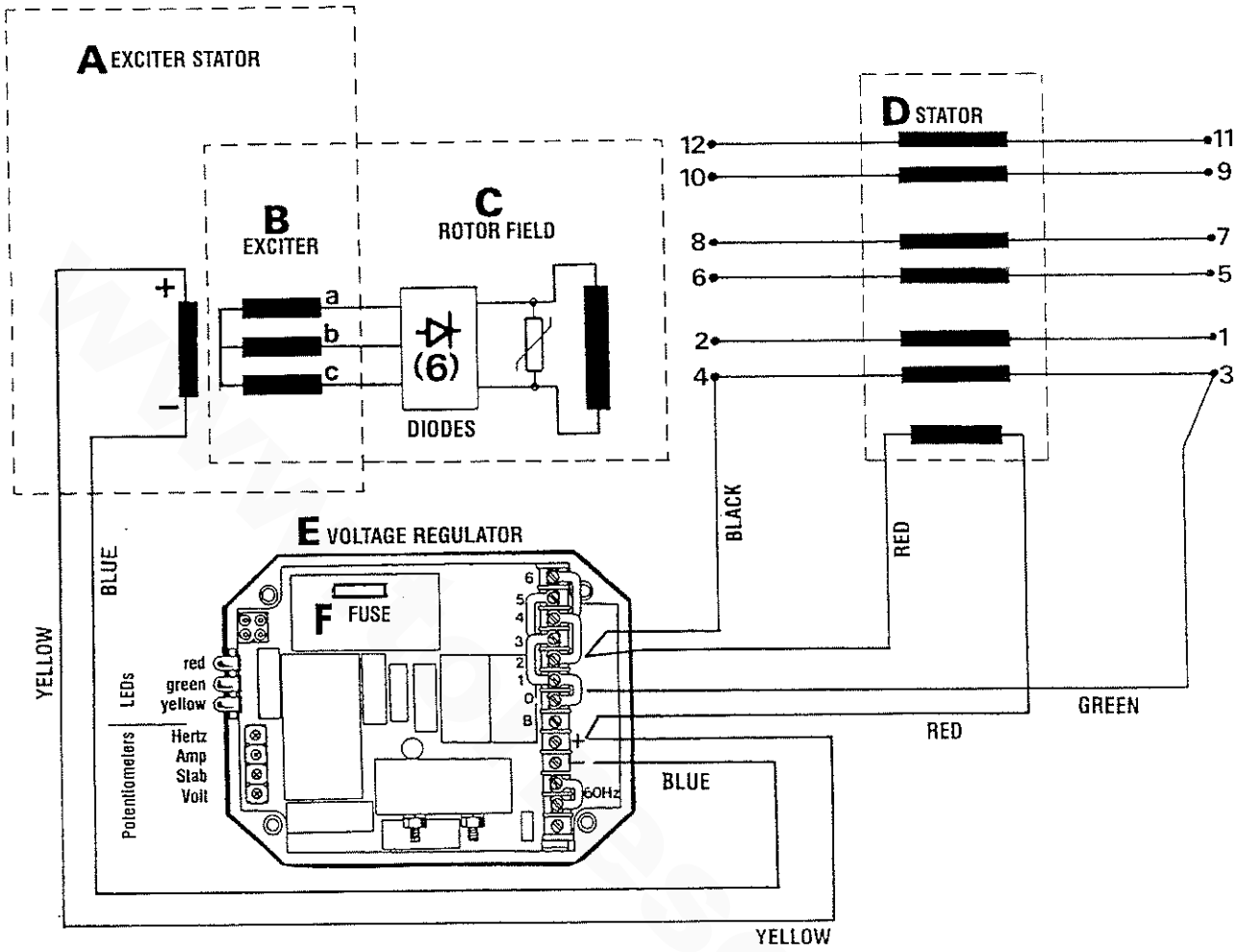
AC TERMINAL BOARD CONNECTIONS [12 STUD]

NOTE: *The frame ground wire must be moved when changing from 115V/50Hz to 230V/50Hz. The frame ground wire connects between the neutral stud and the generator frame.*



NOTE: *For ouput leads from the AC terminal block use terminal ends for 1/4" studs that accept multi-strand copper wire sized for the average rating from the hot lead connection*

BT GENERATOR INTERNAL WIRING
3 PHASE TWELVE WIRE RECONNECTABLE



RESISTANCE VALUES

A. EXCITER STATOR (17.9 ohm)

B. EXCITER ROTOR WINDINGS a b c (0.6 ohm)

C. ROTATING FIELD (2.49 ohm)

D. MAIN STATOR WINDINGS (0.05 ohm)
AUXILIARY WINDING (1.2 ohm)

E. VOLTAGE REGULATOR

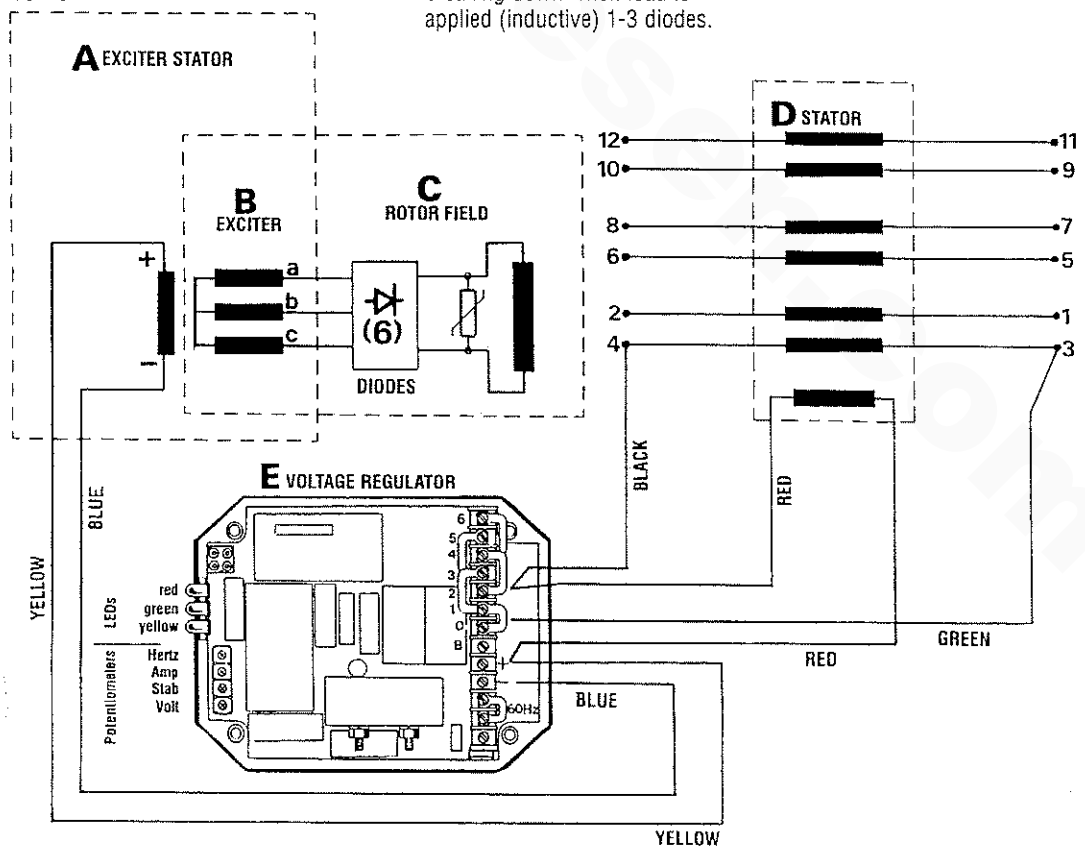
F. AUXILIARY CIRCUIT FUSE

WESTERBEKE
Engines & Generators

BT GENERATOR TROUBLESHOOTING/3 PHASE

NOTE: *AC generator troubleshooting must be performed with the engine operatin at 60 Hz.*

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. Open in exciter stator winding. 5. Open in rotating field winding.
RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.	1. Blown 6 AMP fuse auxiliary circuit 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. 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.	



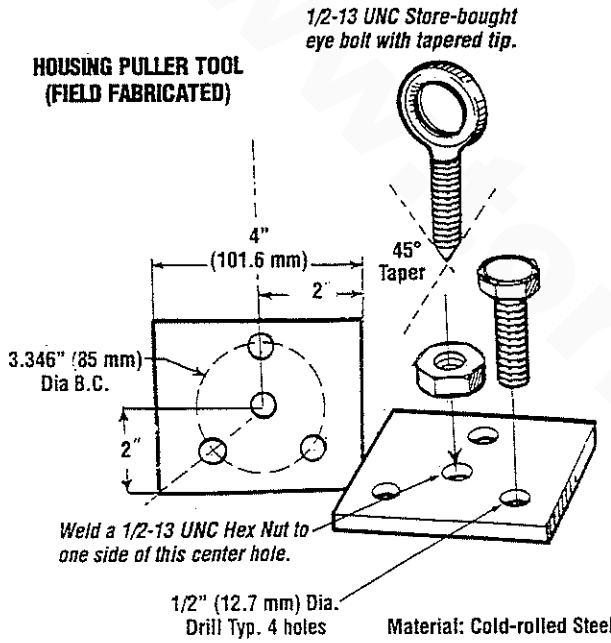
SPECIAL TOOLS - GENERATOR

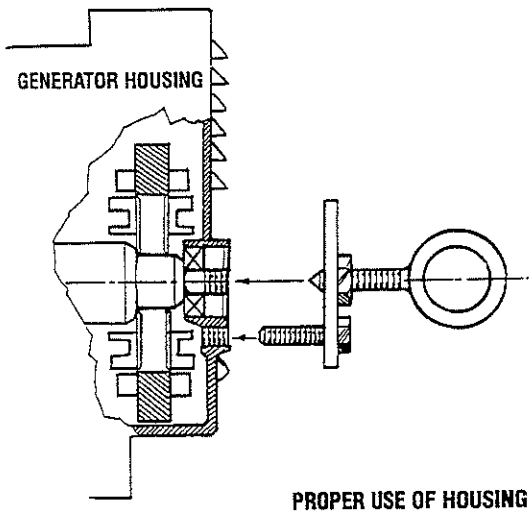
FIELD FABRICATED TOOLS

These drawings provide a means by which simple tools can be made to assist in the removal of the generator end from the engine and in the replacement of the generator end on the engine. A local machine shop should be able to fabricate these tools at a modest price, but first check with your local WESTERBEKE dealer to see if these tools are on hand for loan.

Housing Puller Tool

This tool allows the bearing in the generator housing to be gently pushed straight off the housing without any twisting. If a nut of the same specifications as that of the tapped hole in the pilot tool were to be welded on the end of the eye bolt, this tool would be able to pull the bearing back into place without any twisting. Please refer to these drawings before the generator end is removed.

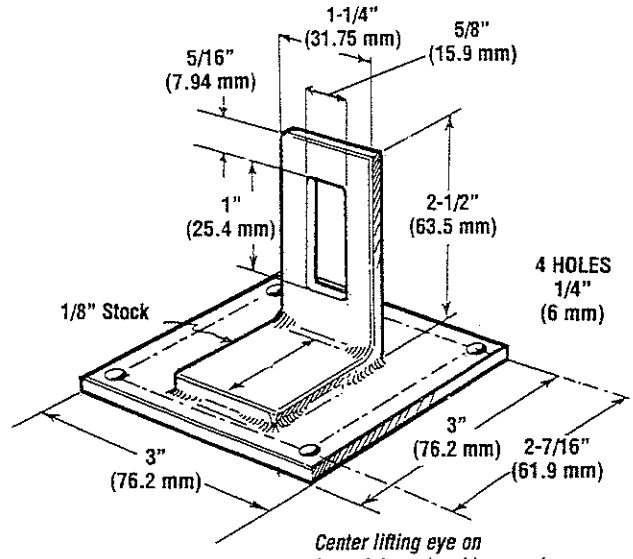




PROPER USE OF HOUSING PULLER

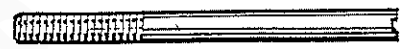
Lifting Eye Tool

This tool allows a mechanic to safely remove the generator end from the engine by attaching this Generator End Lifting Eye to the four screw holes located under the control panel. To use this Lifting Eye, remove the generator's control panel and screw the Lifting Eye to the generator end.



Disk Alignment Tool

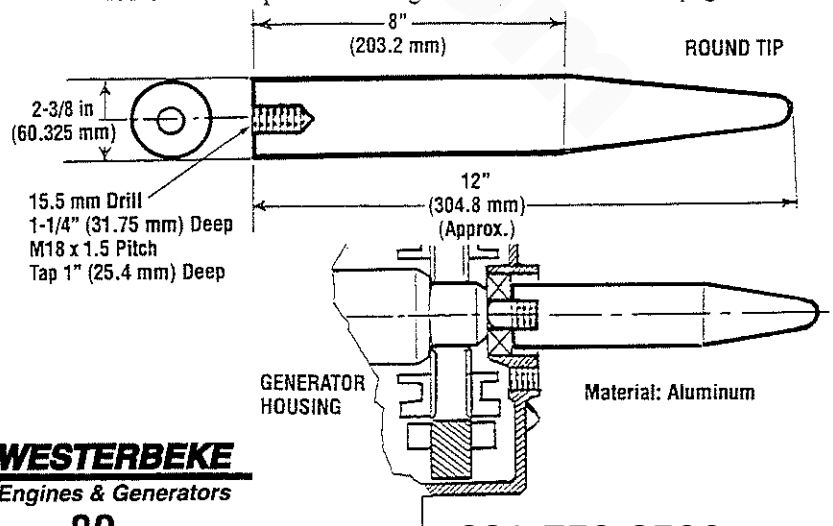
This tool allows a mechanic to safely remove and install the generator drive disks by aligning the disks with the Drive Plate Guide Pin. The Pin screws into the flywheel and acts as a guide. Also the pin helps to support some of the rotor and the drive plate's weight while removing or replacing these parts.



Material: One M8 bolt with the hex head machined off and a screwdriver slot cut in the machined end.

Pilot Tool

The tool below helps keep the rotor from damaging the windings in the generator housing to be removed straight off the engine or to be placed straight on the engine. Refer to the removal and replacement diagram at the bottom of the page.

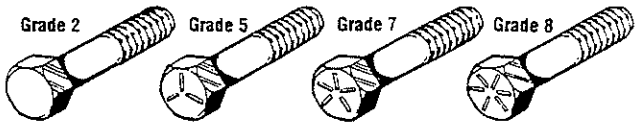


STANDARD HARDWARE

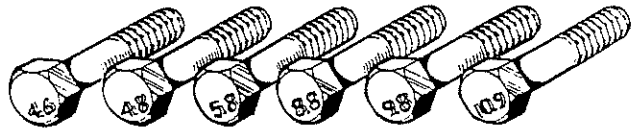
BOLT HEAD MARKINGS

Bolt strength classes are embossed on the head of each bolt.

Customary (inch) bolts are identifed by markings two to grade eight (strongest). The marks correspond to two marks less than the actual grade, i.e.; a grade seven bolt will display five embossed marks.



Metric bolt class numbers identify bolts by their strength with 10.9 the strongest.



NOTES: 1. *Use the torque values listed below when specific torque values are not available.*
2. *These torques are based on clean, dry threads. Reduce torque by 10% when engine oil is used.*
3. *Reduce torques by 30% or more, when threading capscrews into aluminum.*

STANDARD BOLT & NUT TORQUE SPECIFICATIONS

Capsrew Body Size (Inches) - (Thread)	SAE Grade 5 Torque Ft-Lb (Nm)	SAE Grade 6-7 Torque Ft-Lb (Nm)	SAE Grade 8 Torque Ft-Lb (Nm)
1/4 - 20	8 (11)	10 (14)	12 (16)
- 28	10 (14)		14 (19)
5/16 - 18	17 (23)	19 (26)	24 (33)
- 24	19 (26)		27 (37)
3/8 - 16	31 (42)	34 (46)	44 (60)
- 24	35 (47)		49 (66)
7/16 - 14	49 (66)	55 (75)	70 (95)
- 20	55 (75)		78 (106)
1/2 - 13	75 (102)	85 (115)	105 (142)
- 20	85 (115)		120 (163)
9/16 - 12	110 (149)	120 (163)	155 (210)
- 18	120 (163)		170 (231)
5/8 - 11	150 (203)	167 (226)	210 (285)
- 18	170 (231)		240 (325)
3/4 - 10	270 (366)	280 (380)	375 (508)
- 16	295 (400)		420 (569)
7/8 - 9	395 (536)	440 (597)	605 (820)
- 14	435 (590)		675 (915)
1 - 8	590 (800)	660 (895)	910 (1234)
- 14	660 (895)		990 (1342)

METRIC BOLT & NUT TORQUE SPECIFICATIONS

Bolt Dia.	Wrench Size	Grade 4.6 Ft-Lb (Nm)	Grade 4.8 Ft-Lb (Nm)	Grade 8.8 - 9.8 Ft-Lb (Nm)	Grade 10.9 Ft-Lb (Nm)
M3	5.5 mm	0.3 (0.5)	0.5 (0.7)	1 (1.3)	1.5 (2)
M4	7 mm	0.8 (1.1)	1 (1.5)	2 (3)	3 (4.5)
M5	8 mm	1.5 (2.5	2 (3)	4.5 (6)	6.5 (9)
M8	10 mm	3 (4)	4 (5.5)	7.5 (10)	11 (15)
M9	13 mm	7 (9.5)	10 (13)	18 (25)	35 (26)
M10	16 mm	14 (19)	18 (25)	37 (50)	55 (75)
M12	18 mm	26 (35)	33 (45)	63 (85)	97 (130)
M14	21 mm	37 (50)	55 (75)	103 (140)	151 (205)
M16	24 mm	59 (80)	85 (115)	159 (215)	232 (315)
M18	27 mm	81 (110)	118 (160)	225 (305)	321 (435)
M20	30 mm	118 (160)	166 (225)	321 (435)	457 (620)
M22	33 mm	159 (215)	225 (305)	435 (590)	620 (840)
M24	36 mm	203 (275)	288 (390)	553 (750)	789 (1070)
M27	41 mm	295 (400)	417 (565)	811 (1100)	1154 (1565)
M30	46 mm	402 (545)	568 (770)	1103 (1495)	1571 (2130)
M33	51 mm	546 (740)	774 (1050)	1500 (2035)	2139 (2900)
M36	55 mm	700 (950)	992 (1345)	1925 (2610)	2744 (3720)

NOTE: *Formula to convert Ft-Lbs to Nm (Newton Meters) multiply Ft-Lbs by 1.356.*

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

Oil based PERMATEX #2 and it's HIGH TACK equivalent are excellent all purpose sealers. They are effective in just about any joint in contact with coolant, raw water, oil or fuel.

A light coating of OIL or LIQUID TEFLON can be used on rubber gaskets and O-rings.

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

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

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

High-copper ADHESIVE SPRAYS are useful for holding gaskets in position during assembly.

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

Use LIQUID TEFLON for sealing pipe plugs and fillings that connect coolant passages. **Do not use tape sealants!**

BOLTS & FASTENERS/ASSEMBLIES

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

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

Anti-seize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allows them to came apart when necessary. LOCTITE offers levels of locking according to the job.

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

Heavily oil all sliding and reciprocating components when assembling. **Always use clean engine oil!**

WESTERBEKE
Engines & Generators

STANDARD AND METRIC CONVERSION DATA

LENGTH-DISTANCE

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

VOLUME

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

MASS-WEIGHT

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

PRESSURE

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

TORQUE

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

VELOCITY

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

POWER

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

FUEL CONSUMPTION

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

TEMPERATURE

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

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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

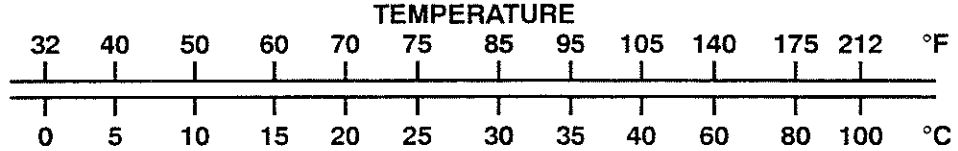
GALLONS TO LITERS / LITERS TO GALLONS

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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