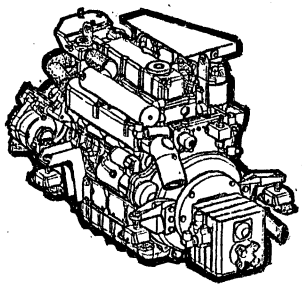
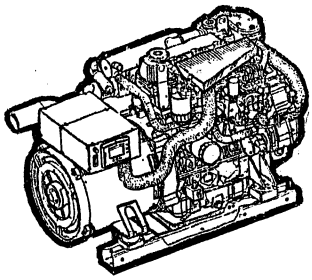
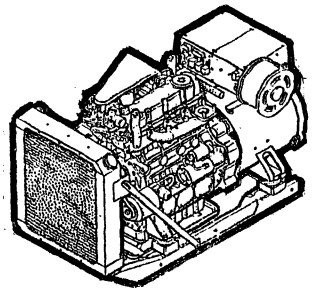
SERVICE MANUAL



65B-FOUR MARINE ENGINE



33.0,28.5 EDEA D-NET MARINE GENERATOR



26.0 EDEAR D-NET MOBILE/INDUSTRIAL GENERATOR

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WESTERBEKE

member NMMA

WESTERBEKE CORPORATION • MYLES STANDISH INDUSTRIAL PARK
150 JOHN HANCOCK ROAD, TAUNTON, MA 02780-7319 U.S.A.
TEL: (508)823-7677 • FAX: (508)884-9688 • WEBSITE: WWW.WESTERBEKE.CO

CALIFORNIA PROPOSITION 65 WARNING

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

⚠ WARNING

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

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

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

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

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

WESTERBEKE
Engines & Generators

SAFETY INSTRUCTIONS

INTRODUCTION

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

PREVENT ELECTRIC SHOCK

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

- Do not operate this machinery without electrical enclosures and covers in place.
- Shut off electrical power before accessing electrical equipment.
- Use insulated mats whenever working on electrical equipment.
- Make sure your clothing and skin are dry, not damp (particularly shoes) when handling electrical equipment.
- Remove wristwatch and all jewelry when working on electrical equipment.

PREVENT BURNS — HOT ENGINE

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

- Monitor engine antifreeze coolant level at the plastic coolant recovery tank and periodically at the filler cap location on the water jacketed exhaust manifold, but only when the engine is COLD.

⚠ 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 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 whenservicing 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 manifold/water-injected elbow is securely attached.
- Be sure the unit and its surroundings are well ventilated. Run blowers when running the generator set or engine.
- Don't run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYC A-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC TH-22 (Educational Information on Carbon Monoxide)

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

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

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

AVOID MOVING PARTS

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

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

SAFETY INSTRUCTIONS

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

HAZARDOUS NOISE

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

- Never operate an engine without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.

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

OPERATORS MANUAL

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

GASOLINE ENGINE AND GENERATOR INSTALLATIONS

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

Sections of the ABYC standards of particular interest are:

H-32 Ventilation for boats using diesel fuel
H-33 Diesel Fuel Systems
P-1 Installatiion of Exhaust Systems for Propulsion and Auxilliary Engines
P-4 Marine Inboard Engines and Transmissions
E-11 AC & DC Electrical Systems on Boats
TA Batteries and Battery Chargers

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

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING MARINE ENGINES AND GENERATORS

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

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

Order From:

ABYC
613 Third Dtreet, Suite 10
Annapolis, MD 21403
(410) 990-4460
www.abycinc.org

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

Order From:

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

USCG (United States Coast Guard)
"CFR 33 AND CFR46"
Code of Federal Regulations

Order From:

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

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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.

OVERHAUL CONDITIONS

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

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

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

ENGINE COMPRESSION

NOTE: *The activation of the starter motor is a function of the ECU (Electronic Control Unit). To by-pass the ECU, a simple electrical jumper arrangement can be fabricated to connect between the battery B+ cable connection on the starter solenoid and the spade type activation connection on the starter solenoid with a push button in this connection to activate the starter solenoid. Refer to the Special Tools section for details.*

1. *Start the engine and allow it to warm up to its normal operating temperature, then shut it down.*
2. *Open the 20 amp DC breaker on the units control box (Propulsion Engine-key switch OFF).*
3. *Close the unit's raw water thru hull opening. This is to prevent the raw water pump from pumping water into the units exhaust system during the test as no or very little engine exhaust pressure will be present during the test to help expel water from the uniys exhaust system during engine cranking.*
4. *Remove all the engune glow plugs. Install the compression gauge adapter into the glow plug opening of cylinder #1 then connect the compression gauge to the adapter.*
5. *Activate the starter motor using the push button on the ELECTRICAL JUMPER for the starter. Allow the engine to crank observing the compression gauge. Allow the engine to crank until the gauge reaches a maximum reading where further cranking does not produce a higher reading on the compression gauge. Record the reading for that cylinder.*
6. *Remove the compression gauge and adapter from the glow plug opening of cylinder #1 and install it in the glow plug opening of cylinder #2 and repeat steps #6 and #7. Proceed to the next cylinder and repeat steps #6 and #7 until all cylinders have been tested.*

COMPRESSION PRESSURE (FACTORY SPECIFICATIONS)
at 250 RPM 626 PSI 44 Kgf/cm² 4.32 MPa
ALLOWABLE LIMIT
at 250 RPM 472 PSI 33.2 Kgf/cm² 3.26 MPa

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

Abnormally high readings on all cylinders indicate heavy carbon accumulation, a condition that might be accompanied by high pressure and noise.

NOTE: *In case of severe vibrations and detonation noise, the cause may be fuel injector problems, see FUEL INJECTORS. Poor fuel quality, contaminant's and loss of positive fuel pressure to the injection pump will result in injector faults.*

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.

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

(continued)

ENGINE TROUBLESHOOTING

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

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
SMOKY EXHAUST *(cont.)*	**WHITISH OR PURPLISH *(cont.)***	
	d. Worn valve stem and valve guide.	**d.** Replace.
	e. Low engine oil viscosity.	**e.** Replace.
	f. Excessive oil pressure.	**f.** Correct.
	3. Injection timing is too late.	**3.** Adjust.
	4. Insufficient compression.	**4.** See *LOW COMPRESSION; HARD STARTING.*
	BLACKISH OR DARK GRAYISH	
	1. Engine body troubles.	
	a. Poor compression.	**a.** See *LOW COMPRESSION; HARD STARTING.*
	b. Improper valve clearance.	**b.** Adjust.
	2. Insufficient intake air.	**2.** Correct.
	3. Improper fuel.	**3.** Replace with proper fuel (cetane #45 or higher).
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.
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. Bent connector rod	b. Check compression
	2. Too early injection timing.	2. Correct.
	3. Too high injection pressure.	3. Correct.
	4. Improper fuel.	4. Replace with proper fuel.
	KNOCKING WITH DARK SMOKE	
	1. Poor compression.	1. See *LOW COMPRESSION; HARD STARTING.*
	2. Injection pump malfunctioning.	a.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. 2. Fuel pipe sucks air. 3. Water mixed in fuel	1. Clean or replace. 2. Retighten pipe joints or replace pipe. 3. Replace fuel.
OVERHEATING	1. V-belt slackening or slippery with oil. 2. Damaged water pump. 3. Lack of coolant. 4. Low oil level or poor oil quality. 5. Knocking. 6. Moving parts seized or damaged. 7. Defective thermostat.	1. Adjust, replace or clean. 2. Replace. 3. Add. 4. Add or change. 5. See *KNOCKING.* 6. Replace. 7. Replace.
LOW OIL PRESSURE	1. Worn Bearings. 2. Relief valve malfunction. 3. Clogged oil cooler. 4. Diesel dilution of the oil.	1. Engine overhaul replace bearings. 2. Overhaul oil pump. 3. Repair. 4. Injection pump repair.
HIGH OIL PRESSURE	1. Wrong type of oil. 2. Relief valve defective..	1. Replace 2. Replace.
RAW WATER IN CYLINDERS	1. Fail of syphon valve or exhaust system.	1. Clean out, inspect exhaust system, replace.
FUEL MIXING WITH LUBE OIL	1. Injection pump broken. 2. Injection pump's plunger is worn. 3. Deficient nozzle injection.	1. Rebuild, replace. 2. Replace. 3. Replace nozzle.
WATER MIXING WITH LUBE OIL	1. Defective gasket head. 2. Cylinder block/cylinder head flawed. 3. Faulty raw water pump shaft water seal. 4. Faulty syphon break. 5. Exhaust system (marine) 6. Leaking raw water pump	1. Rebuild, replace. 2. Replace. 3. Inspect pump for leaks. 4. Check syphon break. 5. Check engine exhaust area 6. Inspect pump

ENGINE TROUBLESHOOTING

LCD DISPLAY FAULTS (D-NET GENERATOR MODELS)

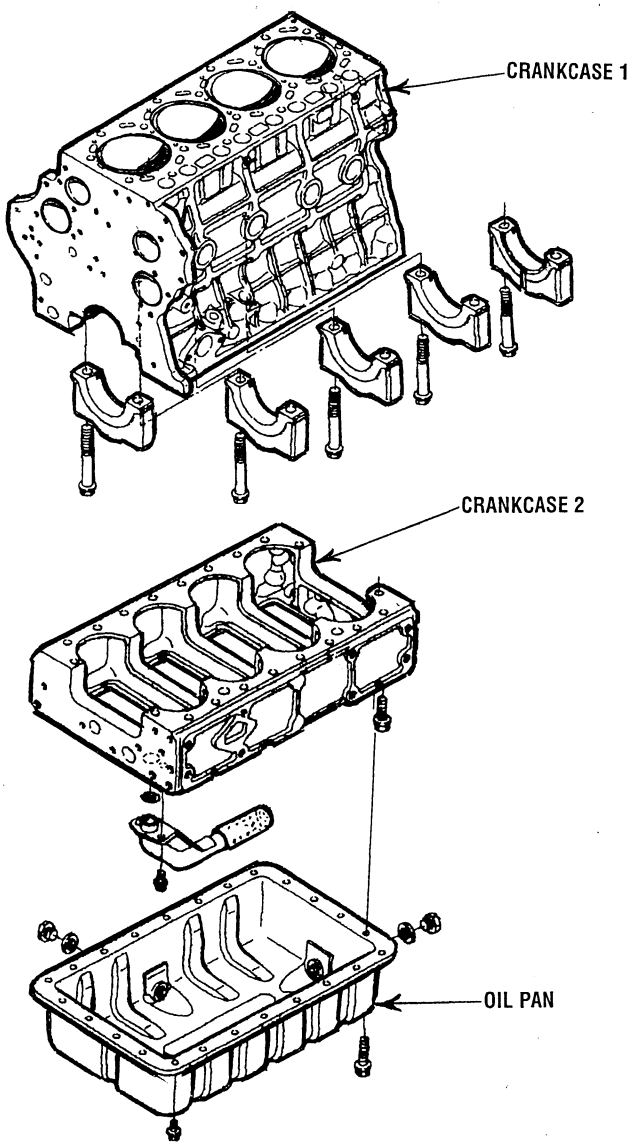
PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
LCD DISPLAY DOES NOT ILLUMINATE	1. Check battery. 2. 20 amp breaker off. 3. Loose display connection. 4. 1 amp fuse blown (faulty).	1. Battery on. 2. Turn breaker on. 3. Check all cable connections. 4. Check/replace. Determine cause
LOW OIL PRESSURE	1. Oil level low/oil leak. 2. Lack of oil pressure 3. Ground connection. 4. Faulty control module (ECU). 5. Faulty oil pressure sensor.	1. Check oil level, add oil and repair leaks. 2. Test oil pressure. If OK, test oil pressure sendor, inspect oil filter, inspect oil pump. 3. Check ground connection. 4. Inspect all the plug connections/replace. 5. Check sensor/replace.
HIGH COOLANT TEMPERATURE	1. Check system coolant level. 2. Sea water pump. 3. Check water pump drive belt. 4. Faulty temperature sensor. 5. Ground connection. 6. Faulty control module (ECU).	1. Add coolant. Check for leaks. 2. Inspect impeller/pump/replace. 3. Adjust belt tension, replace belt. 4. Check sensor/replace. 5. Check ground circuit. 6. Check plug connections/replace.
HIGH EXHAUST TEMPERATURE	1. Check sea water flow. 2. Faulty exhaust temperature switch. 3. Ground Connection. 4. Faulty control module (ECU). 5. Sea water pump. 6. Faulty fire suppression system.	1. Inspect thru hull fitting, hose and strainer. Correct as needed. 2. Test/replace. 3. Check ground circuit. 4. Check plug connections. 5. Inspect impeller/replace. 6. By-pass system/check.
BATTERY VOLTAGE	1. Check alternator drive belt. 2. Check charge voltage. 3. Check battery connections. 4. Faulty control module (ECU).	1. Adjust tension/replace if worn. 2. Check excitation. Replace/repair alternator 3. Check + and - cables from battery to engine. 4. Check plug connections/replace.
GENERATOR FREQUENCY Overspeed (steady LED) Underspeed (flashing LED)	1. Check engine speed. 2. Check fuel supply. 3. Amperage load. 4. Crank cycle with no start. (underspeed fault) 5. Faulty MPU	1. Check speed setting. 2. Inspect filters/replace filters. Test fuel pump operation. 3. Check + and - cables from battery to engine. 4. Check cause for no start. 5. Check MPU AC signal cranking Check MPU coil resistance
LED DISPLAY EDGES TURN PINK	1. Compartment ambient temperature too high.	1. Ventilate compartment. **Note:** *Heat will often change the color of an LCD display. This will not effect the operation of the engine.*
WAITING FOR ECU	1. ECU and LCD display not compatible. 2. Loose cable connection. 3. Panel DC breaker OFF. 4. Blown 8 amp fuse. 5. Terminating Resistors. 6. Battery Voltage to ECU.	1. Check compatibility with Westerlink or NMEA. 2. Check all cable connections. 3. Turn ON, check DC voltage across breaker. 4. Check/replace fuse. Check DC voltage across fuseholder 5. Check all terminating resistors are in place. 120 ohm per resister measured across pin #4 and #5. 6. Check between pins P2-24 and P2-25. P2 ECU plug unplugged from ECU. Power turned ON. If voltage is present, ECU is faulty.
ENGINE SHUTDOWN OVER CRANK	1. No fuel delivery.. 2. Pre-heat faulty.	1. Check fuel delivery to injectors. 2. Check pre-heat circuits.

GENERAL DESCRIPTION

CYLINDER BLOCK

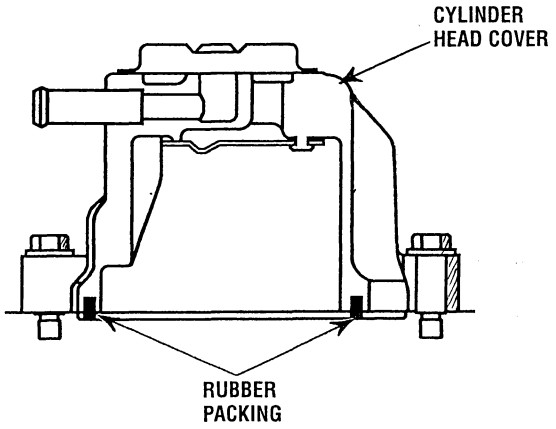
This engine employs separate type crankcases the crankcase 1 with combustion parts and the crankcase 2 which supports the crankcase 1 and reduces noise.

Since it is a hanger type, you can easily assemble and disassemble it. The cylinder is a linerless type which enables good cooling operation, less strain and good abrasion resistance.



HALF-FLOATING HEAD COVER

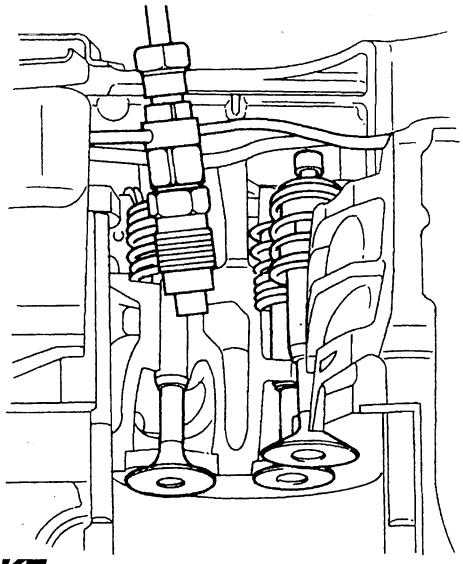
The rubber packing is fitting in to maintain the head cover 0.5 mm or so off the cylinder head. This arrangement helps reduce noise coming from the cylinder head.



CYLINDER HEAD

This engine employs a three valve system: two inlet valves and double ports, and one exhaust valve which produces good inlet inertia to improve combustion efficiency and volumetric efficiency. It also employs a new unique combustion chamber with multiple injection grooves.

Besides the conventional cross port system, it employs the forced cooling method between valves to eliminate heat distortion, thus enabling durable and reliable configuration.



GENERAL DESCRIPTION

PISTON AND PISTON RINGS

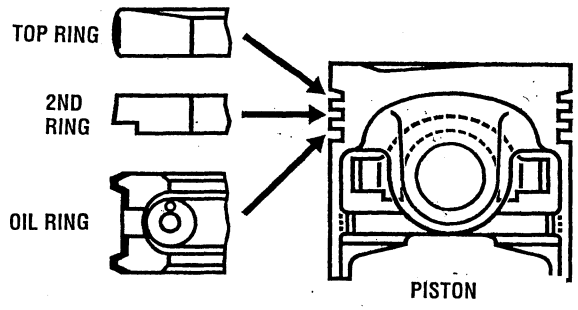
This engine employs the E-TVCS VERSION-II so that the improved combustion surface at the top of the piston enables more complete combustion efficiency than the conventional models.

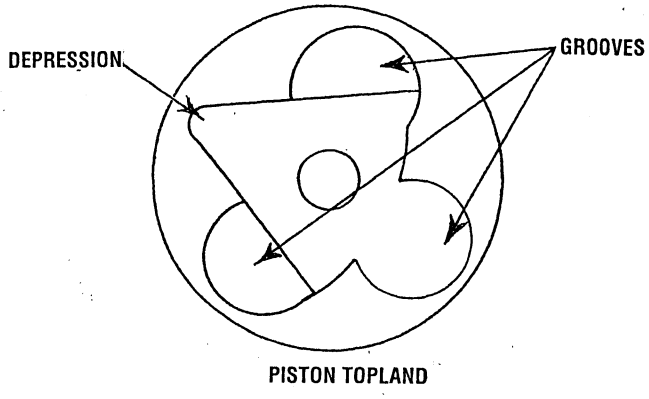
The profile and the offset of the piston are optimized to reduce piston slap. The oil jet at the small end of the connecting rod reduces the heat load of the piston.

Three rings are installed in grooves in the piston. The top ring is made of nitrizing steel to get more reliability than the chrome plated ring. It is a keystone type ring to provide durability against heavy load. At the sliding part, a special piston ring which is conformable to the cylinder wall is employed. The second ring is chrome-plated on the peripheral surface and it is an undercut ring to prevent the holding of oil.

The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

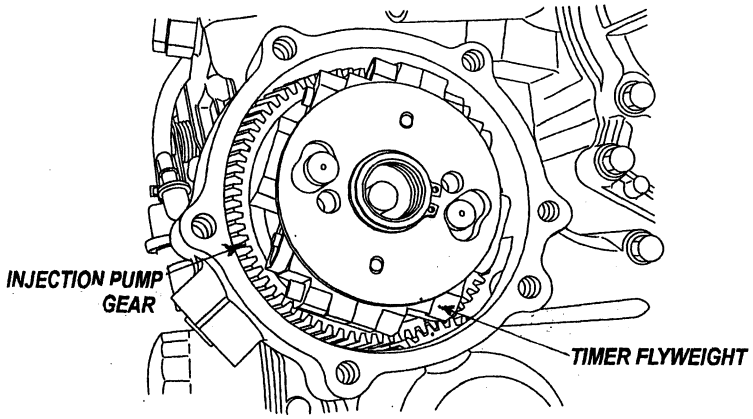
Several grooves are cut on the topland to help heat dissipate and to prevent scuffing.





MECHANICAL TIMER / COLD START ADVANCE FUNCTION

This device makes the fuel injection timing advanced by engine oil temperature and engine rpm in order to improve the engine cold start-ability and reduce the blue white smoke.



■ Thermal control

When the engine rpm is low and engine oil temperature is under 30 °C, the fuel injection timing is max. advanced.

When the engine rpm is low and engine oil temperature is higher than 70 °C, the fuel injection timing advance is 0 degree.

The fuel injection timing advance by engine oil temperature is controlled with shape memory (storage) spring.

■ Speed control

If the engine rpm is higher than a certain rpm, the fuel injection timing advance by engine oil temperature does not work. At that time, the quantity of advance timing is variably, changed by centrifugal force of the timer flyweights which meets engine rpm.

BLOCK HEATER ACCESSORY

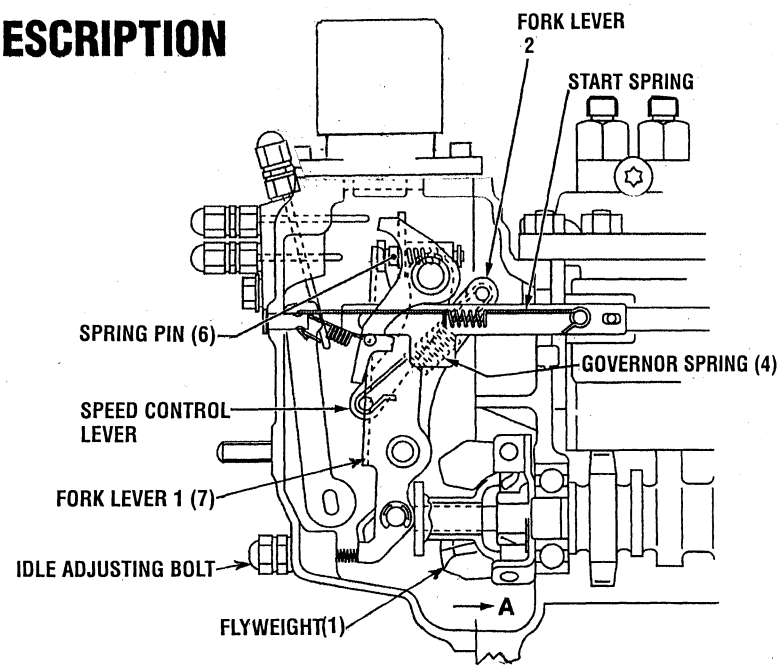
AC Block Heater Kits are available for the 28.5/33.0 Generators in 120V or 240V. Contact your WESTERBEKE dealer.

GOVERNOR

This mechanism maintains engine speed at a constant level even under fluctuating loads and provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

This engine uses a mechanical governor that controls the fuel injection rate at all speed ranges (from idling to maximum speed) by utilizing the balance between the flyweight's centrifugal force and spring tension.

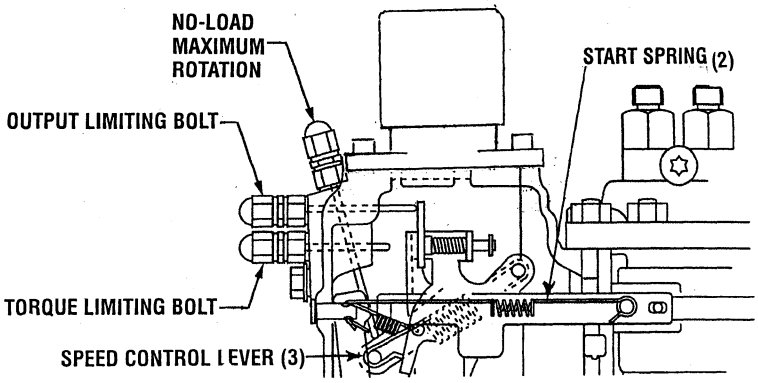
A governor shaft for monitoring engine speed is independent of the injection pump shaft and rotates at twice the speed of conventional types, providing better response to load fluctuation and delivering greater engine output.



At Start

The stop solenoid (energized to run type) is powered to release the stop lever.

As no centrifugal force is applied to the flyweight (1), low tension of the start spring (2) permits the control rack to move to the starting position, supplying the amount of fuel required to start the engine.



At Idling

Turn the speed control lever (3) clockwise to idle the engine. It tensions the governor spring (4) to pull the fork lever 2.

When the fork lever 2 is pulled, it moves the torque spring pin (6) and fork lever 1 (7) in the direction of the arrow **A** to restrain the weight. In combination with the start spring tension, it is balanced with the centrifugal force of the flywheel weight to maintain idling.

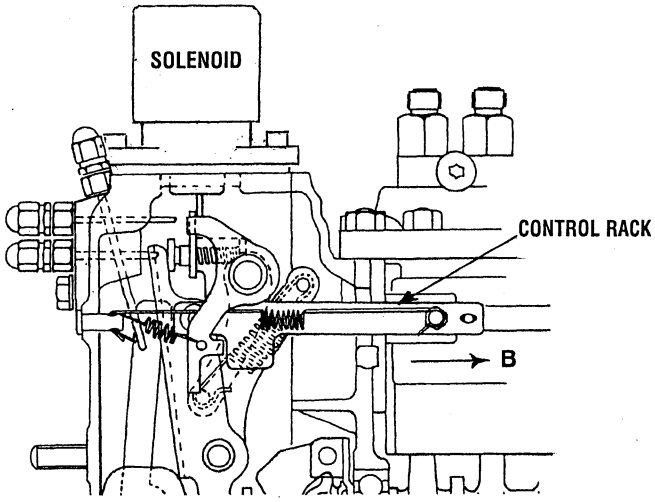
■ At rated speed with full load and overload

As the speed control lever is changed from the middle speed to high speed, the governor spring tension increases to compress the torque spring and move the fork lever 1 in the direction of the arrow **A**.

The fork lever 2 moves until it reaches the output limiting bolt to keep rated rotation and rated output.

When the engine is overloaded, the engine rotating speed decreases and the centrifugal force of flywheel weight decreases. Then the torque spring moves the fork lever 1 in the direction of arrow **A**.

The control rack moves in the direction that increases fuel supply to increase the output. It is balanced with the centrifugal force of the flywheel weight to produce low-speed output (torque output).



■ To stop engine

When the stop solenoid is turned off, the spring tension of the solenoid is released, the rod extrudes and the stop lever moves the control rack in the direction of the arrow **B** which stops the engine.

To stop the engine manually, move the external stop lever to the left.

DISASSEMBLY PROCECURES

GENERATOR

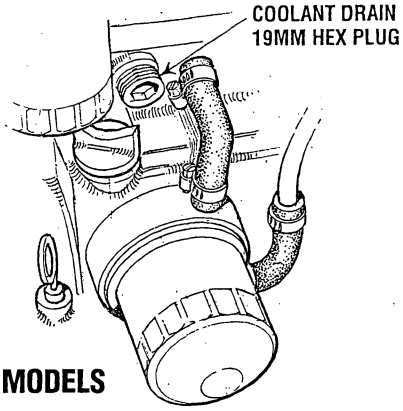
Unplug and disconnect the electrical connections on the outside and inside of the control box to allow for the removal of the control box off the AC generator end. **NOTE:** *Properly photo or mark all connections to ensure proper reconnecting.*

Remove the air hose between the control box and the engine intake box. 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.

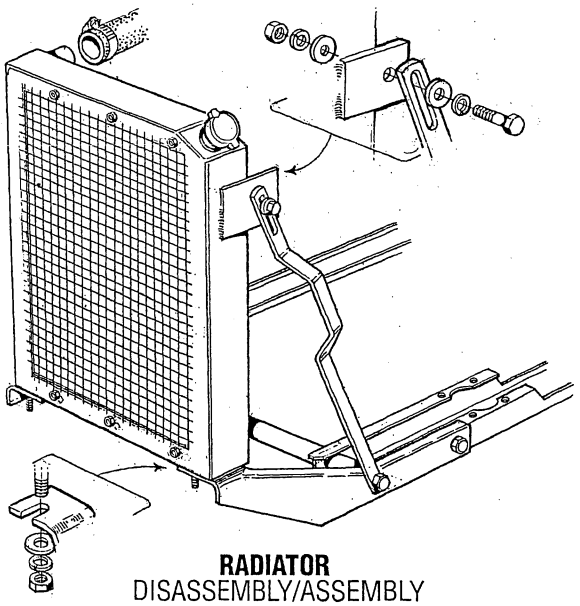
Additional generator information will be found in the *GENERATOR* section of this manual.



RADIATOR MODELS

Drain the coolant using the drain petcock found at the base of the radiator. Unbolt the radiator from the side support brackets and lower the mounting frames. **Remove the radiator** and set aside for servicing.

Remove the DC charging alternator. Remove the four bolts securing the fan to the fresh water pump pulley and remove the fan and pulley. Unbolt the fan guard and remove it.



RADIATOR
DISASSEMBLY/ASSEMBLY

PROPULSION ENGINE

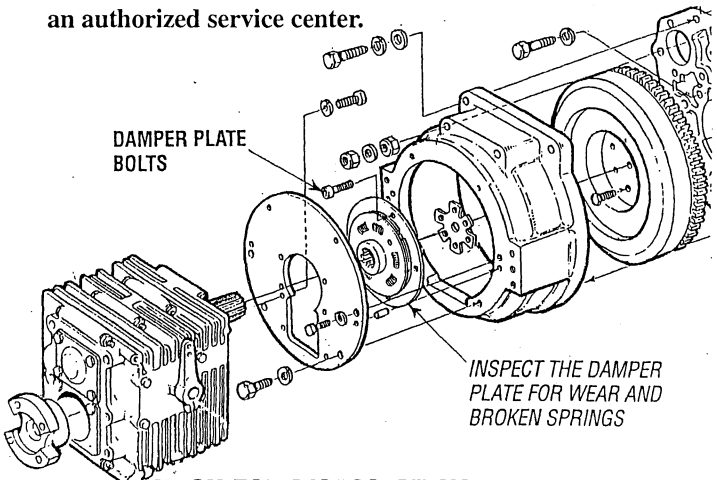
Unplug the instrument panel wiring harness. Drain the transmission fluid and the transmission oil cooler hoses. Detach the oil cooler hoses and **unbolt the transmission from the engine**.

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 the units Operator's manual. To rebuild a transmission contact the transmission manufacturer for the location of an authorized service center.



PREPARATION FOR DISASSEMBLY

- Clean or wash the engine exterior.
- Do not remove or disassemble the parts that require no disassembly.
- When disconnecting sensor wires, label and tape the ends.
- 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.
- 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.
- Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly.
- Carefully check each part or component for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more

DISASSEMBLY PROCEDURES

REMOVE EXTERIOR COMPONENTS

With the transmission/generator/radiator separated from the engine, begin the following step by step procedure to disassemble the exterior parts.

NOTE: *Mount the engine securely on a suitable engine stand.*

1. **Remove the start motor, drive belt, and the alternator. Label the wires and cables.**
2. **With the hoses disconnected, remove the thermostat housing and housing gasket, leaving the temperature sender and switch in place if applicable.**
3. **Remove the magnetic pick-up** from the bell housing (Generators only).
4. **Remove the flywheel bell housing and the circuit breaker/pre-heat solenoid mounting bracket**

   Remove the engine back plate.
5. **Remove the oil filter, oil cooler, oil hoses and mounting bracket.** Make note of the hose arrangements.
6. **Remove the transmission damper plate from the engine flywheel** (Marine Engines).
7. **Remove the engine mounted raw water pump, complete with its adapter mounting plate.** See *RAW WATER PUMP* for parts breakdown. (Marine Engines and Generators only)
8. **Remove the engine heat exchanger.** If possible, leave one end of each hose connected to the part being removed (Marine Engines and Generators only).
9. **Remove the exhaust components from the exhaust manifold**
   a) **Remove the exhaust elbow (if applicable) from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.**
   b) **Remove the exhaust nipples, elbows and plugs from the manifold.**
   c) **Remove the water connectors from the ends of the manifold. Be sure to note the proper location and arrangement of each for proper alignment.**
   d) **Examine all parts for defects, corrosion and wear and replace as needed.**
   e) **Flush out the coolant recovery tank and clear its hose passage. Set aside to re-install on the boat.**
10. **Remove the coolant circulating pump.** Refer to *COOLANT PUMP ASSEMBLY.*
11. **Remove the air intake silencer and the intake manifold.**
12. **Prepare to disassemble the main engine.**

ASSEMBLY PROCEDURES

GENERAL INFORMATION

Surface Preparation

Thoroughly remove all substances deposited on the gasket application surfaces using a gasket scraper or wire brush. Check to ensure that the surfaces to which the silicone gasket is to be applied is flat. Make sure that there are no oils, greases and foreign substances deposited on the application surfaces. Do not forget to remove the old sealant that remains in the bolt holes.

ASSEMBLY

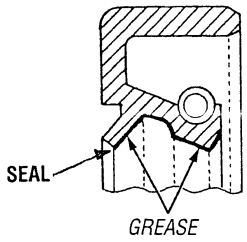
- Wash all parts, except for oil seals, O-rings, rubber sheets, etc. with cleaning solvent and dry them with air pressure.
- Always use tools that are in good condition and be sure you understand how to use them before performing any job.
- Use only good quality lubricants. Be sure to apply a coat of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

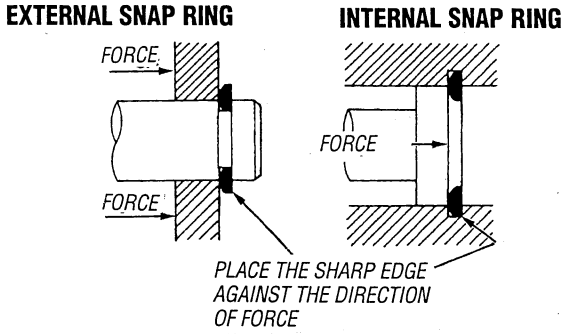
Be aware of these common problems that can occur during assembly.

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

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

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





When reassembling external or internal snap rings, position them so that the sharp edge faces against the direction from which force is applied.

GASKET INFORMATION

The engine has several areas where form-in-place RTV silicone gaskets are used such as LOCTITE 598 or GE RTV 100. To ensure that the gasket fully serves its purpose, it is necessary to observe some precaution when applying the gasket. Bead size, continuity and location are very important. Too thin a bead could cause leaks and too thick a bead could be squeezed out of location causing blocking or narrowing of the fluid feed lines. To eliminate the possibility of leaks from a joint, it is necessary to apply the gasket evenly without a break while observing the correct bead size.

The gasket material used in the engine is a room temperature vulcanization (RTV) type and is supplied in a 14oz (400 gram) applicator/tube. The RTV hardens as it reacts with the moisture in the atmospheric air and can be used for sealing both engine oil and coolant assemblies.

ENGINE ASSEMBLY INSTRUCTIONS

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, or refer to the more detailed alternator section in this manual.

HEAT EXCHANGER (MARINE ENGINES/GENERATORS)

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

MARINE TRANSMISSION (MARINE ENGINES)

1. **Assemble the damper plate to the flywheel.**
2. **Re-install the marine transmission and fill with the correct amount of fluid. Do not overfill.**

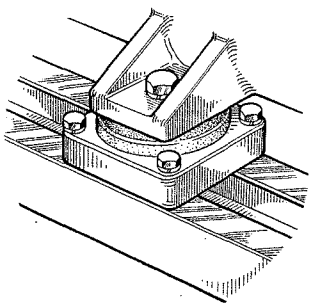
NOTE: *Some transmissions, such as the Borg Warner Velvet Drive require oil coolers. Oil coolers should be cleaned, pressure tested and repainted at engine overhaul. The transmission oil cooler hoses should also be inspected. Refer to the text on HEAT EXCHANGERS.*

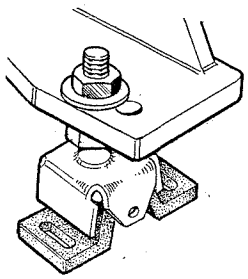
RADIATORS

The radiator, cleaned, flushed, and pressure tested can be assembled to the generator mounting rails. The fan can be assembled to the engine.

Engine Mounts

Inspect the engines flexible mounts. Replace any that show signs of wear, rust, or splits in the rubber isolators. In a complete overhaul, all four should be replaced.





ENGINE TUNING OPERATION

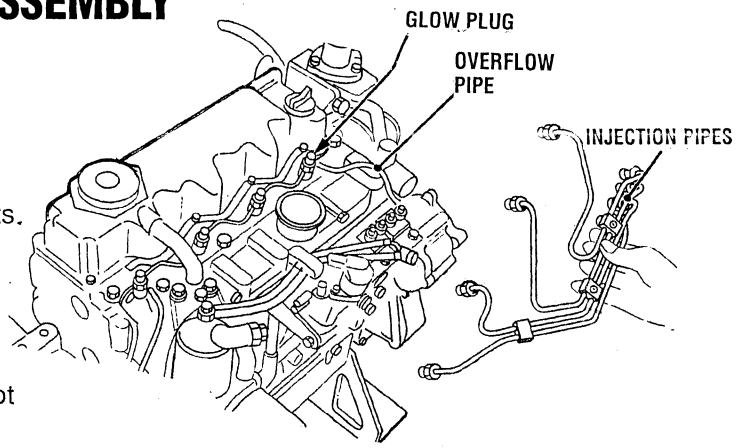
After re-assembly the unit must be test run. This will ensure that the engine/generator operates to its specifications. Fill the engine cooling system with an antifreeze mixture and the engine oil sump with lube oil API Specification of CF, CG-4, CF-4, CG-4, CH-4 or CI-4. SAE 10W-40 or 15W-40.

1. **Mount the unit on a test stand and make the needed fuel, elecrtical, exhaust and coolant connections as required.**
2. **Pre-lube the unit if not already done or disable the fuel solenoid/actuator and intermittently crank the unit to allow the oil pump to prime the oil passages.**
3. **Start the unit and monitor for proper operation like oil pressure, water temperature, DC charge, etc.**
4. **Allow the unit to come up to normal operating temperature and check the engine speed. (Propulsion-adjust engine idle speed for smoothest operation).**
5. **Check unit for any leakage of oil, fuel or coolant. Correct as needed.**
6. **Propulsion - Check full no load rpm.**
7. **Load test the unit in gradual steps 1/4, 1/2, 3/4 and full load**
8. **After load test, stop unit an allow to rest. Check all fasteners and electrical connections to make sure they are tight and secure. Check wire hose chaffing and protect as needed.**

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

DISASSEMBLY/ASSEMBLY

Cylinder Head and Valves

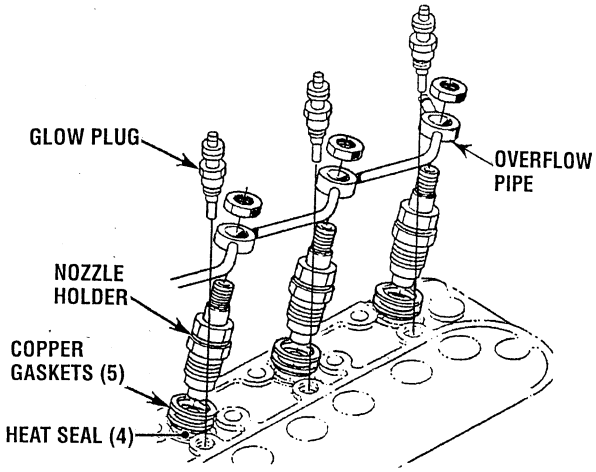


Cylinder Head Cover and Nozzle Holder

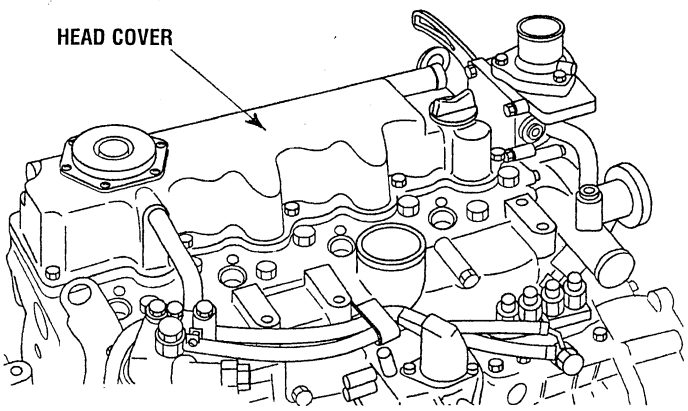
1. Remove the injection pipes (1) and overflow pipes.
2. Remove the glow plugs.
3. Remove the nozzle holder assembly (4) and copper gaskets.
4. Remove the heat seal.
5. Remove the head cover.

(When reassembling)

- Check to see that the cylinder head cover gasket is not defective.
- Be sure to replace the heat seal.
- Tighten the head cover mounting bolts to specified torque.
- Mount the return fuel check valve with the ↓ mark in the direction of flow back to the tank.



Tightening torque	Cylinder head cover mounting screw	6.9 to 11.3 N·m 0.7 to 1.15 kgf·m 5.1 to 8.32 ft-lbs
	Injection pipe retaining nut	22.6 to 36.3 N·m 2.3 to 3.7 kgf·m 16.6 to 26.8 ft-lbs
	Nozzle holder assembly	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs
	Overflow pipe assembly retaining nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Glow Plug	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs

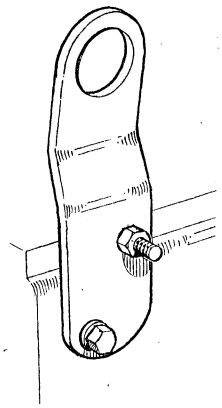


Nozzle Heat Seal Service Removal Procedure

■ IMPORTANT

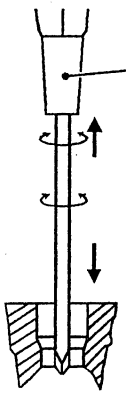
- **Use a plug (phillips) screwdriver that has a dia. which is bigger than the heat seal hole (Approx. 6 mm, 1/4 in.).**

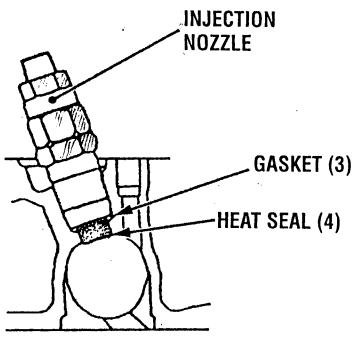
1. Drive screw driver lightly into the heat seal hole.
2. Turn screw driver three or four times each way.
3. While turning the screw driver, slowly pull the heat seal out together with the injection nozzle gasket.
   If the heat seal drops, repeat the above procedure. Heat seal (4) and injection nozzle gasket (3) must be changed when the injection nozzle is removed for cleaning or for service.



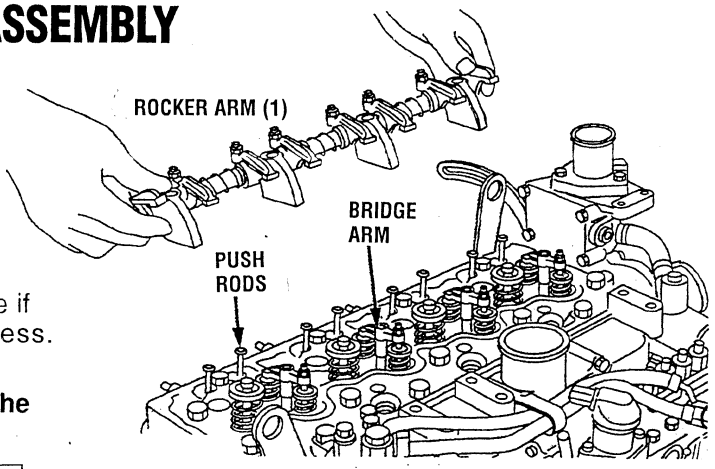
LIFTING EYE

CAUTION: *IF THERE IS REASON TO REMOVE THE ENGINES LIFTING EYE, DO NOT ATTEMPT TO TAKE OUT THIS STUD. SIMPLY REMOVE THE NUT AND THE BOTTOM BOLT. THE STUD IS PERMANENTLY ASSEMBLED THRU THE WATER JACKET.*





DISASSEMBLY/ASSEMBLY



Rocker Arm and Push Rod

1. Remove the rocker arm (1) as a unit.
2. Remove the push rods.
3. Detach the bridge arm.

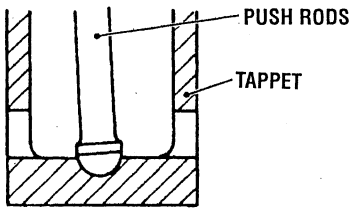
(When reassembling)

- When putting the push rods onto the tappets, check to see if their ends are properly engaged with the tappet recess.

■ IMPORTANT

- **After reassembling the rocker arm, be sure to adjust the valve clearance.**

Tightening torque	Rocker arm bracket screw	49.0 to 55.9 N·m 5.0 to 5.7 kgf·m 36.2 to 41.2 ft-lbs

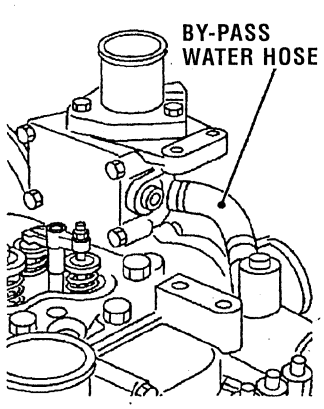


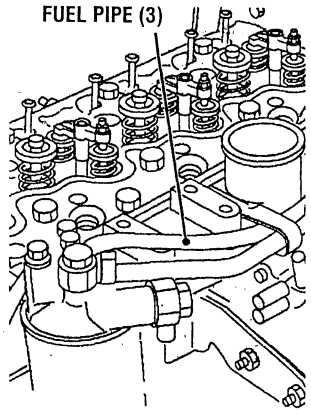
Cylinder Head and Tappet

1. Loosen the hose clamp and remove the by-pass hose
2. Disconnect the fuel pipe (3) first and then the fuel filter.
3. Remove the IN. / EX. Manifold.
4. Remove the cylinder head screw in the order of (18) to (1), and remove the cylinder head.
5. Remove the cylinder head gasket.
6. Remove the tappets from the crank case.

(When reassembling)

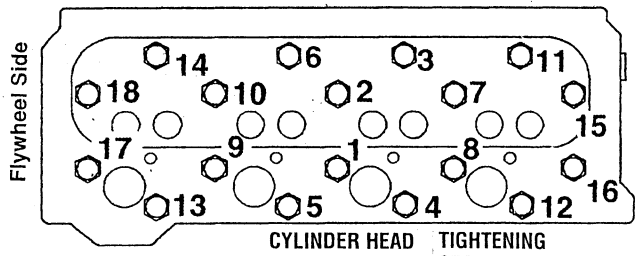
- Replace the head gasket with a new one.
- Before installing the tappets apply engine oil thinly around them.
- When mounting the gasket, set it to the knock pin hole. Take care not to mount it reversely.
- The cylinder head should be free of scratches and dust.
- Take care for handling the gasket not to damage it.
- Install the cylinder head.
- Tighten the cylinder head screw gradually in the order of (1) to (18) after applying engine oil.
- Be sure to adjust the valve clearance. See the "Valve Clearance".
- It is not necessary to retighten the cylinder head screw after running the engine for 30 minutes.





■ IMPORTANT

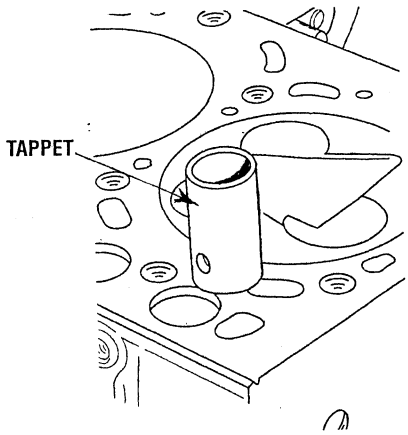
- **When replace the piston, piston pin bush, connecting rod or crankpin bearing, select the cylinder head gasket thickness to meet with the top clearance refer to the "Selecting Cylinder Head Gasket".**



■ NOTE

- **Mark the cylinder number to the tappets to prevent interchanging.**

Tightening torque	Cylinder head mounting screw	98.1 to 107.9 N·m 10.0 to 11.0 kgf·m 72.3 to 79.6 ft-lbs



DISASSEMBLY/ASSEMBLY

Selecting Cylinder Head Gasket

■ **Replacing the Cylinder Head Gasket**

1. Make sure to note the notch **(a)**, **(b)** or **(c)** of cylinder head gasket.
2. Replace the same notch **(a)**, **(b)** or **(c)** as the original cylinder head gasket.

■ **Selecting the Cylinder Head Gasket**

- Select the cylinder head gasket thickness to meet with the top clearance when replacing the piston, piston pin bush, connecting rod or crankpin bearing.

1. Measure the piston head's protrusion or recessing from the crankcase cylinder face 4 spots per each piston (average of four pistons) using the dial gauge as shown.
2. Select the suitable cylinder head gasket refer to the table below.

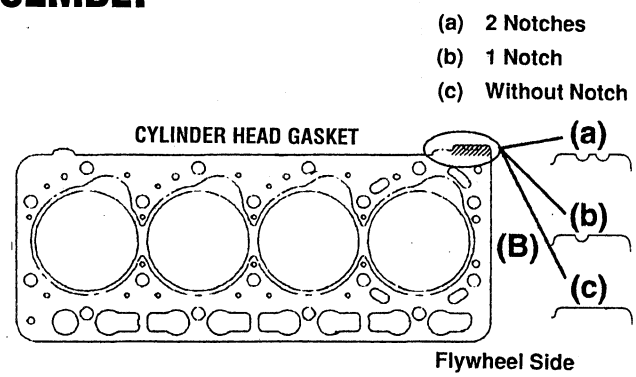
Notch of Cylinder Head Gasket	Thickness of cylinder head gasket			Piston Head's protrusion or recessing from the level of crankcase cylinder face. (average of 4 pistons)
	Before tightening	After tightening		
2 notches **(a)**	0.90 mm 0.0354 in.	0.80 mm 0.0315 in.	———	-0.301 to -0.420 mm -0.0118 to -0.0165 in.
1 notch **(b)**	1.00 mm 0.0394 in.	0.90 mm 0.0354 in.	———	-0.201 to -0.300 mm -0.00791 to -0.0018 in.
Without notch **(c)**	1.05 mm 0.0413 in.	0.95 mm 0.0374 in.	———	-0.150 to -0.200 mm -0.00591 to -0.00787 in.

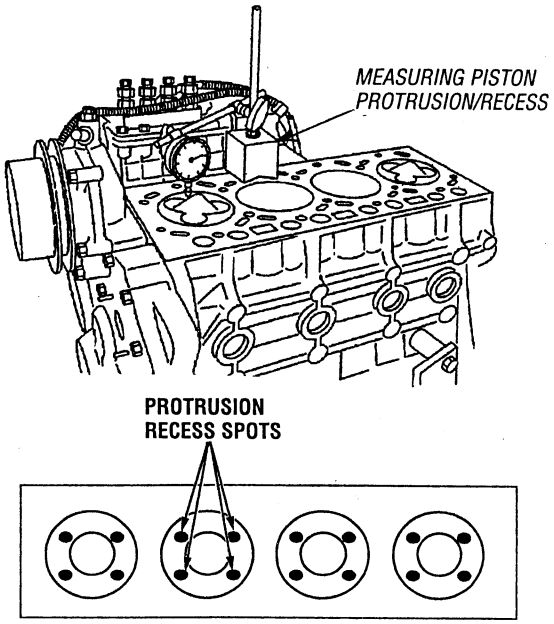
Valve

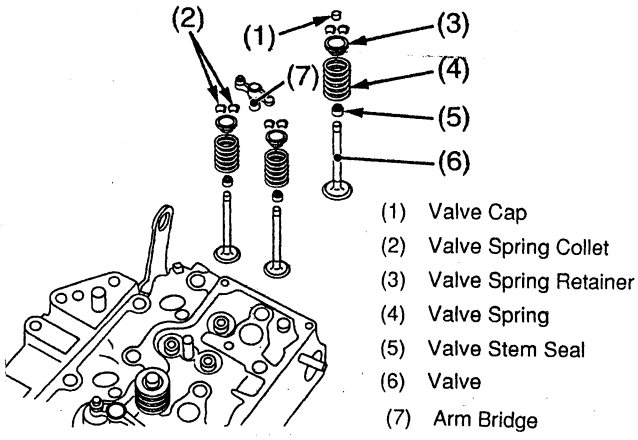
1. Remove the valve cap (1) and the valve spring collets (2) compressing the valve spring (4) with the valve spring retainer (3).

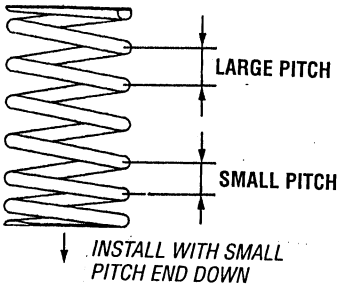
(When reassembling)

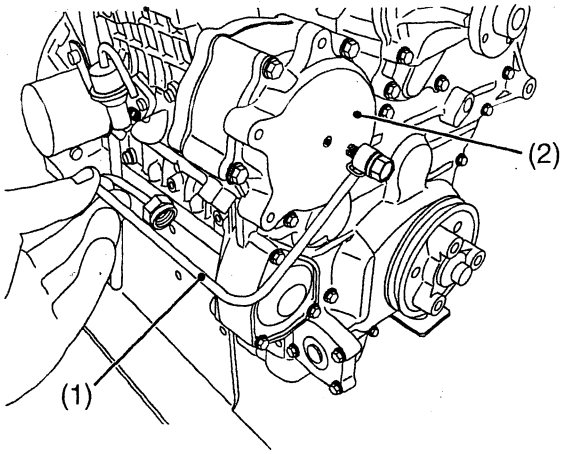
- Install the intake valve spring with its small-pitch end downward (at the head side).
- Wash the valve stem and valve guide hole, and apply engine oil sufficiently.
- After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.

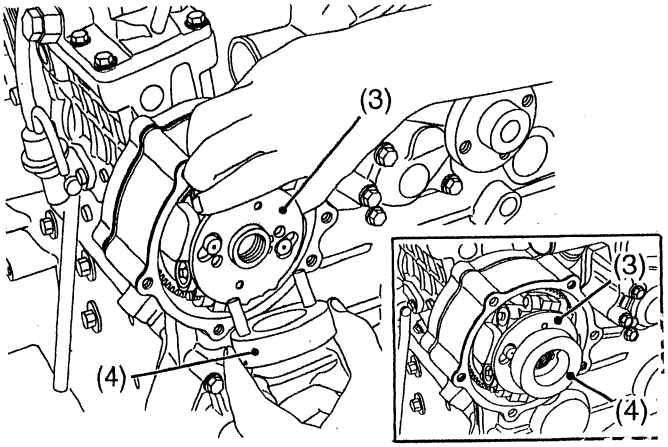


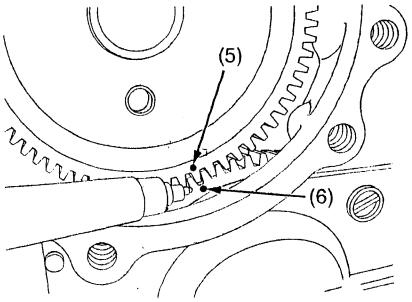


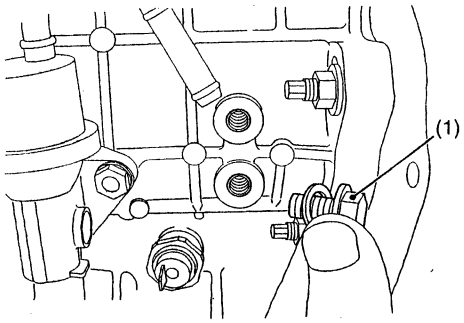


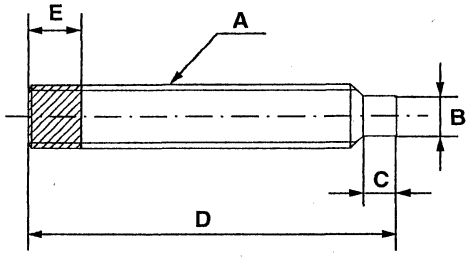












Injection Pump Unit

(Removing)

1. Removing the timer lubricating pipe (1).
2. Remove the injection pump gear cover (2).
3. Set the timer 0 ° restoring jig (4) to the timer gear (3).
4. Turn the flywheel counter-clockwise slowly.
5. Set the flywheel 1 TC mark to align T.D.C. mark on flywheel housing or rear end plate in order to set the No.4 piston at compression top dead center.

■ **IMPORTANT**

- **If the flywheel 1 TC mark passes T.D.C., Turn back the flywheel clockwise around 90 degree, and try to set T.D.C. again. (go back to the procedure 4..)**
- **If you set the T.D.C. by turning flywheel clockwise, the gears backlash becomes maximum.**

6. Check the injection pump gear timing mark.
   If the injection pump gear / timer gear timing mark (5) meshes to the idle gear teeth, No.4 piston is at compression top dead center.
   If not so, turn the flywheel 360 degree counter-clockwise.
   (go back to the procedure 4..)
7. Fix the flywheel not to turn.
8. Put the temporary mark (6) on the idle gear teeth, which the injection pump gear / timer gear timing mark (5) meshes, with white marking pen.
   It is very helpful to reassemble the injection pump gear / timer gear later.
9. Remove the plugs (1).

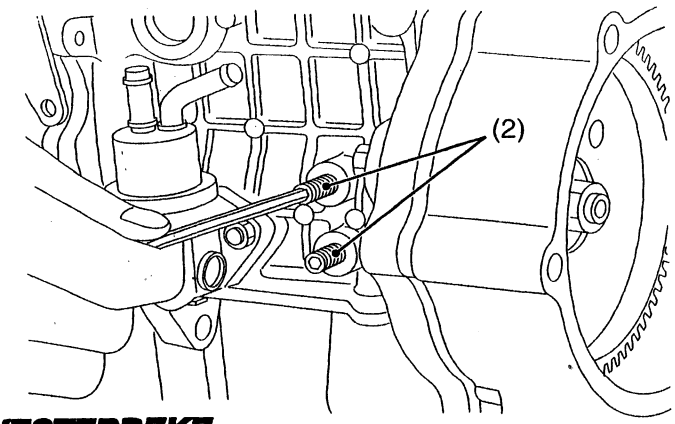
■ **NOTE**

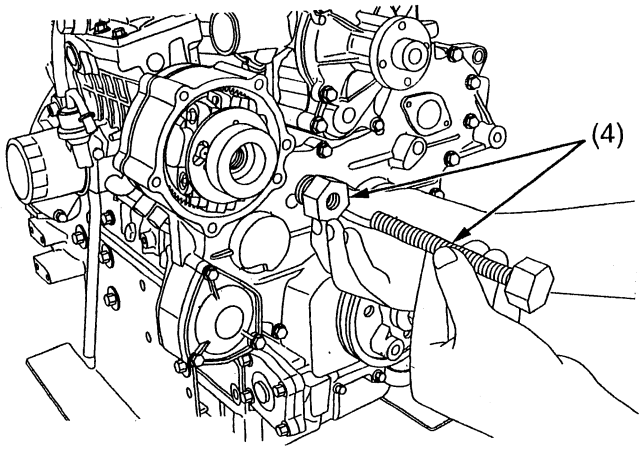
- **When you tighten the fuel camshaft lock screw, the tightening order (upper / lower) is different in the engine model.**
- **Recommend you use a socket set screw (dog point type) as a fuel camshaft lock screw for preventing the damage of screw hole tread.**

A	M8 x Pitch 1.25
B	5.0 mm dia. (0.20 in. dia.)
C	4.0 mm (0.16 in.)
D	45 mm (1.8 in.)
E	10 mm (0.39 in.) : Conspicuously Painted

- **Do not overtighten the fuel camshaft lock screws.**

10. Tighten the upper fuel camshaft lock screw (2) securely.

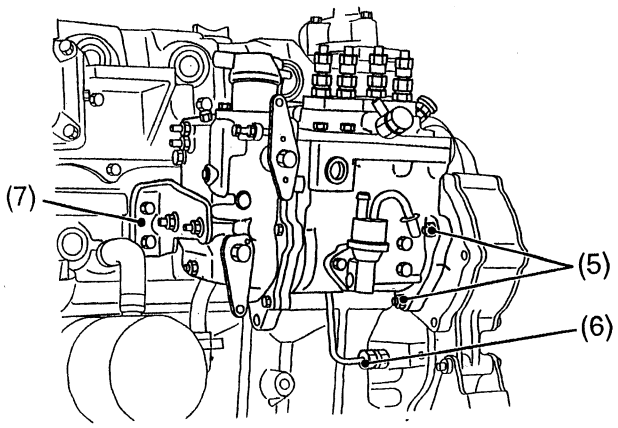




■ **IMPORTANT**

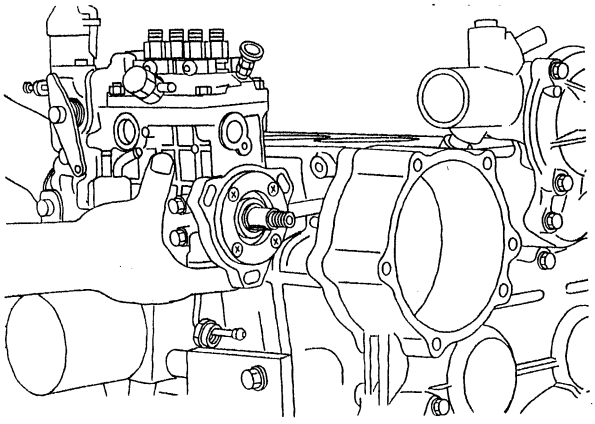
- **When tighten the lock screw at this moment, the timing gears backlash becomes "0" (Zero).**

11. Tighten the lower fuel camshaft lock screw (2) securely.
    Tighten the upper camshaft lock screw (2) securely.
13. Set the injection pump gear puller (3) / timer gear puller (4).
14. Pull out the injection pump gear / timer gear.
15. Disconnect the governor lubricating pipe (6).
16. Remove the injection pump unit support (7).
17. Hold the injection pump unit not to drop.
18. Remove the injection pump unit mounting nuts (5).
19. Remove the injection pump unit.



(Reassembling)

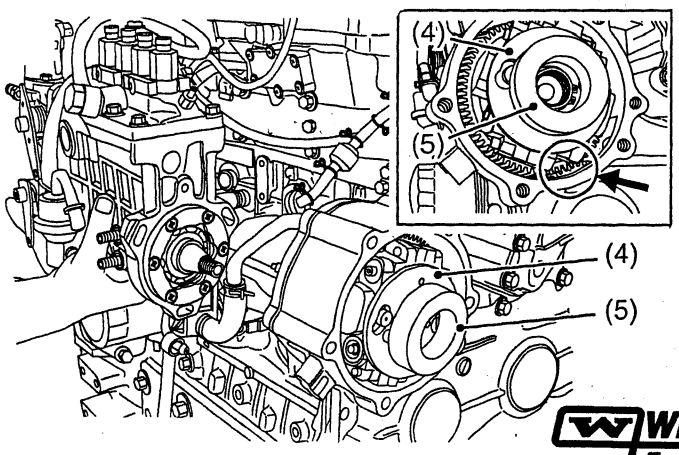
1. Make sure that No.4 piston is at compression top dead center.
2. Set the timer 0 ° restoring jig (5) to the timer gear (4).
3. Set the injection pump gear (1) / timer gear (4) into the gear case position.
4. Make sure that the timing marks between injection pump gear (1) / timer gear (4) and idle gear (3) align correctly.
5. Install the injection pump unit to the injection pump gear (1) timer gear (4) as aligning key of fuel camshaft and key way of injection pump gear (1) / timer gear (4).
6. Set the injection pump gear mounting nut / timer gear mounting nut and washer temporarily.
7. Tighten the injection pump unit mounting nuts securely.
8. Tighten the injection pump gear mounting nut / timer gear mounting nut securely.
9. Set the governor lubricating pipe.
10. Set the injection pump unit support.
11. Remove the timer 0 ° restoring jig (5).
12. Set the injection pump gear cover.
13. Set the timer gear lubricating pipe.
14. Remove the fuel camshaft lock screws (6).



■ **IMPORTANT**

- **Make sure that you remove the fuel camshaft lock screws. Otherwise, injection pump unit housing case can get a damage.**

15. Set the plugs.
16. Remove the flywheel stopper.
17. Check the injection timing. (See the "Injection Timing".)



DISASSEMBLY/ASSEMBLY

Governor Housing Assembly

1. Remove the injection pump unit from the engine. (See the "Injection Pump Unit".)
2. Remove the governor lubricating pipe.
3. Remove the stop solenoid.
4. Detach the sight cover (3) from the injection pump unit.
5. Unhook the start spring (4) from the rack pin (5) of injection pump assembly.
6. Remove the nut.

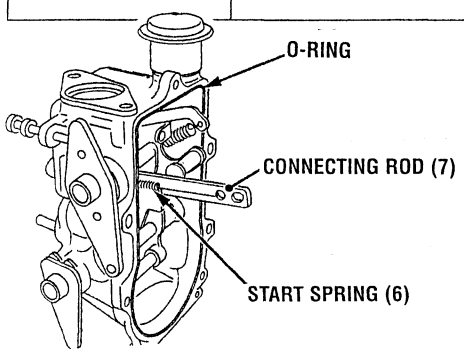
■ NOTE
- **Be careful not to drop the nut inside.**

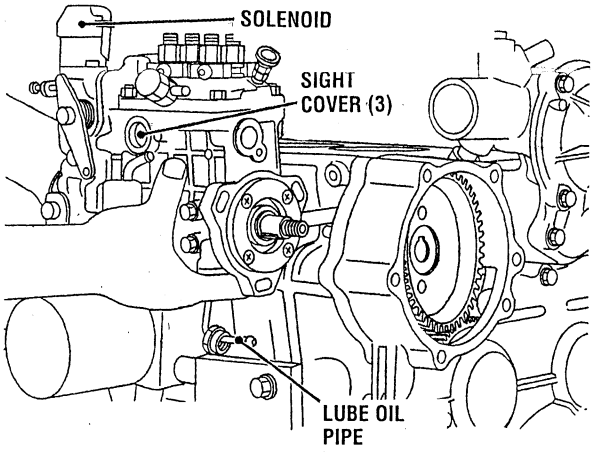
7. Slide off the governor connecting rod (7) from the rack pin of injection pump assembly.
8. For convenient sake, temporarily hook the start spring on the rack pin hole of the governor connecting rod.
9. Remove the governor housing mounting screws.
10. Detach the governor housing assembly (8) from the injection pump unit.

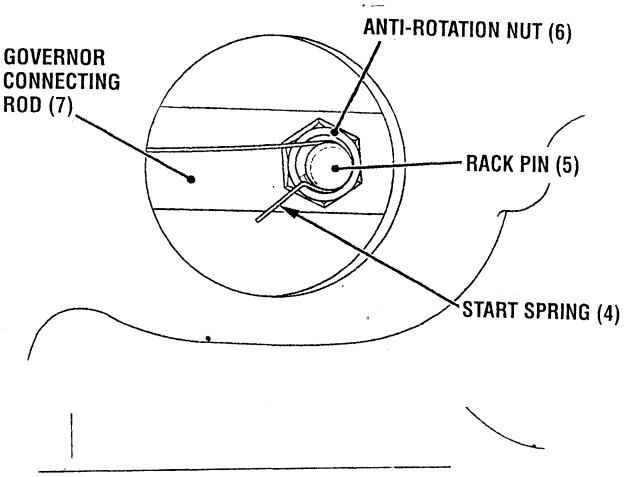
(When reassembling)
- When reassembling the inside parts, put the oil on each inside part slightly.
- After sliding on the governor connecting rod to the rack pin, tighten the nut with the specified torque with using the jig for keeping the governor connecting rod horizontal. (See the Replacing Injection Pump Assembly).
- After tightening the nut, hook the start spring on the rack pin.
- Check the movement of control rack of injection pump assembly by the stop lever.

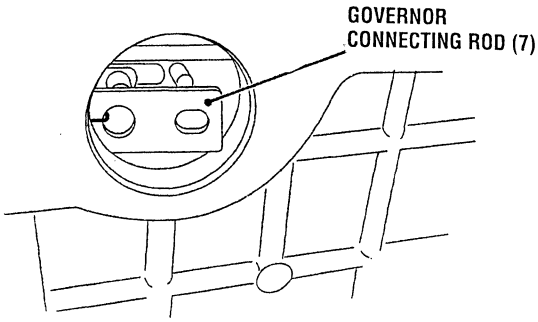
■ NOTE
- **When installing the governor housing assembly to the injection pump unit, be careful not to damage O-ring.**
- **When linking the governor connecting rod to the rack pin of injection pump, use the jig for keeping the governor connecting rod horizontal. Otherwise the control rack may be stuck, and causes to be difficult to start the engine or hunting of governor. (See the Replacing Injection Pump Assembly.)**

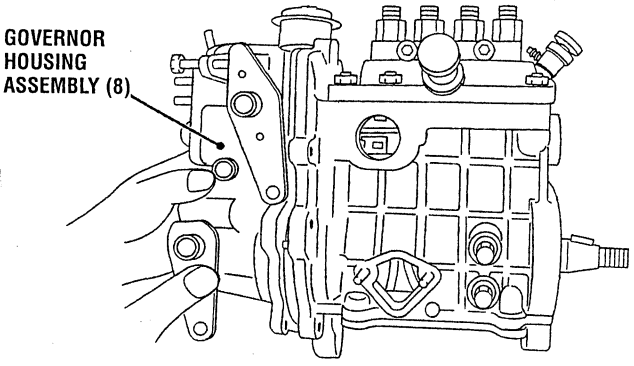
Tightening torque	Governor housing mounting screw	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs
	Anti-rotation nut	2.8 to 4.0 N·m 0.29 to 0.41 kgf·m 2.1 to 3.0 ft-lbs



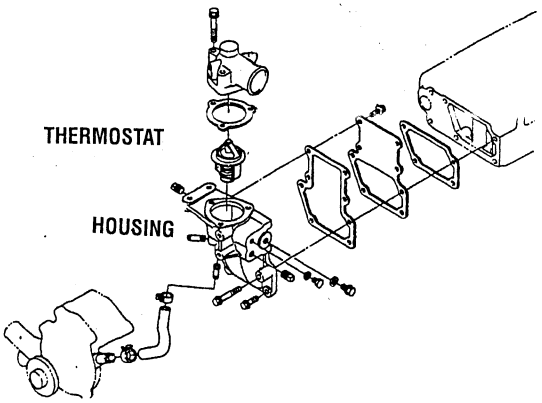








Thermostat

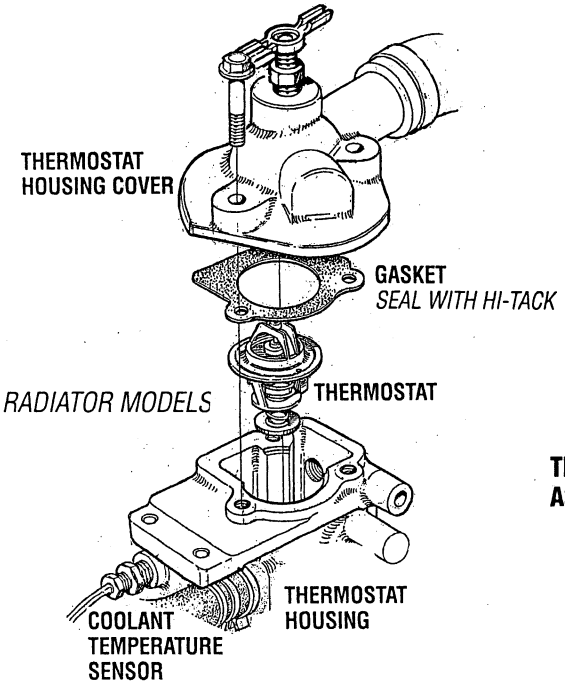


Thermostat Assembly

1. Remove the thermostat cover mounting screws, and remove the thermostat cover.
2. Remove the thermostat assembly.

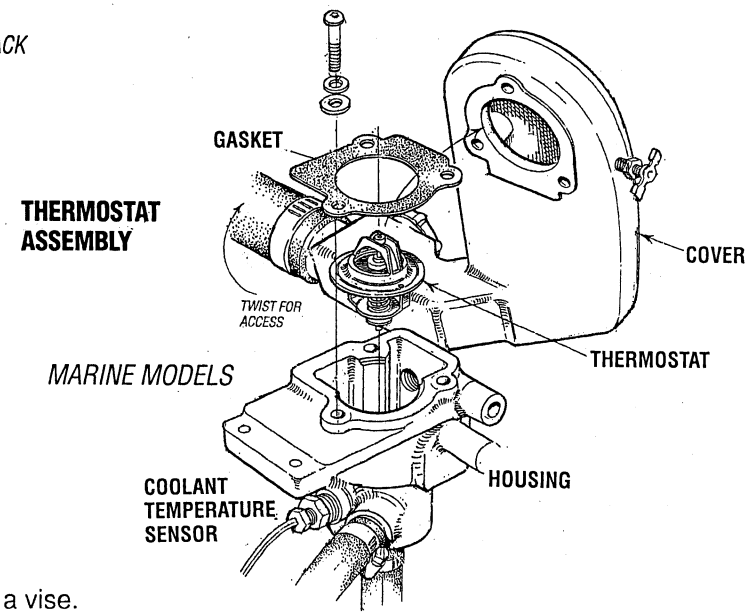
(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) only at the thermostat cover side of the gasket.
- Install the thermostat with its bleed hole facing towards the discharge opening of the thermostat housing.



Re-Assemble and Test

Turn the cover back into place and tighten the three screws. Do not over-tighten! Tighten the hose clamp and close the drains. Top off the coolant and run the engine. Check for normal temperature and for any leaks around the thermostat assembly.



Injection Nozzle

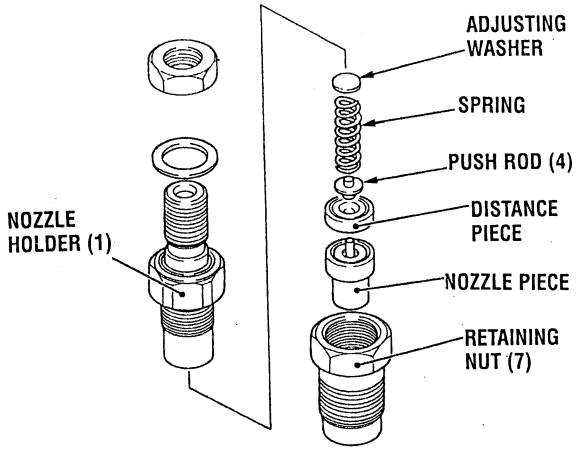
Nozzle Holder

1. Secure the nozzle retaining nut (7) with a vise.
2. Remove the nozzle holder (1), and take out parts inside.

(When reassembling)

- Assemble the nozzle in clean fuel oil.
- Install the push rod (4), noting its direction.
- After assembling the nozzle, be sure to adjust the fuel injection pressure.

Tightening torque	Nozzle holder	34.3 to 39.2 N·m 3.5 to 4.0 kgf·m 25.3 to 28.9 ft-lbs
	Overflow pipe nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Nozzle holder assembly	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs



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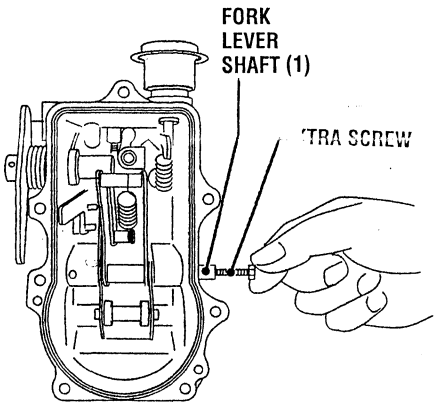


Governor Fork Lever Assembly

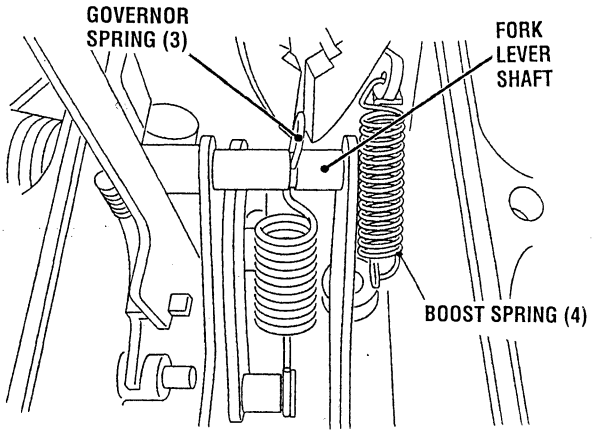
1. Pull off the governor fork lever shaft (1) with the extra screw (Dia.: 4 mm, Pitch : 0.7 mm, Length : more than 25 mm).
2. Unhook the governor spring (3) at the governor fork lever (4) side.
3. Remove the governor fork lever assembly from the governor housing (5).

(When reassembling)

- After reassembling the governor housing assembly, check the movement of the governor fork lever assembly, the speed control lever and the stop lever.

■ NOTE

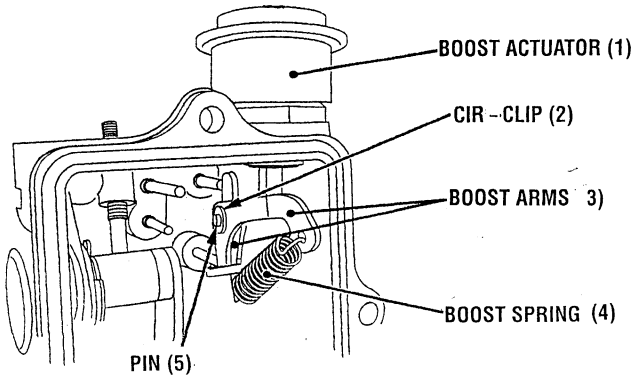
- **When assembling the inside parts, put the oil on each inside part slightly.**
- **Be careful not to deform the start spring.**

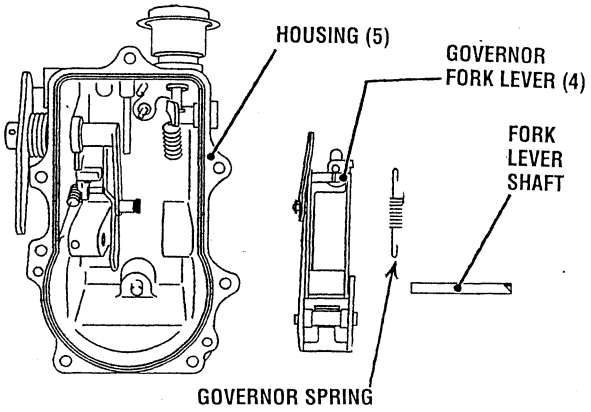


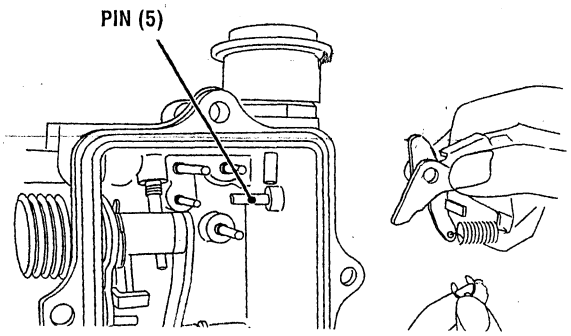
Boost Arms (If equipped Boost Compensator)

1. Remove the boost actuator (1).
2. Remove the cir-clip (2).
3. Remove the boost arms (3) and the boost spring (4) from the pin (5).

Tightening torque	Boost actuator	39.2 to 45.1 N·m 4.0 to 4.6 kgf·m 28.9 to 33.3 ft-lbs



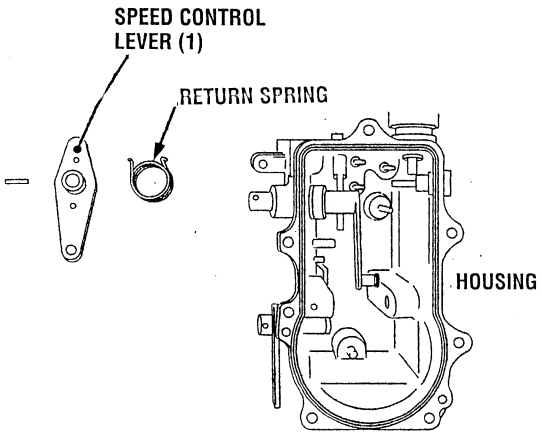




REMOVING THE CIR-CLIP BOOST ARMS AND SPRING

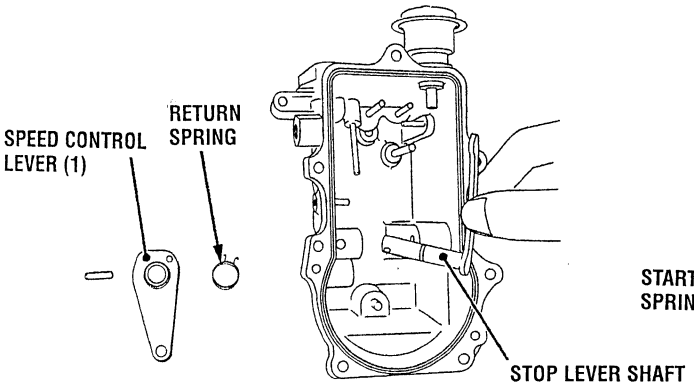
DISASSEMBLY/ASSEMBLY

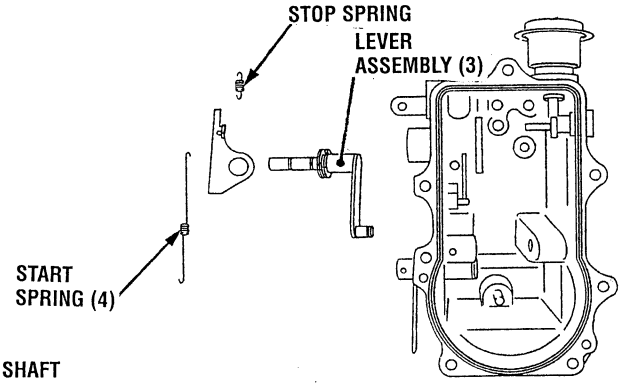
1. Remove the speed control lever (1) and the return spring.
2. Remove the governor lever assembly (3) from the governor housing.
3. Remove the start spring (4) and the stop spring.



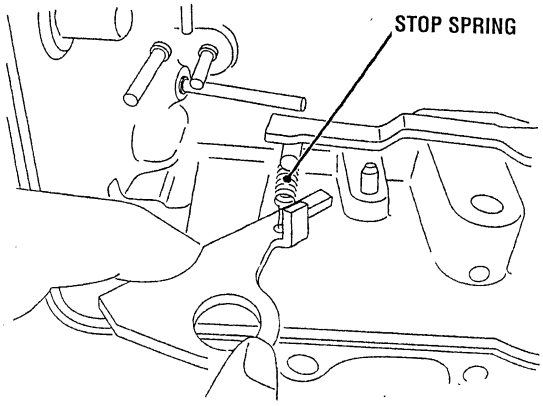
Stop Lever

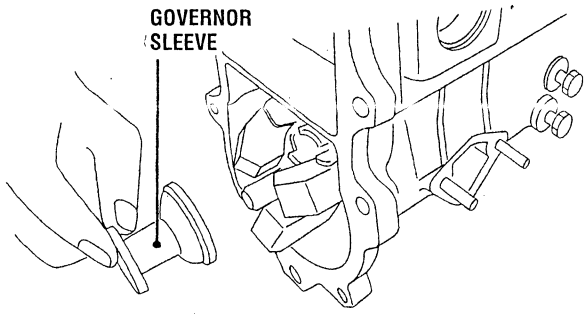
1. Remove the stop lever (1) and the return spring.
2. Remove the stop lever shaft.





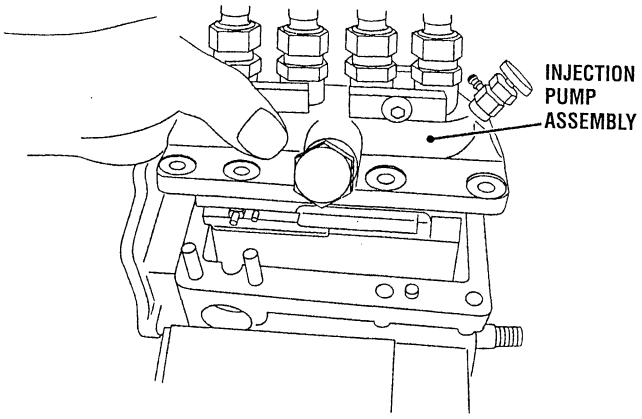
REMOVING THE STOP SPRING





Fuel Camshaft and Governor Weight

1. Separate the governor housing assembly from the injection pump unit. (See the "Injection Pump Unit".)
2. Remove the governor sleeve.
3. Remove the injection pump assembly.
4. Remove the cover.
5. Remove the fuel camshaft lock screws.
6. Fix the fuel camshaft with open end wrench (4), and remove the governor weight mounting nut and the governor weight (5).
7. Loosen the fuel camshaft stopper mounting screws and remove the fuel camshaft stopper (6).
8. Pull out the fuel camshaft (7) and bearings (8) together.
9. After removing the bearing's cir-clip (9), press out the bearings.



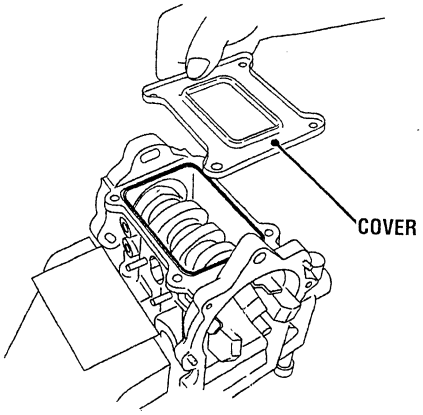
■ **NOTE**

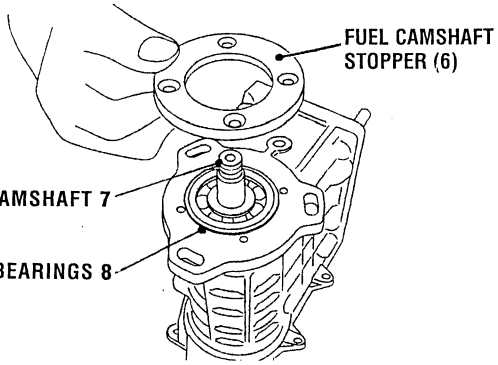
- **Do not use the fuel camshaft lock bolts, when removing the governor weight mounting nut. Otherwise, the lock bolts or injection pump housing might get damage.**

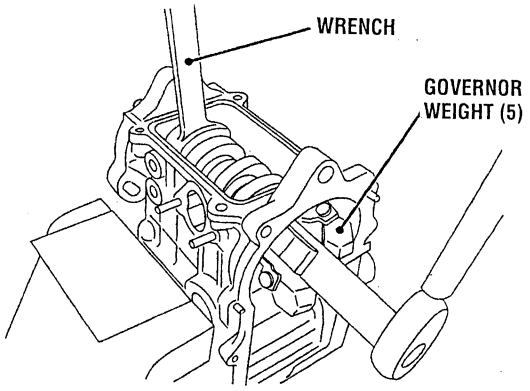
(When reassembling)

- Press the bearings into the fuel camshaft.
- Set the cir-clip at the gear side's bearing.
- Install the fuel camshaft and bearings to the injection pump housing.
- Attach the fuel camshaft stopper and tighten the fuel camshaft stopper mounting screws with the specified torque.
- Attach the governor weight to the fuel camshaft and tighten the governor weight mounting nut with specified torque.

Tightening torque	Injection pump mounting screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs
	Injection pump mounting nut	17.7 to 20.6 N·m 1.8 to 2.1 kgf·m 13.0 to 15.2 ft-lbs



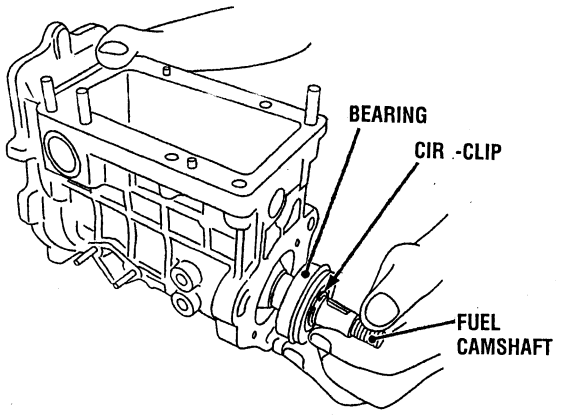




Fuel Camshaft and Governor Weight (Continued)

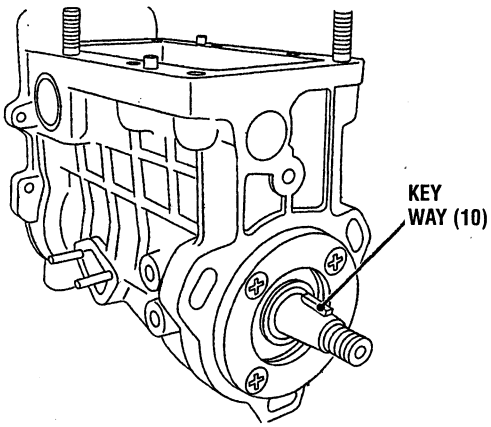
(When reassembling)

- Fix the fuel camshaft with lock bolts as the key way of fuel camshaft (10) is upward.
- Install the injection pump assembly to the injection pump housing.
- Attach the O-ring and the cover and tighten the cover mounting screws.
- Install the governor sleeve to the fuel camshaft.
- Check the movement of the governor sleeve.



■ NOTE

- **Be careful not to damage the O-ring.**
- **Be careful the direction of the governor sleeve.**
- **When reassembling inner parts, oil each part slightly.**

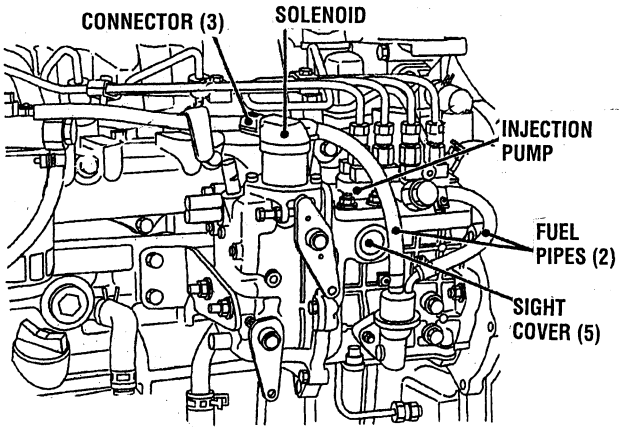


Tightening torque	Fuel camshaft stopper mounting screw	7.9 to 9.3 N·m 0.80 to 0.95 kgf·m 5.8 to 6.9 ft-lbs
	Governor weight mounting nut	62.8 to 72.6 N·m 6.4 to 7.4 kgf·m 46.3 to 53.5 ft-lbs

Replacing Injection Pump Assembly (If necessary)

- **The injection pump can be replaced with the crankshaft in whatever position.**

1. Disconnect all injection pipes.
2. Disconnect the fuel pipe (2) and fuel overflow pipe.
3. Disconnect the connector (3) from the stop solenoid. Then remove the stop solenoid.
4. Detach the sight cover (5) from the injection pump unit.
5. Unhook the starter spring (6), and remove the control rod nut.
6. Slide off the governor connecting rod (7) from the rock pin of injection pump assembly.

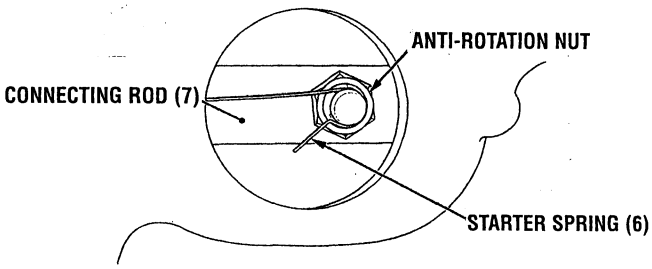


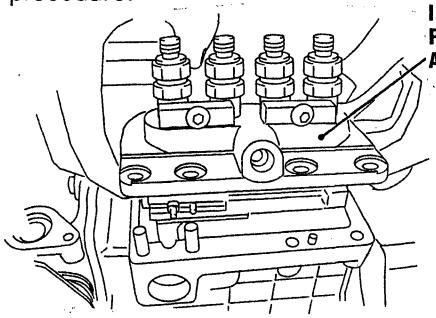
■ NOTE

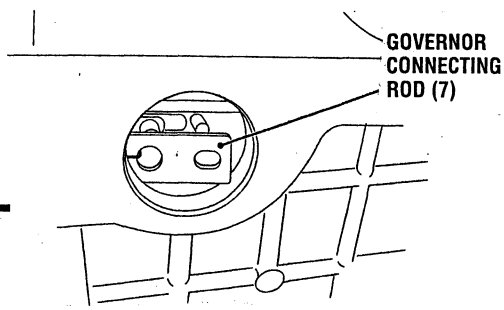
- **Be careful not to drop the anti-rotation nut.**
- **Be careful not to deform the start spring.**
- **When taking out the injection pump assembly, be careful not to hit it against the governor connecting rod.**

(When reassembling)

- Install the new injection pump according to the installing procedure.



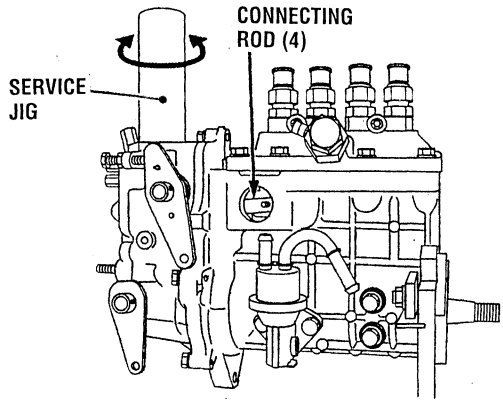


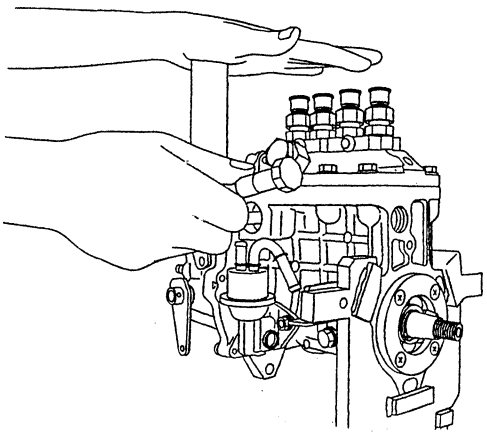


DISASSEMBLY/ASSEMBLY

Installing Procedure of Injection Pump Assembly

1. Install the fuel injection pump assembly (1) in its unit (2), and hook the governor connecting rod to the rack pin of the fuel injection pump assembly.
2. Place the service jig (3) in the stop solenoid mounting hole of the fuel injection pump unit.
3. Make sure the permanent magnet at the tip of the service jig is attracted to the governor connecting rod (4). To do this, turn the jig a little clockwise and counterclockwise and look into the fuel injection pump unit sight hole to see if the governor connecting rod (4) moves right and left accordingly.
4. Slightly tighten the anti-rotation nut of the governor connecting rod.
5. Holding down the service jig (3) by hand, tighten up the anti-rotation nut (5) to the specified torque.
6. Hook the start spring (6) to the rack pin.

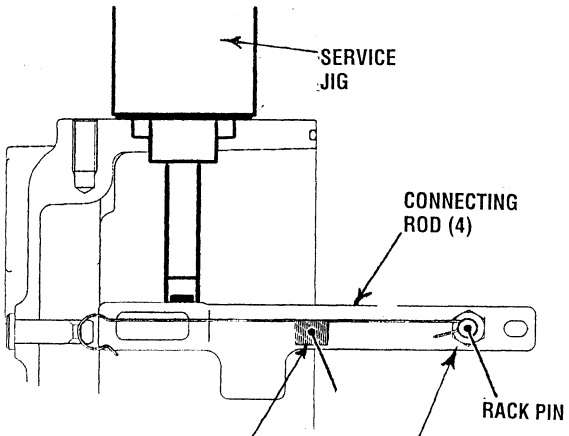


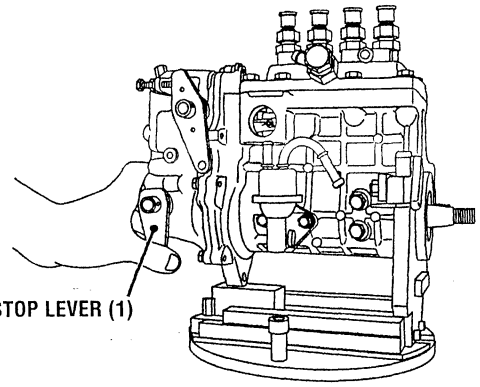


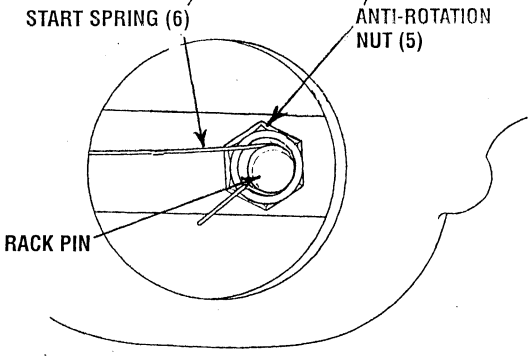
Installing Procedure (Continued)

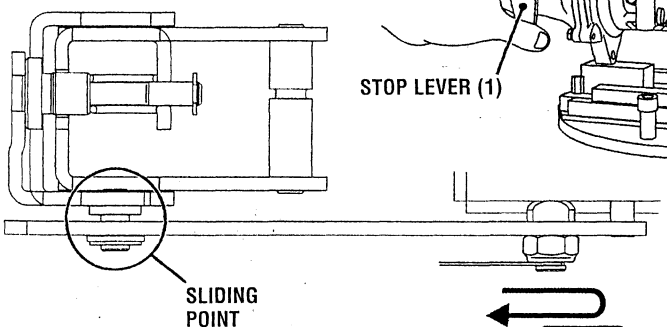
1. Move the stop lever (1) and visually check to see if the fuel injection pump control rack comes smoothly back to the start position by the counter force of the start spring.
2. If the control rack fails to move back smoothly, remove the start spring and the anti-rotation nut, take the above steps from 2 of the former page again.
3. Finally fit the sight cover and the stop solenoid back into place.

Tightening torque	Anti-rotation nut	2.8 to 4.0 N·m 0.29 to 0.41 kgf·m 2.1 to 3.0 ft-lbs
	Injection pump mounting screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs
	Injection pump mounting nut	17.7 to 20.6 N·m 1.8 to 2.1 kgf·m 13.0 to 15.2 ft-lbs







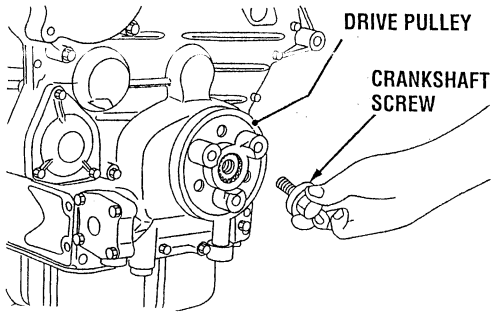


Alternator Drive Pulley

1. Lock the flywheel in place.
2. Remove the crankshaft screw.
3. Draw out the drive pulley.

(When reassembling)

Tightening torque	Crankshaft screw	255.0 to 274.6 N·m 26.0 to 28.0 kgf·m 188.1 to 202.5 ft-lbs



Alternator Drive Fan Pulley *RADIATOR MODELS*

1. Lock the flywheel in place.
2. Remove the crankshaft screw.
3. Draw out the drive fan pulley.

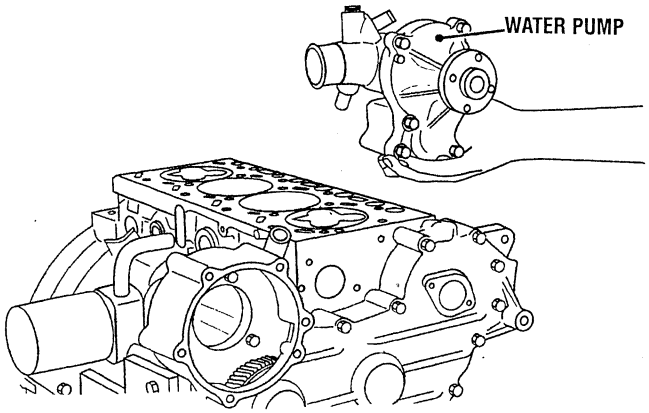
Water Pump and Oil Cooler

Water Pump

1. Remove the pipe band and the water pipe.
2. Remove the water pump.

(When reassembling)

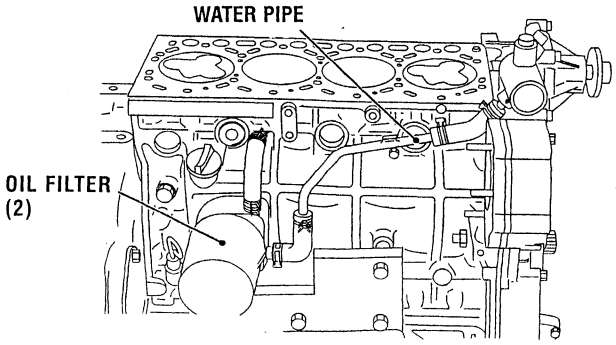
- When mounting the water pump, take care not to forget mounting the O-ring and not to let it out of position.

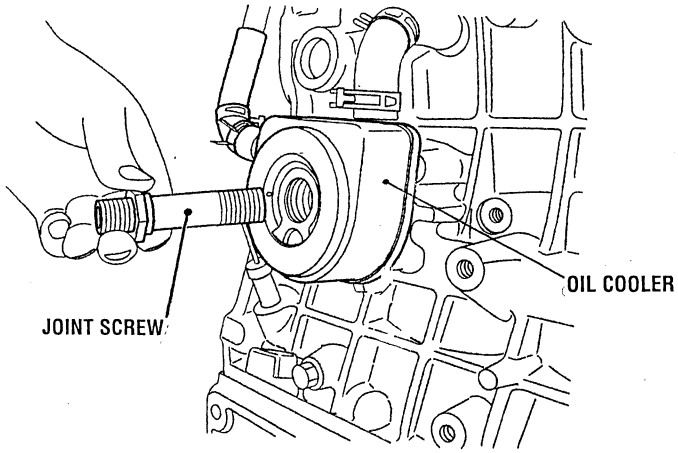


Oil Cooler

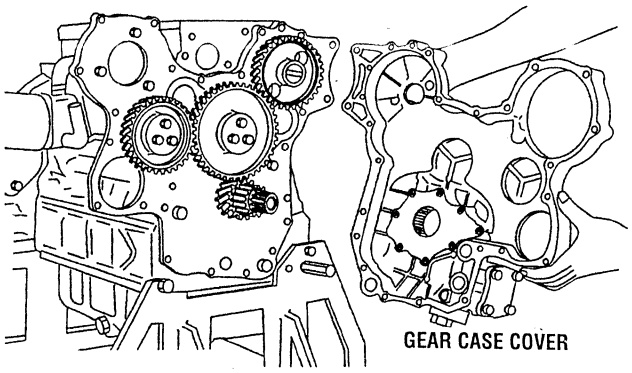
1. Remove the water pipe.
2. Remove the oil filter cartridge (2) and the oil cooler joint screw.
3. Remove the oil cooler.

Tightening torque	Oil cooler joint screw	39.2 to 44.1 N·m 4.0 to 4.5 kgf·m 28.9 to 32.5 ft-lbs





Gear Case



Gear Case Cover

1. Remove the gear case cover.

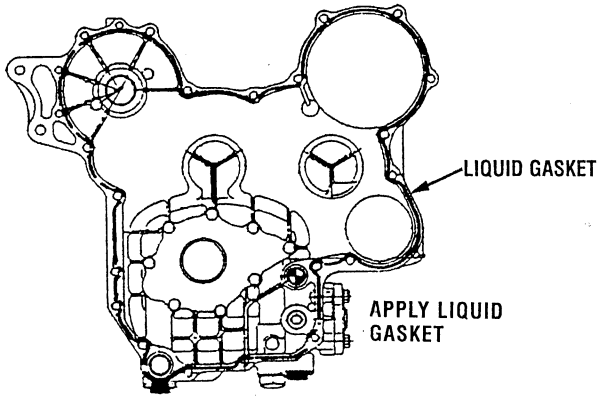
(When reassembling)

- Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.
- Carefully apply the adhesive evenly. Refer to the illustration.

■ NOTE

- **When mounting the adhesive-applied parts, take care to fit them to the mating parts.**
- **Assemble the adhesive-applied parts within ten minutes.**
- **Apply a liquid gasket (Three Bond 1217D) to the gear case cover.**

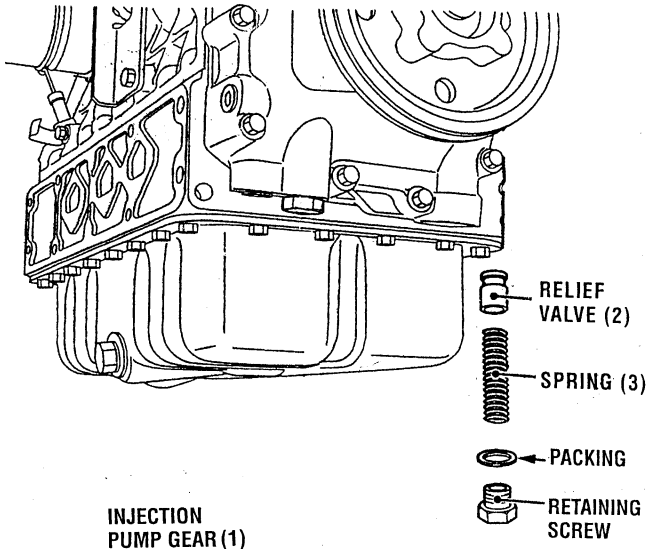
Tightening torque	Gear case cover mounting screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs



Relief Valve

1. Remove the relief valve retaining screw.
2. Remove the relief valve (2), the spring (3) and the packing.

Tightening torque	Relief valve retaining screw	68.6 to 78.4 N·m 7.0 to 8.0 kgf·m 50.6 to 57.9 ft-lbs



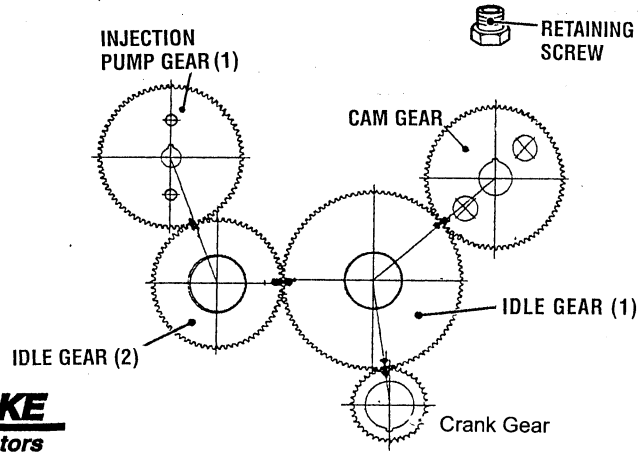
Idle Gear and Camshaft

1. Remove three set screws of the idle gear and draw out the idle gear 1, 2.
2. Remove two set screws of the camshaft stopper and draw out the camshaft.

(When reassembling)

- Set the crankshaft at the top dead center of No. 1 and 4 cylinder and the camshaft key to the top position and align the marks of idle gear 1 and idle gear 2 to assemble them. Refer to the illustration.
- Mount the injection pump gear (1) after installing the gear case.

Tightening torque	Camshaft set screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs
	Idle gear mounting screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs



Oil Pan and Oil Strainer

1. Unscrew the oil pan mounting screws and remove the oil pan.

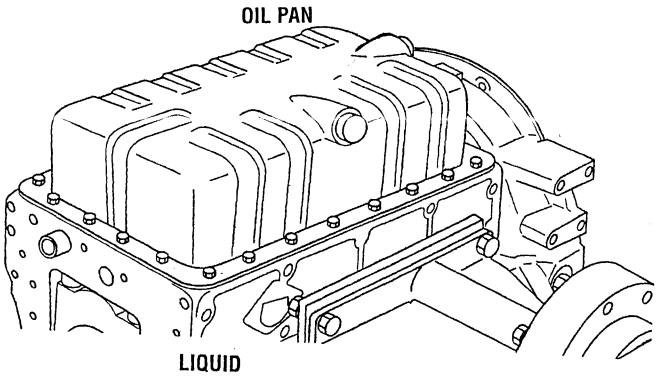
2. Unscrew the oil strainer mounting screw, and remove the oil strainer (2).

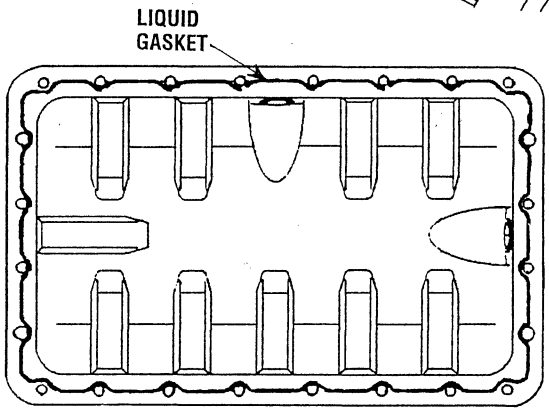
(When reassembling)

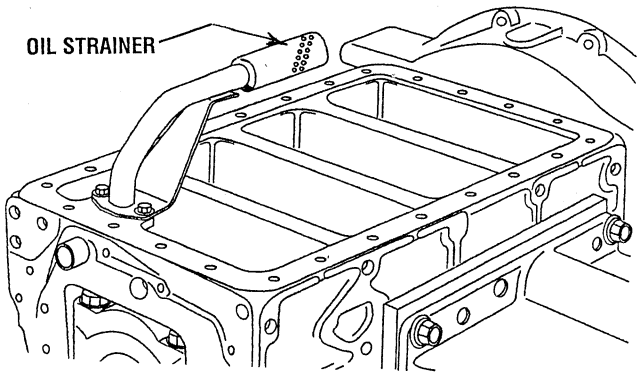
- Install the oil strainer, using care not to damage the O-ring.
- Apply liquid gasket (Three Bond 1217D) to the oil pan as shown.
- Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.
- Carefully apply the adhesive evenly.

■ NOTE

- **When mounting the adhesive-applied parts, take care to fit them to the mating parts.**
- **Assemble the adhesive-applied parts within ten minutes.**
- **To avoid uneven tightening, tighten mounting screws in diagonal order from the center.**
- **After cleaning the oil strainer, install it.**
- **Attach the oil pan with its central drain plug facing toward the air suction side.**







PISTON AND CONNECTING ROD

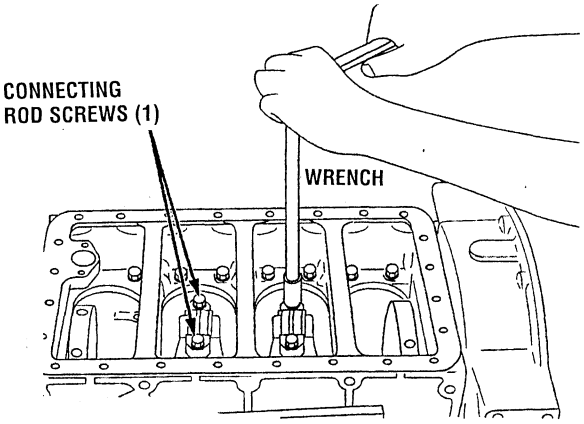
Connecting Rod Cap

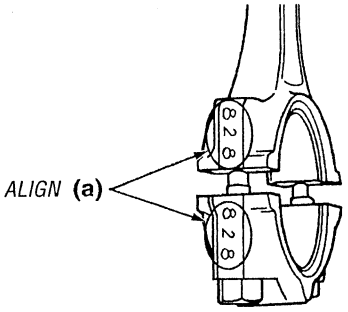
1. Remove the connecting rod screws (1) from connecting rod cap.
2. Remove the connecting rod caps.

(When reassembling)

- Align the marks **(a)** with each other. (Face the marks toward the injection pump.)
- Apply engine oil to the connecting rod screws and lightly screw it in by hand, then tighten it to the specified torque.
  If the connecting rod screw won't be screwed in smoothly, clean the threads.
  If the connecting rod screw is still hard to screw in, replace it.
- When using the existing crank pin bearing again, put tally marks on the crank pin bearing and the connecting rod in order to keep their positioning.
- Fit the crank pin bearing in place : its centrally groove side toward the connecting rod, and the non-grooved side toward the cap.

Tightening torque	Connecting rod screw	78.5 to 83.4 N·m 8.0 to 8.5 kgf·m 57.9 to 61.5 ft-lbs





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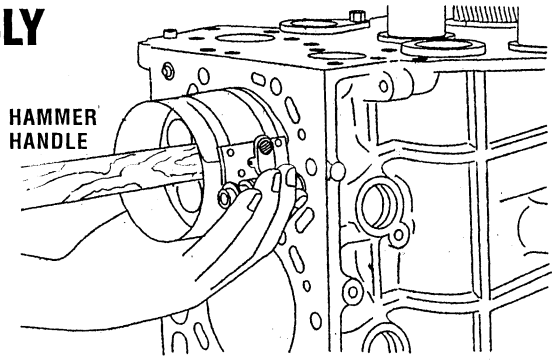


Pistons

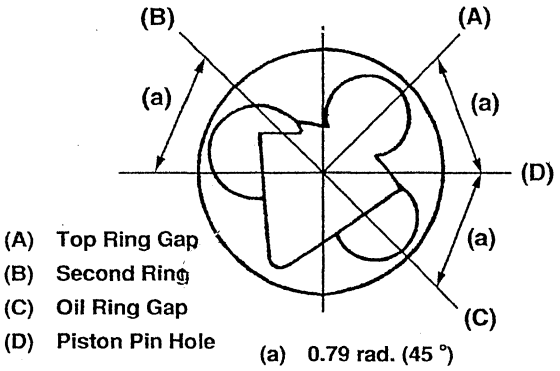
1. Turn the flywheel and set a piston to the top dead center.
2. Pull out the piston upward by lightly tapping it from the bottom of the crankcase with the grip of a hammer.

(When reassembling)

- Before inserting the piston into the cylinder, apply enough engine oil to the cylinder.
- When inserting the piston into the cylinder, face the mark on the connecting rod to the injection pump.

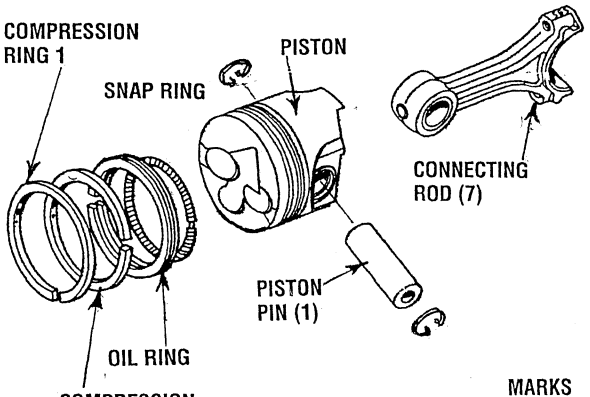
■ IMPORTANT

- **Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking. For example, mark "1" on the No. 1 position.**
- **When inserting the piston into the cylinder, place the gap of the compression ring 1 on the opposite side of the combustion chamber and stagger the gaps of the compression ring 2 and oil ring marking a right angle from the gap of the compression ring 1.**
- **Carefully insert the pistons using a piston ring compressor (1). Otherwise, their chrome-plated section may be scratched, causing trouble inside the liner.**



Piston Ring and Connecting Rod

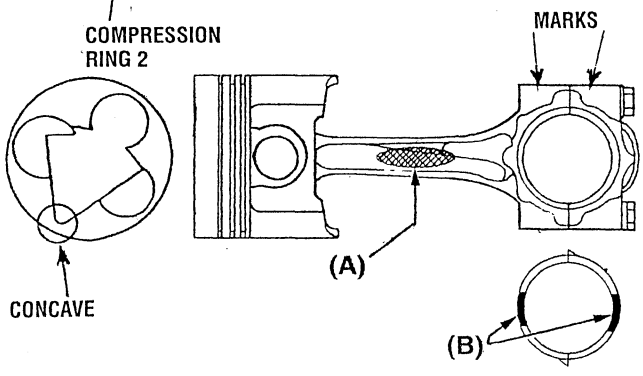
1. Remove the piston rings using a piston ring tool.
2. Put the fan shaped concave (8) on the piston as shown.

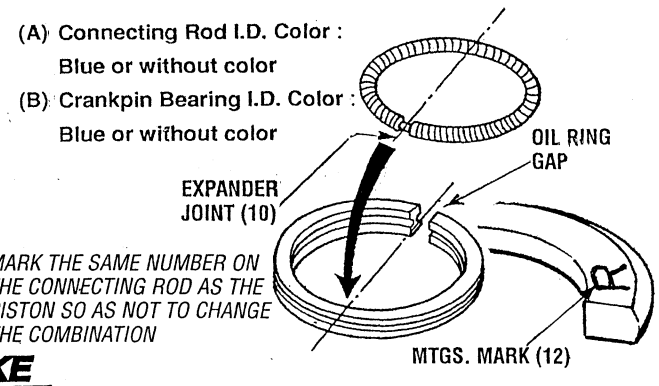


3. Remove the piston pin (1), and separate the connecting rod (7) from the piston.

(When reassembling)

- Be sure to fix the crankpin bearing and the connecting rod are same I.D. colors.
- When installing the ring, assemble the rings so that the manufacture's mark (12) near the gap faces the top of the piston.
- When installing the oil ring onto the piston, place the expander joint (10) on the opposite side of the oil ring gap.
- Apply engine oil to the piston pin.
- When installing the piston pin, immerse the piston in 80 °C (176 °F) oil for 10 to 15 minutes and insert the piston pin to the piston.
- Assemble the piston to the connecting rod with the aligning the direction of the fan shaped concave (8) of piston head and the mark (9) of connecting rod.
- The end faces of the oil ring are plated with hard chrome. In putting the piston into the cylinder, be careful not to get the oil ring scratched by the cylinder. Use the piston ring fitter to tighten up the oil ring. If the ring's planting is scratched, it may get stuck on the cylinder wall, causing a serious trouble.





Flywheel and Crankshaft

Flywheel

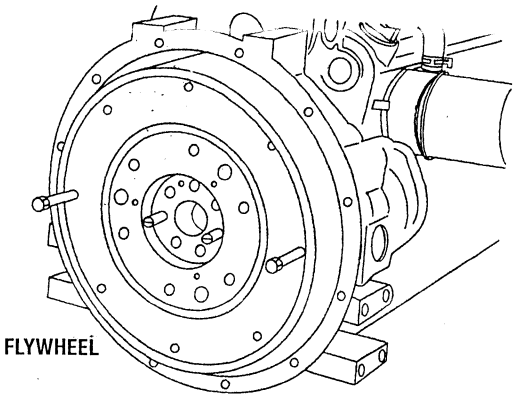
1. Install the flywheel lock so that the flywheel does not turn.

■ NOTE
- **Do not use an impact wench. Serious damage will occur.**

2. Detach the flywheel screws.
3. Remove the flywheel.

(When reassembling)
- Apply engine oil to the flywheel screws.
- Before fitting the flywheel and the crankshaft together, wipe oil, dust and other foreign substances off their mating faces.
- The flywheel and the crankshaft are fitting together in just one position. Make sure they are tightly fit and drive the bolts.

Tightening torque	Flywheel screw	98.1 to 107.9 N·m 10.0 to 11.0 kgf·m 72.3 to 79.6 ft-lbs



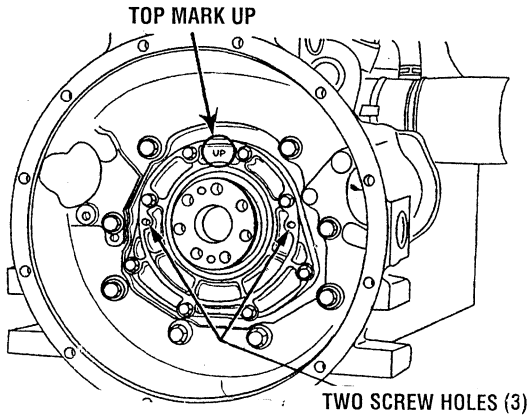
Bearing Case Cover

■ NOTE
- **Before disassembling, check the side clearance of crankshaft. Also check it during reassembly.**

1. Remove the bearing case over mounting screws.
2. Screw two removed screws into the screw hole (3) of bearing case cover to remove it.

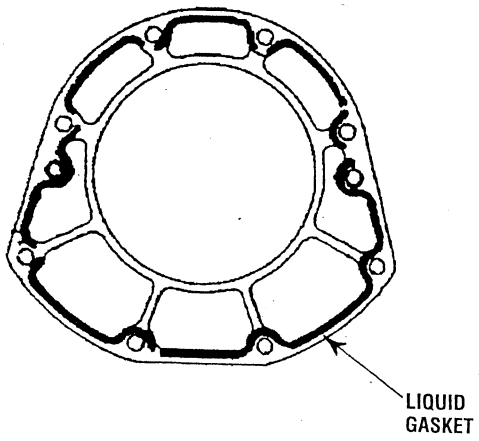
(When reassembling)

■ IMPORTANT
- **In case of replacing the oil seal, use caution when installing the seal in the bearing case cover as not to install it tilted. The seal should be flush with the cover.**
- **Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.**
- **Apply liquid gasket (Three Bond 1217D) to the bearing case cover as shown.**
- **Before installing the bearing case cover / oil seal assembly, lube the seal and be careful not to damage the seal while installing the assembly.**
  Install the bearing case cover / oil seal assembly to position the casting mark "UP" on it upward.
- **Tighten the bearing case cover mounting screws with even force on the diagonal line.**



■ NOTE
- **When mounting the adhesive-applied parts, take care to fit them to the mating parts.**
- **Assemble the adhesive-applied parts within ten minutes.**

Tightening torque	Bearing case cover mounting screw	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs



DISASSEMBLY/ASSEMBLY

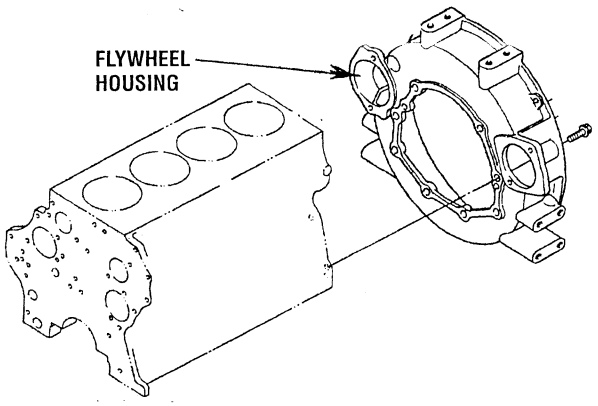
Flywheel Housing

1. Remove the flywheel housing.

(When reassembling)

- Tighten the flywheel housing mounting screws with even force on the diagonal line.
- Make sure the crank cases 1 and 2 are clean. Install them in position, referring to the flywheel housing's contoured face.

Tightening torque	Flywheel housing mounting screw	77.5 to 90.2 N·m 7.9 to 9.2 kgf·m 57.1 to 66.5 ft-lbs



Crankcase 2

1. Remove the crankcase 2.

(When reassembling)

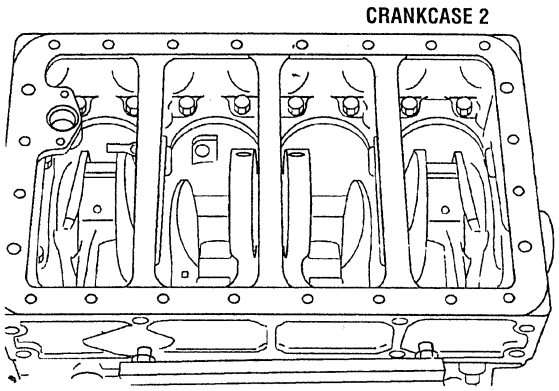
■ IMPORTANT

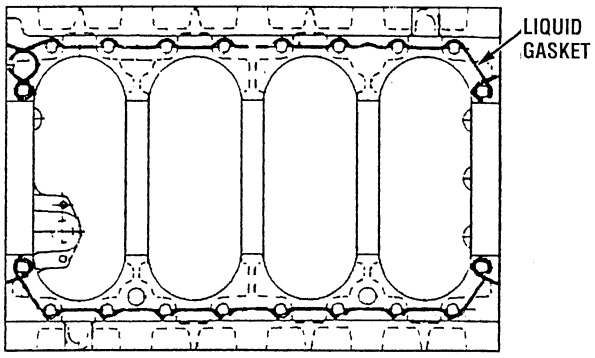
- **Make sure the crankcase 1 and 2 are clean.**
- **Apply liquid gasket (Three Bond 1217D) to the crankcase 2 as shown.**
- **Tighten the crankcase 2 mounting screws with even force on the diagonal line.**
- **Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.**
- **Carefully apply the adhesive evenly.**

■ NOTE

- **When mounting the adhesive-applied parts, take care to fit them to the mating parts.**
- **Assemble the adhesive-applied parts within ten minutes.**

Tightening torque	Crankcase 2 mounting screw	49.0 to 55.9 N·m 5.0 to 5.7 kgf·m 36.2 to 41.2 ft-lbs



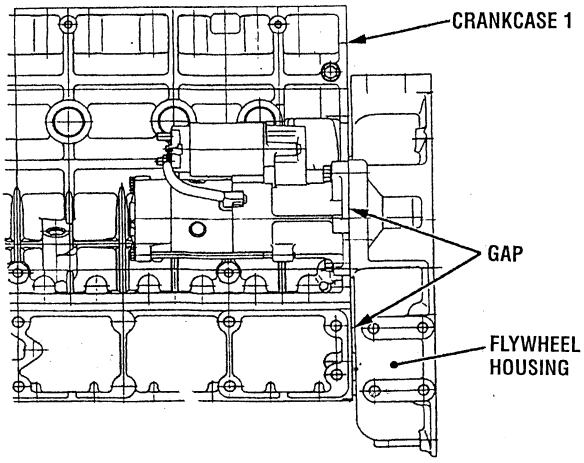


Crankcase 1 and Crankcase 2

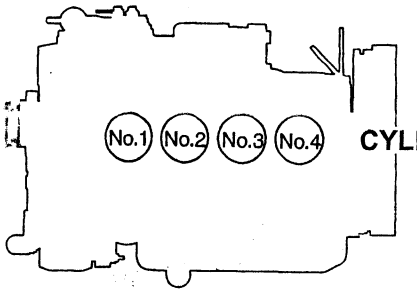
(When reassembling)

- Match the crankcase 1 and 2, referring to the flywheel housing's contoured face.
- Tighten the crankcase 2 mounting screws loosely.
- Tighten up the jig to the specified torque same as the flywheel housing screw. This helps to minimize the level difference between the crankcase 1 and the crankcase 2 (at the flywheel side). Possible gap must be 0.05 mm (0.0020 in.) or smaller.

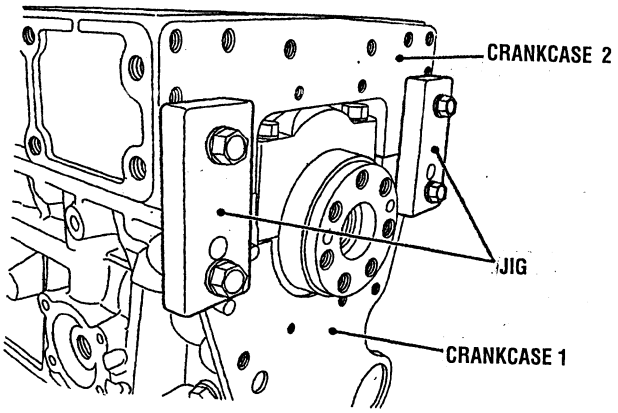
Tightening torque	Crankcase 2 mounting screw	49.0 to 55.9 N·m 5.0 to 5.7 kgf·m 36.2 to 41.3 ft-lbs
	Flywheel housing mounting screw	77.5 to 90.2 N·m 7.9 to 9.2 kgf·m 57.1 to 66.5 ft-lbs



DISASSEMBLY/ASSEMBLY



The sequence of cylinder numbers is given as No.1, No.2, No.3 and No.4 starting from the gear case side.



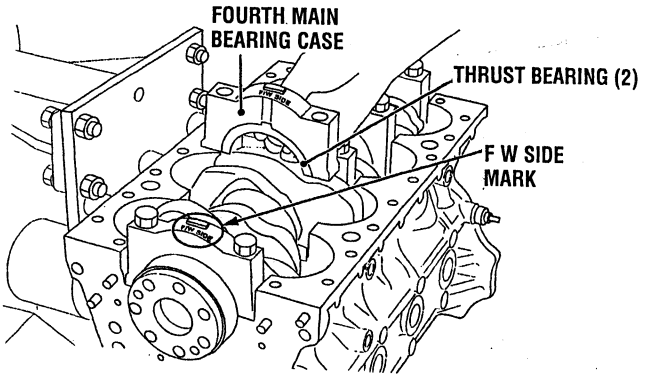
Crankshaft

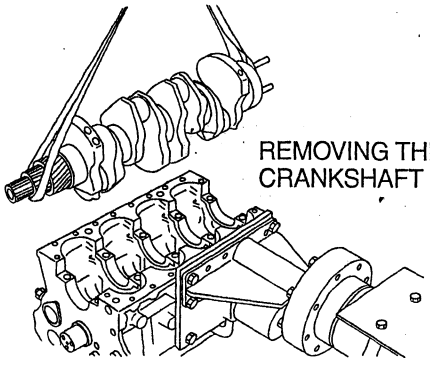
1. Remove the main bearing case.
2. Remove the crankshaft.

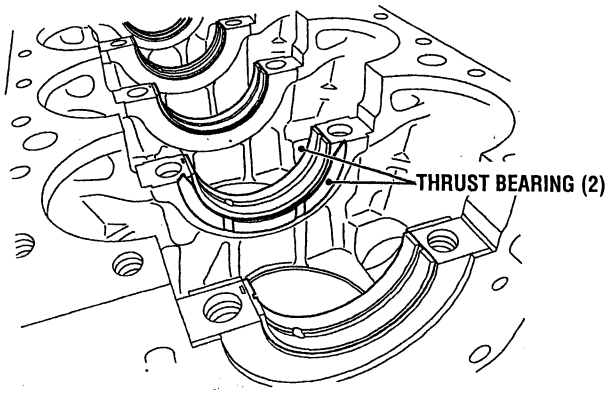
(When reassembling)

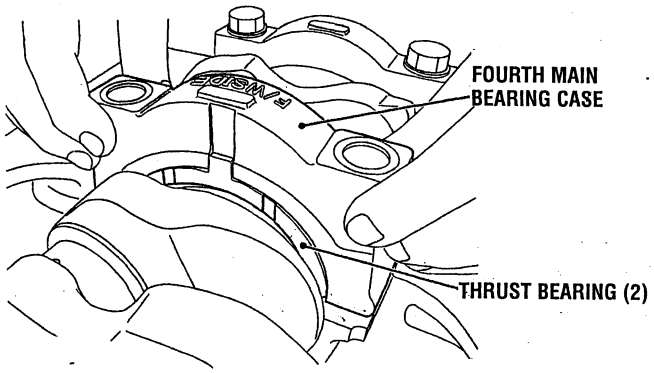
- Reassemble the main bearing case having the same number as the one engraved on the crankcase, and set the casting mark "F / W SIDE" on the main bearing case facing towards the flywheel side.
- Reassemble the thrust bearing (2), with the oil groove facing outside, into both side of the fourth main bearing case.
- Apply oil to the main bearing case screws and tighten them to the specified torque.

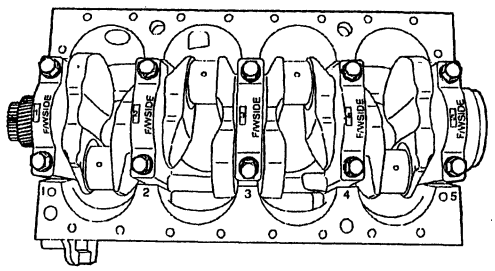
Tightening torque	Main bearing case screw	137.3 to 147.1 N·m 14.0 to 15.0 kgf·m 101.3 to 108.5 ft-lbs







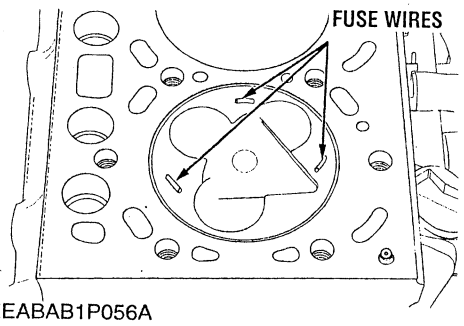




Cylinder Head

Top Clearance

1. Remove the cylinder head (remove the cylinder head gasket completely).
2. Bring the piston to its top dead center fasten 1.5 mm dia. 5 to 7 mm long fuse wires to 3 to 4 spots on the piston top with grease so as to avoid the intake and exhaust valves and the combustion chamber ports.
3. Bring the piston to its middle position, install the cylinder head, and tighten the cylinder head screw to specification. (Head gasket must be changed to new one).
4. Turn the crank shaft until the piston exceeds its top dead center.
5. Remove the cylinder head, and measure squeezed fuse wires for thickness.
6. If the measurement is not within the specified value, check the oil clearance of the crankpin journal and the piston pin.



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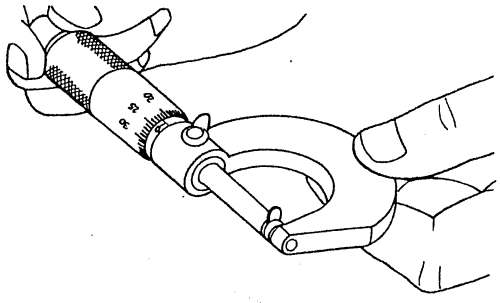
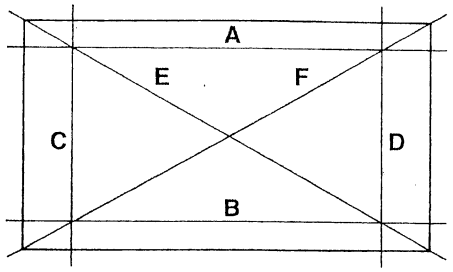


Top clearance	Factory spec.		0.72 to 0.90 mm 0.0283 to 0.0354 in.

Tightening torque	Cylinder head mounting screw	98.1 to 107.9 N·m 10.0 to 11.0 kgf·m 72.3 to 79.6 ft-lbs

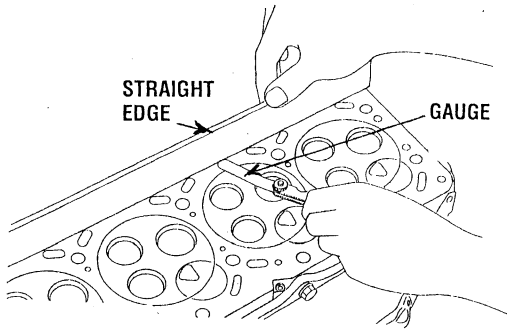
Cylinder Head Surface Flatness

1. Clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides (**A**), (**B**), (**C**) and (**D**) and two diagonal (**E**) and (**F**) as shown in the figure.
   Measure the clearance with a feeler gauge.
3. If the measurement exceeds the allowable limit, correct it with a surface grinder.



■ IMPORTANT

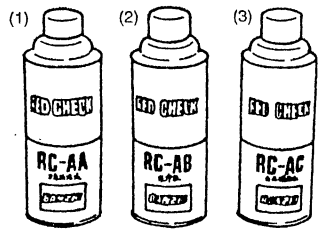
- **Do not place the straightedge on the combustion chamber.**
- **Be sure to check the valve recessing after correcting.**

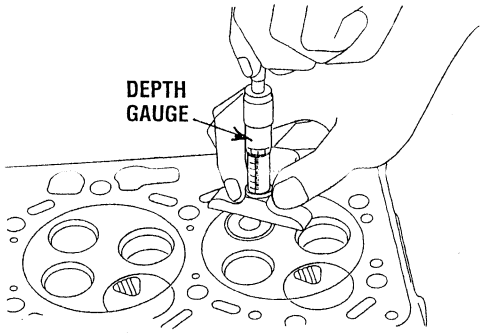


Cylinder head surface flatness	Allowable limit	0.05 mm 0.0020 in.

Cylinder Head Flaw

1. Prepare an air spray red check.(Code No. 07909-31371).
2. Clean the surface of the cylinder head with the detergent (2).
3. Spray the cylinder head surface with the red permeative liquid (1). Leave it five to ten minutes after spraying.
4. Wash away the red permeative liquid on the cylinder head surface with the detergent (2).
5. Spray the cylinder head surface with the white developer (3).
6. If flawed, it can be identified as red marks.

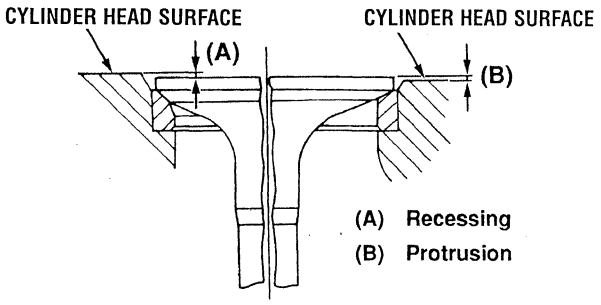




Valve Recessing

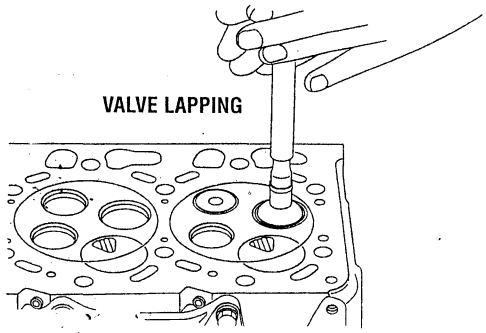
1. Clean the cylinder head, the valve face and seat.
2. Insert the valve into the valve guide.
3. Measure the valve recessing with a depth gauge.
4. If the measurement exceeds the allowable limit, replace the valve.
   If it still exceeds the allowable limit after replacing the valve, replace the cylinder head.

Valve recessing	Factory spec.	Intake valve	(Protrusion) 0 mm (0 in.) to (recessing) 0.2 mm (0.0079 in.)
	Factory spec.	Exhaust valve	(Protrusion) 0.15 mm (0.0059 in.) to (recessing) 0.05 mm (0.0019 in.)
	Allowable limit	(recessing) 0.4 mm (0.0157 in.)	



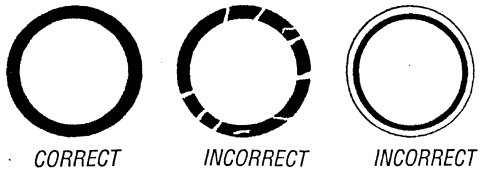
Valve Lapping

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper or screwdriver.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70 %, repeat valve lapping again.



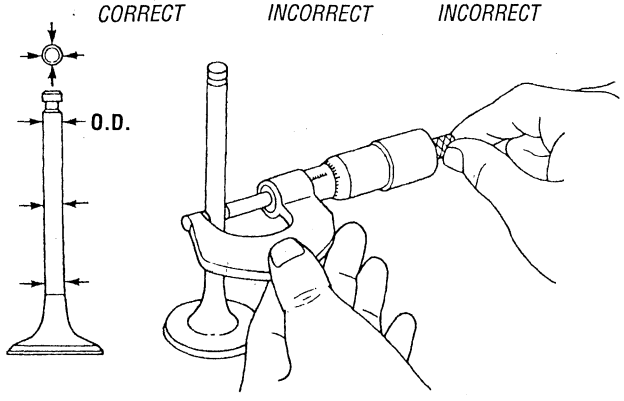
■ IMPORTANT

- **When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.**



Clearance between Valve Stem and Valve Guide

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure the valve guide I.D. of the cylinder head at the most wear part as shown with a small hole gauge.
   And calculate the clearance.
4. If the clearance exceeds the allowable limit, replace the valves. If it still exceeds the allowable limit, replace the valve guide.



Valve stem O.D.	Factory spec.	Intake valve	6.960 to 6.975 mm 0.2740 to 0.2746 in.
		Exhaust valve	7.960 to 7.975 mm 0.3134 to 0.3140 in.
Valve guide I.D.	Factory spec.	Intake valve	7.030 to 7.045 mm 0.2768 to 0.2774 in.
		Exhaust valve	8.015 to 8.030 mm 0.3155 to 0.3161 in.

Clearance between valve stem and guide	Factory spec.	Intake valve	0.055 to 0.085 mm 0.0022 to 0.0033 in.
		Exhaust valve	0.040 to 0.070 mm 0.0016 to 0.0028 in.
	Allowable limit		0.1 mm 0.0039 in.

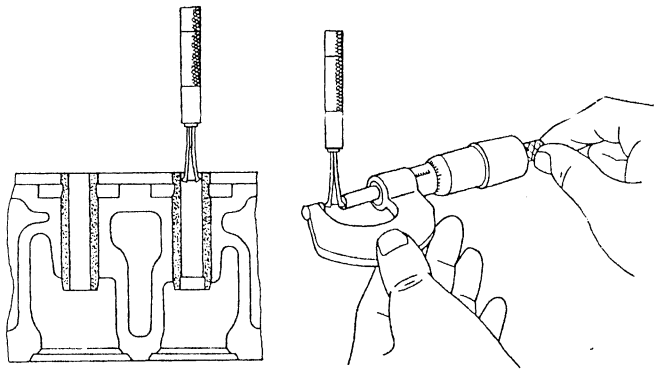
Replacing Valve Guide

(When removing)

1. Using a valve guide replacing tool, press out the used valve guide.

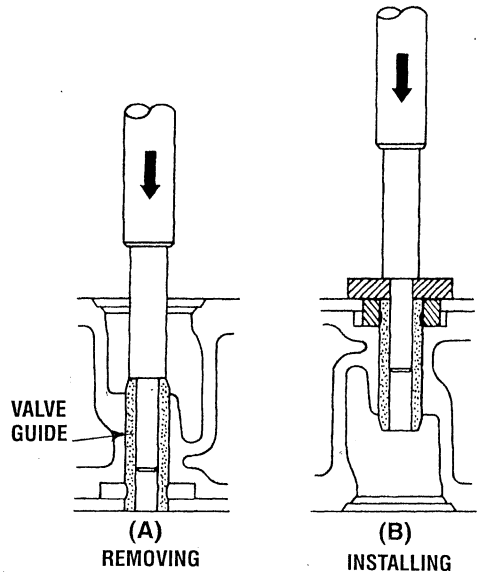
(When installing)

1. Clean a new valve guide, and apply engine oil to it.
2. Using a valve guide replacing tool, press in a new valve guide until it is flush with the cylinder head as shown.
3. Ream precisely the I.D. of the valve guide to the specified dimension.



■ IMPORTANT

- **Do not hit the valve guide with a hammer, etc. during replacement.**



(A) When removing (B) When installing

Correcting Valve and Valve Seat

■ NOTE

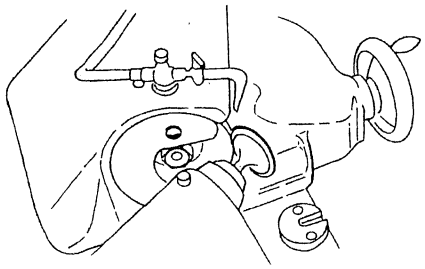
- **Before correcting the valve and seat, check the valve stem and the I.D. of valve guide section, and repair them if necessary.**
- **After correcting the valve seat, be sure to check the valve recessing.**

1) Correcting Valve

1. Correct the valve with a valve refacer.

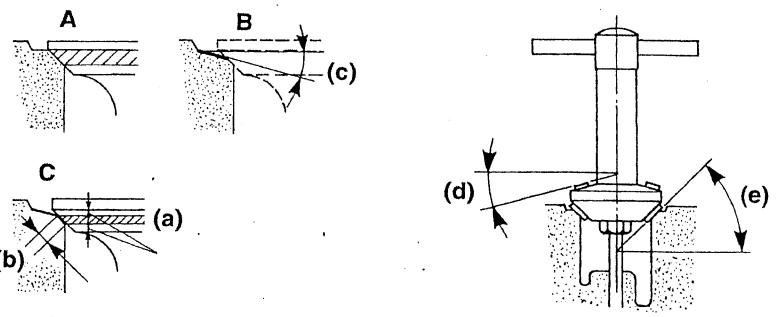
2) Correcting Valve Seat

1. Slightly correct the seat surface with a 1.047 rad (60 °) (intake valve) or 0.785 rad (45 °) (exhaust valve) seat cutter (Code No. 07909-33102).
2. Resurface the seat surface with a 0.523 rad (30 °) valve seat cutter to intake valve seat and with a 0.262 rad (15 °) valve seat cutter to exhaust valve seat so that the width is close to specified valve seat width (2.12 mm, 0.0835 in.).
3. After resurfacing the seat, inspect for even valve seating, apply a thin film of compound between the valve face and valve seat, and fit them with valve lapping tool.
4. Check the valve seating with prussian blue. The valve seating surface should show good contact all the way around.



(a) Identical Dimensions
(b) Valve Seat Width
(c) 0.523 rad (30 °) or 0.262 rad (15 °)
(d) 0.262 rad (15 °) or 0.523 rad (30 °)
(e) 0.785 rad (45 °) or 1.047 rad (60 °)

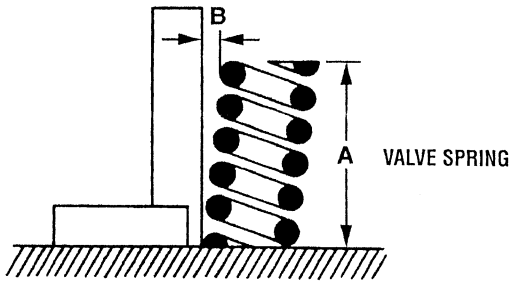
(A) Check Contact
(B) Correct Seat Width
(C) Check Contact



SERVICING

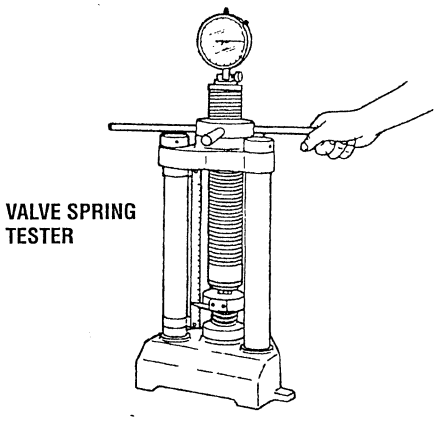
Free Length and Tilt of Valve Spring

1. Measure the free length (**A**) with vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the spring on a surface plate, place a square on the side of the spring, and check to see if the entire side is contact with the square. Rotate the spring and measure the maximum (**B**). If the measurement exceeds the allowable limit, replace.
3. Check the entire surface of the spring for scratches. Replace it, if any.



Free length (**A**)	Factory spec.	Intake valve	35.1 to 35.6 mm 1.3819 to 1.4016 in.
		Exhaust valve	41.7 to 42.2 mm 1.6417 to 1.6614 in.
	Allowable limit	Intake valve	34.6 mm 1.3622 in.
		Exhaust valve	41.2 mm 1.6220 in.

Tilt (**B**)	Allowable limit	1.0 mm 0.039 in.



Valve Spring Setting Load

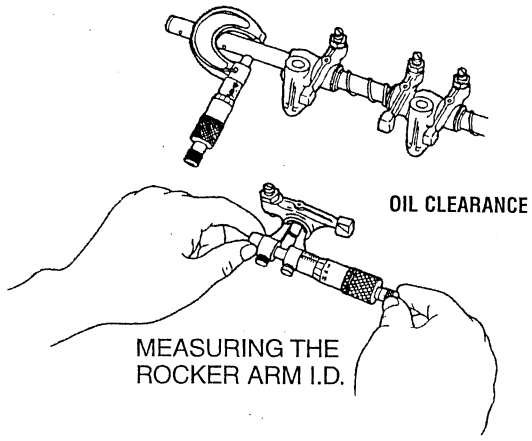
1. Place the valve spring on a tester and compress it to the same length it is actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.

Setting load / Setting length	Factory spec.	Intake valve	63.547 N / 31.5 mm 6.48 kgf / 31.5 mm 14.256 lbs / 1.2401 in.
		Exhaust valve	117.6 N / 35 mm 12.0 kgf / 35 mm 26.4 lbs / 1.3780 in.
	Allowable limit	Intake valve	45.864 N / 31.5 mm 4.68 kgf / 31.5 mm 10.296 lbs / 1.2401 in.
		Exhaust valve	100.0 N / 35 mm 10.2 kgf / 35 mm 22.5 lbs / 1.3780 in.

Oil clearance of rocker arm shaft and bearing	Factory spec.	0.016 to 0.045 mm 0.00063 to 0.00177 in.
	Allowable limit	0.15 mm 0.0059 in.

Rocker arm shaft O.D.	Factory spec.	15.973 to 15.984 mm 0.6289 to 0.6293 in.
Rocker arm I.D. for shaft	Factory spec.	16.000 to 16.018 mm 0.6299 to 0.6306 in.

MEASURING THE SHAFTS O.D.



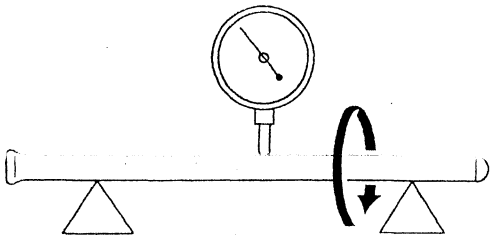
Oil Clearance between Rocker Arm Shaft and Bearing

1. Measure the rocker arm bearing I.D. with an inside micrometer.
2. Measure the rocker arm shaft O.D. with an outside micrometer, and then calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the rocker arm and measure the oil clearance again. If it still exceeds the allowable limit, replace also the rocker arm shaft.

Push Rod Alignment

1. Place the push rod on V blocks.
2. Measure the push rod alignment
3. If the measurement exceeds the allowable limit, replace the push rod.

Push rod alignment	Allowable limit	0.25 mm 0.0098 in.

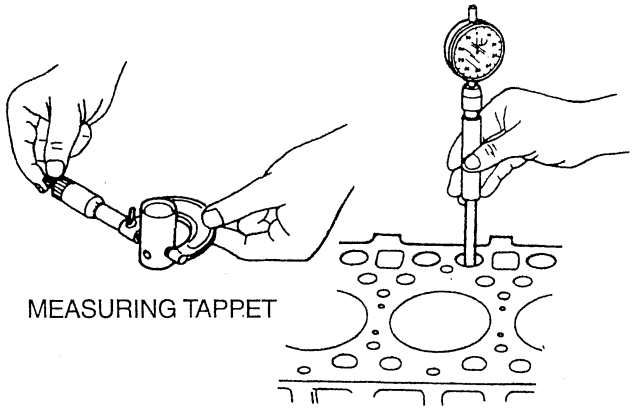


MEASURING PUSH ROD ALIGNMENT

Oil Clearance between Tappet and Tappet Guide Bore

1. Measure the tappet O.D. with an outside micrometer.
2. Measure the I.D. of the tappet guide bore with a cylinder gauge, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit or the tappet is damaged, replace the tappet.

Oil clearance between tappet and tappet guide bore	Factory spec.	0.020 to 0.062 mm 0.0008 to 0.0024 in.
	Allowable limit	0.07 mm 0.0028 in.



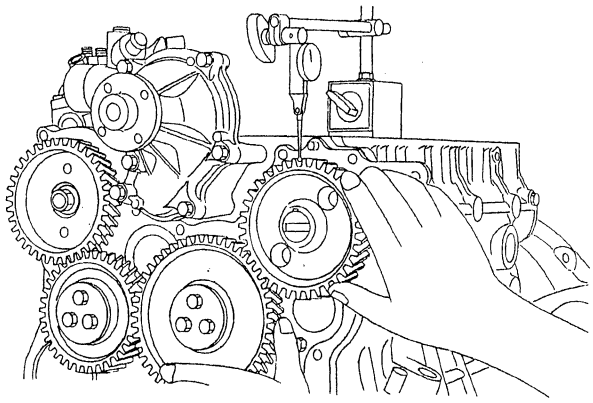
MEASURING TAPPET

Tappet O.D.	Factory spec.	23.959 to 23.980 mm 0.9433 to 0.9411 in.
Tappet guide bore I.D.	Factory spec.	24.000 to 24.021 mm 0.9449 to 0.9457 in.

Timing Gear and Camshaft

Timing Gear Backlash

1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance isn't proper, replace the gear.



Backlash between crank gear and idle gear 1	Factory spec.	0.049 to 0.193 mm 0.0019 to 0.0076 in.
	Allowable limit	0.22 mm 0.0087 in.

Backlash between idle gear 1 and cam gear	Factory spec.	0.049 to 0.189 mm 0.0019 to 0.0074 in.
	Allowable limit	0.22 mm 0.0087 in.

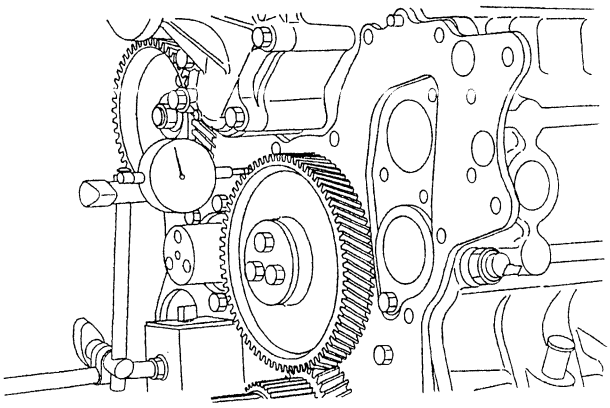
Backlash between idle gear 1and idle gear 2	Factory spec.	0.044 to 0.185 mm 0.0017 to 0.0073 in.
	Allowable limit	0.22 mm 0.0087 in.

Backlash between idle gear 2 and injection pump gear	Factory spec.	0.044 to 0.177 mm 0.0017 to 0.0070 in.
	Allowable limit	0.22 mm 0.0087 in.

Idle Gear Side Clearance

1. Set a dial indicator with its tip on the idle gear.
2. Measure the side clearance by moving the idle gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

Idle gear side clearance	Factory spec.	0.15 to 0.30 mm 0.0059 to 0.0118 in.
	Allowable limit	0.9 mm 0.0354 in.

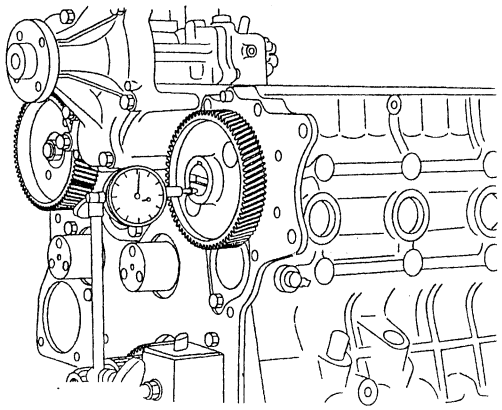


MEASURING GEAR SIDE CLEARANCE

Camshaft Alignment

1. Support the camshaft with V block on the surface plate and set a dial indicator with its tip on the intermediate journal at right angle.
2. Rotate the camshaft on the V blocks and get the misalignment (half of the measurement).
3. If the misalignment exceeds the allowable limit, replace the camshaft.

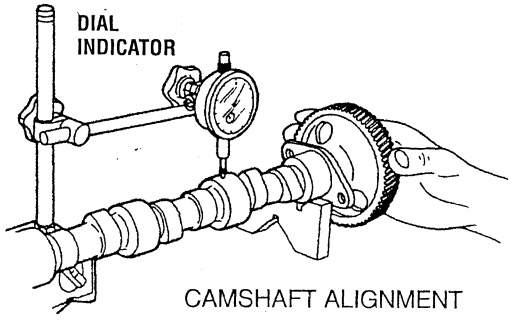
Camshaft alignment	Allowable limit	0.01 mm 0.00039 in.



Camshaft Side Clearance

1. Set a dial indicator with its tip on the camshaft.
2. Measure the side clearance by moving the cam gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

End play of camshaft	Factory spec.	0.07 to 0.22 mm 0.0028 to 0.0087 in.
	Allowable limit	0.30 mm 0.0118 in.

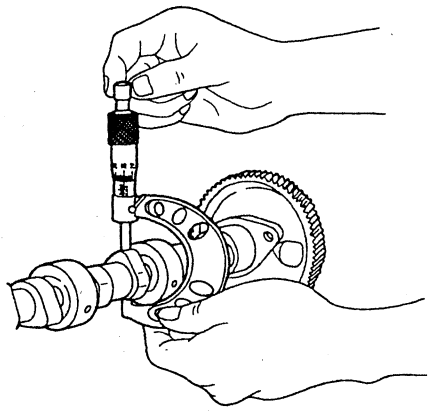


CAMSHAFT ALIGNMENT

Cam Height

1. Measure the height of the cam at its highest point with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

Intake and exhaust cam height	Factory spec.	Intake valve	37.63 mm 1.4815 in.
		Exhaust valve	38.96 mm 1.5338 in.
	Allowable limit	Intake valve	37.13 mm 1.4618 in.
		Exhaust valve	38.46 mm 1.5141 in.



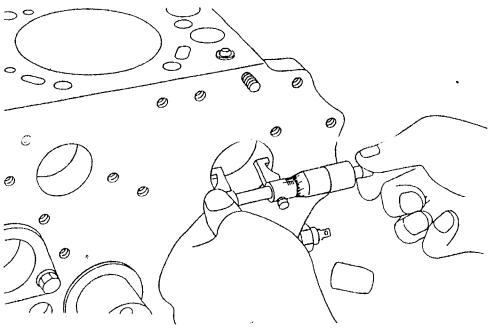
MEASURING CAM HEIGHT

Oil Clearance of Camshaft Journal

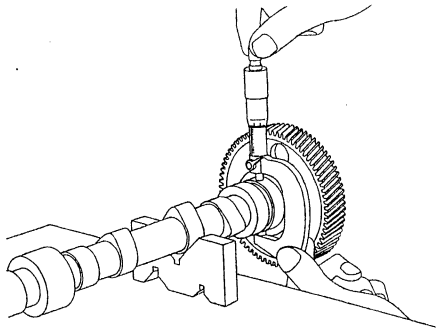
1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the cylinder block bore I.D. for camshaft with an inside micrometer.
3. If the oil clearance exceeds the allowable limit, replace the camshaft.

Oil clearance of camshaft journal	Factory spec.	0.050 to 0.091 mm 0.00197 to 0.00358 in.
	Allowable limit	0.15 mm 0.0059 in.

Camshaft journal O.D.	Factory spec.	45.934 to 45.950 mm 1.8084 to 1.8091 in.
Camshaft bearing I.D.	Factory spec.	46.000 to 46.025 mm 1.8110 to 1.8120 in.



MEASURING THE CYLINDER BORE I.D.

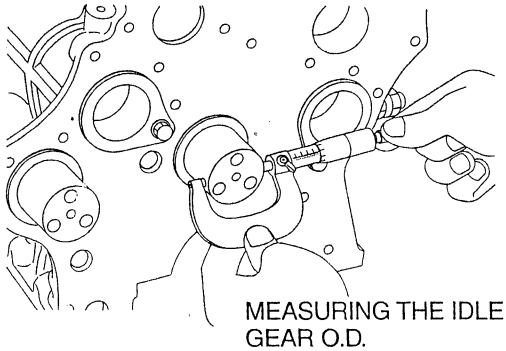


Oil Clearance between Idle Gear Shaft 1, 2 and Idle Gear 1, 2 Bushing

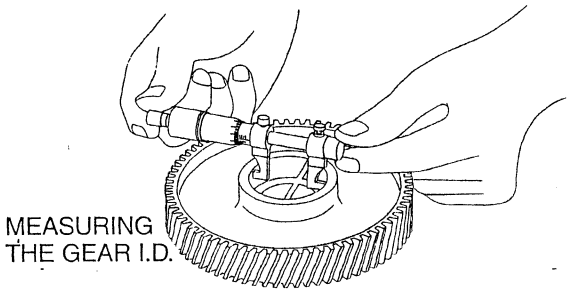
1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear bushing I.D. with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing.

Clearance between idle gear 1, 2 shaft and idle gear 1, 2 bushing	Factory spec.	0.050 to 0.091 mm 0.0020 to 0.0036 in.
	Allowable limit	0.10 mm 0.0039 in.

Idle gear 1, 2 bushing I.D.	Factory spec.	45.025 to 45.050 mm 1.7726 to 1.7736 in.
Idle gear 1, 2 shaft O.D.	Factory spec.	44.959 to 44.975 mm 1.7700 to 1.7707 in.



MEASURING THE IDLER GEAR O.D.



MEASURING THE GEAR I.D.

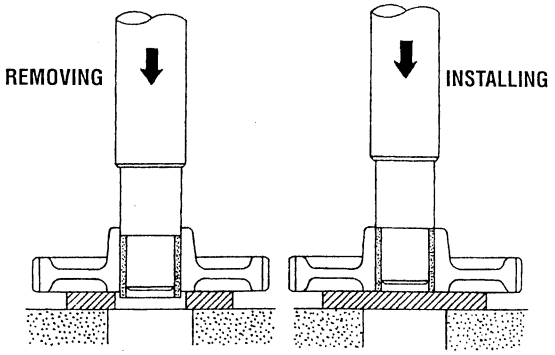
Replacing Idle Gear Bushing

(When removing)

1. Using an idle gear bushing replacing tool, press out the used bushing.

(When installing)

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Using an idle gear bushing replacing tool, press in a new bushing (service parts) to the specified dimension.



REPLACING THE IDLER GEAR BUSHING

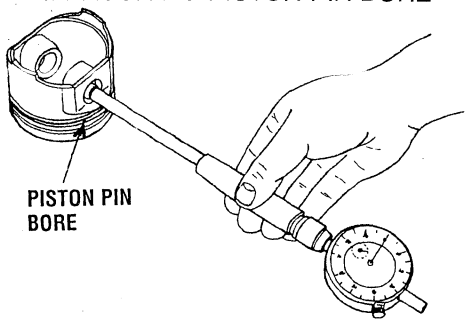
Piston and Connecting Rod

Piston Pin Bore I.D.

1. Measure the piston pin bore I.D. in both the horizontal and vertical directions with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

Piston pin bore I.D.	Factory spec.	30.000 to 30.013 mm 1.1811 to 1.1816 in.
	Allowable limit	30.05 mm 1.1831 in.

MEASURING PISTON PIN BORE

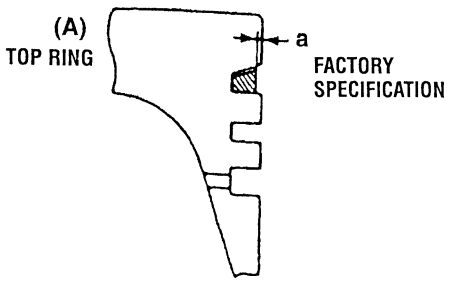


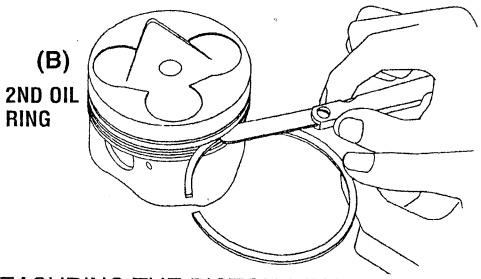
Clearance between Piston Ring and Groove

1. Remove carbon from the ring grooves.
2. Measure the clearance between the ring and the groove with a feeler gauge or depth gauge.
3. If the clearance exceeds allowable limit, replace the ring since compression leak and oil shortage result.
4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

Factory spec.	Compression ring 2	0.093 to 0.120 mm 0.0037 to 0.0047 in.
	Oil ring	0.020 to 0.060 mm 0.0008 to 0.0023 in.
Allowable limit	Compression ring 2	0.20 mm 0.0079 in.
	Oil ring	0.15 mm 0.0059 in.

Factory specification : **a**	More than 0.2 mm 0.0079 in.





MEASURING THE PISTON RING CLEARANCE

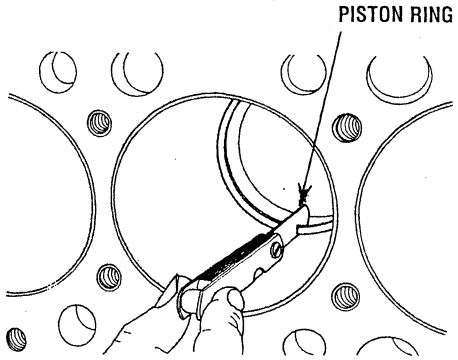
(A) Top Ring (Key Store Type) **(B) 2nd, Oil Ring**

Piston Ring Gap

1. Insert the piston ring into the lower part of the liner (the least worn out part) with the piston.
2. Measure the ring gap with a feeler gauge.
3. If the gap exceeds the allowable limit, replace the piston ring.

Compression ring 1, 2	Factory spec.	0.30 to 0.45 mm 0.0118 to 0.0177 in.
	Allowable limit	1.25 mm 0.0492 in.

Oil ring	Factory spec.	0.25 to 0.45 mm 0.0098 to 0.0177 in.
	Allowable limit	1.25 mm 0.0492 in.



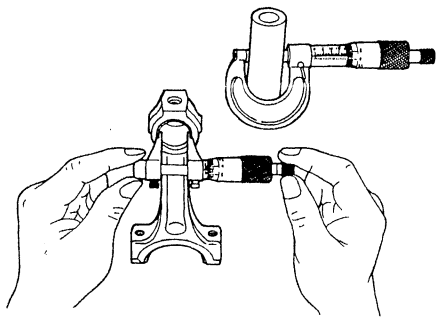
MEASURING THE RING GAP

Oil Clearance between Piston Pin and Small End Bushing

1. Measure the O.D. of the piston pin where it contacts the bushing with an outside micrometer.
2. Measure the I.D. of the piston pin bushing at the connecting rod small end with a cylinder gauge.
   Calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the bushing.
   If it still exceeds the allowable limit, replace the piston pin.

Oil clearance between piston pin and small end bushing	Factory spec.	0.020 to 0.040 mm 0.0008 to 0.0016 in.
	Allowable limit	0.15 mm 0.0059 in.

Piston pin O.D.	Factory spec.	30.006 to 30.011 mm 1.1813 to 1.1815 in.
Small end bushing I.D.	Factory spec.	30.031 to 30.046 mm 1.1823 to 1.1829 in.



MEASURING THE PISTON PIN

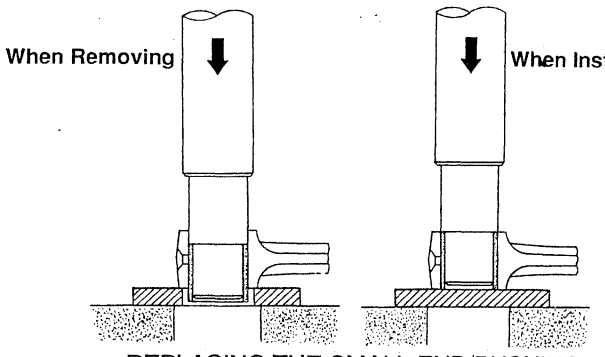
Replacing Small End Bushing

(When removing)

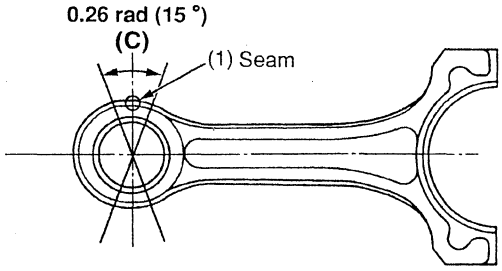
1. Press out the used bushing using a small end bushing replacing tool.

(When installing)

1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Insert a new bushing onto the tool and press-fit it with a press so that the seam (1) of bushing position as shown until it is flush with the connecting rod.



REPLACING THE SMALL END BUSHING



Connecting Rod Alignment

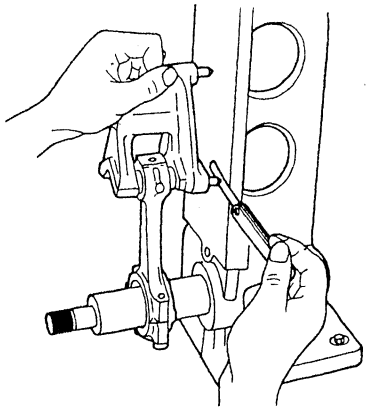
■ **NOTE**

- **Since the I.D. of the connecting rod small end bushing is the basis of this check, check the bushing for wear beforehand.**

1. Remove the piston pin in the connecting rod.
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool (Code No. 07909-31661).
4. Put a gauge over the piston pin, and move it against the face plate.
5. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.

Connecting rod alignment	Allowable limit	0.05 mm 0.0020 in.

ALIGNING THE CONNECTING ROD



Crankshaft

Crankshaft Side Clearance

1. Set a dial indicator with its tip on the end of the crankshaft.
2. Measure the side clearance by moving the crankshaft to the front and rear.
3. If the measurement exceeds the allowable limit, replace the thrust bearings.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an oversize one referring to the table and figure.

Crankshaft side clearance	Factory spec.	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable limit	0.50 mm 0.0197 in.

(Reference)

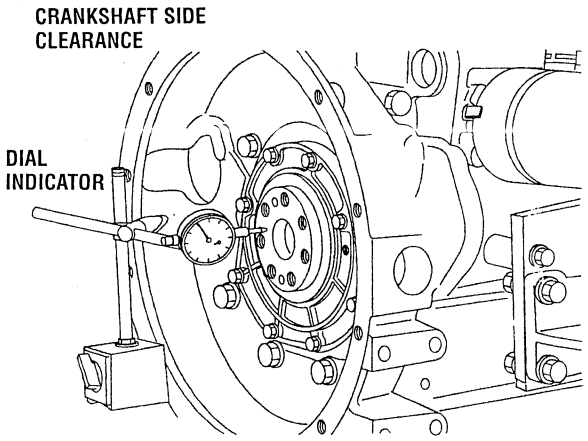
- Oversize dimensions of crankshaft journal

Oversize	0.2 mm 0.008 in.	0.4 mm 0.016 in.
Dimension **A**	29.20 to 29.25 mm 1.1496 to 1.1515 in.	29.40 to 29.45 mm 1.1574 to 1.1594 in.
Dimension **B**	169.1 to 169.15 mm 6.6575 to 6.6594 in.	169.2 to 169.25 mm 6.6614 to 6.6634 in.
Dimension **C**	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius
The crankshaft journal must be fine-finished to higher than ▽▽▽ (0.8-S)		

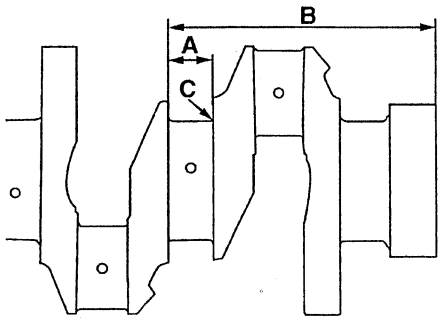
Crankshaft Alignment

1. Support the crankshaft with V block on the surface plate and set a dial indicator with its tip on the intermediate journal at right angle.
2. Rotate the crankshaft on the V block and get the misalignment (half of the measurement).
3. If the misalignment exceeds the allowable limit, replace the crankshaft.

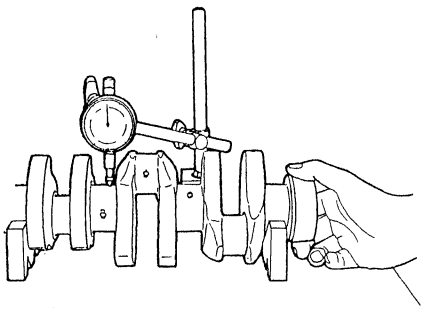
Crankshaft alignment	Allowable limit	0.02 mm 0.00079 in.



CRANKSHAFT JOURNAL DIMENSIONS



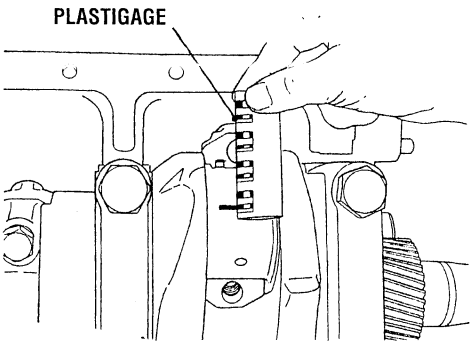
CRANKSHAFT JOURNAL



CRANKSHAFT

Oil Clearance between Crankpin and Crankpin Bearing

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage on the center of the crankpin.
3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque, and remove the cap again.
4. Measure the amount of the flattening with the scale, and get the oil clearance.
5. If the oil clearance exceeds the allowable limit, replace the crankpin bearing.
6. If the same size bearing is useless because of the crankpin wear, replace it with an undersize one referring to the table.

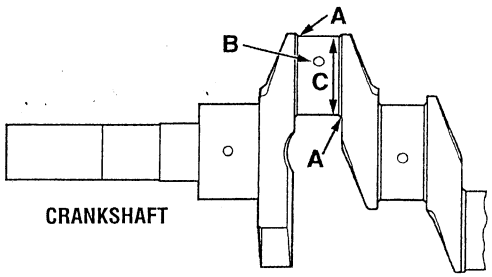


■ NOTE

- **Never insert the plastigage into the crankpin oil hole.**
- **Be sure not to move the crankshaft while the connecting rod screws are tightened.**

Crankpin O.D.	Factory spec.	52.977 to 52.990 mm 2.0857 to 2.0862 in.

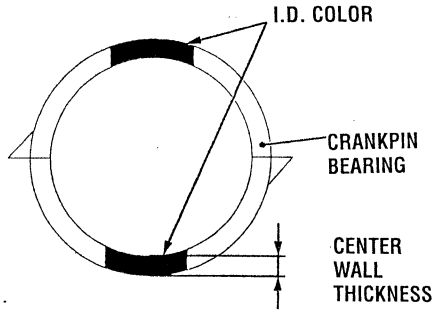
Oil clearance between crankpin and crankpin bearing	Factory spec.	0.018 to 0.051 mm 0.0007 to 0.0020 in.
	Allowable limit	0.20 mm 0.0079 in.



Oil Clearance between Crankpin and Crankpin Bearing (Continued)

■ IMPORTANT

- **STD size crankpin bearing.**
  To replace it with a specific STD service part, make sure the crankpin bearing has the same ID color as the connecting rod.



ID Color	Connecting rod	Crankpin bearing		
	Large-end in. dia.	Class	Part code	Center wall thick
Blue	56.01 to 56.02 mm 2.2051 to 2.2055 in.	L		1.496 to 1.501 mm 0.0589 to 0.0591 in.
Without color	56.00 to 56.01 mm 2.2047 to 2.2051 in.	S		1.491 to 1.496 mm 0.0587 to 0.0589 in.

- Undersize dimensions of crankpin

Undersize	0.2 mm 0.008 in.	0.4 mm 0.016 in.
Dimension **A**	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius
Dimension **B**	1.0 to 1.5 mm radius 0.0394 to 0.0591 in. radius	1.0 to 1.5 mm radius 0.0394 to 0.0591 in. radius
Dimension **C**	52.777 to 52.790 mm 2.0778 to 2.0783 in.	52.577 to 52.590 mm 2.0700 to 2.0705 in.
(0.8-S) The crankpin must be fine-finished to higher than ▽▽▽▽		

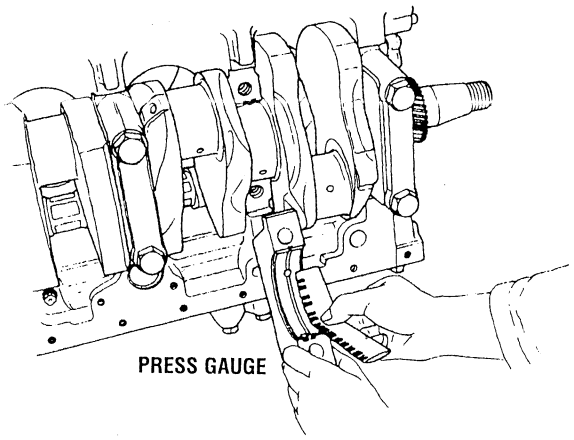
Oil Clearance between Crankshaft Journal and Crankshaft Bearing

1. Clean the crankshaft journal and crankshaft bearing.
2. Put a strip of press gauge on the center of the journal.

■ **IMPORTANT**

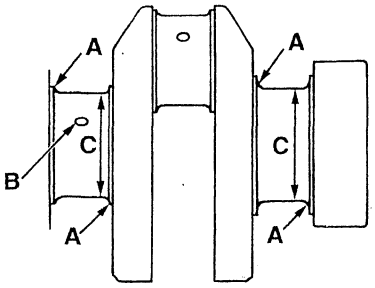
- **Never insert the press gauge into the oil hole of the journal.**

3. Install the main bearing case and tighten the screws to the specified torque, and remove the cases again.
4. Measure the amount of the flattening with the scale and get the oil clearance.
5. If the clearance exceeds the allowable limit, replace the crankshaft bearing.



Crankshaft journal O.D.	Factory spec.	74.977 to 74.990 mm 2.9518 to 2.9524 in.

Oil clearance between crankshaft journal and crankshaft bearing	Factory spec.	0.018 to 0.062 mm 0.0007 to 0.0024 in.
	Allowable limit	0.20 mm 0.0079 in.



CRANKSHAFT JOURNAL

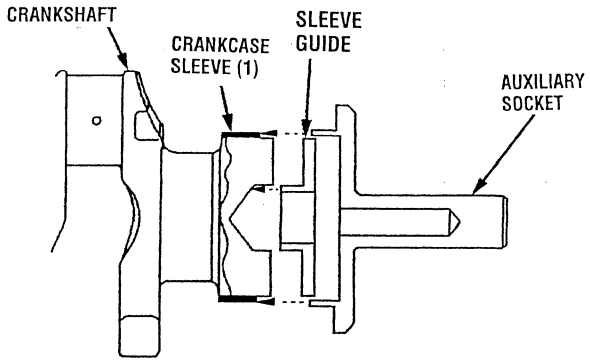
(Reference)

- Undersize dimensions of crankshaft journal.

Undersize	0.2 mm 0.008 in.	0.4 mm 0.016 in.
Dimension **A**	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius	2.8 to 3.2 mm radius 0.1102 to 0.1260 in. radius
Dimension **B**	1.0 to 1.5 mm radius 0.0394 to 0.0591 in. radius	1.0 to 1.5 mm radius 0.0394 to 0.0591 in. radius
Dimension **C**	74.777 to 74.790 mm 2.9440 to 2.9445 in.	74.577 to 74.590 mm 2.9361 to 2.9366 in.
The crankpin must be fine-finished to higher than ▽▽▽		(0.8-S)

Replacing Crankshaft Sleeve

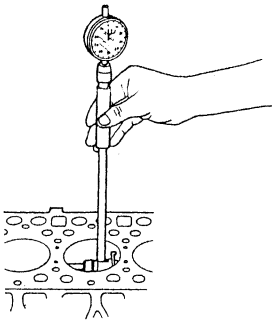
1. Remove the used crankshaft sleeve (1) using a special-use puller set.
2. Set the sleeve guide (4) to the crankshaft.
3. Heat a new sleeve to a temperature between 150 to 200 ℃ (302 to 392 ℉), and fix the sleeve to the crankshaft as shown.
4. Press fit the sleeve using the auxiliary socket for pushing.



■ **NOTE**

- **Mount the sleeve with its largely chamfered surface facing outward.**

Cylinder



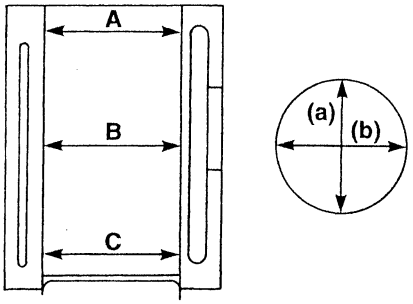
Cylinder Wear

1. Measure the I.D. of the cylinder at the six positions with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Get the difference (Maximum wear) between the maximum and the minimum I.D.'s.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension. (Refer to **"Correcting Cylinder"**.)
4. Visually check the cylinder wall for scratches. If deep scratches are found, the cylinder should be bored. (Refer to **"Correcting Cylinder"**.)

Cylinder Bore I.D.	Factory spec.	98.000 to 98.022 mm 3.8582 to 3.8591 in.
	Allowable limit	98.15 mm 3.8642 in.

(A) Top
(B) Middle
(C) Bottom (Skirt)

(a) Right-angled to Piston Pin
(b) Piston Pin Direction

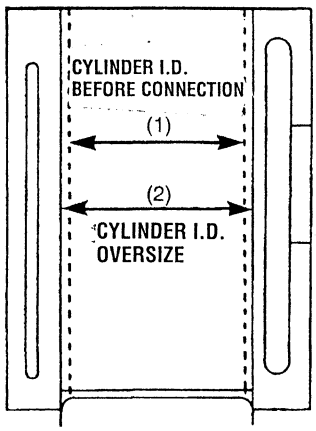


MEASURING CYLINDER WEAR

Correcting Cylinder (Oversize + 0.5 mm)

1. When the cylinder is worn beyond the allowable limit, bore and hone it to the specified dimension.

Cylinder I.D. (2)	Factory spec.	98.500 to 98.522 mm 3.8780 to 3.8788 in.
Maximum wear	Allowable limit	98.65 mm 3.8839 in.
Finishing	Horn to 1.2 to 2.0 mm μR max. ▽▽▽▽ (0.000047 to 0.000079 in. μR max.)	

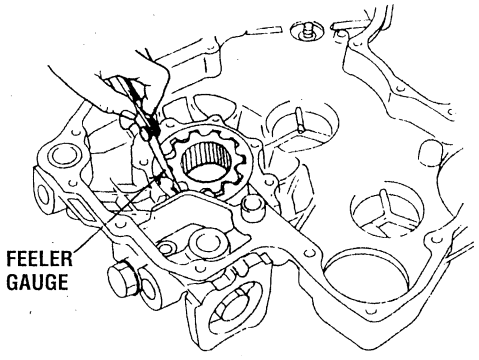


2. Replace the piston and piston rings with oversize (0.5 mm)ones.

■ **NOTE**

- **When the oversize cylinder is worn beyond the allowable limit, replace the cylinder block with a new one.**

Oil Pump



Rotor Lobe Clearance

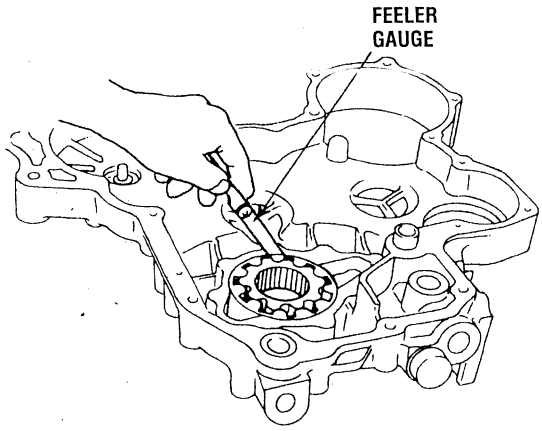
1. Measure the clearance between lobes of the inner rotor and the outer rotor with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

Clearance between inner rotor and outer rotor	Factory spec.	0.04 to 0.16 mm 0.0016 to 0.0063 in.
	Allowable limit	0.3 mm 0.0118 in.

Clearance between Outer Rotor and Pump Body

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

Clearance between outer rotor and pump body	Factory spec.	0.100 to 0.184 mm 0.0039 to 0.0072 in.
	Allowable limit	0.3 mm 0.0118 in.

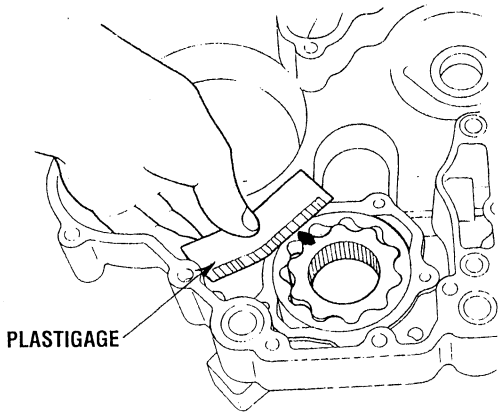


Clearance between Rotor and Cover

1. Put a strip of plastigage onto the rotor face with grease.
2. Install the cover and tighten the screws with the specified torque.
3. Remove the cover carefully, and measure the amount of the flattening with the scale and get the clearance.
4. If the clearance exceeds the allowable limit, replace oil pump rotor assembly and the cover.

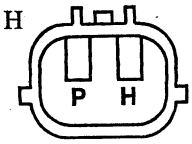
Clearance between rotor and cover	Factory spec.	0.025 to 0.075 mm 0.0010 to 0.0030 in.
	Allowable limit	0.225 mm 0.0089 in.

Tightening torque	Oil pump cover screw	7.9 to 9.3 N·m 0.80 to 0.95 kgf·m 5.8 to 6.9 ft-lbs

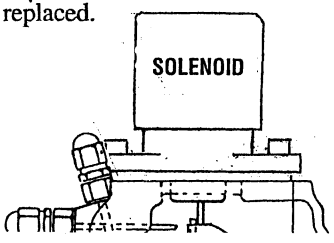


ENGINE STOP SOLENOID (PROPULSION)

1. Remove the stop solenoid from then engine.
2. Measure the coil resistance valves between P and H terminals and the metal of the solenoid case.
   12 VDC Solenoid:
   P terminal to case 0.8 Ohm
   H terminal to case 15.0 Ohm



3. Apply solenoid voltage B+ to P terminal and negative (-) to metal of case. Plunger should pull in.
   NOTE: *Apply voltage no more than 2-3 seconds.*
4. Apply solenoid voltage B+ to H terminal and negative (-) to metal of case. Manually push plunger into solenoid until it bottoms. Plunger should stay in solenoid.
   NOTE: *Remove voltage connection within 2-3 seconds after pushing plunger into solenoid.*
5. Should the solenoid fail any of these tests, it is faulty and should be replaced.



ACTUATOR (Electric Governing)

1. Remove the actuator from the engine.
2. Measure the coil resistance.
   12 VDC 3.0 Ohm
   24 VDC 10.08 Ohm
3. Momentarily (2-3 seconds) apply coil DC voltage rating across the coil connections. The plunger should pull fully into the coil body.
4. If the actuator fails any of these tests, it is faulty and should be replaced.

SERVICING SPECIFICATIONS

ENGINE BODY

Item		Factory Specification	Allowable Limit
Cylinder Head Surface	Flatness	—	0.05 mm 0.0020 in.
Top Clearance		1.05 to 1.27 mm 0.0414 to 0.0500 in.	—
Compression Pressure		4.32 MPa / 250 min^{-1} (rpm) 44 kgf/cm^2 / 250 min^{-1} (rpm) 626 psi / 250 min^{-1} (rpm)	3.26 MPa / 250 min^{-1} (rpm) 33.2 kgf/cm^2 / 250 min^{-1} (rpm) 472 psi / 250 min^{-1} (rpm)
Variance Among Cylinders		—	10 % or less
Valve Seat Width	IN.	2.12 mm 0.0835 in.	—
	EX.	2.12 mm 0.0835 in.	—
Valve Seat Angle	IN.	1.047 rad 60 °	—
	EX.	0.785 rad 45 °	—
Valve Face Angle	IN.	1.047 rad 60 °	—
	EX.	0.785 rad 45 °	—
Valve Recessing	IN.	-0.2 to 0 mm -0.079 to 0 in.	-0.4 mm -0.0157 in.
	EX.	-0.05 to 0.15 mm -0.0019 to 0.0059 in.	-0.4 mm -0.0157 in.
Valve Clearance (Cold)		0.23 to 0.27 mm 0.0091 to 0.0106 in.	—
Intake Valve Timing	Open	0.17 rad (10 °) before T.D.C.	—
	Close	0.63 rad (36 °) after B.D.C.	—
Exhaust Valve Timing	Open	0.79 rad (45 °) before B.D.C.	—
	Close	0.29 rad (17 °) after T.D.C.	—

SERVICING SPECIFICATIONS

Item		Factory Specification	Allowable Limit
Valve Stem to Valve Guide	Clearance (IN.)	0.055 to 0.085 mm 0.0022 to 0.0033 in.	0.1 mm 0.0039 in.
Valve Stem	(Exhaust)	0.040 to 0.070 mm 0.0016 to 0.0027 in.	0.1 mm 0.004 in.
	O.D. (Intake)	6.960 to 6.975 mm 0.2741 to 0.2746 in.	—
	(Exhaust)	7.960 to 7.975 mm 0.3134 to 0.3139 in.	0.1 mm 0.0039 in.
Valve Guide	I.D. (Intake)	7.030 to 7.045 mm 0.2768 to 0.2773 in.	—
	(Exhaust)	8.015 to 8.030 mm 0.3156 to 0.3161 in.	—
Valve Spring	Intake	35.1 to 35.6 mm 1.3819 to 1.4016 in.	34.6 mm 1.3622 in.
	Exhaust	41.7 to 42.2 mm 1.6417 to 1.6614 in.	41.2 mm 1.6220 in.
Setting Load / Setting Length	Intake	63.547 N / 31.5 mm 6.48 kgf / 31.5 mm 14.256 lbs / 1.2401 in.	45.864 N / 31.5 mm 4.68 kgf / 31.5 mm 10.296 lbs / 1.2401 in.
	Exhaust	117.6 N / 35 mm 12 kgf / 35 mm 26.4 lbs / 1.3780 in.	100 N / 35 mm 10.2 kgf / 35 mm 22.5 lbs /1.3780 in.
Tilt (Valve Spring)		—	1.0 mm 0.039 in.
Rocker Arm Shaft to Rocker Arm	Oil Clearance	0.016 to 0.045 mm 0.00063 to 0.00177 in.	0.15 mm 0.0059 in.
	Rocker Arm Shaft O.D.	15.973 to 15.984 mm 0.6289 to 0.6293 in.	—
	Rocker Arm I.D. for Shaft	16.000 to 16.018 mm 0.6299 to 0.6306 in.	—
Valve Arm Bridge and Valve Arm Bridge Shaft	Clearance	0.018 to 0.042 mm 0.0007 to 0.0017 in.	0.15 mm 0.0059 in.
	Valve Arm Bridge (I.D.)	9.050 to 9.065 mm 0.3563 to 0.3569 in.	—
	Valve Arm Bridge Shaft (O.D.)	9.023 to 9.032 mm 0.3552 to 0.3556 in.	—
Push Rod	Alignment	—	0.25 mm 0.0098 in.

SERVICING SPECIFICATIONS

Item		Factory Specification	Allowable Limit
Piston Ring Gap	Compression Ring 1	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.25 mm 0.0492 in.
	Compression Ring 2	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.25 mm 0.0492 in.
	Oil Ring	0.25 to 0.45 mm 0.0098 to 0.0177 in.	1.25 mm 0.0492 in.
Connecting Rod	Alignment	—	0.05 mm 0.0020 in.
Piston Pin to Small End Bushing	Clearance	0.020 to 0.040 mm 0.0008 to 0.0016 in.	0.15 mm 0.0059 in.
	Piston Pin (O.D.)	30.006 to 30.011 mm 1.1813 to 1.1815 in.	—
	Small End Bushing (I.D.)	30.031 to 30.046 mm 1.1823 to 1.1829 in.	—
Crankshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.50 mm 0.0197 in.
	Alignment	—	0.02 mm 0.00079 in.
Crankshaft Journal	O.D.	74.977 to 74.990 mm 2.9518 to 2.9524 in.	—
Crankshaft Journal to Crankshaft Bearing	Oil Clearance	0.018 to 0.062 mm 0.0007 to 0.0024 in.	0.20 mm 0.0079 in.
Crank Pin	O.D.	52.977 to 52.990 mm 2.0857 to 2.0862 in.	—
Crank Pin to Pin Bearing	Oil Clearance	0.018 to 0.051 mm 0.0007 to 0.0020 in.	0.20 mm 0.0079 in.
Cylinder Bore	I.D.	98.000 to 98.022 mm 3.8582 to 3.8591 in.	98.15 mm 3.8642 in.
Cylinder Bore (Oversize)	I.D.	98.500 to 98.522 mm 3.8780 to 3.8788 in.	98.65 mm 3.8839 in.
Crankshaft Journal	O.D.	74.977 to 74.990 mm 2.9519 to 2.9523 in.	

SERVICING SPECIFICATIONS

Item		Factory Specification	Allowable Limit
Timing Gear	Idle Gear 1 to Crank Gear (Backlash)	0.049 to 0.193 mm 0.0019 to 0.0076 in.	0.22 mm 0.0087 in.
	Idle Gear 1 to Cam Gear (Backlash)	0.049 to 0.189 mm 0.0019 to 0.0074 in.	0.22 mm 0.0087 in.
	Idle Gear 1 to Idle Gear 2 (Backlash)	0.044 to 0.185 mm 0.0017 to 0.0073 in.	0.22 mm 0.0087 in.
	Idle Gear 2 to Injection Pump Gear (Backlash)	0.044 to 0.177 mm 0.0017 to 0.0070 in.	0.22 mm 0.0087 in.
Idle Gear Shaft 1, 2 to Idle Gear 1, 2 Bushing	Oil Clearance	0.050 to 0.091 mm 0.0020 to 0.0036 in.	0.10 mm 0.0039 in.
	Idle Gear 1, 2 Bushing (I.D.)	45.025 to 45.050 mm 1.7726 to 1.7736 in.	—
	Idle Gear 1, 2 Shaft (O.D.)	44.959 to 44.975 mm 1.7700 to 1.7707 in.	—
Idle Gear	Side Clearance	0.15 to 0.30 mm 0.0059 to 0.0118 in.	0.9 mm 0.0354 in.
Piston Pin Bore	I.D.	30.000 to 30.013 mm 1.1811 to 1.1816 in.	30.05 mm 1.1831 in.
Compression Ring 2 to Ring Groove	Clearance	0.093 to 0.120 mm 0.0037 to 0.0047 in.	0.20 mm 0.0079 in.
Oil Ring to Ring Groove	Clearance	0.02 to 0.06 mm 0.0008 to 0.0023 in.	0.15 mm 0.0059 in.

SERVICING SPECIFICATIONS

Item		Factory Specification	Allowable Limit
Tappet to Tappet Guide	Clearance	0.020 to 0.062 mm 0.0008 to 0.0024 in.	0.07 mm 0.0028 in.
	Tappet Guide Bore (I.D.)	24.000 to 24.021 mm 0.9449 to 0.9457 in.	—
	Tappet (O.D.)	23.959 to 23.980 mm 0.9433 to 0.9441 in.	—
Camshaft	Side Clearance	0.07 to 0.22 mm 0.0028 to 0.0087 in.	0.3 mm 0.0118 in.
	Alignment	—	0.01 mm 0.00039 in.
Cam Height	IN.	37.63 mm 1.4815 in.	37.13 mm 1.4618 in.
	EX.	38.96 mm 1.5338 in.	38.46 mm 1.5141 in.
Camshaft	Oil Clearance	0.050 to 0.091 mm 0.00197 to 0.00358 in.	0.15 mm 0.0059 in.
	Camshaft Journal (O.D.)	45.934 to 45.950 mm 1.8084 to 1.8091 in.	—
	Camshaft Bearing (I.D.)	46.000 to 46.025 mm 1.8110 to 1.8120 in.	—

FUEL SYSTEM

Item		Factory Specification	Allowable Limit
Injection Timing		0.127 to 0.152 rad (7.25 to 8.75 °) before T.D.C.	—
Fuel Injection Nozzle	Injection Pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi	—
	Valve Seat Tightness	When the pressure is 12.75 MPa (130 kgf/cm^2, 1849 psi), the valve seat must be fuel tightness	—
Pump Element	Fuel Tightness	–	13.73 MPa 140.0 kgf/cm^2 1991 psi
Delivery Valve	Fuel Tightness	10 seconds 13.73 → 12.75 MPa 140.0 → 130.0 kgf/cm^2 1991 → 1849 psi	5 seconds 13.73 → 12.75 MPa 140.0 → 130.0 kgf/cm^2 1991 → 1849 psi

SERVICING SPECIFICATIONS

LUBRICATING SYSTEM

Item		Factory Specification	Allowable Limit
Engine Oil Pressure	At Idle Speed	—	50 kPa 0.5 kgf/cm^2 7 psi
	At Rated Speed	200 to 390 kPa 2.0 to 4.0 kgf/cm^2 29 to 56 psi	150 kPa 1.5 kgf/cm^2 21 psi
Engine Oil Pressure Switch	Working Pressure	40 to 50 kPa 0.4 to 0.6 kgf/cm^2 6 to 8 psi	—
Inner Rotor to Outer Rotor	Clearance	0.04 to 0.16 mm 0.0016 to 0.0063 in.	0.3 mm 0.0118 in.
Outer Rotor to Pump Body	Clearance	0.100 to 0.184 mm 0.0039 to 0.0072 in.	0.3 mm 0.0118 in.
Rotor to Cover	Clearance	0.025 to 0.075 mm 0.0010 to 0.0030 in.	0.225 mm 0.0089 in.
Relief Valve	Working Pressure	885 kPa 9.04 kgf/cm^2 129 psi	—

ELECTRICAL SYSTEM

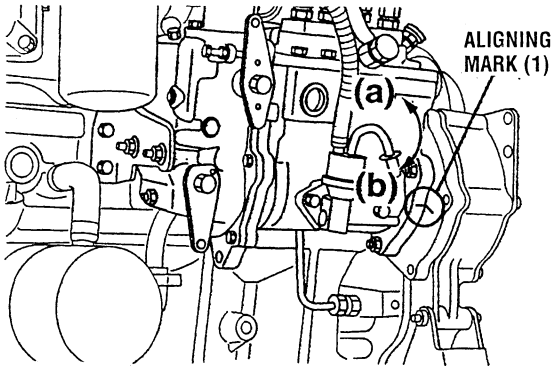
Item		Factory Specification	Allowable Limit
Commutator	O.D.	32 mm 1.2598 in.	31.4 mm 1.2362 in.
Mica	Undercut	0.5 mm 0.0197 in.	0.2 mm 0.0079 in.
Brush (Starter)	Length	18 mm 0.7086 in.	11 mm 0.4331 in.
Alternator	No-load Voltage	14 V at 4000 min^{-1} (rpm)	—
Rotor Coil	Resistance	2.8 to 3.3 Ω	—
Slip Ring	O.D.	22.7 mm 0.894 in.	22.1 mm 0.870 in.
Brush (Alternator)	Length	18.5 mm 0.728 in.	5.0 mm 0.197 in.
Glow Plug	Resistance	Approx. 1.0 Ω	—

COOLING SYSTEM

Item		Factory Specification	Allowable Limit
Thermostat	Valve Opening Temperature	74.5 to 78.5 °C 166.1 to 173.3 °F	—
	Valve Opening Temperature (Opened Completely)	90 °C 194 °F	—

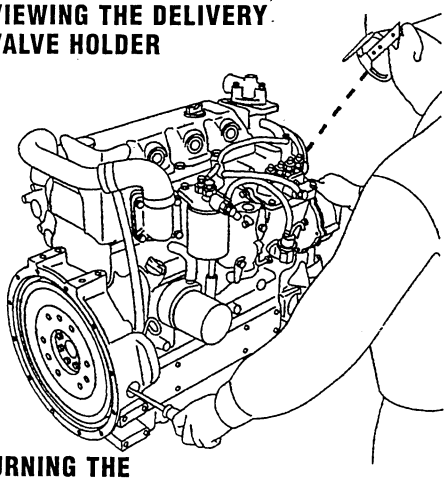
CHECKING INJECTION TIMING

1. Make sure of matching the injection timing align mark (1) of the injection pump unit and the plate (gearcase), as shown in the illustration.
2. Remove the injection pipes.
3. Remove the stop solenoid.
4. Turn the flywheel counterclockwise (viewed from flywheel side) until the fuel fills up to the hole of the delivery valve holder (2) for No.1 cylinder.
5. After the fuel fills up to the hole of the delivery valve holder for No.1 cylinder, turn back (clockwise) the flywheel around 1.57 rad (90 °).
6. Turn the flywheel counterclockwise to set at around 0.35 rad (20 °) before T.D.C.
7. Slowly turn the flywheel counterclockwise and stop turning when the fuel begins to come up, to get the present injection timing.
8. Check to see the degree on flywheel.
   The flywheel has mark "1TC", "10" and "20" for the crank angle before the top dead center of No.1 piston.
9. If the injection timing is not within the specification, rotate the injection pump unit to adjust the injection timing.



(a) Injection Timing Advanced
(b) Injection Timing Delayed

VIEWING THE DELIVERY VALVE HOLDER

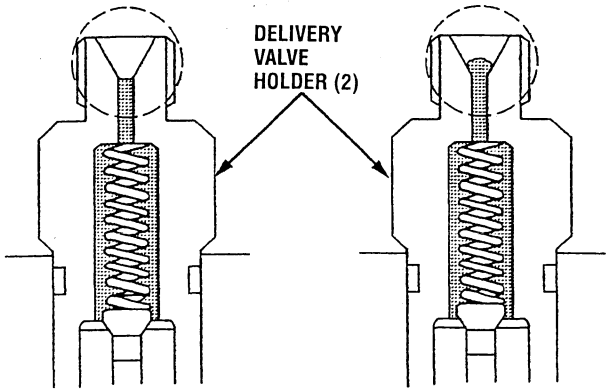


Injection timing	Factory spec.	0.127 to 0.152 rad (7.25 ° to 8.75 °) before T.D.C.

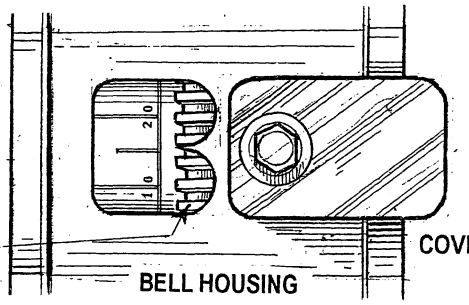
Tightening torque	Injection pipe retaining nut	22.6 to 36.3 N·m 2.3 to 3.7 kgf·m 16.6 to 26.8 ft-lbs
	Injection pump unit mounting nut	17.7 to 20.6 N·m 1.8 to 2.1 kgf·m 13.0 to 15.2 ft-lbs

See the "Injection Pump Unit" Disassembly and Assembly section.

TURNING THE FLYWHEEL



VIEWING THE FLYWHEEL THRU THE TIMING WINDOW



ENGINE ADJUSTMENTS

CHECKING VALVE CLEARANCE

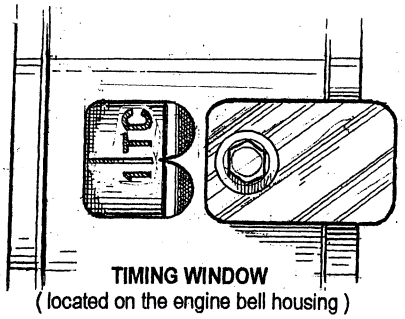
NOTE: *Valve clearance must be checked and adjusted when the engine is cold.*

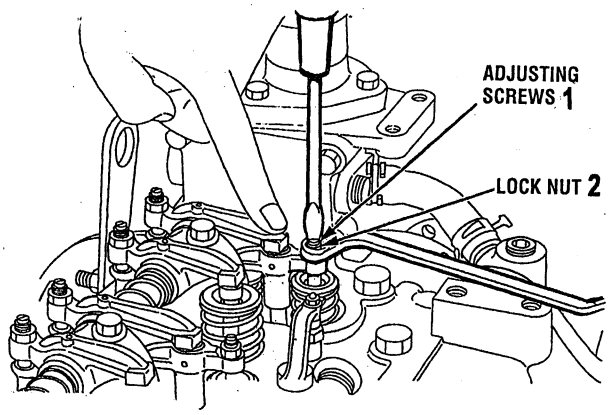
1. Remove the head cover.
2. Align the ITC timing mark on the flywheel (as viewed thru the timing window on the bell housing) so that the #1 piston comes to the top dead center of its compression stroke.
3. Loosen the lock nut (2) and loosen the adjusting screw (1).
4. Loosen the lock nut and return the adjusting screw.
5. Slightly push the rocker arm (intake side) by your fingers and screw in the adjusting screw slowly until you feel the screw touch the top of the valve stem, then tighten the lock nut.
6. Loosen the lock nut (4) of adjusting screw (3) (push rod side) and insert the thickness gauge between the rocker arm and the bridge head. Set the adjusting screw to the specific clearance, then tighten the lock nut.
7. Adjust the clearance between the rocker arm (exhaust side) and the exhaust valve to the specific clearance.

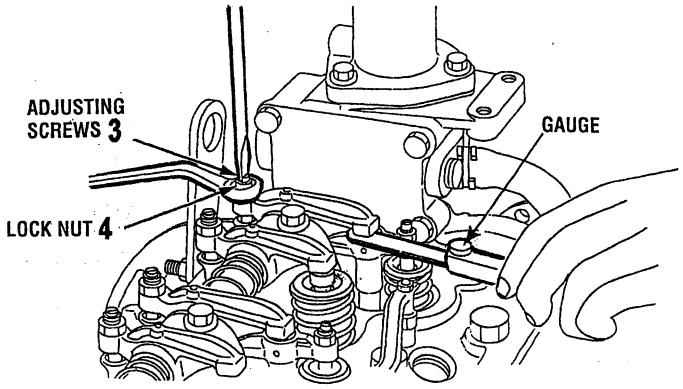
VALVE CLEARANCE FACTORY SPEC. 0.23 - 0.27MM
0.0091 - 0.0106IN

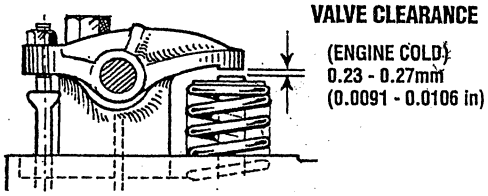
Valve arrangement Adjustment cylinder Location of piston		IN.	EX.
When No.1 piston is compression top dead center	1st	☆	☆
	2nd	☆	
	3rd		☆
	4th		
When No.1 piston is overlap position	1st		
	2nd		☆
	3rd	☆	
	4th	☆	☆

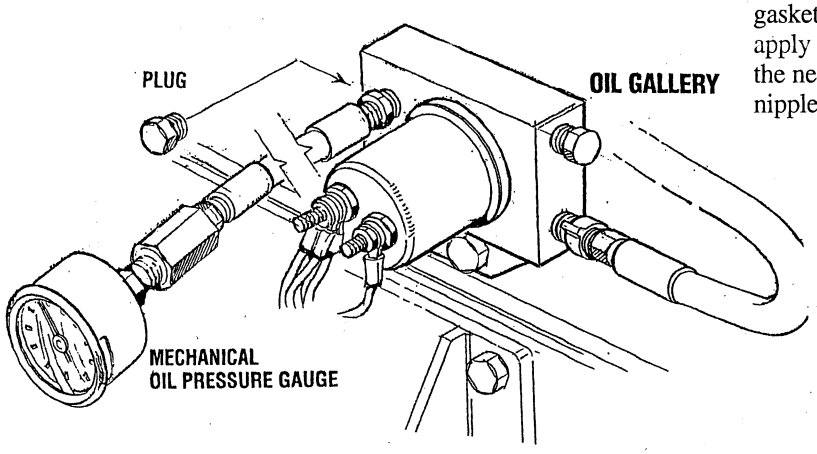
Tightening torque	Cylinder head cover screw	6.9 to 11.3 N·m 0.7 to 1.15 kgf·m 5.1 to 8.32 ft-lbs











TESTING OIL PRESSURE

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

OIL PRESSURE WILL RANGE BETWEEN 50 AND 55 PSI AT 1800 RPM.

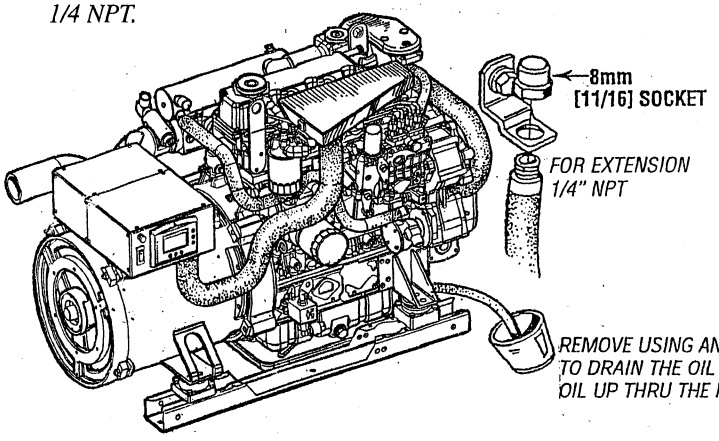
LOW OIL PRESSURE

The specific safe minimum oil pressure is 5 - 10 psi. A gradual loss of oil pressure usually indicates worn bearings.

ENGINE OIL CHANGE

1. ***Draining the Oil Sump.*** Discharge the used oil through the sump drain hose (attached to the front of the engine) while the engine is still warm. Drain the used oil completely, replace the hose in its bracket, and replace the end cap securely.

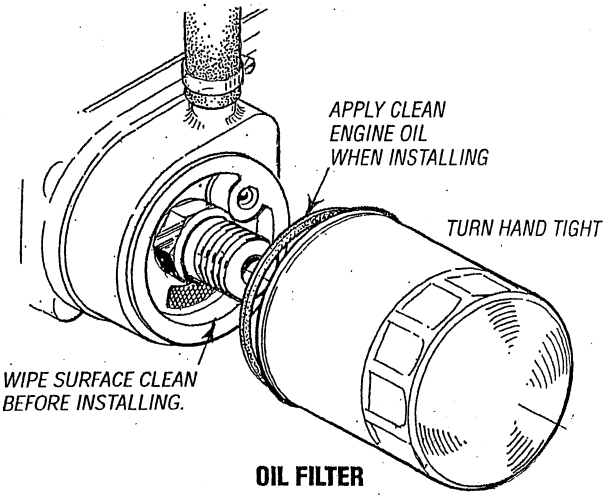
NOTE: *Thread size for the lube oil drain hose capped end is 1/4 NPT.*



2. ***Replacement of the Oil Filter.*** When removing the used oil filter, you may find it helpful and cleaner to punch a hole in the upper and lower portion of the old filter to drain the oil from it into a container before removing it. This helps to lessen spillage. A small style automotive filter wrench should be helpful in removing the old oil filter.

NOTE: *Do not punch this hole without first loosening the filter to make certain it can be removed!*

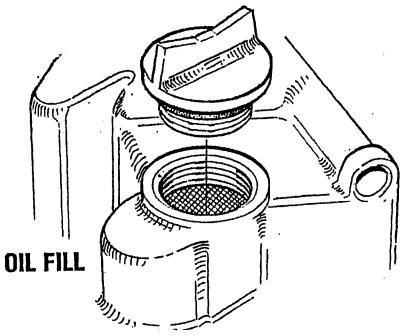
When installing the new oil filter element, wipe the filter gasket's sealing surface on the engine block free of oil and apply a thin coat of clean engine oil to the rubber gasket on the new oil filter. Screw the filter onto the threaded oil filter nipple, and then tighten the filter firmly by hand.

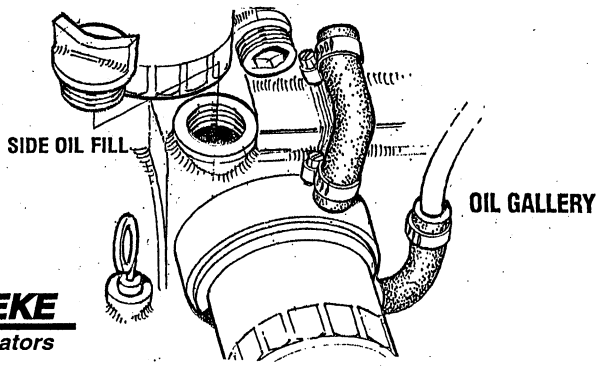


3. **Filling the Oil Sump.** Add new oil through the oil filler cap on the top of the engine or through the side oil fill. After refilling, run the generator for a few moments while checking the oil pressure. Make sure there is no leakage around the new oil filter or from the oil drain system, and stop the engine. Then check the quantity of oil with the lube oil dipstick. Fill to, but not over the high mark on the dipstick, should the engine require additional oil.

Use a good brand of engine oil having an API and SAE specification as stated in the SPECIFICATIONS section of this manual.

Change the engine oil and oil filter after the initial 50 hours of engine break-in operation and then every 250 hours of operation thereafter.

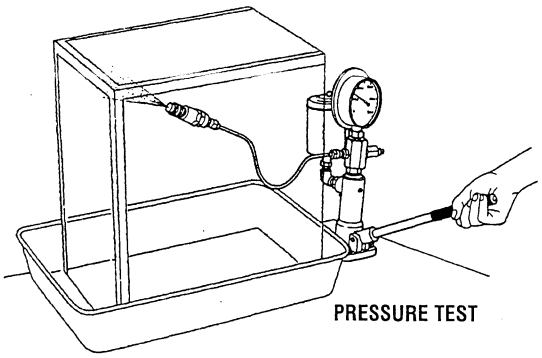




Fuel Injection Pressure

1. Set the injection nozzle to a nozzle tester.
2. Slowly move the tester handle to measure the pressure at which fuel begins jetting out from the nozzle.
3. If the measurement is not within the factory specifications, replace the adjusting washer (1) in the nozzle holder to adjust it.
   See the "Disassembling and Assembling" for nozzle holder.

Fuel injection pressure	Factory spec.	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi

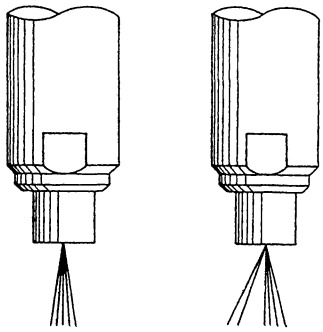

PRESSURE TEST

(Reference)

- Pressure variation with 0.01 mm (0.0004 in.) difference of adjusting washer thickness.
  Approx. 235 kPa (2.4 kgf/cm^2, 34 psi)

Nozzle Spraying Condition

1. Set the injection nozzle to a nozzle tester, and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the nozzle piece.


GOOD DEFECTIVE

Valve Seat Tightness

1. Set the injection nozzle to a nozzle tester.
2. Raise the fuel pressure, and keep at 12.75 MPa (130 kgf/cm^2, 1849 psi) for 10 seconds.
3. If any fuel leak is found, replace the nozzle piece.

Valve seat tightness	Factory spec.	No fuel leak at 12.75 MPa 130 kgf/cm^2 1849 psi

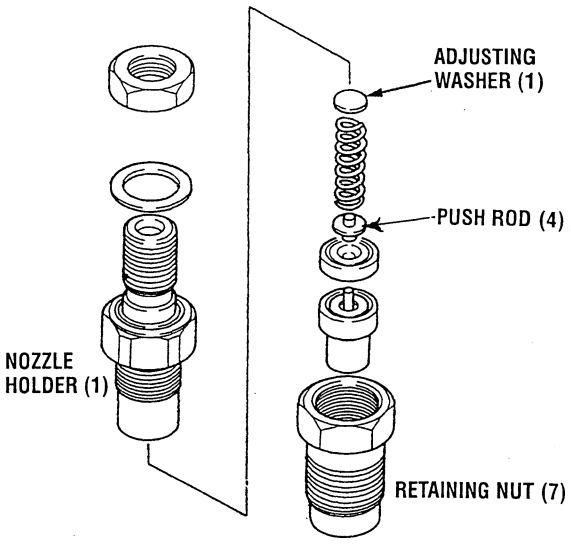
DISASSEMBLY

Nozzle Holder

1. Secure the nozzle retaining nut (7) with a vise.
2. Remove the nozzle holder (1), and take out parts inside.

(When reassembling)

- Assemble the nozzle in clean fuel oil.
- Install the push rod (4), noting its direction.
- After assembling the nozzle, be sure to adjust the fuel injection pressure.



Tightening torque	Nozzle holder	34.3 to 39.2 N·m 3.5 to 4.0 kgf·m 25.3 to 28.9 ft-lbs
	Overflow pipe nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Nozzle holder assembly	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs

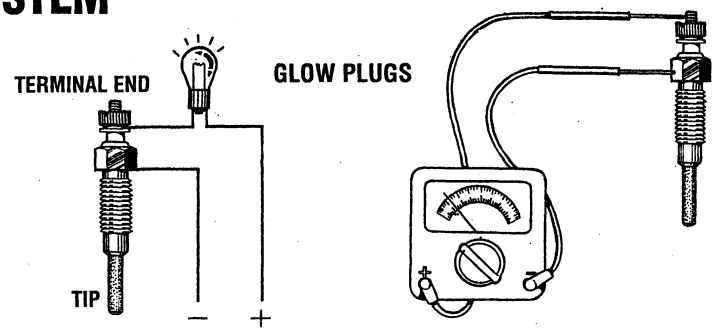
FUEL SYSTEM

GLOW PLUGS

To inspect the plug, remove the electrical terminal connections, then unscrew each plug from the cylinder head. Thoroughly clean each plug's tip and threads with a soft brush and cleaning solution to remove any carbon and oil deposits. Visually examine the plug tip for electrical erosion if this is evident, replace the glow plug.

Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 1.0 - 1.5 ohm resistance. This method can be used with the plug in or out of the engine. You can also use an ammeter to test the power drain (8 - 9 amps per plug)

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. (sparingly).



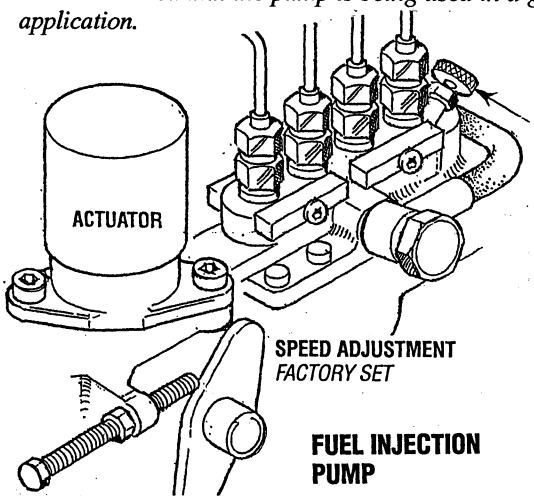
Tightening torque	Glow plug	20 to 24 N·m 2.0 to 2.5 kgf·m 15 to 18 lbf·ft

FUEL INJECTION PUMP

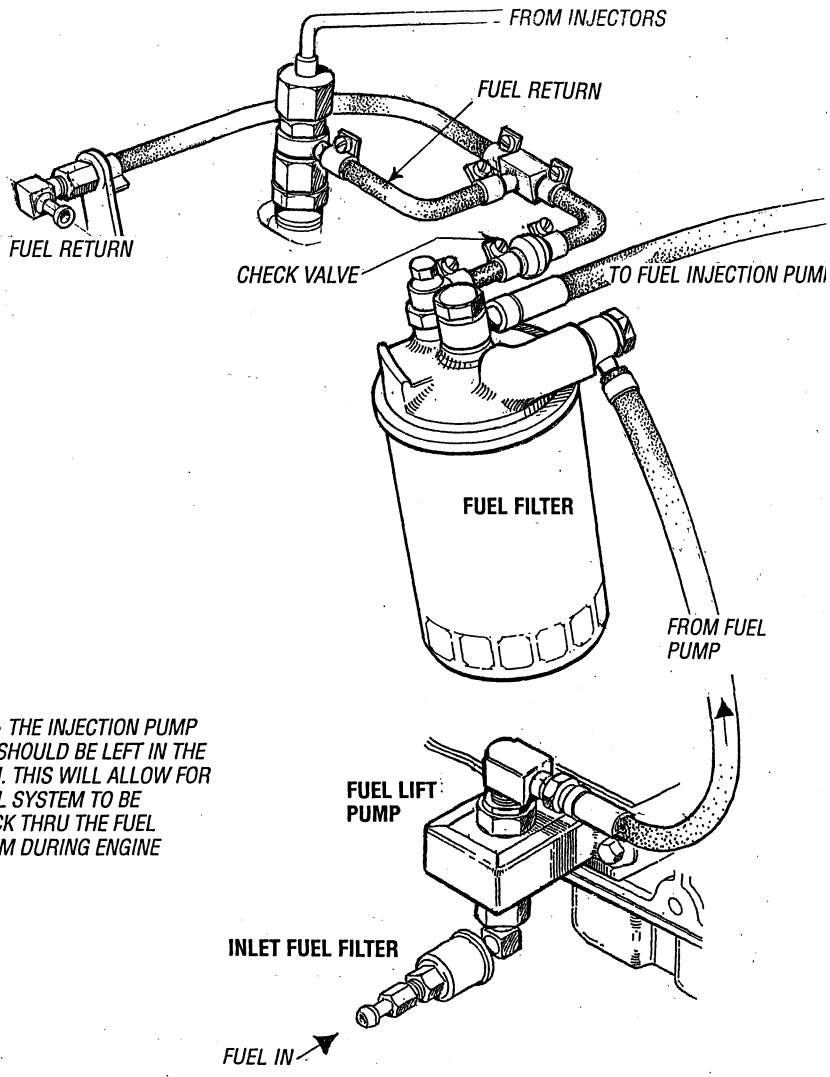
The fuel injection pump is the most important component of the diesel engine and, therefore, calls for the utmost caution in handling. The fuel injection pump has been thoroughly bench-tested and should not be tampered with.

Speed (hertz) and timing are the only adjustments the servicing dealer can perform on the injection pump. See the *ENGINE ADJUSTMENT* section in this manual. Other types of adjustments or repairs must be performed by a qualified injection service shop.

NOTE: *When servicing the injection pump, the service shop must be advised that the pump is being used in a generator application.*



BLEED SCREW - *THE INJECTION PUMP BLEED SCREW SHOULD BE LEFT IN THE OPEN POSITION. THIS WILL ALLOW FOR AIR IN THE FUEL SYSTEM TO BE DELIVERED BACK THRU THE FUEL RETURN SYSTEM DURING ENGINE OPERATION.*



FUEL LIFT PUMP

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

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

INLET FUEL FILTER

1. Shut off the fuel supply to the generator. Disconnect the fuel supply line to the inlet filter and unscrew the filter from the pump inlet. Take care to catch any fuel that may be present.
2. Thread on the replacement inlet filter and connect the fuel supply line. Use care when connecting and tightening the fuel supply line so as not to distort the inlet filter.

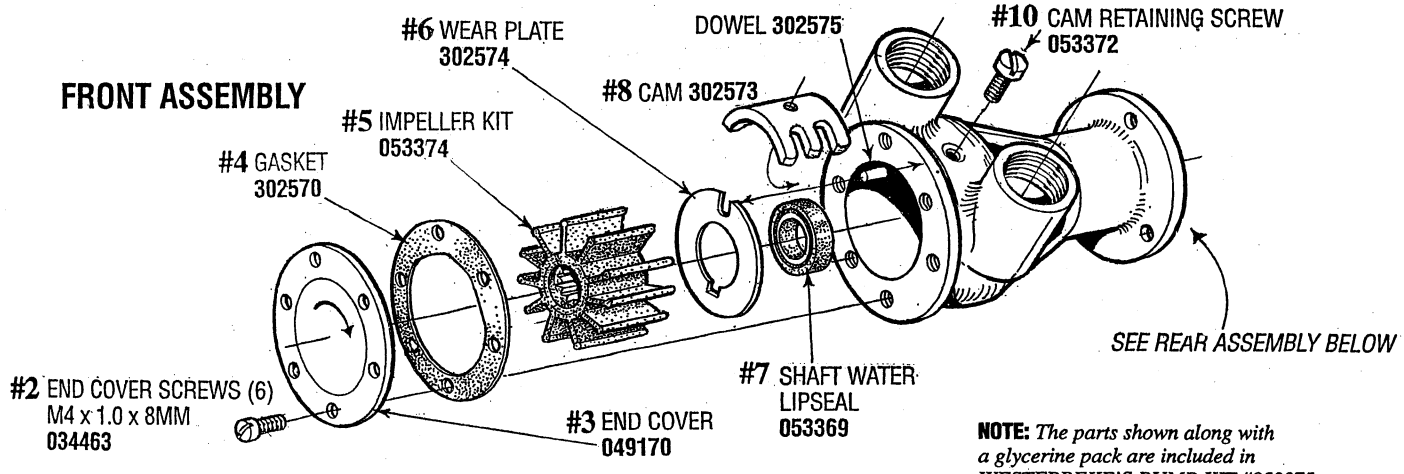
RAW WATER PUMP #052650

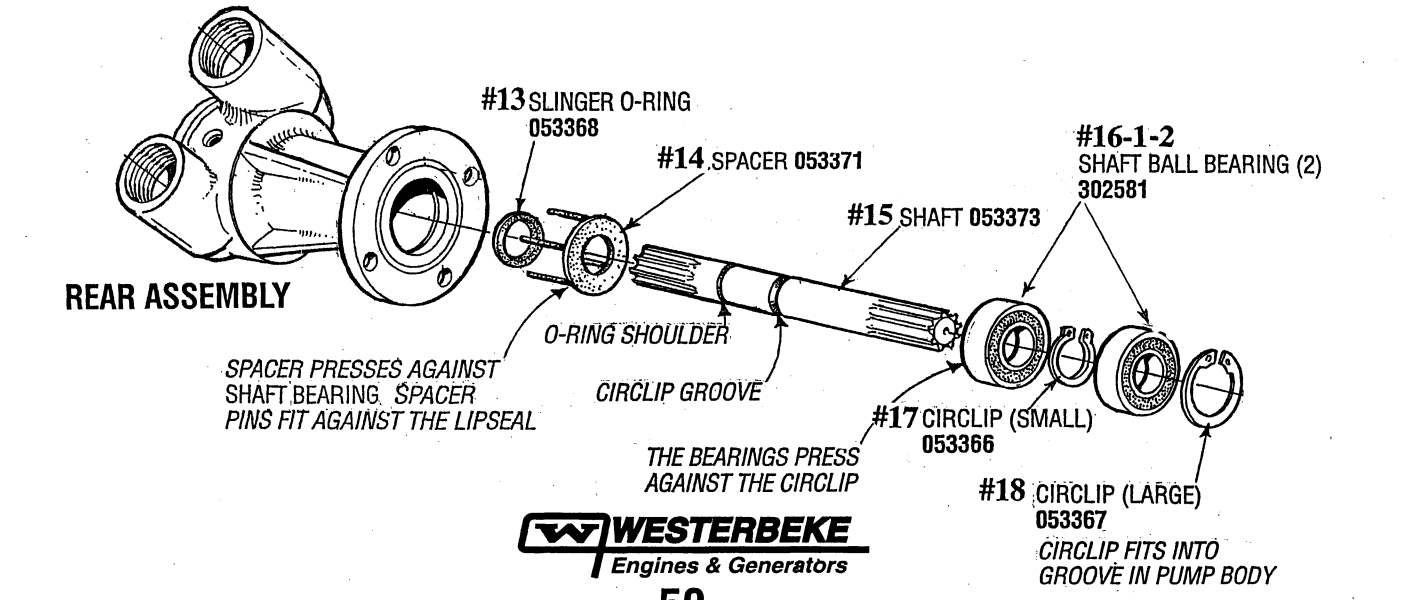
DISASSEMBLY

1. With the pump removed from the engine, remove cover **#3**, the gasket **#4** and withdraw the impeller **#5**.
2. Remove the cam securing screw **#10** and remove the cam **#8**.
3. Remove the inner wear plate **#6**.
4. Remove the internal circlip **#18**.
5. Support the pump housing on a press with the impeller opening up.
6. Press the shaft assembly **#15**, **#16-1**, **#17** and **#16-2** out of the pump housing through the drive end. Spacer **#14** and slinger **#13** will come out with the shaft assembly.
7. Remove bearing **#16-2** from the shaft, external circlip **#17** and bearing **#16-1**.
8. Push shaft water seal **#7** out of the pump housing through the impeller opening. Note the orientation of the seal for correct installation of the new seal.

ASSEMBLY

1. Assemble bearing **#16-2** onto the shaft. Install external circlip **#17** and position bearing **#16-2** so it just contacts the circlip. Install bearing **#16-1** onto the shaft and position it so it contacts the circlip and bearing **#16-2**.
2. Install the spacer **#14** and slinger **#13** on the shaft. Warm the housing so to provide an easier press fit of the shaft/bearing assembly into the housing. Using an appropriate press, press the shaft bearing assembly into the housing so that the bearing **#16-2** just clears the internal circlip **#18** retaining slot.
3. Install the internal circlip **#18**.
4. Press the shaft bearing assembly so the bearing **#16-2** just contacts the internal circlip **#18**. Rotate the shaft to ensure no binding.
5. Apply some glycerine to the sealing lip of the shaft water seal **#7** properly orientated. Using a twisting motion, slide the seal over the shaft until it contacts the recess for the seal in the housing. Then carefully press the seal fully into the recess.
6. Install the inner wear plate **#6** and the cam **#8**, applying some sealant on the cams securing screw **#10**.
7. Apply some glycerine to the surface of the impeller's housing and install the impeller **#5**.
8. Apply some glycerine to the vanes of the impeller that will contact the cover **#3**. Install the gasket **#4** and cover **#3** and secure with the 6 screws **#2**.
9. Re-install the pump on the engine.





TORQUE SPECIFICATIONS

Screws, bolts and nuts must be tightened to the specified torque using a torque wrench, several screws, bolts and nuts such as those used on the cylinder head must be tightened in proper sequence and the proper torque.

TIGHTENING TORQUES FOR GENERAL USE SCREWS, BOLTS AND NUTS

When the tightening torques are not specified, tighten the screws, bolts and nuts according to the table below.

Grade / Nominal Diameter / Unit	Standard Screw and Bolt ④			Special Screw and Bolt ⑦		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
M8	18 to 20	1.8 to 2.1	13 to 15	24 to 27	2.4 to 2.8	18 to 20
M10	40 to 45	4.0 to 4.6	29 to 33	48 to 55	4.9 to 5.7	36 to 41
M12	63 to 72	6.4 to 7.4	47 to 53	78 to 90	7.9 to 9.2	58 to 66

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below.

Punched number	Screw and bolt material grade
None or 4	Standard screw and bolt SS41, S20C
7	Special screw and bolt S43C, S48C (Refined)

- **For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.**
- **The letter "M" in Size x Pitch means that the screw, bolt or nut dimension stands for metric. The size is the nominal outside diameter in mm of the threads. The pitch is the nominal distance in mm between two threads.**

Item	Size x Pitch	N·m	kgf·m	lbf·ft
Cylinder head cover screw	–	6.9 to 11.2	0.70 to 1.15	5.1 to 8.31
*Cylinder head screw	M12 x 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
*Connecting rod screw	M10 x 1.25	79 to 83	8.0 to 8.5	58 to 61
*Flywheel screw	M12 x 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
*Crankshaft screw	M16 x 1.5	255 to 274	26.0 to 28.0	188 to 202
*Main bearing case screw	M14 x 1.5	138 to 147	14.0 to 15.0	102 to 108
Rocker arm bracket screw	M10 x 1.25	49 to 55	5.0 to 5.7	37 to 41
Nozzle holder assembly	M20 x 1.5	49 to 68	5.0 to 7.0	37 to 50
Nozzle holder	—	35 to 39	3.5 to 4.0	26 to 28
Injection pipe retaining nut	M12 x 1.5	23 to 36	2.3 to 3.7	17 to 26
Overflow pipe assembly retaining nut	M12 x 1.5	20 to 24	2.0 to 2.5	15 to 18

TORQUE SPECIFICATIONS

Oil cooler joint screw	–	40 to 44	4.0 to 4.5	29 to 32
Oil pump cover screw	–	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8
Glow plugs (V3600-E3B,	M10 x 1.25	20 to 24	2.0 to 2.5	15 to 18

Starter's terminal **B** mounting nut	M8 x 1.25	9.8 to 11	1.0 to 1.2	7.3 to 8.6

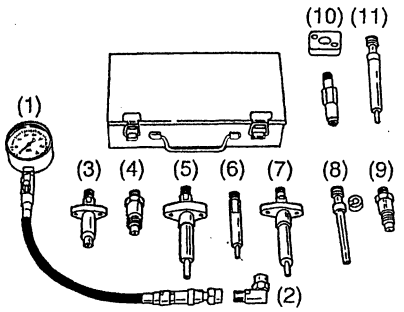
Timer gear mounting nut	–	74 to 83	7.5 to 8.5	55 to 61
Injection pump unit mounting nut	M8 x 1.25	18 to 20	1.8 to 2.1	13 to 15
Gear case cover	M8 x 1.25 (7T)	24 to 27	2.4 to 2.8	18 to 20
	M8 x 1.25 (10T)	33 to 36	3.3 to 3.7	24 to 26
Relief valve retaining screw	–	69 to 78	7.0 to 8.0	51 to 57
Idle gear mounting screw	M8 x 1.25	24 to 27	2.4 to 2.8	18 to 20

Camshaft set screw	M8 x 1.25	24 to 27	2.4 to 2.8	18 to 20
Flywheel housing mounting screw	M12 x 1.25	78 to 90	7.9 to 9.2	58 to 66
Crankcase 2 mounting screw	M10 x 1.25	49 to 55	5.0 to 5.7	37 to 41
Injection pump mounting screw	M8 x 1.25	24 to 27	2.4 to 2.8	18 to 20
Injection pump mounting nut	M8 x 1.25	18 to 20	1.8 to 2.1	13 to 15

Governor weight mounting nut	M12 x 1.25	63 to 72	6.4 to 7.4	47 to 53
Fuel camshaft stopper mounting screw	–	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8
Governor housing mounting screw	M6 x 1.0	9.8 to 11.2	1.00 to 1.15	7.24 to 8.31
Anti-rotation nut	M5 x 0.8	2.8 to 4.0	0.29 to 0.41	2.1 to 2.9

Bearing case cover mounting screw	M8 x 1.25	24 to 27	2.4 to 2.8	18 to 20
Alternator pulley nut	–	58.4 to 78.9	5.95 to 8.05	43.1 to 58.2

SPECIAL TOOLS

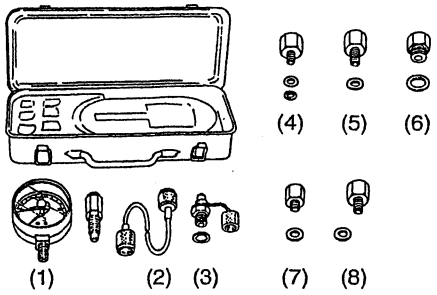


Diesel Engine Compression Tester

Application : Use to measure diesel engine compression and diagnostics of need for major overhaul.

(1) Gauge
(2) L Joint
(3) Adaptor
(4) Adaptor
(5) Adaptor
(6) Adaptor
(7) Adaptor
(8) Adaptor
(9) Adaptor
(10) Adaptor
(11) Adaptor

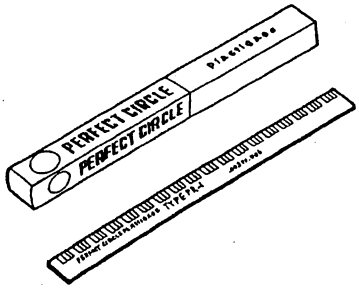
Oil Pressure Tester



Application : Use to measure lubricating oil pressure.

(1) Gauge
(2) Cable
(3) Threaded Joint
(4) Adaptor **1**
(5) Adaptor **2**
(6) Adaptor **3**
(7) Adaptor **4**
(8) Adaptor **5**

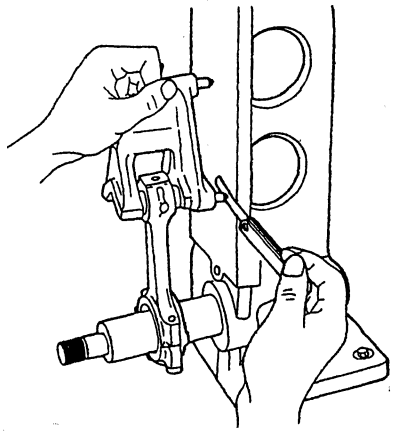
Plastigage



Application : Use to check the oil clearance between crankshaft and bearing, etc..

Measuring range :
Green.....0.025 to 0.076 mm (0.001 to 0.003 in.)
Red.....0.051 to 0.152 mm (0.002 to 0.006 in.)
Blue.....0.102 to 0.229 mm (0.004 to 0.009 in.)

Connecting Rod Alignment Tool



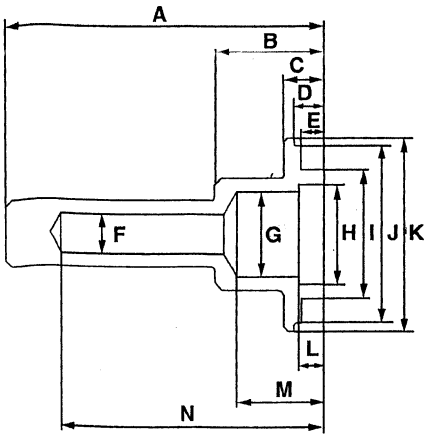
Application : Use to check the connecting rod alignment.

Applicable range :
Connecting rod big end I.D.
30 to 75 mm (1.18 to 2.95 in.) dia.
Connecting rod length
65 to 300 mm (2.56 to 11.81 in.)

Red Check

Application : Use to check cracks on cylinder head, cylinder block, etc..

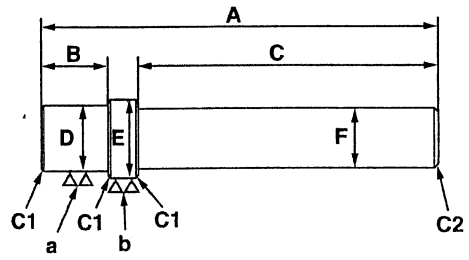
SPECIAL TOOLS



Gear Case Oil Seal Replacing Tool

Application : Use to press fit the oil seal.

A	148.8 mm (5.8582 in.)
B	50 mm (1.9685 in.)
C	18.8 mm (0.7401 in.)
D	13.7 to 13.9 mm (0.5394 to 0.5472 in.)
E	11 mm (0.433 in.)
F	18 mm dia. (0.7087 in. dia.)
G	38 mm dia. (1.4961 in. dia.)
H	45 mm dia. (1.7716 in. dia.)
I	57.9 to 58.1 mm dia. (2.2795 to 2.2874 in. dia.)
J	79.5 mm dia. (3.1299 in. dia.)
K	87 mm dia. (3.452 in. dia.)
L	12 mm (0.4724 in.)
M	40 mm (1.5748 in.)
N	120 mm (4.7244 in.)



Small End Bushing Replacing Tool

Application : Use to press out and to press fit the small end bushing.

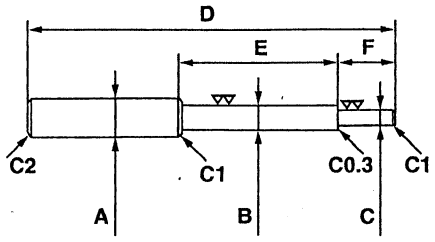
[Press out]

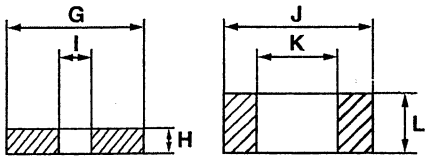
A	157 mm (6.1811 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.7244 in.)
D	30.0 mm dia. (1.1811 in. dia.)
E	32.95 mm dia. (1.2972 in. dia.)
F	20 mm dia. (0.7874 in. dia.)
a	6.3 μm (250 μin.)
b	6.3 μm (250 μin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

[Press fit]

A	157 mm (6.1811 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.7244 in.)
D	30.0 mm dia. (1.1811 in. dia.)
E	42.000 mm dia. (1.6535 in. dia.)
F	20 mm dia. (0.7874 in. dia.)
a	6.3 μm (250 μin.)
b	6.3 μm (250 μin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

SPECIAL TOOLS





Valve Guide Replacing Tool

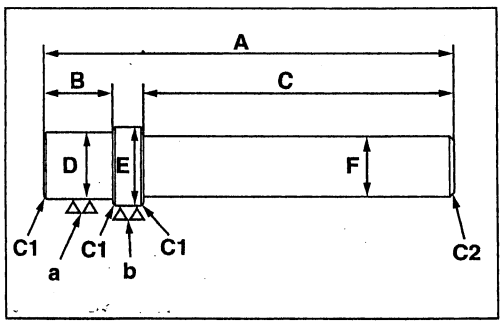
Application : Use to press out and press fit the valve guide.

[Intake valve guide]

A	20 mm dia. (0.79 in. dia.)
B	11.7 to 11.9 mm dia. (0.460 to 0.468 in.dia.)
C	6.5 to 6.6 mm dia. (0.256 to 0.259 in.dia.)
D	225 mm (8.86 in.)
E	70 mm (2.76 in.)
F	45 mm (1.77 in.)
G	25 mm (0.98 in.)
H	5 mm (0.197 in.)
I	6.7 to 7.0 mm dia. (0.263 to 0.275 in.dia.)
J	20 mm dia. (0.787 in.dia.)
K	12.5 to 12.8 mm dia. (0.492 to 0.504 in.dia.)
L	8.9 to 9.1 mm (0.350 to 0.358 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)
C0.3	Chamfer 0.3 mm (0.012 in.)

[Exhaust valve guide]

A	20 mm dia. (0.79 in. dia.)
B	12.96 to 12.98 mm dia. (0.510 to 0.511 in.dia.)
C	7.50 to 7.70 mm dia. (0.295 to 0.303 in.dia.)
D	225 mm (8.86 in.)
E	80 mm (3.15 in.)
F	40 mm (1.57 in.)
G	14.5 to 15.5 mm (0.57 to 0.61 in.)
H	5 mm (0.197 in.)
I	8.0 to 8.1 mm dia. (0.31 to 0.32 in.dia.)
J	17.5 to 18.5 mm dia. (0.689 to 0.728 in.dia.)
K	13.1 to 13.2 mm dia. (0.516 to 0.520 in.dia.)
L	9.9 to 10.1 mm (0.390 to 0.398 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)
C0.3	Chamfer 0.3 mm (0.012 in.)



Idle Gear Bushing Replacing Tool

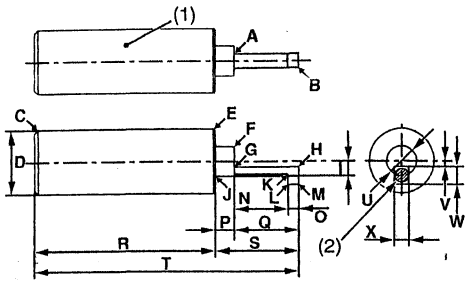
Application: Use to press out and to press fit the bushing.

A	196 mm (7.72 in.)
B	37.5 mm (1.48 in.)
C	150 mm (5.91 in.)
D	44.95 mm dia. (1.770 in. dia.)
E	48.075 to 48.100 mm dia. (1.8928 to 1.8937 in. dia.)
F	20 mm dia. (0.79 in. dia.)
a	6.3 μm (250 μin.)
b	6.3 μm (250 μin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

SPECIAL TOOLS

Jig for Governor Connecting Rod

Application :Use for connecting the governor connecting rod to the rack pin of the fuel injection pump assembly.



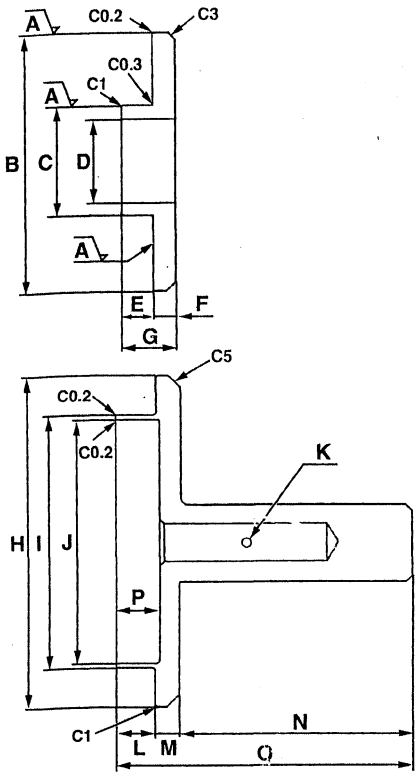
(1) Material: S45C-D

(2) Permanent Magnet: ϕ 8 mm (0.3150 in. dia.) Thickness: 3 mm (0.1181 in.)

A	R1 mm (0.0394 in. radius)	V	3 mm (0.1181 in.)
B	Chamfer 0.2 mm (0.0079 in.)	W	10 mm (0.3937 in.)
C	Chamfer 2 mm (0.0787 in.)	X	8 mm (0.3150 in.)
D	35 mm dia.(1.3780 in. dia.)		
E	Chamfer 1 mm (0.0394 in.)		
F	Chamfer 0.1 mm (0.0039 in.)		
G	R1 mm (0.0394 in. radius)		
H	Chamfer 0.2 mm (0.0079 in.)		
I	R8 mm (0.3150 in. radius)		
J	R1 mm (0.0394 in. radius)		
K	R1 mm (0.0394 in. radius)		
L	Chamfer 0.2 mm (0.0079 in.)		
M	Chamfer 0.2 mm (0.0079 in.)		
N	29 mm (1.1417 in.)		
O	6 mm (0.2362 in.)		
P	10.7 mm (0.4213 in.)		
Q	35 mm (1.3780 in.)		
R	99.3 mm (3.9095 in.)		
S	45.65 to 45.75 mm (1.7972 to 1.8012 in.)		
T	145 mm (5.7087 in.)		
U	16.15 to 16.35 mm dia. (0.6359 to 0.6439 in. dia.)		

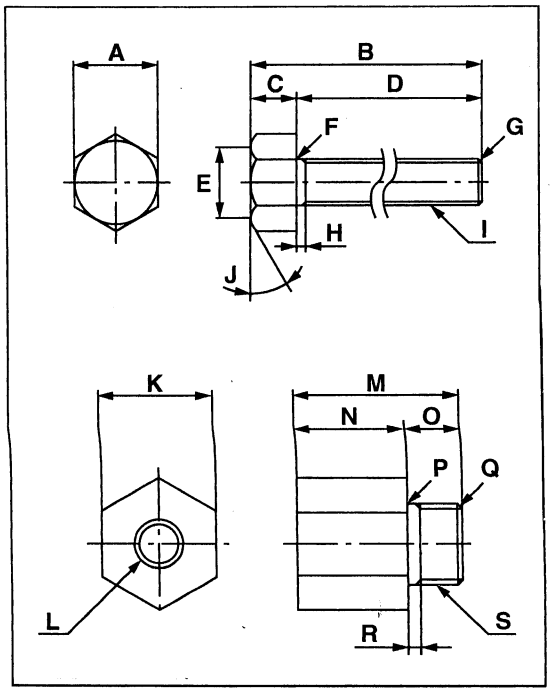
Auxiliary Socket for Fixing Crankshaft Sleeve

Application : Use to fix the crankshaft sleeve.



A	Rmax = 12.5 S
B	94.5 to 95.0 mm (3.7205 to 3.7402 in.)
C	40 mm (1.5748 in.)
D	30 mm (1.1811 in.)
E	12 mm (0.4724 in.)
F	7.9 to 8.1 mm (0.3110 to 0.3189 in.)
G	20 mm (0.0787 in.)
H	130 mm (5.1181 in.)
I	99.4 to 99.6 mm (3.9134 to 3.9213 in.)
J	95.05 to 95.20 mm (3.7421 to 3.7480 in.)
K	3 mm dia. (0.1181 in.dia.)
L	15 mm (0.5905 in.)
M	10 mm (0.3937 in.)
N	90 mm (3.5433 in.)
O	115 mm (4.5275 in.)
P	16.9 to 17.1 mm (0.6654 to 0.6732 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C3	Chamfer 3.0 mm (0.1181 in.)
C5	Chamfer 5.0 mm (0.1969 in.)
C0.2	Chamfer 0.2 mm (0.0079 in.)
C0.3	Chamfer 0.3 mm (0.0118 in.)

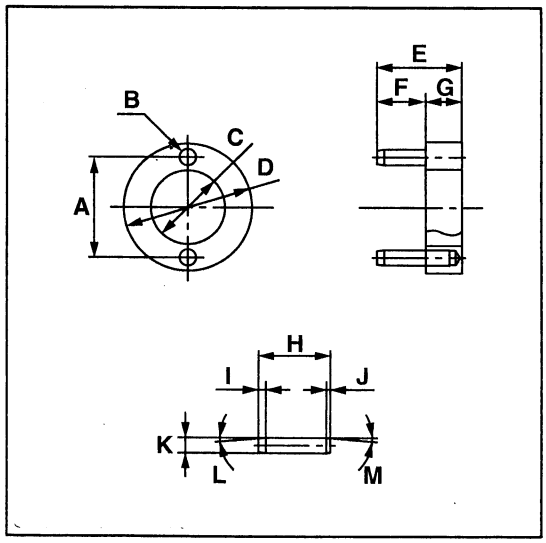
SPECIAL TOOLS



Timer Gear Puller

Application: Use for removing the timer gear from governor shaft.

A	27 mm (1.1 in.)
B	130 mm (5.12 in.)
C	15 mm (0.59 in.)
D	115 mm (4.53 in.)
E	26 mm dia. (1.0 in. dia.)
F	0.8 mm radius (0.03 in. radius)
G	Chamfer 1 mm (0.04 in.)
H	Less than 3 mm (Less than 0.1 in.)
I	M14 x Pitch 1.5
J	0.52 rad (30 °)
K	32 mm (1.3 in.)
L	M14 x Pitch 1.5
M	45 mm (1.8 in.)
N	30 mm (1.2 in.)
O	15 mm (0.59 in.)
P	0.8 mm radius (0.03 in. radius)
Q	Chamfer 1 mm (0.04 in.)
R	Less than 3 mm (Less than 0.1 in.)
S	M24 x Pitch 1.5



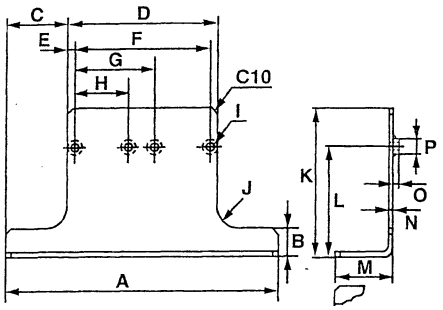
Timer 0° Restoring Jig

Application: Use for restoring 0° in the timer gear.

A	50.98 to 51.02 mm (2.007 to 2.008 in.)
B	8 mm dia. depth 12 mm (0.31 in. dia. depth 0.472 in.)
C	37 mm dia. (1.5 in. dia)
D	65 mm dia. (2.6 in. dia)
E	42 mm (1.7 in.)
F	24 mm (0.94 in.)
G	18 mm (0.71 in.)
H	36 mm (1.4 in.)
I	3.5 mm (0.14 in.)
J	1.5 mm (0.059 in.)
K	8 mm dia. (0.31 in. dia.)
L	0.09 rad (5 °)
M	0.09 rad (5 °)

SPECIAL TOOLS

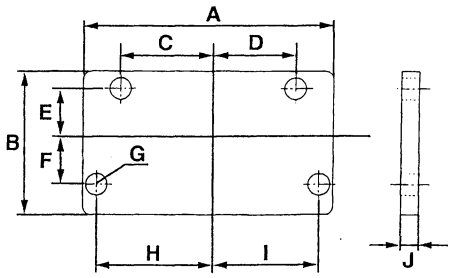
The following special tools are not provided, so make them referring to the figure.



Engine Stand

Application :Use to support engine.

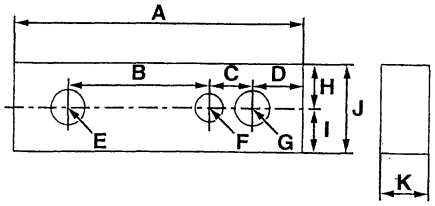
A	480 mm (18.90 in.)
B	50 mm (1.97 in.)
C	108.5 mm (4.272 in.)
D	263 mm (10.35 in.)
E	12.5 mm (0.492 in.)
F	237.5 mm (9.350 in.)
G	142.5 mm (5.610 in.)
H	95 mm (3.74 in.)
I	4.14 mm dia. (0.55 in. dia.)
J	40 mm (1.57 in.)
K	210 mm (8.27 in.)
L	190 mm (7.48 in.)
M	100 mm (3.94 in.)
N	6 mm (0.24 in.)
O	6 mm (0.24 in.)
P	25 mm dia. (0.98 in. dia.)
C10	Chamfer 10 mm (0.394 in.)



Flywheel Stopper (for SAE Flywheel and Housing)

Application : Use to loosen and tighten the flywheel screw.

A	140 mm (5.5 in.)
B	80 mm (3.15 in.)
C	49.3 mm (1.94 in.)
D	49.3 mm (1.94 in.)
E	23.8 mm (0.94 in.)
F	23.8 mm (0.94 in.)
G	11 mm dia. (0.43 in. dia.)
H	56.5 mm (2.22 in.)
I	56.5 mm (2.22 in.)
J	8 mm (0.31 in.)

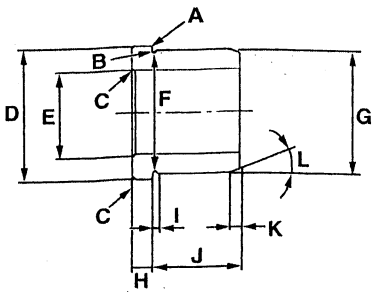


Tool for Aligning the Crankcase 1 and 2

Application : Use for aligning the crankcase 1 and 2.

A	115 mm (4.5276 in.)
B	56 mm (2.2047 in.)
C	17 mm (0.6693 in.)
D	20 mm (0.7874 in.)
E	14 mm dia. (0.5512 in. dia.)
F	11 mm dia. (0.4331 in. dia.)
G	14 mm dia. (0.5512 in. dia.)
H	17.5 mm (0.6890 in.)
I	17.5 mm (0.6890 in.)
J	35 mm (1.3780 in.)
K	19 mm (0.7480 in.)

SPECIAL TOOLS



3) Piece 2

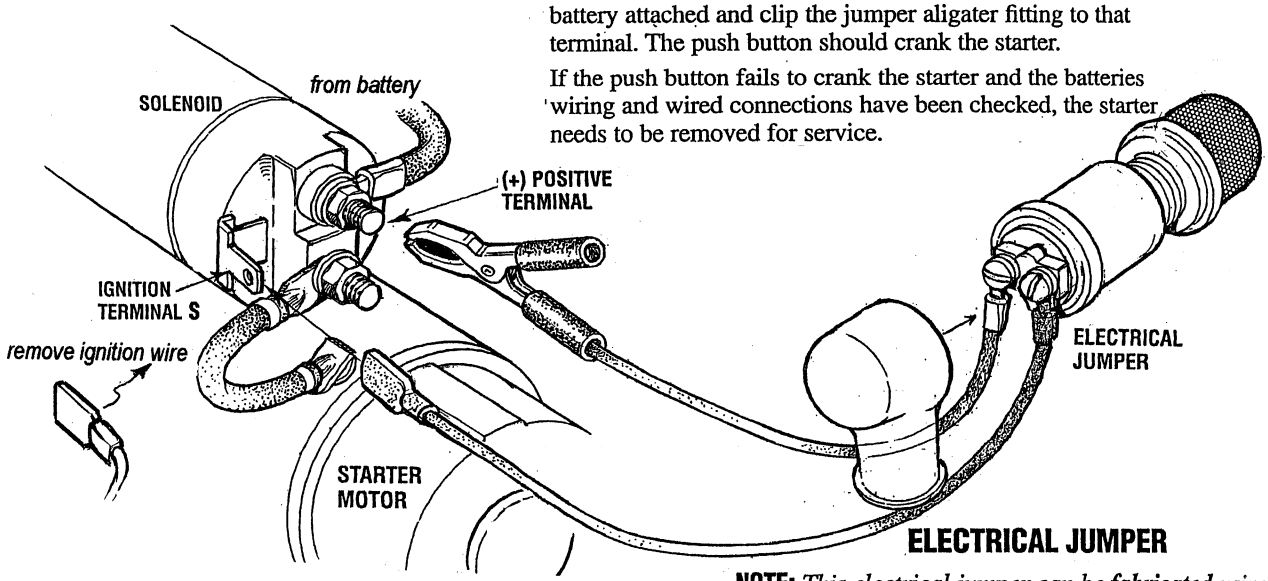
A	Chamfer 0.1 mm (0.004 in.)
B	1 mm (0.04 in.)
C	Chamfer 1 mm (0.04 in.)
D	54.3 to 54.4 mm dia. (2.1378 to 2.1417 in. dia.)
E	34.025 to 34.05 mm dia. (1.3396 to 1.3406 in. dia.)
F	48.5 mm dia. (1.9094 in. dia.)
G	50.421 to 50.44 mm dia. (1.9851 to 1.9858 in. dia.)
H	8 mm (0.31 in.)
I	2 mm (0.08 in.)
J	35 mm (1.38 in.)
K	5 mm (0.20 in.)
L	0.26 rad (15 °)

ELECTRICAL JUMPER field fabricated
For starter motor (to by-pass the control panel start)

STARTER/SOLENOID TESTING

Remove the **Terminal S** wire from the ignition and attach the lead from the electrical jumper. Leave the **+ positive** battery attached and clip the jumper aligater fitting to that terminal. The push button should crank the starter.

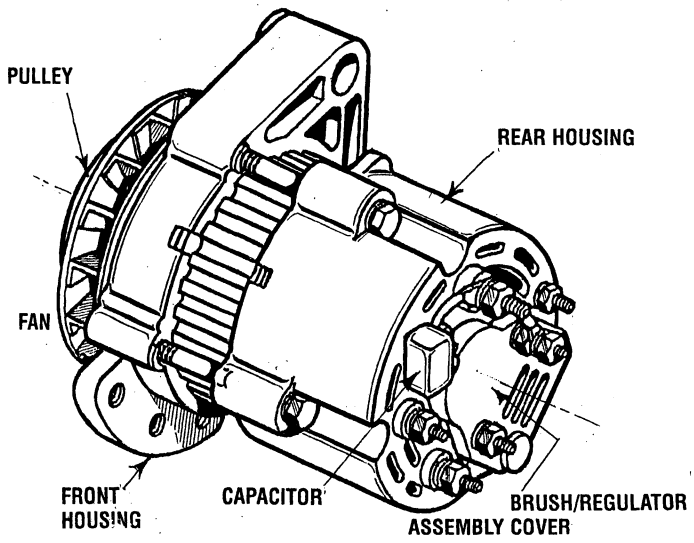
If the push button fails to crank the starter and the batteries wiring and wired connections have been checked, the starter needs to be removed for service.

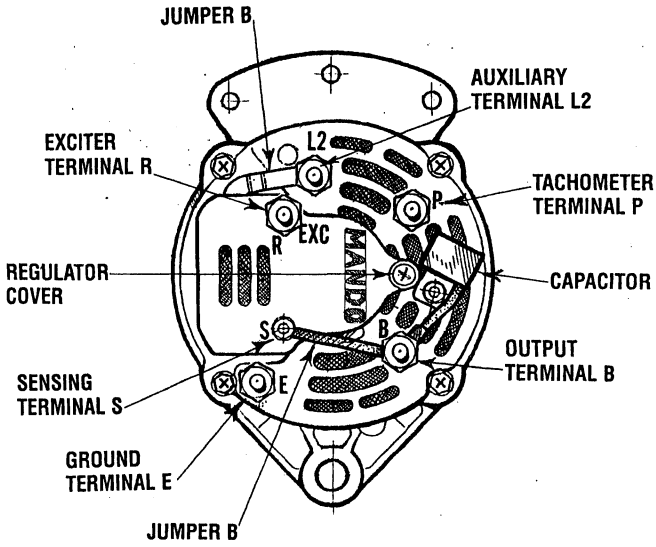


ELECTRICAL JUMPER

NOTE: *This electrical jumper can be **fabricated** using a standard push button and two connecting wires.*

WESTERBEKE 51A MANDO ALTERNATOR
DISASSEMBLY AND TESTING





TESTING THE OUTPUT CIRCUIT

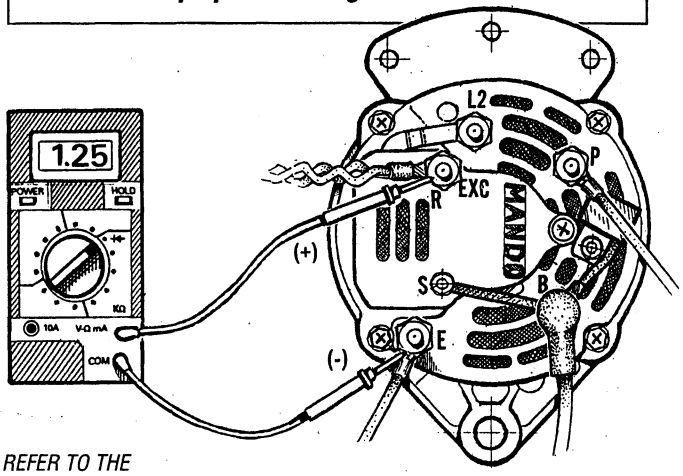
1. Connect the positive voltmeter lead to the output terminal B and connect the negative lead to the ground terminal E on the alternator.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is 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.*

⚠ 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.



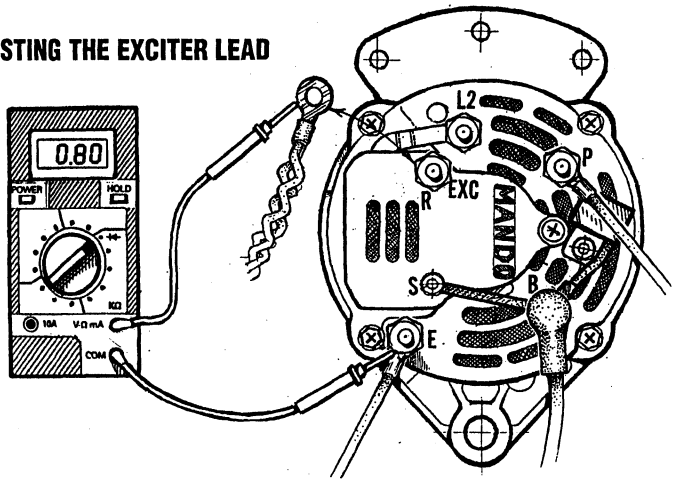
REFER TO THE WIRING DIAGRAMS FOR THE ABOVE WIRING HARNESS CONNECTIONS

TESTING THE 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



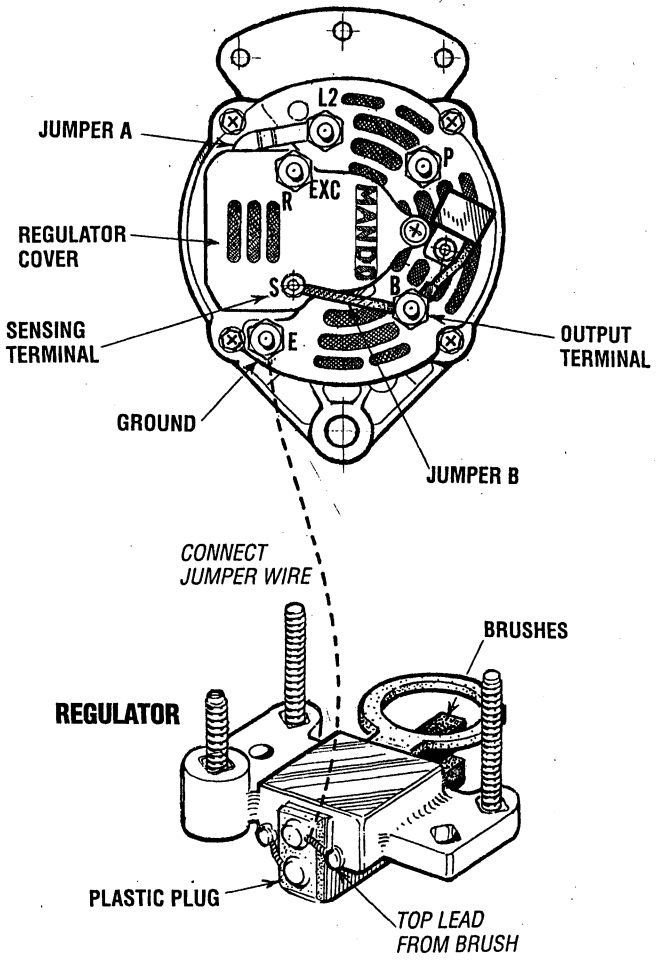
5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal R. Connect the positive voltmeter lead to the excitation lead and the negative voltmeter lead to ground terminal E. If the voltmeter 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**.

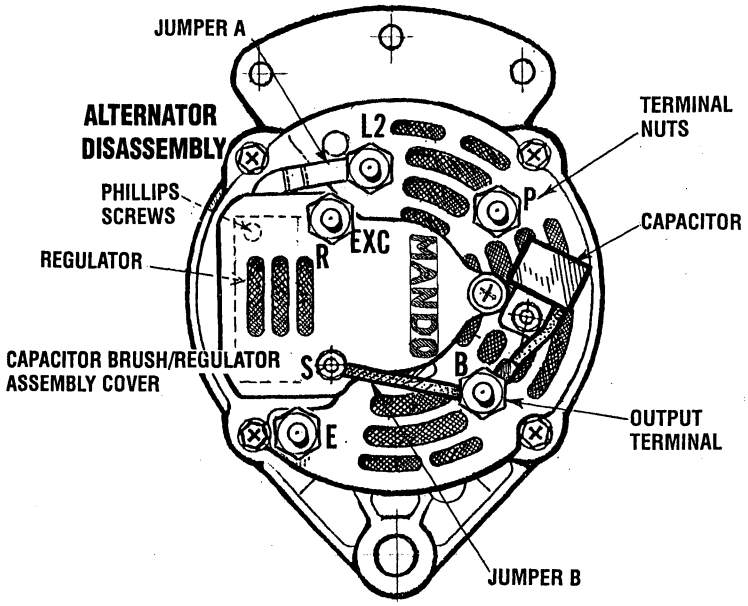
NOTE: *Do not let the voltage exceed 16 volts.*

   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

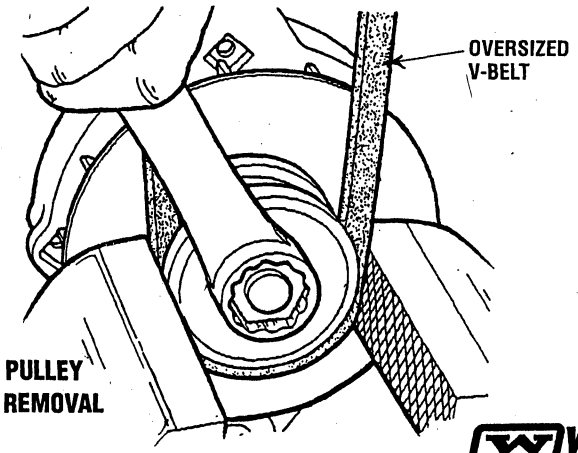
REMOVE ALTERNATOR

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.

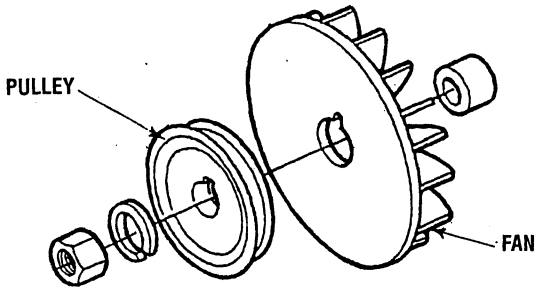


DISASSEMBLE ALTERNATOR

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.

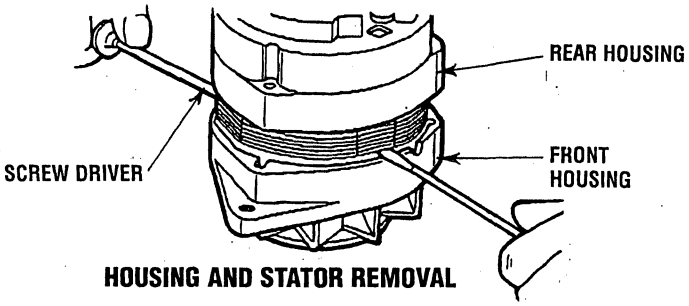


PULLEY AND FAN COMPONENTS

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

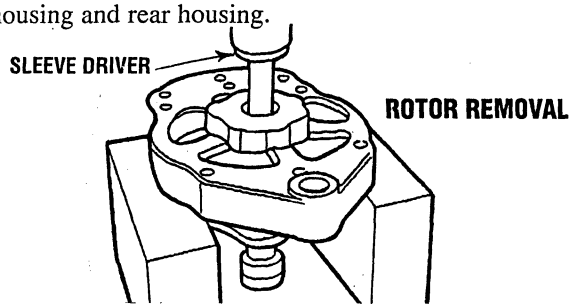
NOTE: *Score the stator, and the front and rear housings so the unit may be reassembled correctly.*

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



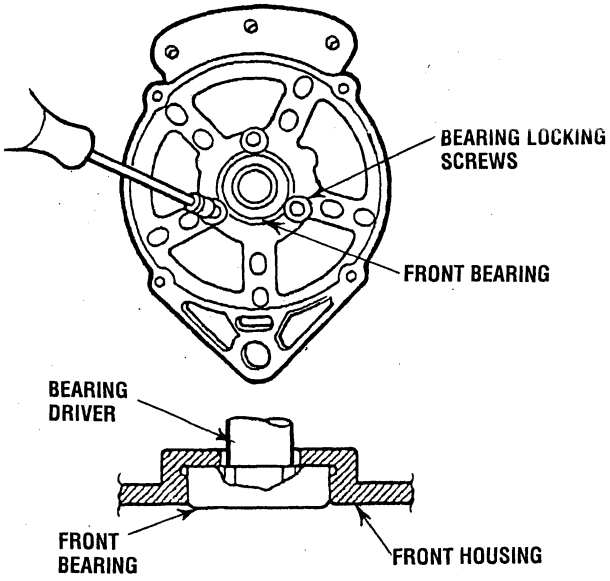
HOUSING AND STATOR REMOVAL

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

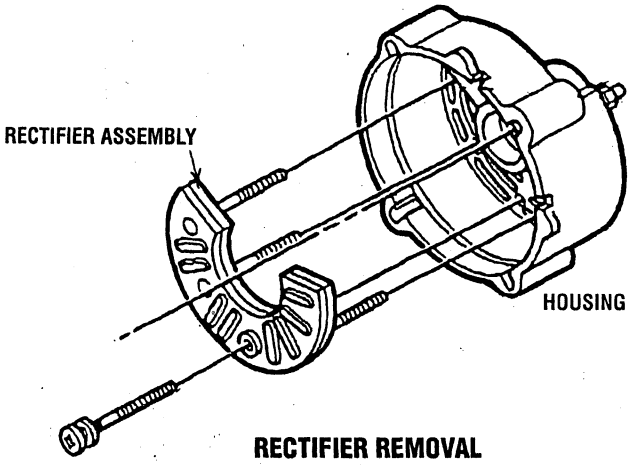


NOTE: *If the bearing is removed from the housing, a new bearing must be installed.*

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.

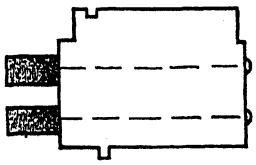


RECTIFIER REMOVAL

CLEAN AND TEST ALTERNATOR COMPONENTS

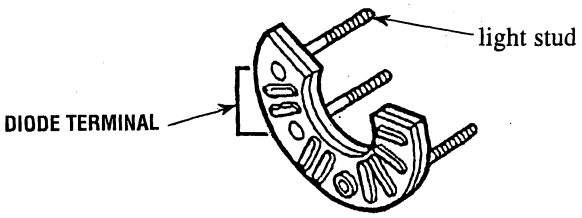
1. Inspect and test the brush/regulator assembly. The brush set may be reused if the brushes are 1/4 in. (6 mm) or longer. The brushes must not be oil soaked, cracked or grooved.

   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.



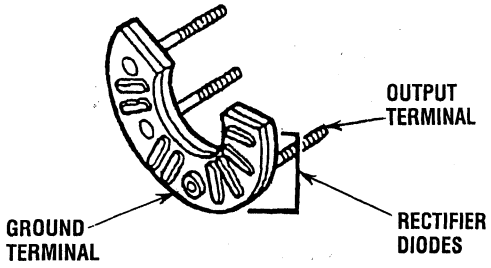
TESTING BRUSH ASSEMBLY

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.

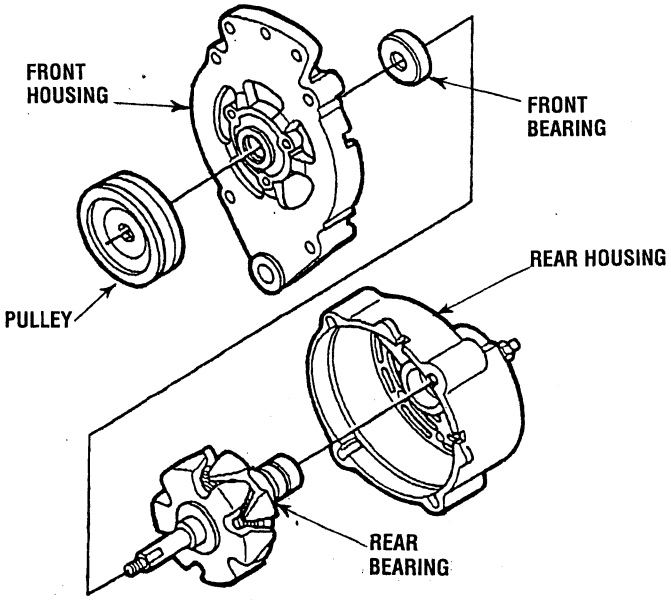


   b. Reverse the tester leads and repeat Step a.
   c. Continuity should exist in only one direction and all diodes should check alike.
   d. Perform the same continuity checks between the three terminals and strap ground terminal. This should show continuity in only one direction through the diodes and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

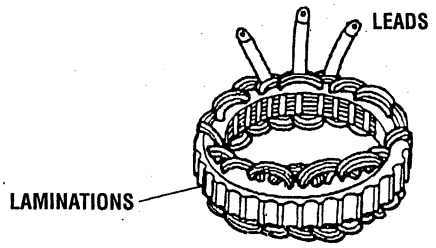
4. Clean and inspect the front and rear housings:
   a. Inspect the rear housing for cracks or breaks in the casting, stripped threads or a damaged bearing bore. Replace the housing if any of these conditions exist.
   b. Inspect the front housing for cracks, stripped or damaged threads in the adjusting 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.

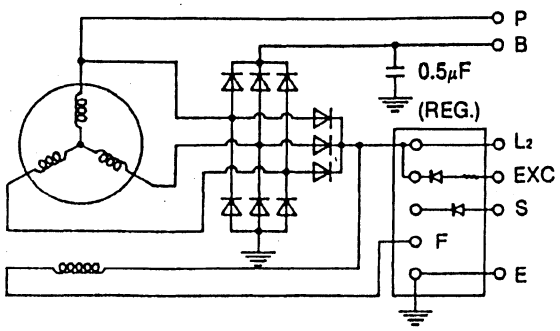


7. Test the stator windings as follows:
   a. Using an ohmmeter or test lamp, check for continuity between all three leads (1, 2, and 3). A low ohm reading or lit test lamp should be observed.



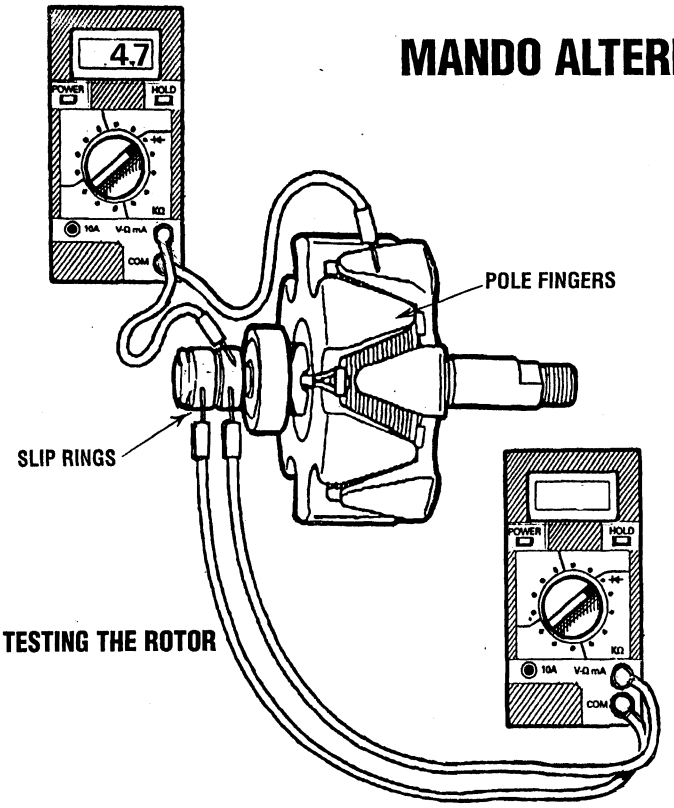
   b. Check the resistance from each lead (1, 2, and 3) to the laminations (4). There should be no continuity if the insulation is good.
   c. Inspect the stator windings for signs of discoloration. A discolored winding should be replaced.
   d. If a winding shows a high resistance or an open circuit between 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.



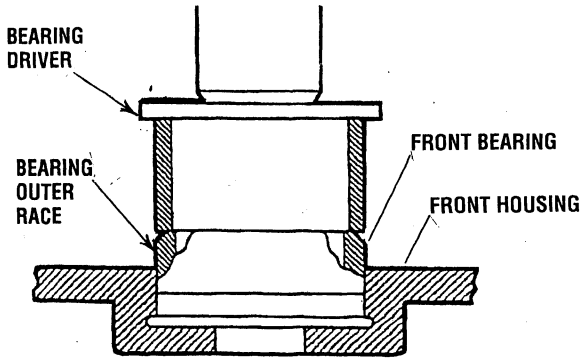
INTERNAL CIRCUIT WIRING

MANDO ALTERNATOR SERVICE

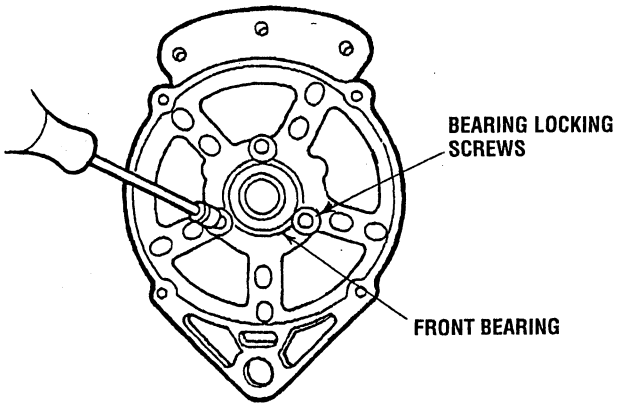


ASSEMBLE ALTERNATOR

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)

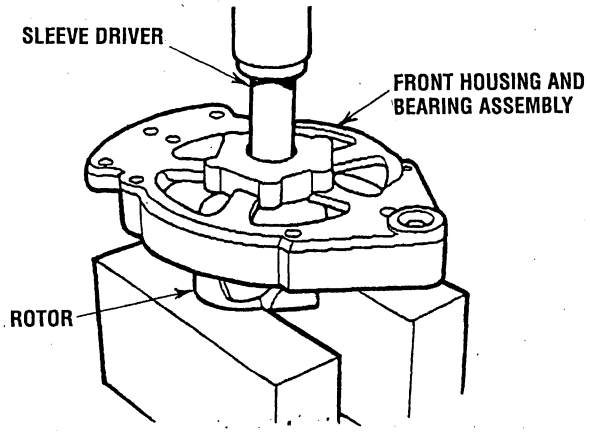


FRONT BEARING ASSEMBLY



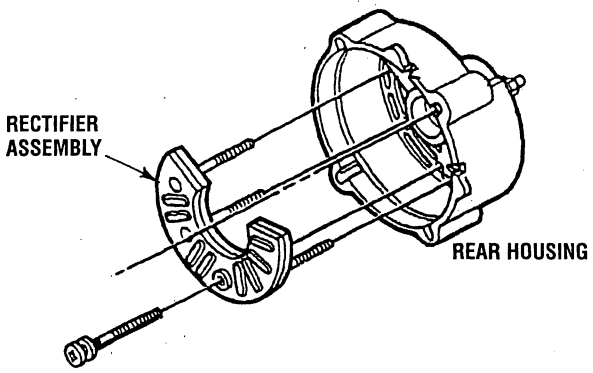
ASSEMBLING THE BEARINGS

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

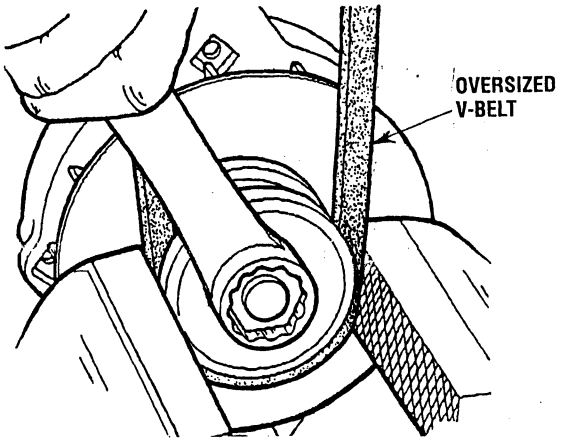
4. Install the rectifier assembly into the rear housing.
5. Insert the Phillips screw and tighten it.



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.

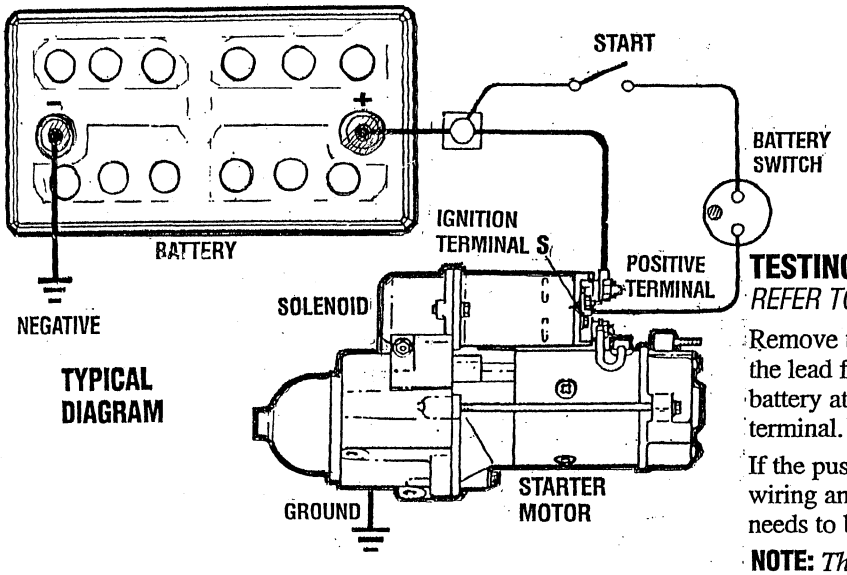
INSTALL ALTERNATOR

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

STARTER MOTOR



TESTING WITH AN ELECTRICAL JUMPER

REFER TO THE ILLUSTRATION BELOW

Remove the **Terminal S** wire from the ignition and attach the lead from the electrical jumper. Leave the **+ positive** battery attached and clip the jumper aligater fitting to that terminal. The push button should crank the starter.

If the push button fails to crank the starter and the batteries wiring and wired connections have been checked, the starter needs to be removed for service.

NOTE: *This electrical jumper can be **fabricated** using a standard push button and two connecting wires.*

TROUBLESHOOTING/INSPECTION

Prior to testing, make certain the ships batteries are at full charge and that the starting system wiring connections (terminals) are clean and tight. Pay particular attention to the ground wire connections on the engine block.

To check the wiring, try cranking the starter for a few cycles, not more than three crank cycles at a time, then run your hand along the wires and terminals looking for warm spots that indicate resistance. Repair or replace any trouble spots.

Using a multimeter, test the voltage between the positive terminal stud on the start solenoid and the engine block (ground).

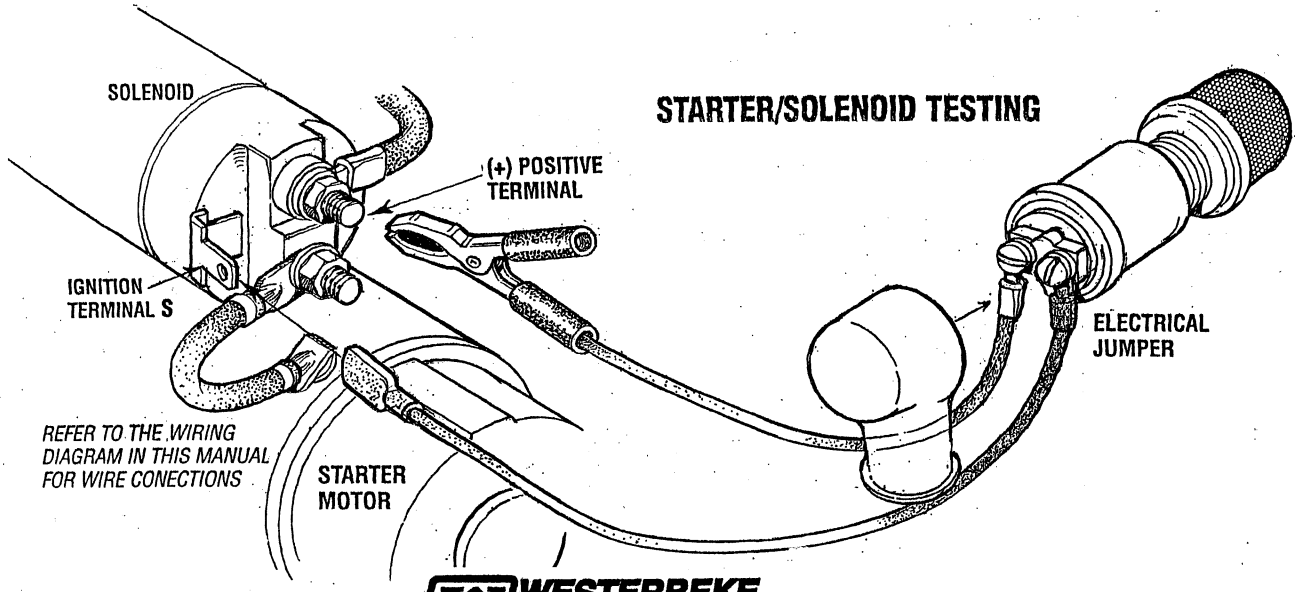
If you read 12 volts, the starter is faulty.

If nothing happens at all, the solenoid is not getting current. Check the battery and inspect the wiring connections. It is also possible that the solenoid is defective.

TO REMOVE FOR SERVICE

1. Turn off the DC battery switch.
2. If necessary, remove any components to gain full access to the starter motor.
3. Label and disconnect the wiring from the starter. (Do not allow wires to touch, tape over the terminals).
4. Remove the starter mounting bolts.
5. Remove the starter from the engine. In some cases the starter will have to be turned to a different angle to clear obstructions,

NOTE: *WESTERBEKE uses an ignition proof starter approved by the U.S. Coast Guard. If it is necessary to replace the starter, purchase a new starter from a WESTERBELE dealer/distributor.*



STARTER MOTOR

BENCH TESTING THE STARTER MOTOR

When bench testing the starter motor, make certain it is securely held in place.

Motor Test

1. Using a fully charged battery, run a jumper from the batteries (+) post to the connecting lead that has been removed from terminal **C**..
2. Connect another jumper from the battery (-) post to the starter motor's housing (momentarily). If the motor fails to run, the motor is the problem.

DISASSEMBLING THE MOTOR

NOTE: *Closed type bearings are used on this series of generators. During the dismantling, be careful not to damage the protective cover rings.*

To prevent damage to the rotor and stator windings while removing the rotor, place cardboard between the packages and remove the rotor by pulling it out gentle.

Magnetic Switch Test

1. Connect a jumper lead from the starter's **S** terminal to the battery (+) post.
2. Connect a jumper from the battery (-) post to the starter motor's **C** terminal (momentarily).
3. If the pinion gear fails to pop out, the problem is with the magnetic switch.

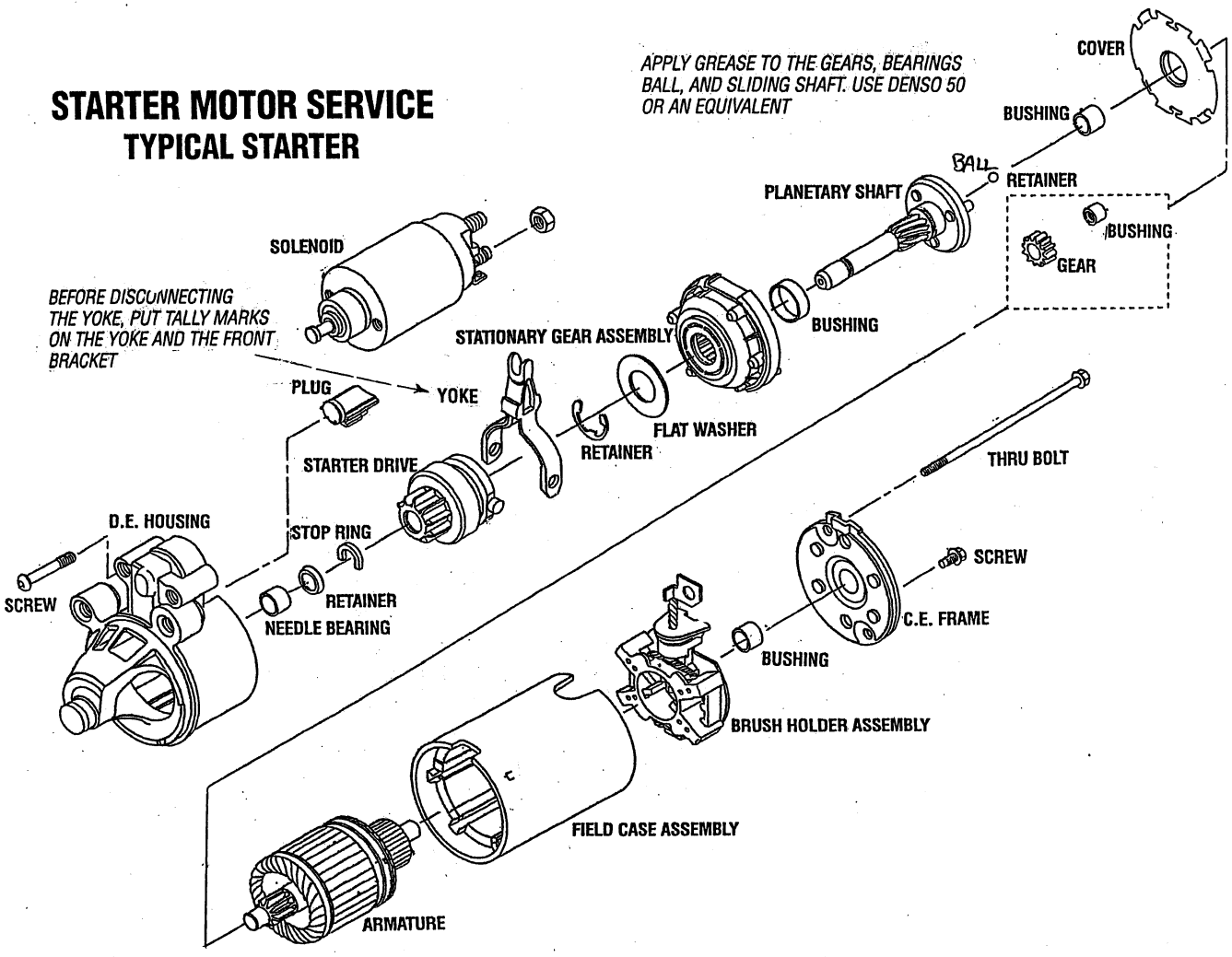
DISASSEMBLING THE MAGNETIC SWITCH

1. Remove the drive end frame mounting screws.
2. Disassemble carefully the overrunning clutch, ball, spring, gears, rollers, and retainer.
3. Remove the plunger end cover screws and take out the plunger.

NOTE: *When reassembling, apply grease to all the gear teeth, the overrunning clutch and the ball.*

TIGHTENING TORQUE B TERMINAL NUT	**5.9 - 11.8 Nm**
	4.3 - 8.7 ft-lb

STARTER MOTOR SERVICE
TYPICAL STARTER



STARTER MOTOR SERVICE

BRUSH WEAR

1. If the contact face of the brush is dirty or dusty, clean it with emery paper.
2. Measure the brush length (A) with vemler calipers.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

BRUSH LENGTH (A) 18.0MM (0.7086IN)
LIMIT 11.0MM (0.4331IN)

ARMATURE COIL

1. Check the continuity across the commutator and armature coil core with an ohmmeter.
2. If it conducts, replace the armature.
3. Check the continuity across the segments of the commutator with an ohmmeter.
4. If it does not conduct, replace the armature.

RESISTANCE: COMMUTATOR ARMATURE COIL - INFINITY
COMMUTATOR SEGMENT - 0Ω

BRUSH HOLDER

1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

RESISTANCE: BRUSH HOLDER TO HOLDER SUPPORT - INFINITY

FIELD COIL

1. Check the continuity across the lead (1) and brush (2) with an ohmmeter.
2. If it does not conduct, replace the yoke assembly.
3. Check the continuity across the brush (2) and yoke (3) with an ohmmeter.
4. If it conducts, replace the yoke assembly.

RESISTANCE: LEAD (1) - BRUSH (2) 0Ω / BRUSH (2) - YOKE (3) - INFINITY

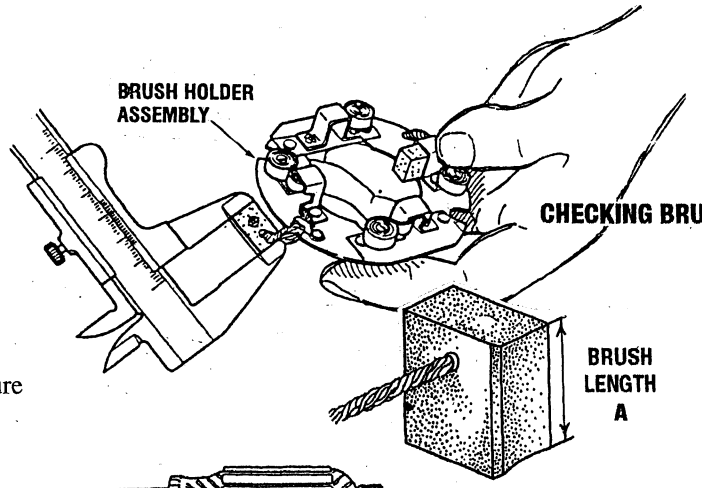
BEARING

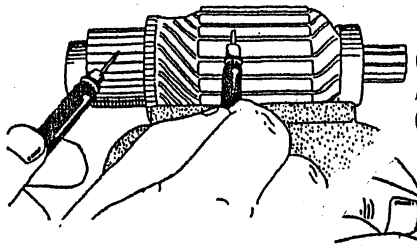
1. Check the bearing for smooth rotation.
2. If it does not rotate smoothly, replace it.

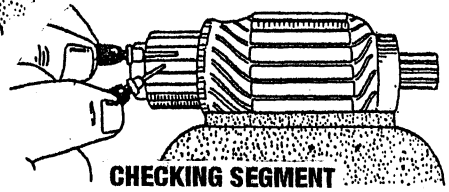
STATOR

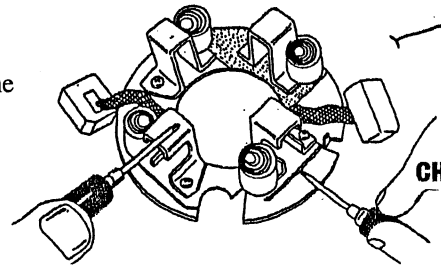
1. Measure the resistance across each lead of the stator coil with an ohmmeter.
2. If the measurement is not within factory specifications, replace it.
3. Check the continuity across each stator coil lead and core with an ohmmeter.
4. If infinity in not indicated, replace it.

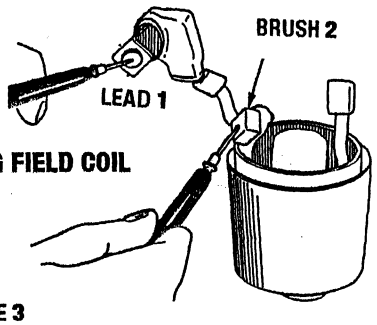
RESISTANCE: LESS THAN 1.0Ω

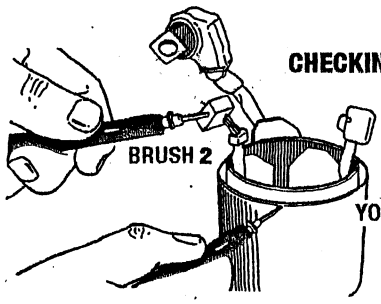


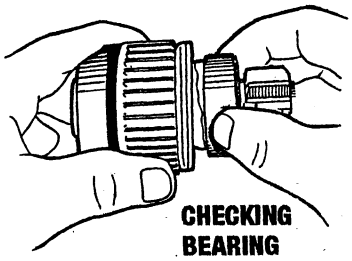


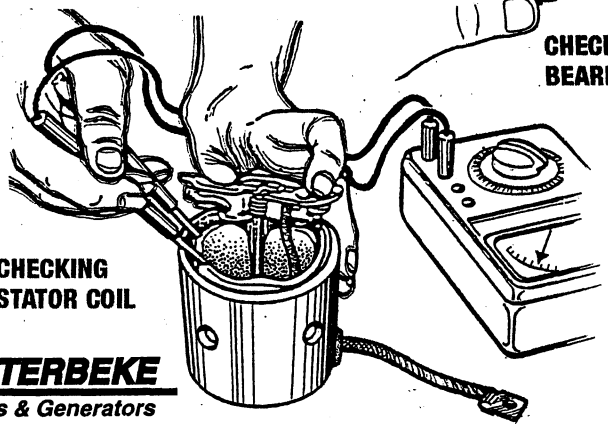








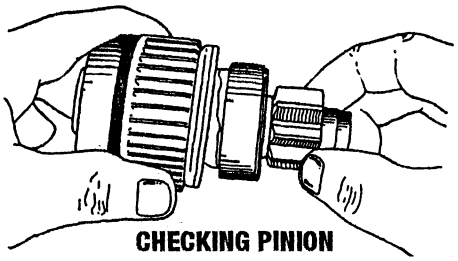




STARTER MOTOR SERVICE

OVER-RUNNING CLUTCH

1. Inspect the pinion gear for wear or damage. If there is any defect, replace the over-running clutch assembly.
2. Check that the pinion gear turns freely and smoothly in the over-running direction and does not slip in the cranking direction. If the pinion slips or fails to rotate in both directions, replace the over-running clutch assembly.

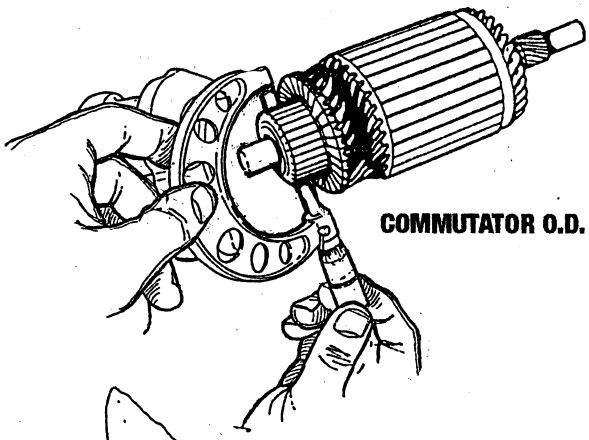


CHECKING PINION

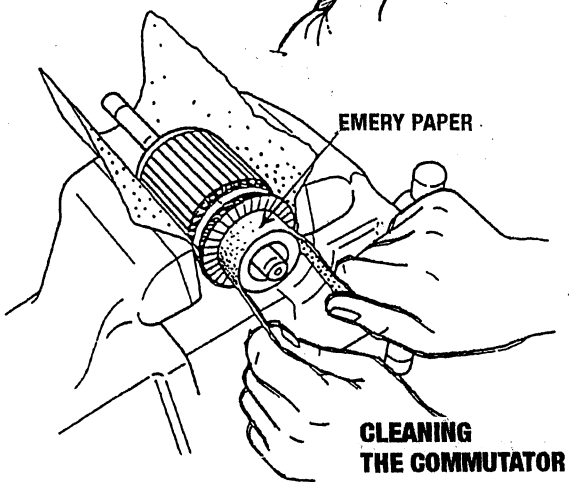
COMMUTATOR AND MICA

1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the O.D. exceeds the allowable limit, correct the commutator on a lathe to the factory specifications.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct it with a saw blade and chamfer the segment edges.

COMMUTATOR O.D. - 32MM (1.2598IN)
LIMIT - 31.4MM (1.2362IN)
MICA UNDERCUT - 0.50 - 0.80MM (0.0197 - 0.0315IN)
LIMIT - 0.20MM (0.0079IN)

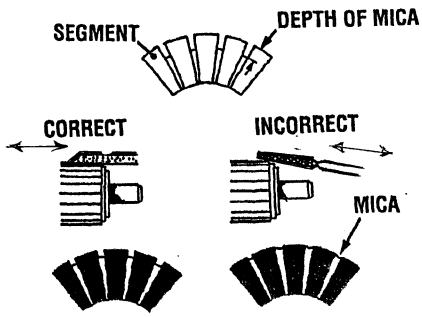


COMMUTATOR O.D.



EMERY PAPER

CLEANING THE COMMUTATOR



CHECKING MICA

⚠ CAUTION: ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all 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.***

65B-FOUR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Aspiration	Naturally aspirated
Compression Ratio	22.6:1
Governor	Mechanical
Combustion Chamber	Swirl type
Bore & Stroke	98 x 120 mm (3.86 x 4.72 inches)
Piston Displacement	3.62 liters (220.9 cubic inches)
Hp @ 2600 RPM	66
Firing Order	1 - 3 - 4 - 2
Inclination	Continuous 14° Temporary 25° (not to exceed 10 min.)
Weight (dry)	730 lbs (331 kgs)

TUNE-UP SPECIFICATIONS

Compression Pressure (allowable limit)	626 psi (44 kgf/cm²) at 250 rpm 472 psi (30.5 kgf/cm²) at 250 rpm
Variation between cylinders	10% or less
Injection Timing	9° BTDC
Engine Speed	Idle: 800 - 1000 Cruise: 1800 - 2200 Max: 2550 - 2600
Valve Clearance (engine cold)	0.23 to 0.27 mm (0.00091 to 0.0106 inches)
Injector Pressure	1991 to 2134 psi (140 to 150 kgf/cm²)
Valve Timing	Intake Opens 14° BTDC Intake Closes 36° ABDC Exhaust Opens 45° BBDC Exhaust Closes 17° ATDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt DC (-) negative ground
Battery Capacity	800-1000 CCA
DC Charging Alternator	60 Amp rated, belt-driven
Starter	2.5Kw, 12VDC direct drive
Starting Aid	Glow plugs, sheathed type
DC Cranking Current	400 - 600 Amps (includes glow plugs)

NOTE: *Engine Idle Speed must be adjusted with the engine at normal operating temperature. Idle speed should be adjusted in the range specified where it operates the smoothest.*
Different model transmisions will affect engine idle speeds.

COOLING SYSTEM

General	Fresh water-cooled engine block, thermostatically-controlled with heat exchanger.
Operating Temperature	160 - 180° F (71 - 82° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
Raw Water Flow (at 2600 rpm	17.0 US gpm (41.6 lpm)
System Capacity (fresh water)	16 qts (15.1 liters)
Air Flow Engine Cooling	150 cfm (4.2 cmm)

NOTE: *The pressure differential between the outside of the engine compartment verses the inside of the engine compartment should not exceed 2 inches of water (51mm) at full open throttle (measure with a manometer)*

FUEL SYSTEM

General	Open flow, self bleeding, self priming (electromagnetic fuel pump)
Fuel	No. 2-D (cetane rating of #45 or higher) SAE J313 Grade of diesel fuel according to ASTM D975
Fuel Injection Pump	Bosch type mini-pump
Fuel Injection Timing	9° BTDC
Injector Nozzle	Bosch throttle type
Fuel Filter	Spin-on type
Air Intake	Metal screen/intake silencer box
Air Flow Combustion	165 cfm (4.7 cmm)

LUBRICATION SYSTEM

General	Pressure fed system
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (includes oil filter)	14 U.S. qts (13.2 liters)
Operating Oil Pressure (engine hot)	28 - 57 psi (2.0 - 4.0 kg/cm²)
Oil Grade	API Catagory CF, CF-4, CG-4, CH-4 or CI-4 or better SAE 10W-40, 15W-40

EXHAUST SYSTEM

Exhaust Elbow	45° elbow
Exhaust Hose Size	3" I.D. (76.2 mm)

SPECIFICATIONS 33.0 / 26.0 EDEA
SPECIFICATIONS 28.5/23.5 KW EDEA

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism (48 hp at 1800 rpm maximum)
Aspiration	Naturally aspirated
Compression Ratio	22.6:1
Governor	Electronic
Combustion Chamber	Swirl type
Bore & Stroke	98 x 120 mm (3.86 x 4.72 iinches)
Piston Displacement	3.62 litre (220.9 cubic inches)
Firing Order	1 - 3 - 4 - 2
Inclination	Continuous 20° Temporary 30° (not to exceed 10 min.)
Weight (dry)	1135 lbs (514.8 kgs)

TUNE-UP SPECIFICATIONS

Compression Pressure (allowable limit)	626 psi (44 kgf/cm²) at 250 rpm 472 psi (30.5 kgf/cm²) at 250 rpm
Variation between cylinders	10% or less
Injection Timing	9° BTDC
Engine Speed	1800 rpm 60 Hertz 1500 rpm 50 Hertz
Valve Clearance (engine cold)	0.23 to 0.27 mm (0.00091 to 0.0106 inches)
Injector Pressure	1991 to 2134 psi (140 to 150 kgf/cm²)
Valve Timing	Intake Opens 14° BTDC Intake Closes 36° ABDC Exhaust Opens 45° BBDC Exhaust Closes 17° ATDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt DC (-) negative ground
Battery Capacity	800-1000 CCA
DC Charging Alternator	50 Amp rated, belt-driven
Starter	2.5Kw, 12VDC direct drive
Starting Aid	Glow plugs, sheathed type
DC Cranking Current	400-60 Amps

LUBRICATION SYSTEM

General	Pressure fed system with external relief valve
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (includes oil filter)	14.0 U.S. qts (13.2 liters)
Operating Oil Pressure (engine hot)	28 - 57 psi (2.0 - 4.0 kg/cm²)
Oil Grade	API Specification CF, CF-4, CG-4 or CI-4 SAE 10W-40, 15W-40

COOLING SYSTEM

General	Fresh water-cooled engine block, thermostatically-controlled with heat exchanger.
Operating Temperature	160 - 180° F (71 - 82° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
System Capacity (fresh water)	16 qts (15.1 liters)
Raw Water Flow Rate (at 1800 rpm)	11.0 gpm (41.6 lpm)

FUEL SYSTEM

General	Open flow, self bleeding, self priming (electromagnetic fuel pump)
Fuel	No. 2-D (Cetane rating of #45 or higher) SAE J313. Grade of diesel fuel according to ASTM D975
Fuel Injection Pump	Bosch type mini-pump
Fuel Injection Timing	9° BTDC
Injector Nozzle	Bosch throttle type
Fuel Filter	Spin-on type
Air Intake	Metal screen/intake silencer box
Air Flow Combustion	105 cfm (3.0 cmm)

GENERATOR COOLING

Air Requirements (generator cooling)	0.8 Power factor unit. 500 CFM (15.0 CMM)
NOTE: *Increase cooling air flow 15% for slower turning 50hz units.*	
Generator Compartment Ambient Temperature	122° F (50° C) maximum **NOTE:** *Forced ventilation should be provided to maintain gererator compartment temperature below 122° F (50 °C).*

AC GENERATOR

General - 3 Phase	Brushless, four pole revolving field, sealed lubricated single bearing design. 12 wire reconnectable with solid state voltage regulator.
Single Phase	Reconnectable to Double Delta
Voltage - 3 Phase	Reference conection chart and AC voltages (multiple)
Voltage - Single Phase	120 or 120/240 volts 60 Hz 115/230 volts 50 Hz
Voltage Regulation	+ or - 2% no load to full rated amperage output
Frequency Regulation	+ or - .3 hz (.5%) no load to full rated amperage output

NOTE: ***There is a AC BLOCK HEATER available for the 33.0Kw and the 28.5KW in 240V and 120V. Contact your WESTERBEKE dealer for more information.***

SPECIFICATIONS 33.0/26.0KW EDEA

AC GENERATOR (Single Phase)

Single Phase	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable (Double Delta for 120/240 volts, 60hz) (Series Star for 230 volts, 50hz) with solid state voltage regulator.	
Voltage	120 or 120/240 Volts - 60 Hertz 230 Volts - 50 Hertz.	
Voltage regulation:	±2% no load to full load.	
Frequency regulation:	.3 Hertz (.5%) no load to full load.	
Rating (Volts AC)		
60 Hertz (1800 rpm)	120 Volts 120/240 Volts	275 Amps 275/137.5 Amps
50 Hertz (1500 rpm)	230 Volts	113 Amps
Generator Cooling Air Requirements (Single and 3 Phase)	500 cfm (14.1 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C)*	

AC GENERATOR (3 Phase)

Three Phase	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable Solid state voltage regulator.	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 277 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	99.3 Amps 49.6 Amps 86.0 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	46.9 Amps 81.6 Amps
Generator Cooling Air Requirements (60hz) at 1800 rpm	500 cfm (14.1 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C)*	

SPECIFICATIONS 26.0/21.0 EDEAR

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism (48 hp at 1800 rpm maximum)
Aspiration	Naturally aspirated
Compression Ratio	22.6:1
Governor	Electronic
Combustion Chamber	Swirl type
Bore & Stroke	98 x 120 mm (3.86 x 4.72 iinches)
Piston Displacement	3.62 litre (220.9 cubic inches)
Firing Order	1 - 3 - 4 - 2
Inclination	Continuous 20° Temporary 30° (not to exceed 10 min.)
Weight (dry)	1196 lbs (542.5 kgs)

TUNE-UP SPECIFICATIONS

Compression Pressure (allowable limit)	626 psi (44 kgf/cm²) at 250 rpm 472 psi (30.5 kgf/cm²) at 250 rpm
Variation between cylinders	10% or less
Injection Timing	9° BTDC
Engine Speed	1800 rpm 60 Hertz 1500 rpm 50 Hertz
Valve Clearance (engine cold)	0.23 to 0.27 mm (0.00091 to 0.0106 inches)
Injector Pressure	1991 to 2134 psi (140 to 150 kgf/cm²)
Valve Timing	Intake Opens 14° BTDC Intake Closes 36° ABDC Exhaust Opens 45° BBDC Exhaust Closes 17° ATDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt DC (-) negative ground
Battery Capacity	800-1000 CCA
DC Charging Alternator	50 Amp rated, belt-driven
Starter	2.5Kw, 12VDC direct drive
Starting Aid	Glow plugs, sheathed type
DC Cranking Current	400-600 Amps

LUBRICATION SYSTEM

General	Pressure fed system with external relief valve
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (includes oil filter)	14.0 U.S. qts (13.2 liters)
Operating Oil Pressure (engine hot)	28 - 57 psi (2.0 - 4.0 kg/cm²)
Oil Grade	API Specification CF, CG-4, CF-4 or CI-4 SAE 10W-40, 15W-40

COOLING SYSTEM

General	Fresh water-cooled engine block, thermostatically-controlled with radiator.
Operating Temperature	160 - 180° F (71 - 82° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
System Capacity (fresh water)	17 qts (16.1 liters)

FUEL SYSTEM

General	Open flow, self bleeding, self priming (electromagnetic fuel pump)
Fuel	No. 2-D (Cetane rating of #45 or higher) SAE J313. Grade of diesel fuel according to ASTM D975
Fuel Injection Pump	Bosch type mini-pump
Fuel Injection Timing	9° BTDC
Injector Nozzle	Bosch throttle type
Fuel Filter	Spin-on type
Air Intake	Metal screen/intake silencer box
Air Flow Combustion	115 cfm (3.2 cmm)

GENERATOR COOLING

Air Requirements (generator cooling)	0.8 Power factor unit. 500 CFM (15.0 CMM)

NOTE: *Increase cooling air flow 15% for slower turning 50hz units.*

Generator Compartment Ambient Temperature	122° F (50° C) maximum **NOTE:** *Forced ventilation should be provided to maintain gererator compartment temperature below 122° F (50 °C).*

AC GENERATOR

General - 3 Phase	Brushless, four pole revolving field, sealed lubricated single bearing design. 12 wire reconnectable with solid state voltage regulator.
Single Phase	Reconnectable to Double Delta
Voltage - 3 Phase	Reference conection chart and AC voltages (multiple)
Voltage - Single Phase	120 or 120/240 volts 60 Hz 230 volts 50 Hz
Voltage Regulation	+ or - 2% no load to full rated amperage output
Frequency Regulation	+ or - .3 hz (.5%) no load to full rated amperage output

SPECIFICATIONS 28.5/23.5 KW EDEA

AC GENERATOR (Single Phase)

Single Phase	Brushless, six-pole, revolving field. Seal lubricated, single bearing design. 12 lead reconnectable, (Double Delta for 120/240 volts, 60hz.) (Series Star for 230 volts, 50hz) with solid state regulator.	
Voltage	120 or 120/240 volts - 60 hertz 230 Volts - 50 Hertz	
Voltage Regulation	±2% no load to full load.	
Frequency Regulation	.3 Hertz (.5%) no load to full load.	
Rating (Volts AC)		
60 Hz (1800 rpm)	120 volts 120/240 volts	237.5 amps 237.5/118.8 amps
50 Hz (1500 rpm)	230 volts	102.2 amps
Generator Cooling Air requirements (Single & 3 phase)	400 cfm (11.3 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm)*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C).*	

AC GENERATOR (3 Phase)

Three Phase	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable. Solid state voltage regulator.	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 277 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	85.8 Amps 49.2 Amps 74.3 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	42.4 Amps 73.8 Amps
Generator Cooling Air requirements (Single & 3 phase)	400 cfm (11.3 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm)*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C).*	

SPECIFICATIONS 26.0/21.0 EDEAR

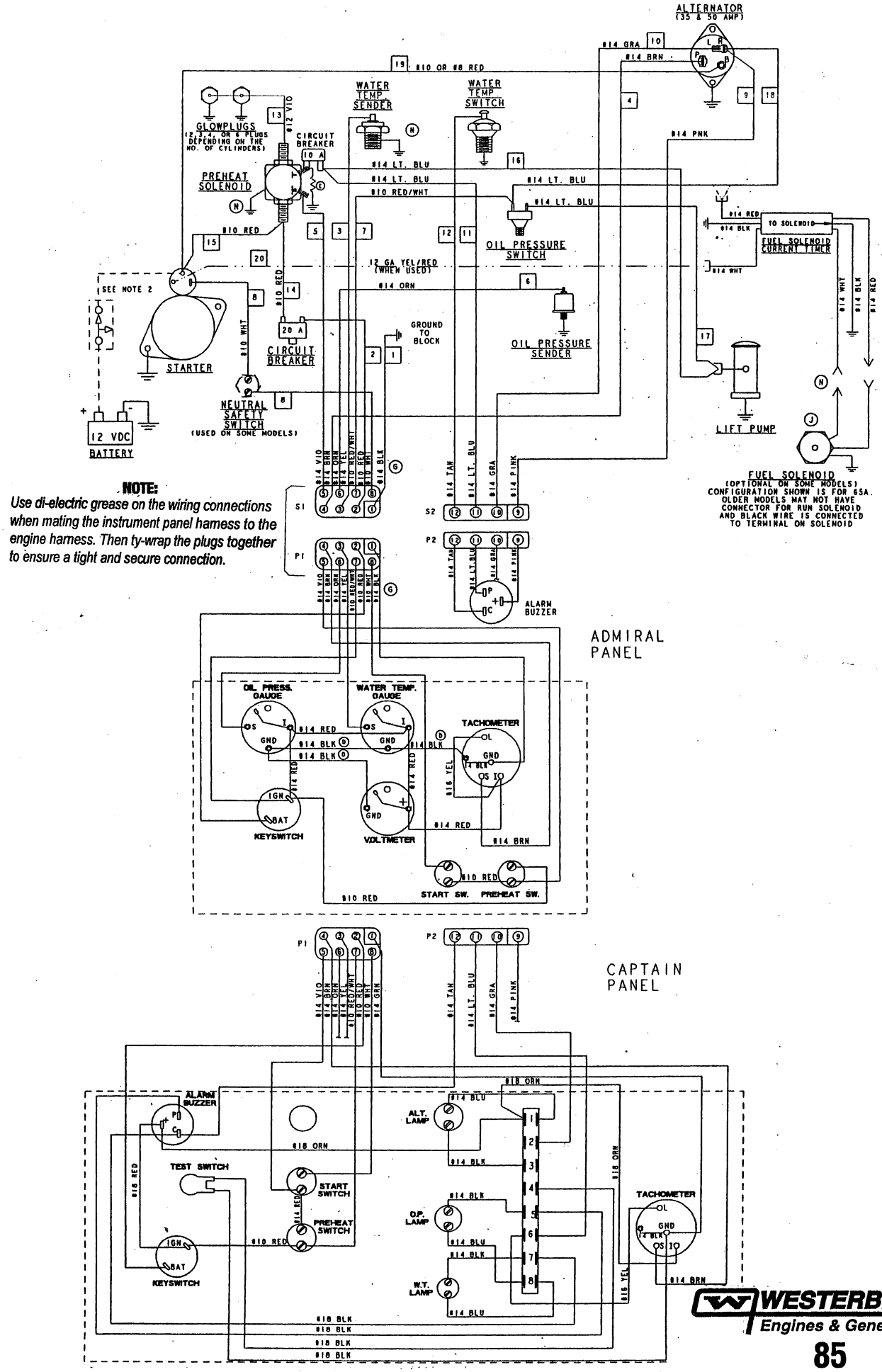
AC GENERATOR (Single Phase)

Single Phase	Brushless, six-pole, revolving field. Seal lubricated, single bearing design. 12 lead reconnectable, (Double Delta for 120/240 volts, 60hz.) (Series Star for 230 volts, 50hz) with solid state regulator.	
Voltage	120 or 120/240 volts - 60 hertz 230 Volts - 50 Hertz	
Voltage Regulation	±2% no load to full load.	
Frequency Regulation	.3 Hertz (.5%) no load to full load.	
Rating (Volts AC)		
60 Hz (1800 rpm)	120 volts 120/240 volts	216.6 amps 216.6/108.3 amps
50 Hz (1500 rpm)	230 volts	91.3 amps
Generator Cooling Air requirements (Single & 3 phase)	400 cfm (11.3 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm)*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C).*	

AC GENERATOR (3 Phase)

Three Phase	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable. Solid state voltage regulator.	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 277 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	78 Amps 39 Amps 67 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	37 Amps 66 Amps
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C)*	

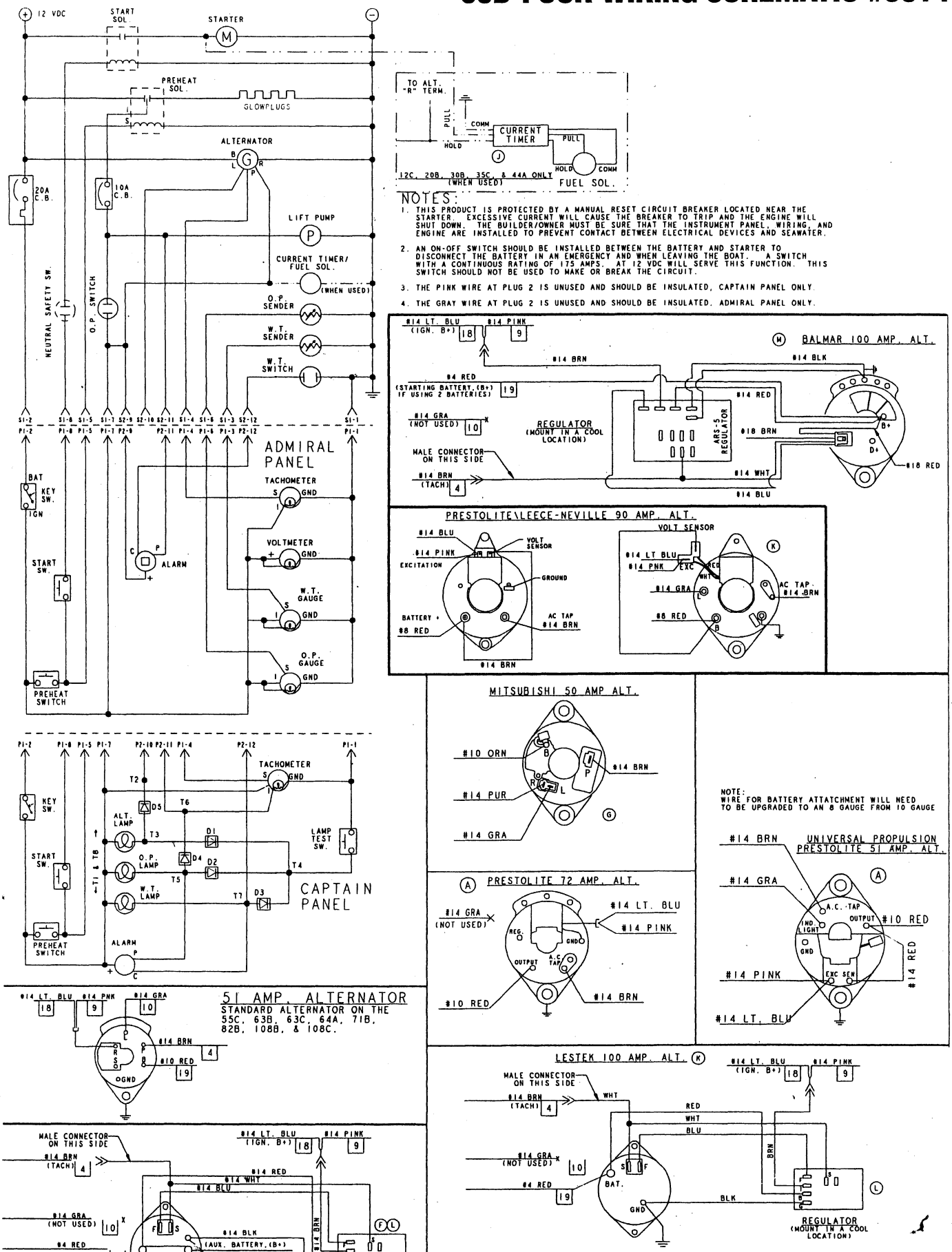
65B-FOUR WIRING DIAGRAM #39144



NOTE:

Use di-electric grease on the wiring connections when mating the instrument panel harness to the engine harness. Then ty-wrap the plugs together to ensure a tight and secure connection.

65B-FOUR WIRING SCHEMATIC #39144

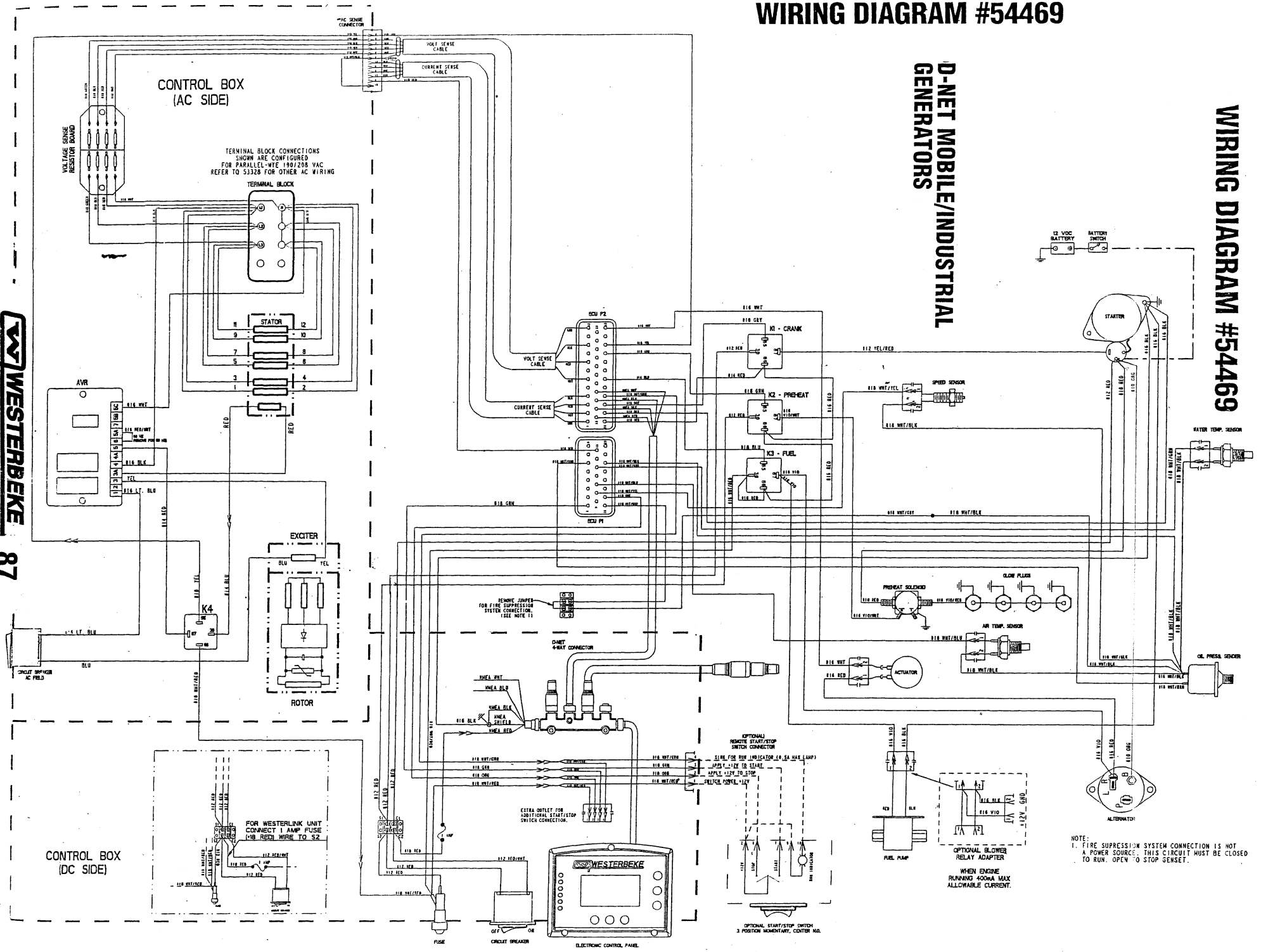


NOTES:

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.

WIRING DIAGRAM #54469

D-NET MOBILE/INDUSTRIAL GENERATORS

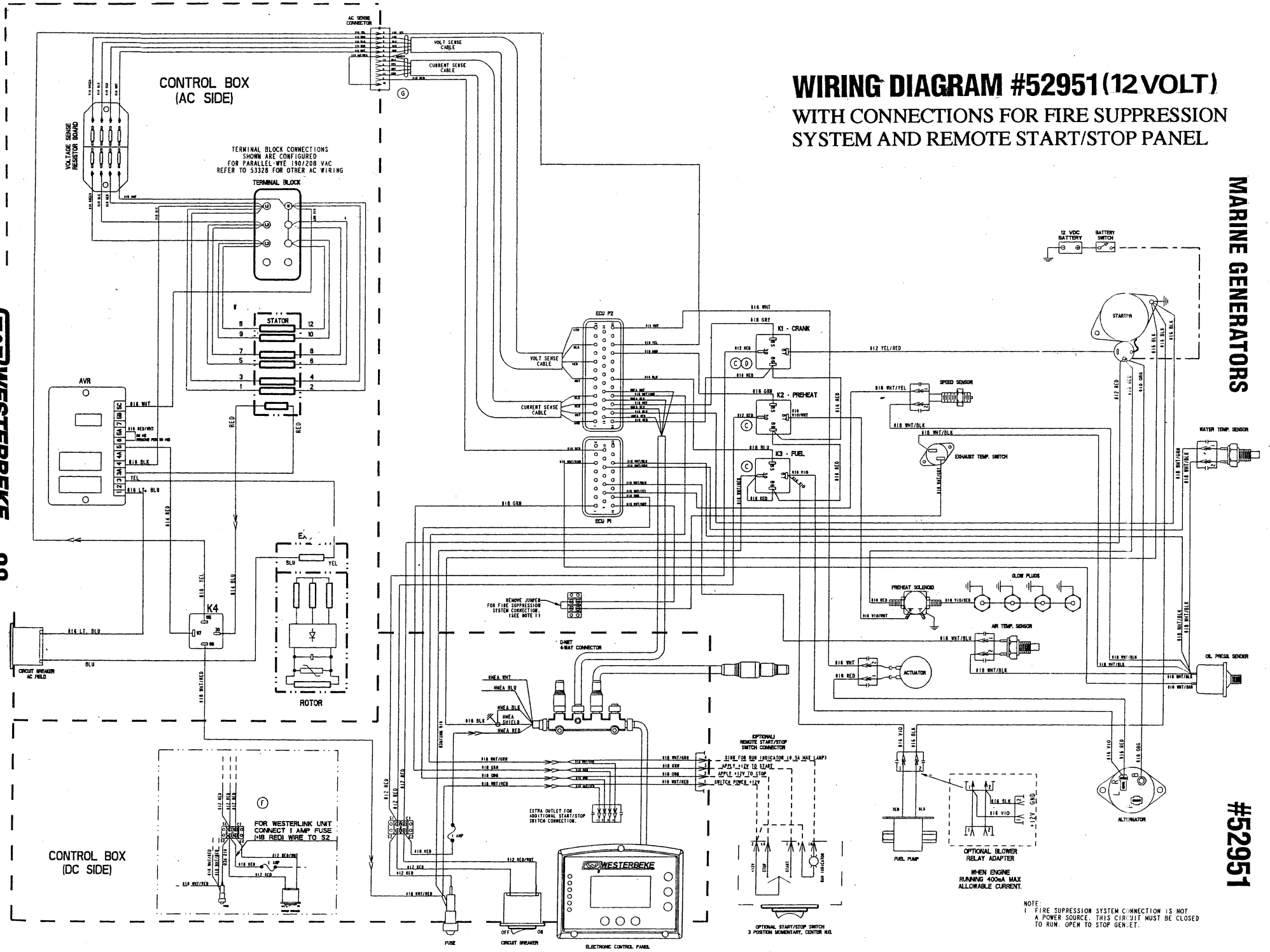


WIRING DIAGRAM #54469

WESTERBEKE Engines & Generators

WIRING DIAGRAM #52951 (12 VOLT)

WITH CONNECTIONS FOR FIRE SUPPRESSION SYSTEM AND REMOTE START/STOP PANEL



MARINE GENERATORS

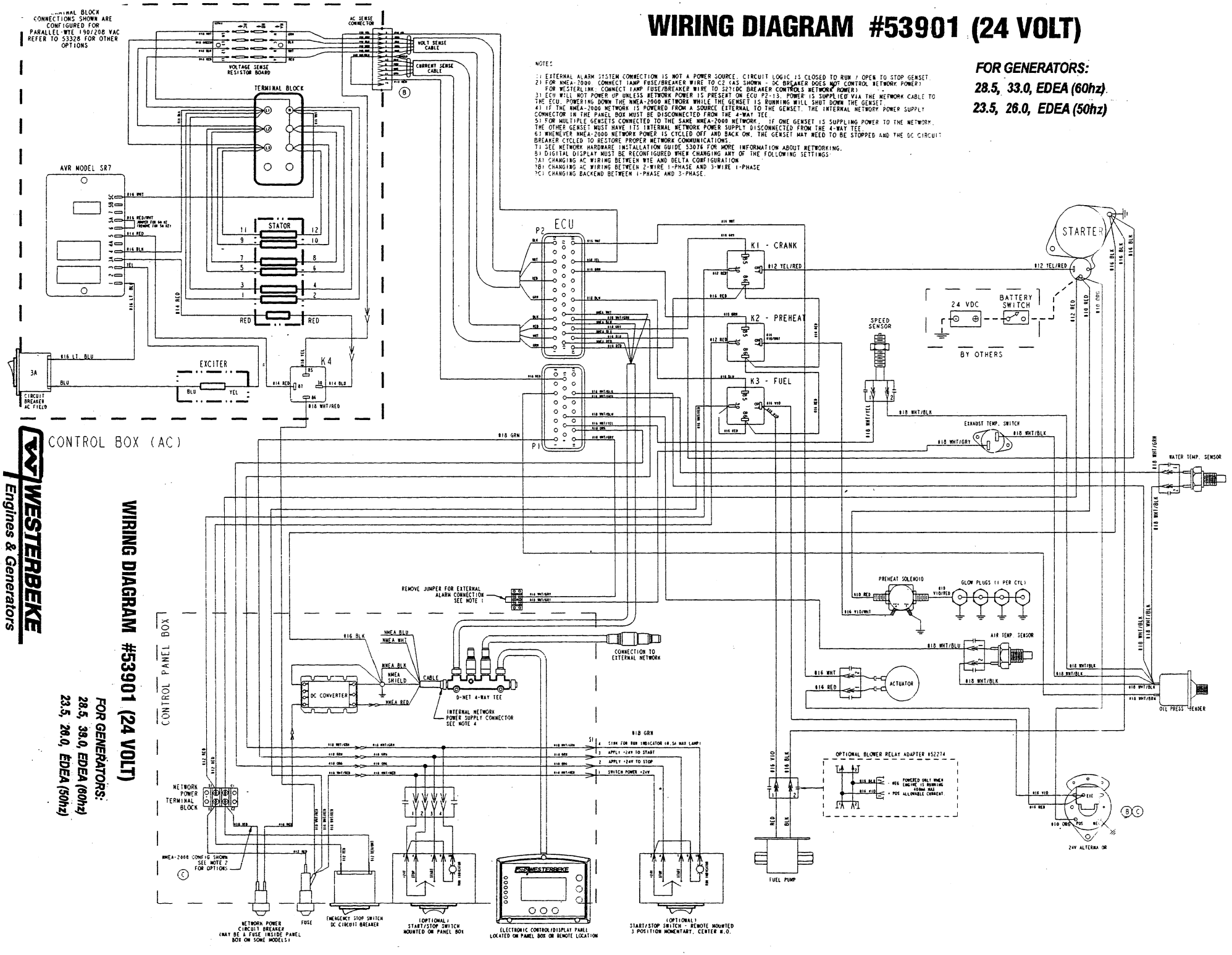
#52951

WESTERBEKE Engines & Generators

88

WIRING DIAGRAM #53901 (24 VOLT)

FOR GENERATORS:
28.5, 33.0, EDEA (60hz)
23.5, 26.0, EDEA (50hz)



NOTES:

1) EXTERNAL ALARM SYSTEM CONNECTION IS NOT A POWER SOURCE. CIRCUIT LOGIC IS CLOSED TO RUN / OPEN TO STOP GENSET.
2) FOR NMEA-2000 CONNECT 1AMP FUSE/BREAKER WIRE TO C2 (AS SHOWN - DC BREAKER DOES NOT CONTROL NETWORK POWER)
FOR WESTERLINK CONNECT 1AMP FUSE/BREAKER WIRE TO S27(DC BREAKER CONTROLS NETWORK POWER)
3) ECU WILL NOT POWER UP UNLESS NETWORK POWER IS PRESENT ON ECU P2-13. POWER IS SUPPLIED VIA THE NETWORK CABLE TO THE ECU. POWERING DOWN THE NMEA-2000 NETWORK WHILE THE GENSET IS RUNNING WILL SHUT DOWN THE GENSET.
4) IF THE NMEA-2000 NETWORK IS POWERED FROM A SOURCE EITERNAL TO THE GENSET, THE INTERNAL NETWORK POWER SUPPLY CONNECTOR IN THE PANEL BOX MUST BE DISCONNECTED FROM THE 4-WAY TEE.
5) FOR MULTIPLE GENSETS CONNECTED TO THE SAME NMEA-2000 NETWORK, IF ONE GENSET IS SUPPLING POWER TO THE NETWORK, THE OTHER GENSET MUST HAVE ITS INTERNAL NETWORK POWER SUPPLY DISCONNECTED FROM THE 4-WAY TEE.
6) WHENEVER NMEA-2000 NETWORK POWER IS CYCLED OFF AND BACK ON, THE GENSET MAY NEED TO BE STOPPED AND THE DC CIRCUIT BREAKER CYCLED TO RESTORE PROPER NETWORK COMMUNICATIONS.
7) SEE NETWORK HARDWARE INSTALLATION GUIDE 53076 FOR MORE INFORMATION ABOUT NETWORKING.
8) DIGITAL DISPLAY MUST BE RECONFIGURED WHEN CHANGING ANY OF THE FOLLOWING SETTINGS:
7A) CHANGING AC WIRING BETWEEN WYE AND DELTA CONFIGURATION
7B) CHANGING AC WIRING BETWEEN 2-WIRE 1-PHASE AND 3-WIRE 1-PHASE
7C) CHANGING BACKEND BETWEEN 1-PHASE AND 3-PHASE.

WIRING DIAGRAM #53901 (24 VOLT)

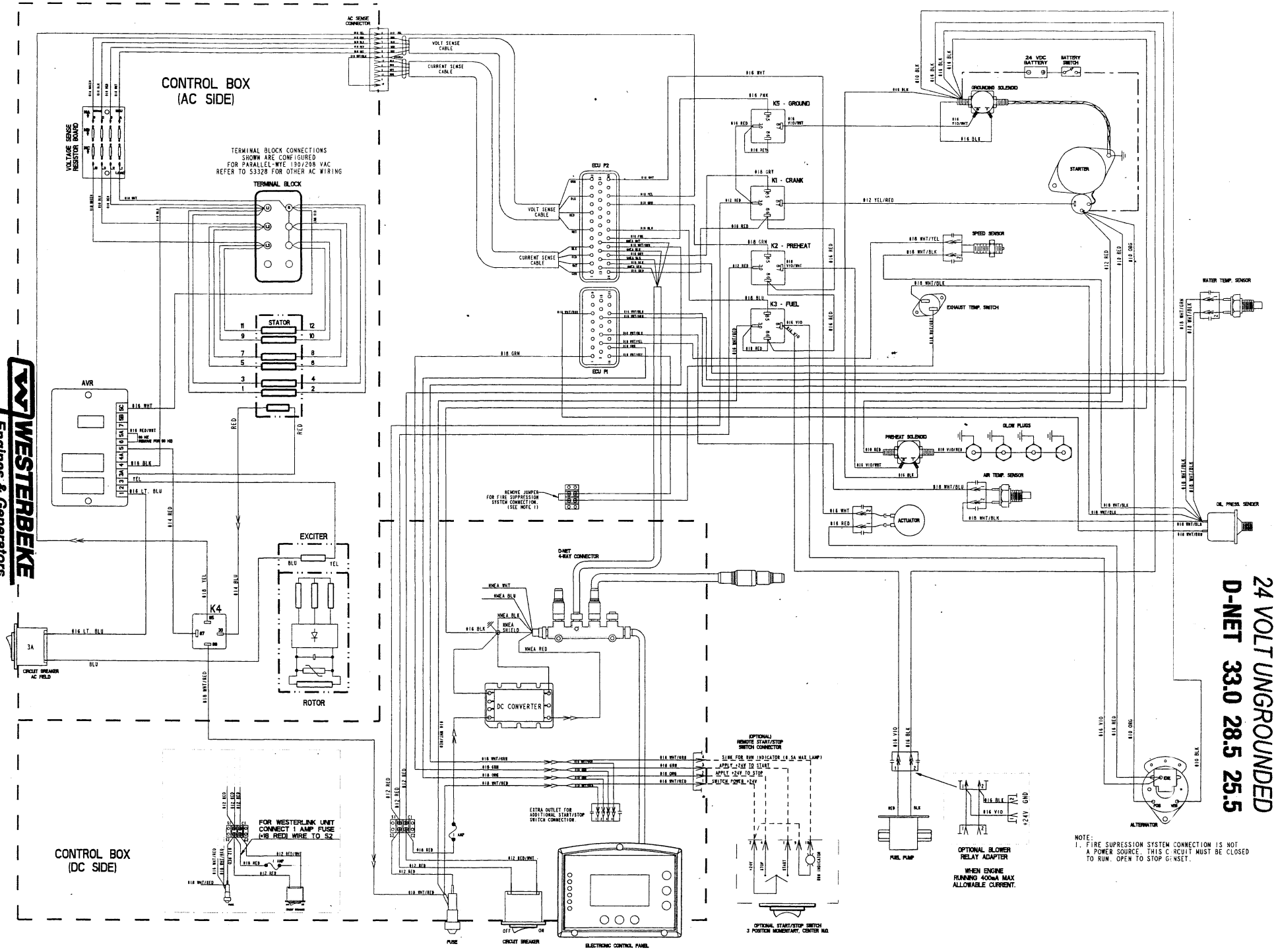
FOR GENERATORS:
28.5, 33.0, EDEA (60hz)
23.5, 26.0, EDEA (50hz)

WESTERBEKE
Engines & Generators

WIRING DIAGRAM #54533

24 VOLT UNGROUNDED

D-NET 33.0 28.5 25.5



NOTE:
1. FIRE SUPRESSION SYSTEM CONNECTION IS NOT A POWER SOURCE. THIS CIRCUIT MUST BE CLOSED TO RUN. OPEN TO STOP GENSET.

GENERATOR INFORMATION

USE OF ELECTRIC MOTORS

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

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

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

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

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

Required Operating Speed

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

Generator Frequency Adjustment

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

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

Therefore, to change the generator's frequency/voltage, the generator's drive engine's speed must be changed using the dipswitch on the ECU. The AC output configuration of the generator changed and the connections on the voltage sensing PC board changed.

Generator Maintenance

☐ Maintaining reasonable cleanliness is important. Connections of terminal boards and rectifiers may become corroded, and insulation surfaces may start conducting if salts, dust, engine exhaust, carbon, etc. are allowed to build up. Clogged ventilation openings may cause excessive heating and reduced life of windings.

☐ For unusually severe conditions, thin rust-inhibiting petroleum-base coatings, should be sprayed or brushed over all surfaces to reduce rusting and corrosion. Typical materials suggested are Daubert Chemical Co. "Non-Rust AC-410" and Ashland "Tectyle 506" or equivalent.

☐ The drive discs on single bearing generators should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.

☐ The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.

☐ Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. if side motion is detectable, bearings are wearing or wear on shaft of bearing socket outside bearing has occurred. Repair must be made quickly or major components will rub and cause major damage to generator.

Carbon Monoxide Detector

WESTERBEKE recommends mounting a carbon monoxide detector in the vesssel's living quarters. **Carbon Monoxide, even in small amounts, is deadly.**

The presence of carbon monoxide indicates an exhaust leak from the engine or generator or from the exhaust elbow/ exhaust hose, or that fumes from a nearby vessel are entering your boat.

If carbon monoxide is present, ventilate the area with clean air and correct the problem immediately!

ELECTRONIC FUEL INJECTION
EARLIER MODELS

DESCRIPTION

The ECU (Electronic Control Unit) is factory programmed and requires no adjustments by the generator operator. It controls all starting, operating and safety shutdown features on the engine. The Gain Pot is set at #50 midpoint for optimum system response.

Dipswitch #1 is used to charge the generator frequency. ON is for 50 hertz and OFF is for 60 hertz operation. The remaining switches #2, #3 and #4 service no function.

The vacant program connector is used by the factory to input the operating program into the ECU. This connector can be used with software to monitor the operation of the Low CO system. Contact your MD to obtain the software kit.

The electrical connections from the engine electrical harness are made to the ECU through two plug connections, one 23 pin and one 35 pin and may therefore vary in number according to the generator model. For further details, consult the engine circuit wiring diagram in this manual.

The ECU is normally set for operation at 60 Hz unless specified otherwise, and is internally configured for a 4 pole generator. If it is necessary to replace the ECU, make sure it is configured by label for the generator in use.

ECU ADJUSTMENTS

Stability Trim (Gain)

When changing engine speed, or if an engine hunting condition should occur, the gain pot may require adjustment. There is no specific set point for this adjustment and it is normally set to the middle of its range or to a point in its range which obtains optimal engine speed response without any tendency of hunting.

NOTE: *The Electrical Control Unit (ECU) for current generators is shown on the following page. Adjustments on this page are for earlier model generators.*

Setting/Changing Engine Speed

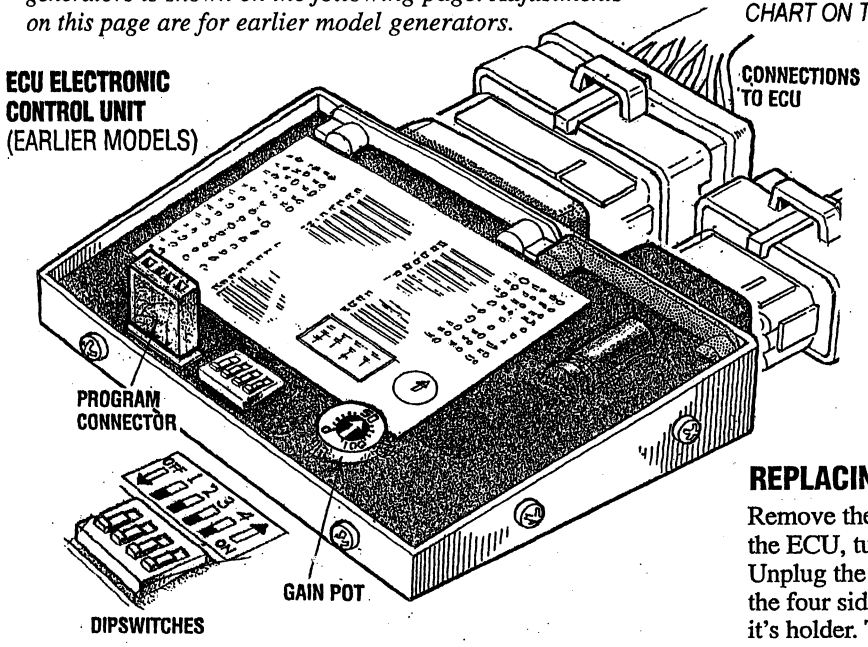
The engine speed can be set for operation at either 60Hz (1800 rpm) or 50Hz (1500 rpm) to correspond to the engine speeds for a 4 pole AC generator. :

1. Turn OFF the Control Box DC breaker and move the #1 dipswitch on the ECU of the OFF position for 60 hertz and ON for 50 hertz operation.
2. When changing the engine speed/generator hertz, a corresponding change is made to the AC voltage output configuration of the generator. The AC voltage output configurations are illustrated in this manual for both single and three phase models.*
3. The AC breaker in the control box will also need to be changed to correspond to the amperage rating change of the generator that this Hertz/AC voltage output configuration change will produce. The AC breakers are listed in this manual.
4. Once all of the above has been accomplished, the generators AC breaker should be turned OFF and the unit test run. Hertz and AC output should be monitored. The AC voltage (if needed) can be adjusted using the voltage pot on the regulator.
5. There is a GAIN adjustment on the ECU that usually gives the best system reaction to amperage load changes when set between #40-#60.

   NOTE: *A higher GAIN adjustment can induce unstable engine operation. In such cases, lessen the GAIN adjustment.*

With the test run performed and adjustments are made as needed, turn ON the AC breaker and load test the generator.

*REFER TO THE SENSING BOARD CONNECTION CHART ON THE FOLLOWING PAGE.



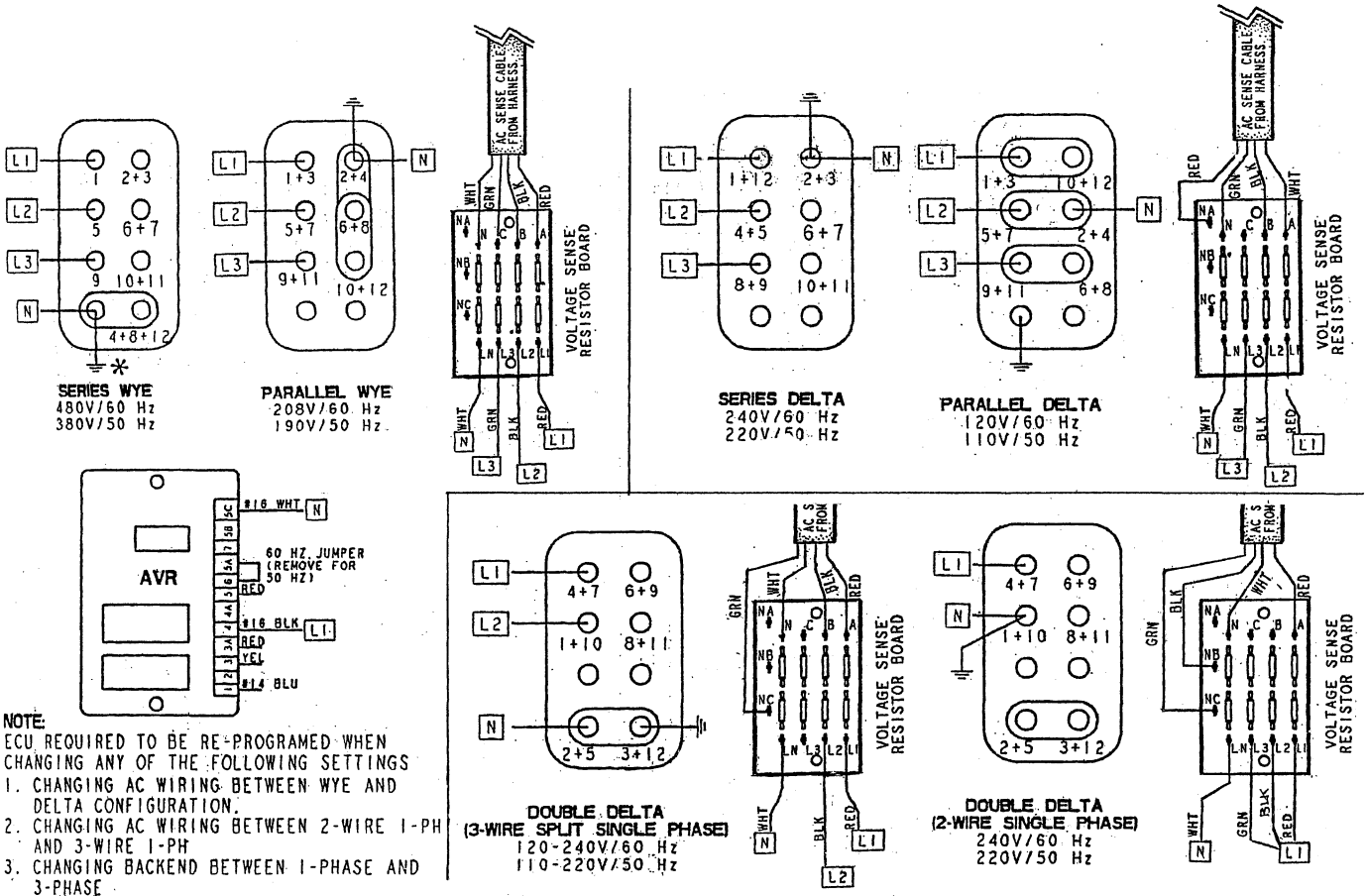
REPLACING THE ECU

Remove the control box cover. Before attempting to remove the ECU, turn OFF the 20 amp DC control panel breaker. Unplug the two engine harness connections. Then unscrew the four side screws securing the ECU and remove it from it's holder. To install a new ECU, reverse the procedure.

AC OUTPUT CONFIGURATIONS

VOLTAGE SENSING BOARD CONNECTIONS

Single and Three phase



NOTE:
ECU REQUIRED TO BE RE-PROGRAMED WHEN CHANGING ANY OF THE FOLLOWING SETTINGS

1. CHANGING AC WIRING BETWEEN WYE AND DELTA CONFIGURATION.
2. CHANGING AC WIRING BETWEEN 2-WIRE 1-PH AND 3-WIRE 1-PH
3. CHANGING BACKEND BETWEEN 1-PHASE AND 3-PHASE

*** connect AC bond wire if required by local regulation**

ELECTRONIC CONTROL UNIT (ECU)
CURRENT MODELS

DESCRIPTION

The ECU (Electronic Control Unit) is factory programmed and requires no adjustment. No adjustments in the field can be made to the programming other than engine speed for 50 or 60 hertz operation. The ECU controls starting, engine operation, safety shutdown features and stopping the engine.

The 10 pin communications port is used by the factory to input the operating program into the ECU. This connection can be used with available software Diagnostic Software Kit (#055410) to monitor the operation of the Low CO system and also with the same software to change engine speed for 50 or 60 hertz operation.

The ECU is normally programmed for 60 hertz operation unless specified otherwise. If it is necessary to change the hertz setting of the ECU, the available software has to be used to change this program setting in the ECU. It can not be done any other way.

Setting/Changing Engine Speed

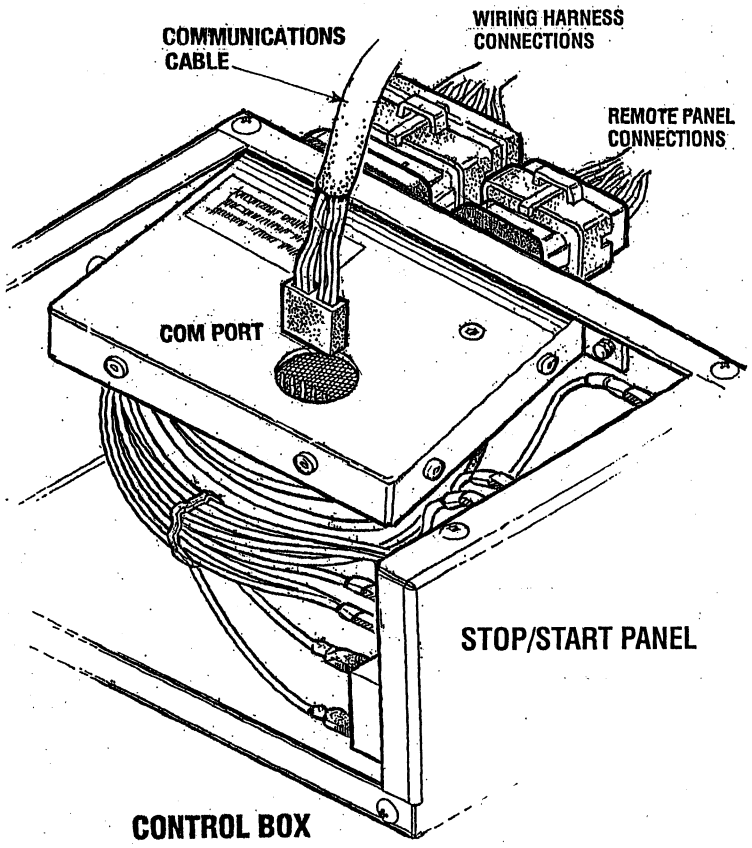
The engine speed can be set for generator operation at either 60Hz (1800 rpm) or 50Hz (1500 rpm). Once the AC voltage output for the generator has been reconfigured as described in the BE Generator section of this manual, proceed as follows:

1. Open the control box on the generator. Shut OFF the DC breaker on the control.
2. Access the opening on the ECU by removing the plug. Connect your laptop (with the software installed) using the communications cable included in the kit to the ECU and turn the laptop ON.

   NOTE: *The arrow on the communications cable connecting plug for the ECU* ***must*** *face the harness connections for the ECU.*
3. Turn the DC breaker to the ON position.
4. Using the EC11 software, start communications. Follow the HELP menu instructions for HELP US using the PC Interface. Program the ECU for the hertz that the generator is being converted to.

   NOTE: *The PC Interface can be left conected to confirm proper rpm during testing. Always stop the generator and turn OFF the DC breaker before disconnecting the communications cable from the ECU.*
5. Along with a hertz change/engine speed, the AC output configuration of the generator will need to be changed to correspond to the new hertz the generator will now be programmed for. AC configurations are illustrated in this manual for both single and three phase models.*
6. Along with the reconfiguring of the generators AC output, the generator's AC circuit breaker will need to be changed to correspond to the new amperage rating of the generator. Single phase AC breakers are listed in this manual.

   NOTE: *AC circuit breakers are not supplied with the 3 phase model.*



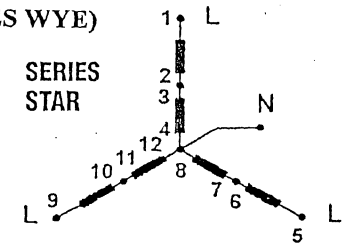
REFER TO THE SENSING BOARD CONNECTION CHART ON THE PRECEDING PAGE.

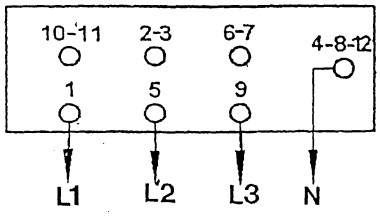
TWELVE LEAD WINDING/TERMINAL BOARD CONNECTIONS

AND (NOMINAL) VOLTAGES

(SERIES WYE)

SERIES STAR

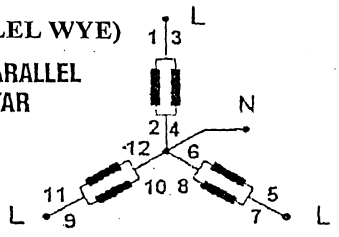


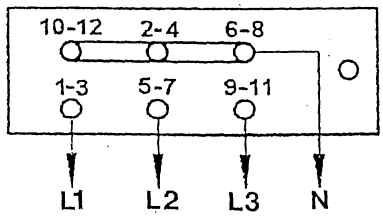


50 Hz L-L 400 volts
50 Hz L-N 230 volts
60 Hz L-L 480 volts
60 Hz L-N 277 volts

(PARALLEL WYE)

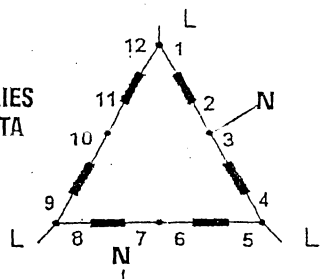
PARALLEL STAR

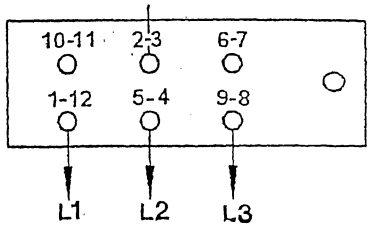




50 Hz L-L 200 volts
50 Hz L-N 115 volts
60 Hz L-L 240 volts
60 Hz L-N 138 volts

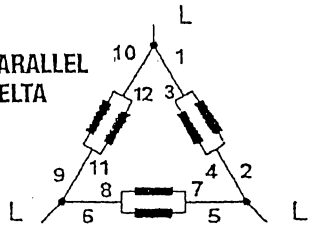
SERIES DELTA

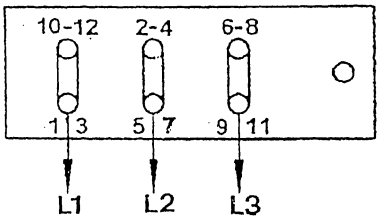




50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 277 volts
60 Hz L-N 138 volts
(Refer to Note #1)

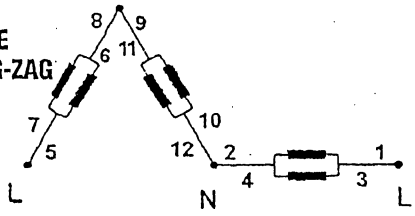
PARALLEL DELTA

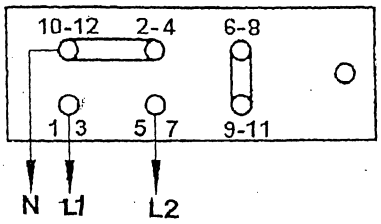




50 Hz L-L 115 volts
60 Hz L-L 138 volts

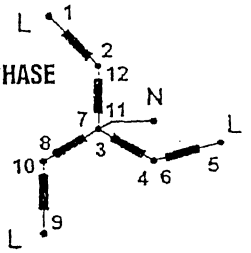
SINGLE PHASE PARALLEL ZIG-ZAG

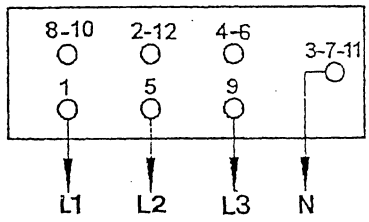




50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 277 volts
60 Hz L-N 138 volts
(Refer to Note #1)

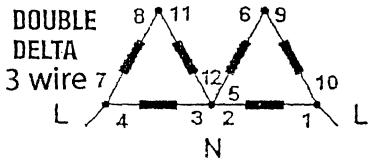
THREE PHASE ZIG-ZAG

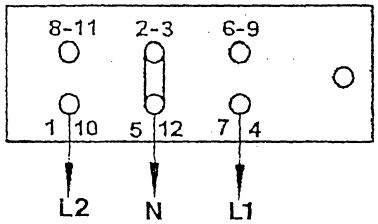




50 Hz L-L 346 volts
50 Hz L-N 200 volts
60 Hz L-L 415 volts
60 Hz L-N 240 volts
(Refer to Note #2)

DOUBLE DELTA
3 wire



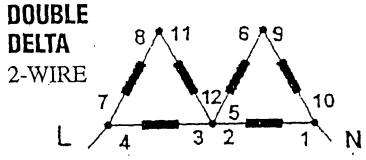


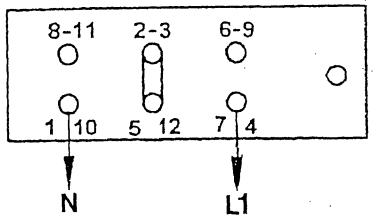
50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 240 volts
60 Hz L-N 120 volts

Note #1 *Single phase amperage load. The phase current must not exceed the nominal value.*

Note #2 *Three phase zig-zag connection. The rated power must be multiplied by 0.866.*

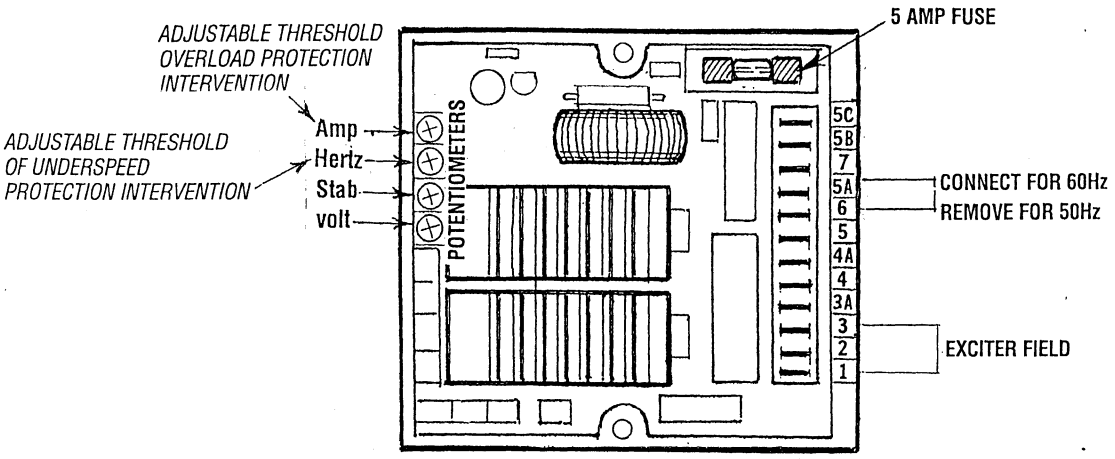
DOUBLE DELTA
2-WIRE





50 Hz L-N 230 volts
60 Hz L-N 240 volts

ELECTRONIC REGULATION SR7-2G AVR



DESCRIPTION

The voltage regulator (AVR) ensures optimum AC generator performance. This advanced design AVR is equipped with circuitry protection to guard against operating conditions that could be detrimental to the AC generator. The following information details the voltage regulators adjustments and connections. These procedures should be performed by a qualified technician.

TERMINAL CONNECTIONS

#1. Excitation field DC negative.

#2. Exciter field jumper to **3** if the regulator AC supply between **5** and **3A** is less than 160 VAC.

#3. Exciter field DC positive.

#3A. Supply voltage to regulator (AC).

#4. Sensing voltage.

#5. Supply voltage to regulator (AC).

#6. Jumper to **5A** for 60 Hz operation.

#7. Not used.

#5B. Not used.

#5C. Sensing voltage.

POSSIBLE CONNECTIONS

Exciter Field: The exciter field negative should be connected to terminal **1** of the electronic regulator (normally dark blue or black), while the positive (normally red or yellow) should be connected to terminal **3**.

Supply: There are two possibilities.

1. The supply coincides with the sensing. In this case the SR7/2 supply should be connected to terminals **3** and **5** (in case of three-phase generators, terminal **5** is normally connected with the star point). Terminals **3** and **4** should be connected to each other in such a way that the supply is also sensing. This connection in necessary when the generator does not have auxiliary winding for supplying the regulator.
2. The supply and sensing separate. This is the case of a generator equipped with auxiliary winding for regulator supply. Supply is always connected to terminals **3** and **5** of the regulator.

In both of these cases, the SR7/2 supply can vary from 80 to 270 VAC. But it should be noted that terminals 2 and 3 should be bridged for supply with voltage between 80 and 160 VAC, while the same terminals should be left open if the voltage is between 160 and 270 VAC.

Sensing: Sensing should be connected to terminals **4** and **5** and can vary from 80 to 350 VAC. The sensing is single phase only and therefore is normally connected to one alternator phase.

Operation at 60 Hz: When operating at 60 Hz, terminals **5A** and **6** should be connected to each other in order to keep the low frequency protection correctly regulated.

> ⚠ **WARNING:** ***Be aware that high voltages may be present. Take all necessary precautionms to safe guard against electrical hazards.***

FUNCTIONS OF THE REGULATOR POTENTIOMETERS

Volt: With this potentiometer, it is possible to adjust the voltage generated by the alternator in a very simple way. If the screw is turned clockwise, the voltage increases, if the screw is turned counterclockwise it decreases.

Stab: This potentiometer optimizes alternator performance. If turned clockwise, the stability decreases and the response time decreases but the voltage tends to be less stable. If turned counterclockwise, the response time increases and the voltage tends to be more stable.

In order to adjust this potentiometer correctly, we advise using the following method.

1. The generator must be working, starting from zero load and the potentiometer must be at maximum stability (turned fully counterclockwise).
2. Slightly turn clockwise until the light generated by the filament lamp oscillates, at this point, turn the potentiometer slowly counterclockwise until the light stabilizes.

ELECTRONIC REGULATION SR7-2G AVR

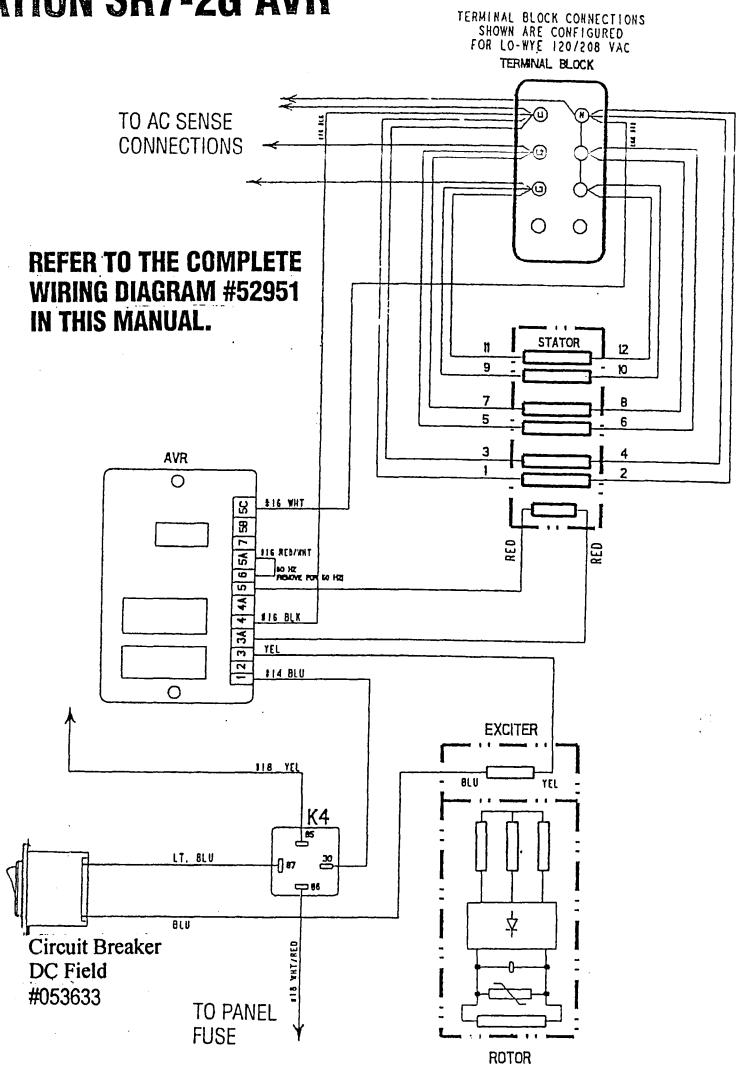
Hertz: With this potentiometer, which is normally pre-calibrated then sealed by the manufacturer, it is possible to adjust the low frequency protection intervention. To recalibrate this protection, you must take the generator to a normal zero load condition, turn the potentiometer clockwise until the limit position is reached, then decrease the nominal speed by 10 %. Then turn the potentiometer counterclockwise and measure the voltage value until it has decreased by 5 volts.

When the speed decreases by more than 10% of the nominal value, the voltage also decreases proportionally, blocking generator overheating. Even if we advise calibrating this protection at 10% of the nominal value, it is obviously possible to calibrate the threshold at other values.

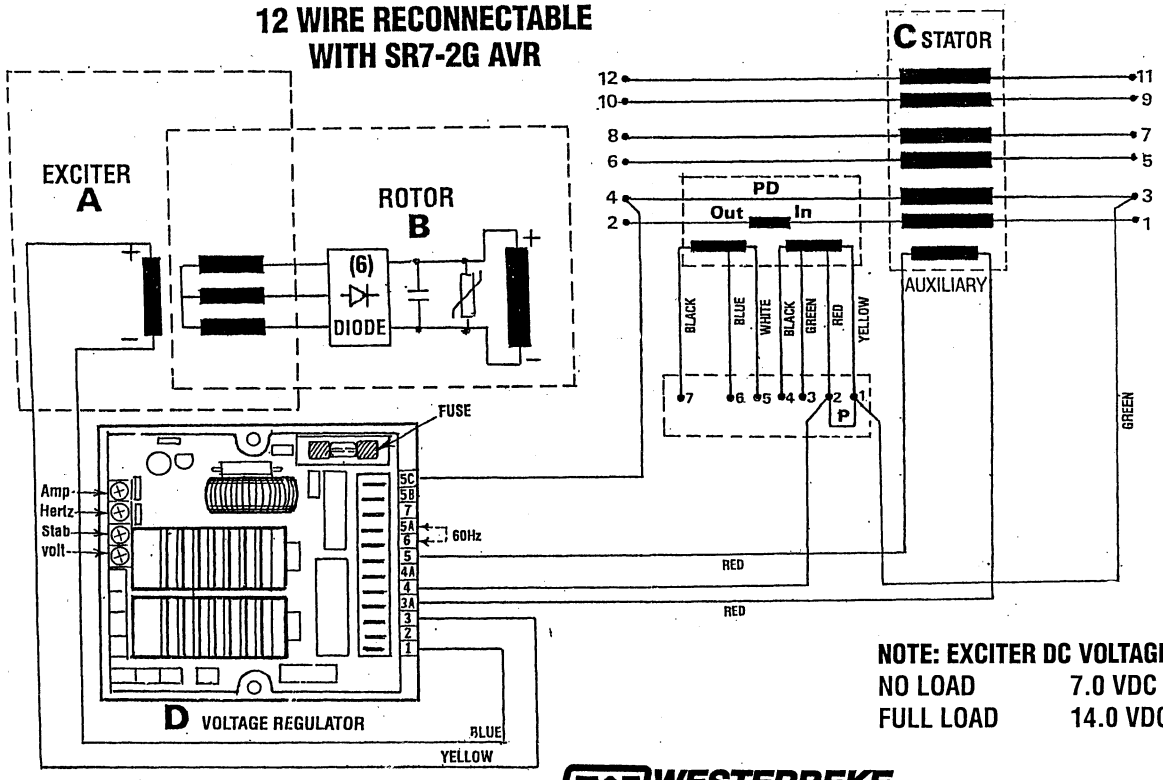
Amp: With this potentiometer, it is possible to adjust the intervention level of the overload protection. This protection system has an intervention delay, which permits a temporary overload, necessary when starting motors or similar applications.

To modify this protection, you must overload the generator by 15% of the normal load, turn the potentiometer to minimum (counterclockwise) and wait about twenty seconds. During this period of time the voltage value decreases. In this condition and while turning the potentiometer clockwise, fix the generator voltage value at 10% less than the nominal one. At this point, while the initial overload is being removed, the voltage increases to the nominal value.

Fuse: The electronic regulator is equipped with a fuse, which protects the alternator from overheating in cases of regulator malfunction. The fuse (250V-5A, quick acting, F type) can be replaced easily.



INTERNAL WIRING DIAGRAM 12 WIRE RECONNECTABLE WITH SR7-2G AVR



COMPONENT RESISTANCE VALUES IN OHMS (AT 86°F)

STATOR (each winding)	0.041
AUXILIARY	0.9
EXCITER STATOR	11.3
EXCITER ROTOR (each pair)	0.72
ROTOR	2.7

NOTE: EXCITER DC VOLTAGE / AUXILIARY VOLTAGE

NO LOAD	7.0 VDC	215 VAC
FULL LOAD	14.0 VDC	222 VAC

TESTING THE MAGNETIC PICK UP COIL

Test the speed sensor connector for voltage and resistance values.

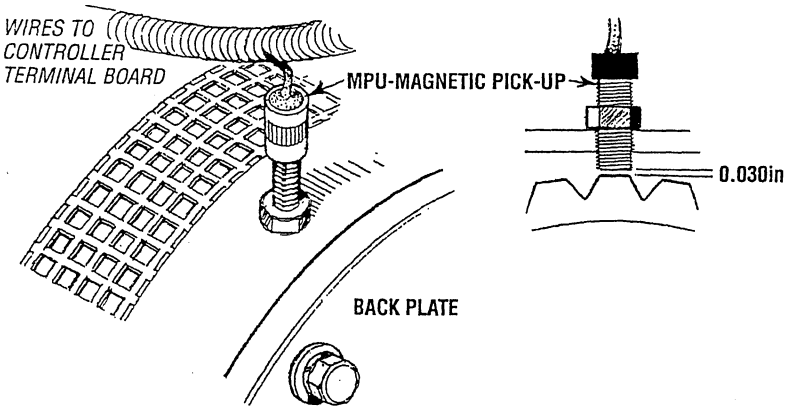
If the values are correct, remove and inspect the magnetic pick up. With the wires disconnected, unscrew the magnetic pick up from the generator housing and visually inspect the contact end. If any damage is detected, replace the unit.

NOTE: *Carefully follow the installation instructions provided with the new magnetic pick up coil.*

SPEED SENSOR TEST VALUES

Voltage (while cranking)
1.5 - 2.5 VAC

Resistance (at rest) **950 - 1000 ohm**



MAGNETIC PICK-UP [MPU] INSTALLATION

The MPU is installed in the threaded opening on the side of the flywheel bellhousing. This positions the MPU over the teeth of the flywheel ring gear.

Viewing through this opening, manually rotate the engine crankshaft so as to position the flat of one of the ring gear's teeth directly under the opening. Thread the MPU into the opening until it gently contacts the flat of this tooth (Thread is 3/8" x 24). Back the MPU out of the opening one turn and then lock it in this position with the jam nut. This will position the end of the MPU approximately 0.030 inches away from the flats of the ring gear teeth.

To ensure the MPU is positioned correctly, slowly rotate the crankshaft by 360° by hand to assure there is no physical contact between the MPU and the ring gear teeth.

If contact is felt between the MPU and the flywheel teeth, the MPU may be damaged. Remove the MPU and inspect it. Replace if necessary and repeat the above installation procedure.

NOTE: *When replacing the Magnetic Pick-Up (MPU) it **MUST** be replaced without cutting and splicing into the existing wiring cable. Doing so will cause a erratic AC signal to the controller.*

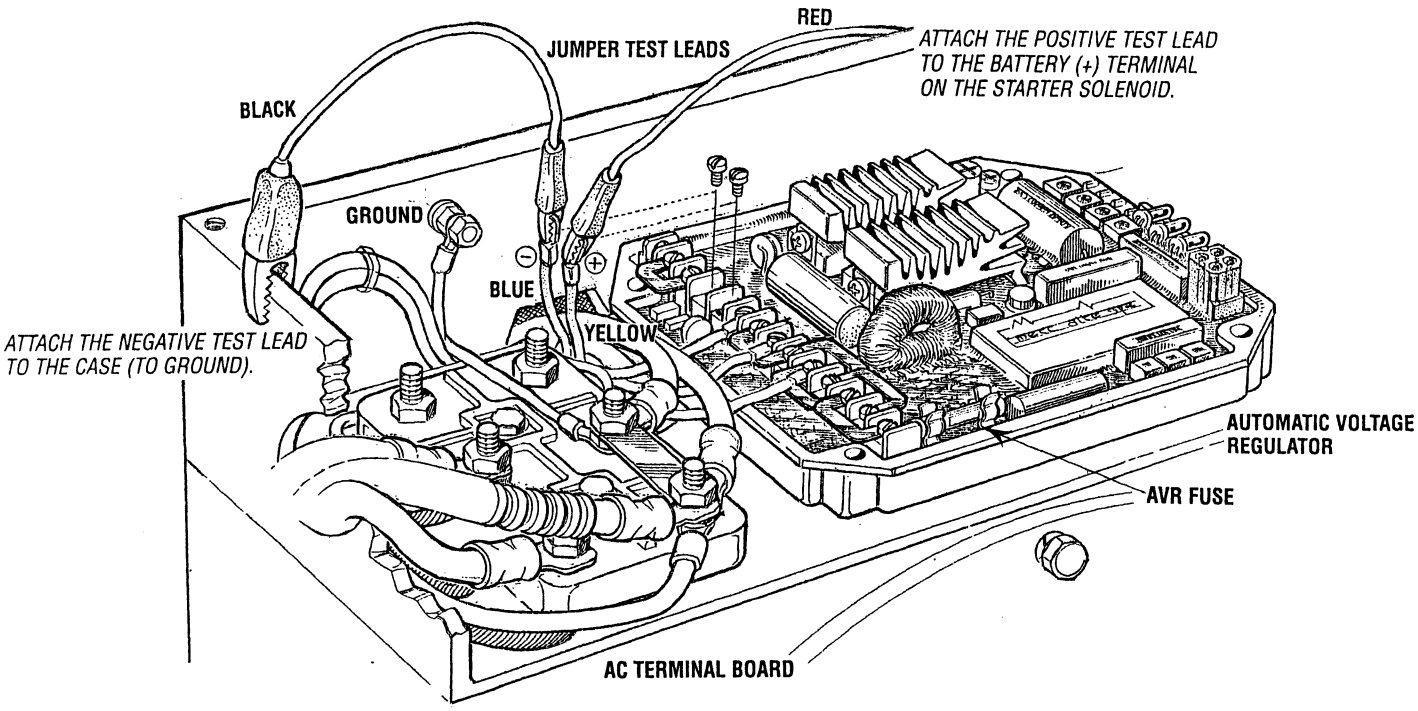
GENERATOR TROUBLESHOOTING

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

FAULT	PROBABLE CAUSE	
NO AC VOLTAGE OUTPUT AT NO LOAD.	1. Short or open in the main stator winding. 2. Shorted suppressor 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. 6. Shorted condenser on exciter rotor.
RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.	1. Blown 6 AMP fuse auxiliary circuit feed to AVR. 2. Faulty voltage regulator	3. Shorted or open main stator auxiliary winding.
LOW AC VOLTAGE OUTPUT AT NO LOAD 60 - 100 VAC.	1. Reset voltage potentiometer. 2. Open or shorted diodes in. exciter rotor 1 to 3 diodes. 3. Open or short in one of the three exciter rotor windings.	4. Faulty voltage regulator. 5. Short in rotating field winding. 6. Short in the exciter stator.
HIGH AC OUTPUT VOLTAGE 150 VAC OR HIGHER.	1. Reset voltage potentiometer. 2. Faulty voltage regulator.	
UNSTABLE VOLTAGE OUTPUT. (ENGINE SPEED STEADY)	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.	

EDE GENERATOR TROUBLESHOOTING

TESTING THE VOLTAGE



TO EXCITE THE GENERATOR

1. Lift the (DC+) yellow wire and the (DC-) blue wire off the regulator. Attach the test leads to these wires as shown: black to the blue wire, red to the yellow wire.
2. Connect the red test lead (+) to the battery voltage (12VDC) at the battery cable connection on the adjacent starter motor solenoid.
3. Open the generator's AC breaker. start the generator and observe the AC output voltage between the line and neutral (residual 15-20VAC).
4. Connect the black test lead (-) to the metal case (ground) of the generator. This will now put a 12VDC circuit through the exciter stator of the generator.
5. AC output voltage should be about 30% higher than normal. This indicates that the exciter stator, main rotor and stator windings are OK.
6. Monitor the auxiliary circuit voltage into the regulator, correct voltage should be 220 - 230 VAC indicating this circuit is ok.
7. When exciting, if the AC output voltage rises slightly, with a load on the engine and possible growling noise from the AC generator, this indicates a short exists in the main stator winding.,
8. No reaction from the generator when exciting, check the integrity of the exciter stator winding. With zero AC voltage being found between the line and neutrals, there is a possibility of an open circuit in the main stator.

EXCITER ROTOR TROUBLESHOOTING

LOW VOLTAGE - EXCITER ROTOR AND ROTATING FIELD

Position the exciter rotor/rotating field so the transient suppressor is visible at the 12 O'Clock position.

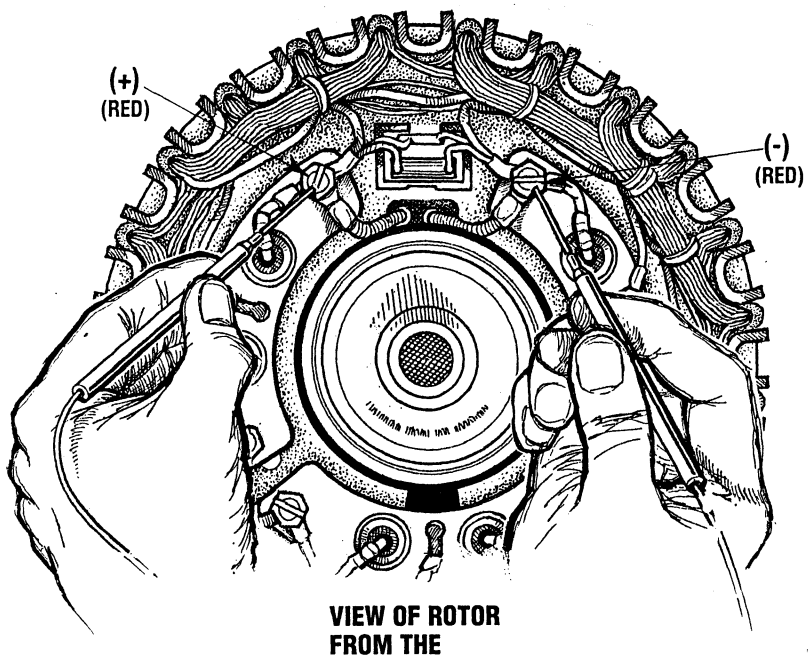
TESTING THE ROTATING FIELD WINDINGS

Place the ohm meter probes on the two large red wires (+) and (-). These are the connecting wires for the rotating field windings.

These wires do not need to be lifted off their connections unless, when testing, there is an ohm valve discrepancy or a continuity to ground (the rotor shaft).

If this occurs, lift these two flarge field wires off the diode plates, isolate them, and repeat the above test.

NOTE: *When removing these wires, be careful not to drop the screws or washers into the rotor.*

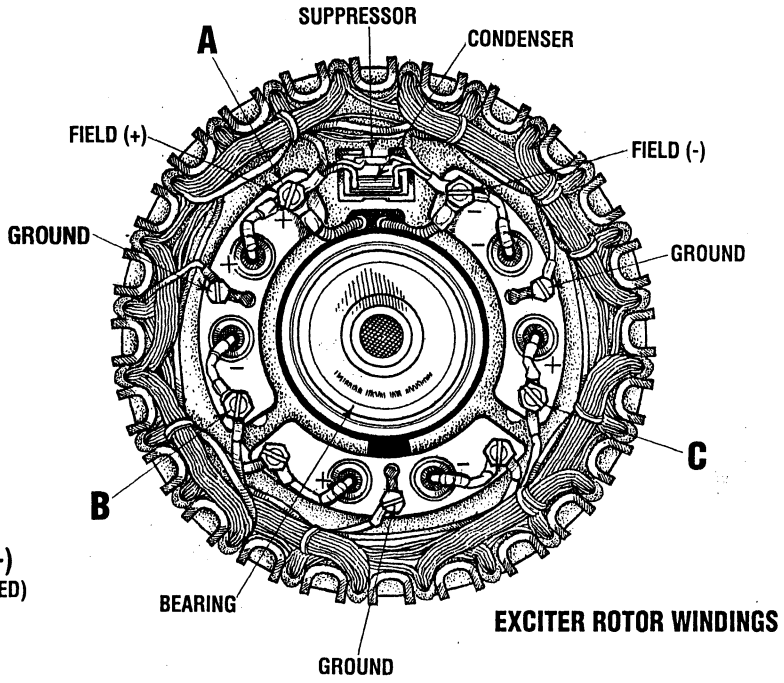


VIEW OF ROTOR FROM THE BEARING END

12 O-CLOCK POSITION

TESTING THE EXCITER ROTOR WINDINGS

These windings are tested in pairs: **A** to **B**, **B** to **C**, and **C** to **A** as shown on the drawing.



EXCITER ROTOR WINDINGS

Disconnect these three wires from the diode bridge plates taking care not to drop any screws or washers.

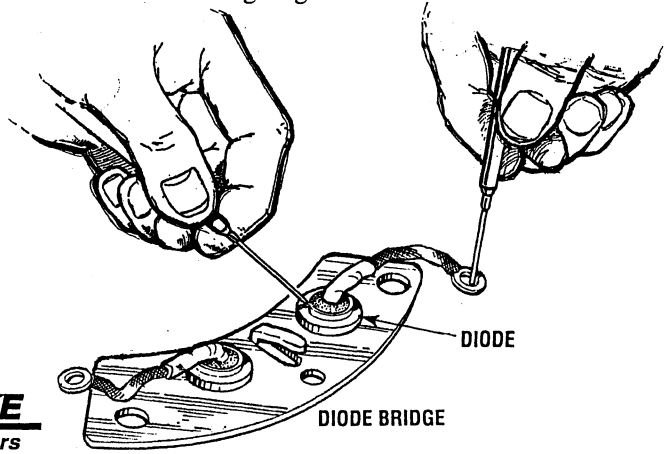
With the wires clear from the bridge plates, test each pair with an ohm meter, **A** to **B**, **B** to **C**, and **C** to **A.**

No continuity should be found between the rotor and any of these three winding pairs.

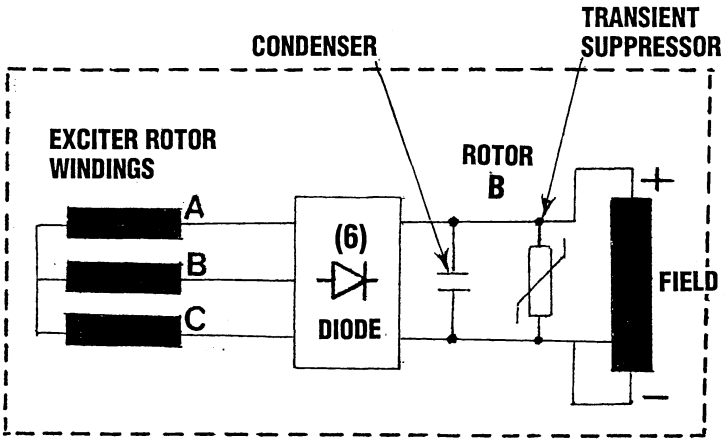
TESTING THE DIODES

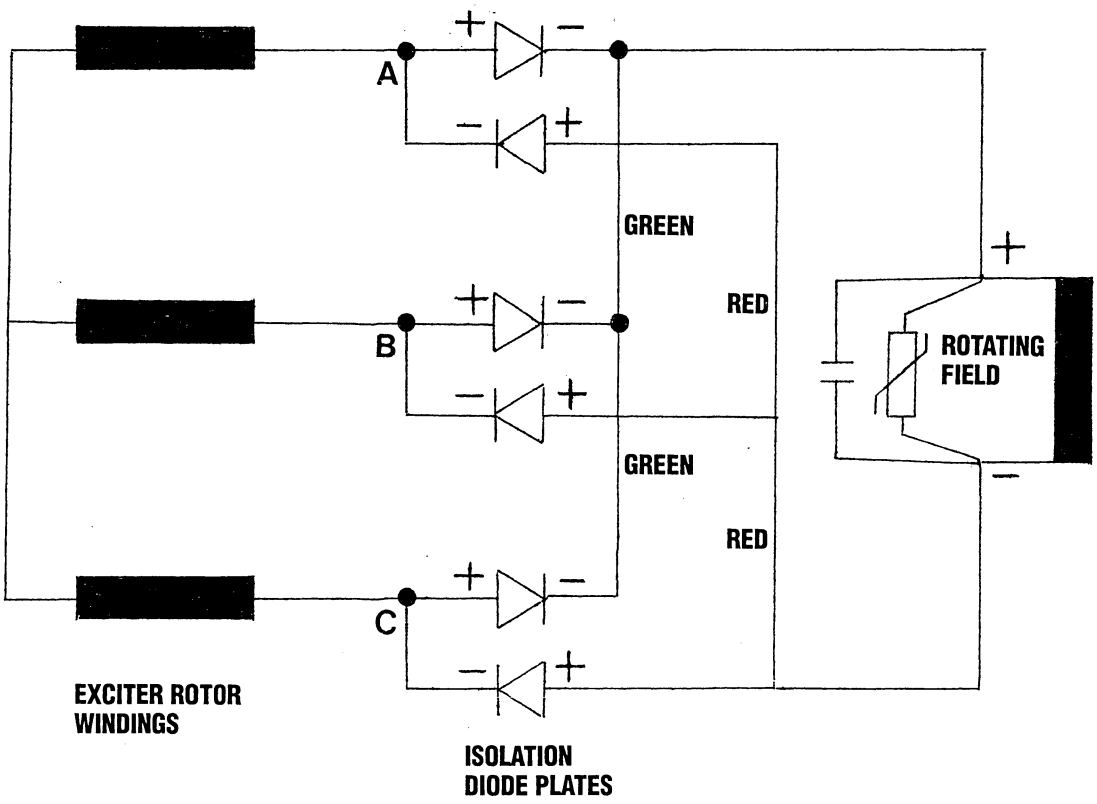
Diodes can be checked with an ohmmeter. Disconnect the wire of the particular diode and test its resistance in both directions. A perfectly functioning diode will show a very high resistance in one direction and a very low resistance in the opposite direction. A faulty diode will show either a very low resistance, or an infinite resistance in both directions.

Should the whole bridge be replaced, remember to tighten the screws with a suitable wrench and strictly comply with the polarities and internal wiring diagrams in this manual.



INTERNAL WIRING SCHEMATIC
EXCITER ROTOR/ROTATING FIELD





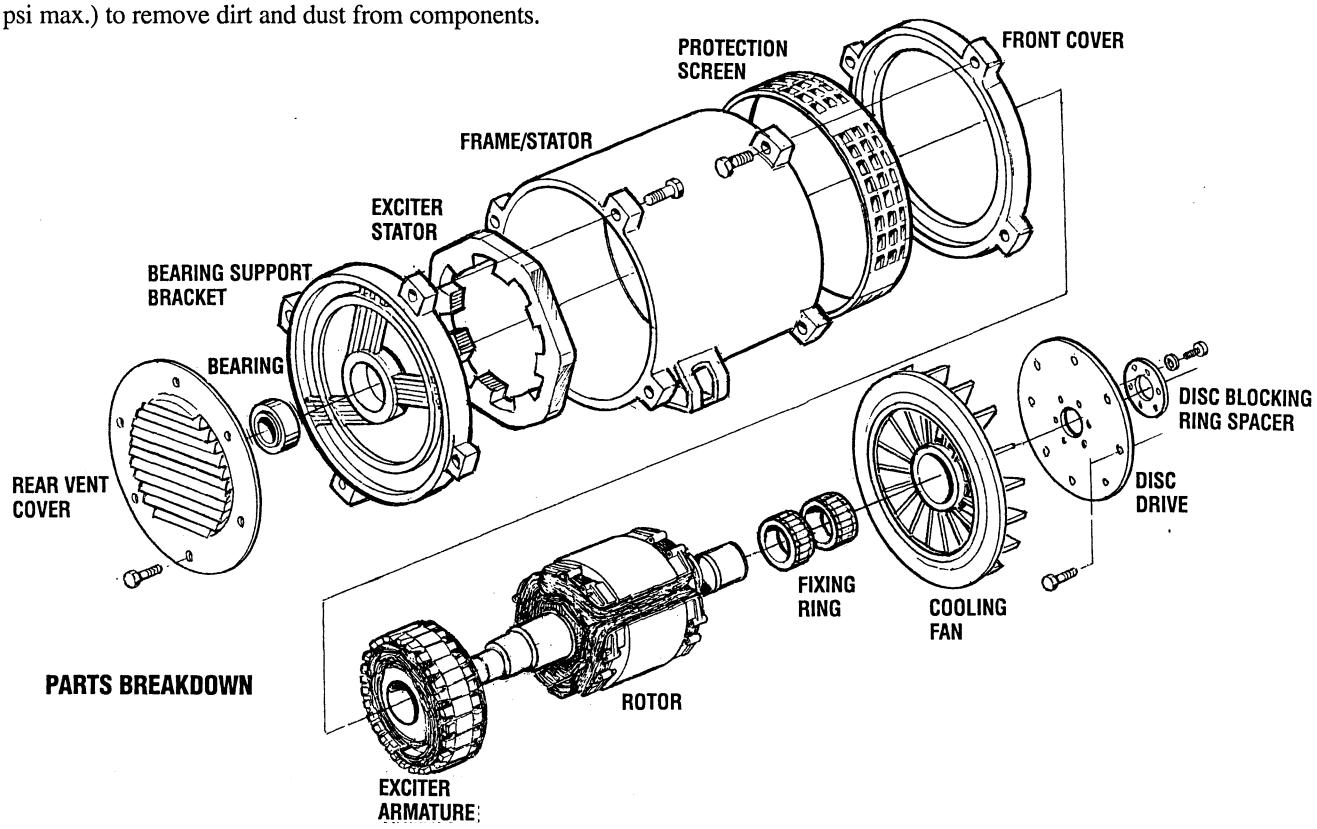
MECC ALTE GENERATOR
MAINTENANCE/PARTS BREAKDOWN

INSPECTION/CLEANING

Periodically inspect the rotor carrier bearing. Replace this bearing at 10,000 hours of normal operation or sooner if wear is evident.

Inspect and clean the control box interior, look for loose, broken, or burned wires and terminals. Use low air pressure (25 psi max.) to remove dirt and dust from components.

Remove all dirt, oil, grease and dust build up from the external surface of the generator. Build-up reduces heat dissipation and causes the AC generator end to operate at a higher temperature. This results in a loss of efficiency and reduces service life.

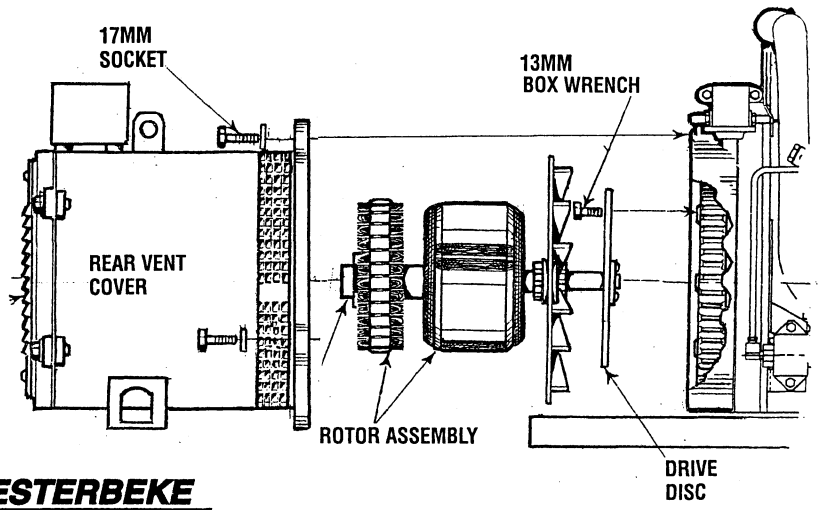


PARTS BREAKDOWN

DISASSEMBLY

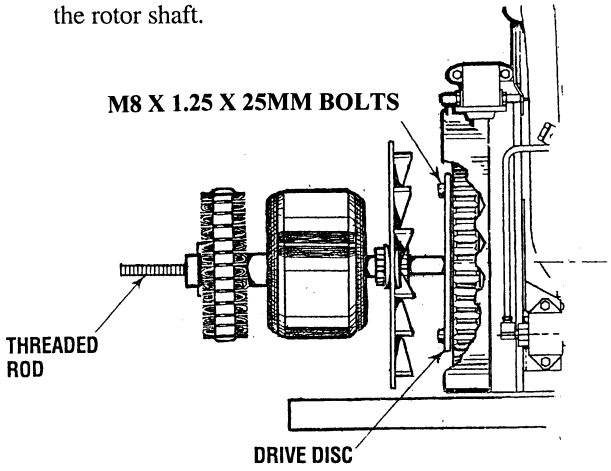
Should it become necessary to disassemble the stator/rotor assembly from the engine, use the following as a guide.

1. Properly support/lift the rear of the engine to allow the generator to be unbolted from the rear support isolators.
2. Mark, then disconnect the electrical leds that exit the generator from their connections in the control box. Be sure to properly mark the connection points the generator leds connect to. Make an illustration if needed whether the generator is to be reinstalled or a replacement is to be installed. This is to ensure proper reconnection of electrical leds. Unbolt the control box and lift it off the generator.
3. Remove the rear vent cover. Support the generator with a sling or fabricated lifting eye. Using a 17mm socket wrench remove the four bolts that attach the generator stator housing assembly to the flywheel housing. carefully work the stator assembly off the rear bearing and off and over the rotor assembly.
4. Support the rotor assembly with a sling and using a 17mm box wrench, unbolt the rotor assembly from the flywheel.

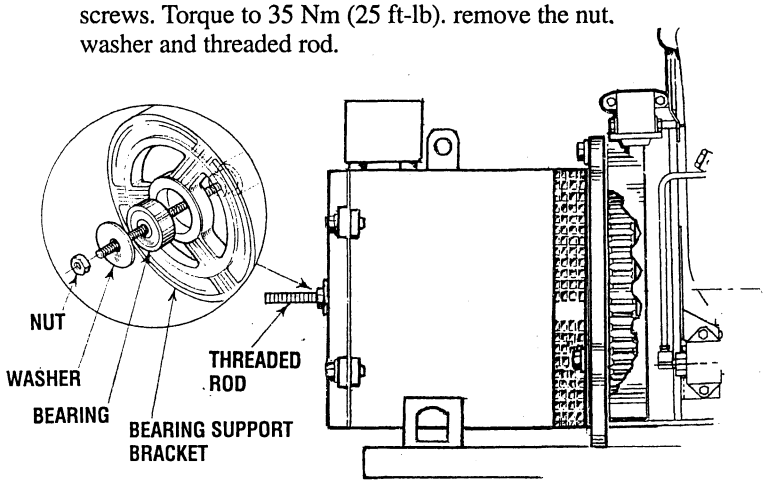


ASSEMBLY OF THE GENERATOR TO THE ENGINE

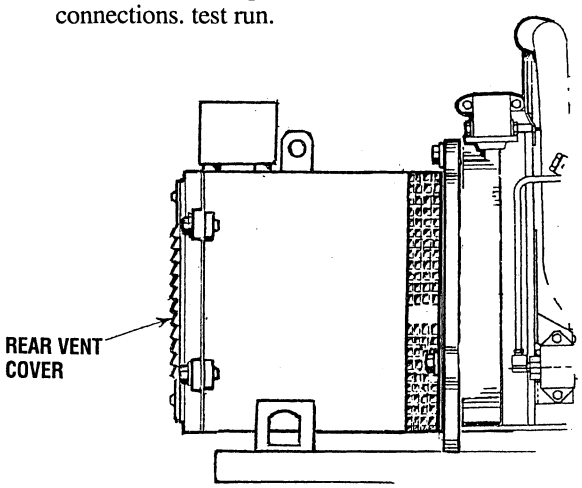
1. Position the rotor assembly onto the flywheel aligning the holes in the drive discs with the holes in the flywheel. Install the M8 x 1,25 x 25mm bolts (blue loctite on threads) and torque to 21 Nm (16 ft-lb). Install a threaded rod M12 x 1.75 x 90mm long into the threaded end of the rotor shaft.



2. With the aid of a sling or fabricated lifting eye, support the stator housing assembly and carefully guide it over the rotor assembly until the rear bearing contacts the bearing boss in the rear support.
3. Place a large washer of at least 80mm in diameter with a center hole of 15mm onto the threaded rod followed by a 12mm x 1.75 nut. Center the rear bearing in the bearing boss of the support plate. Tighten the nut until the bearing seats fully into the boss. Secure the stator housing assembly to the bell housing using the four M10 x 35mm screws. Torque to 35 Nm (25 ft-lb). remove the nut. washer and threaded rod.



4. Rotate the generator by hand two full revolutions to ensure the generator rotates freely. Reinstall the rear vent cover.
5. Secure the generator to its rear isolators. Route the generator wiring into the control box and mount the control box to the generator. Reconnect all wire connections. test run.



DECIMAL TO METRIC EQUIVALENT CHART

Fractions of an inch	Decimal (in.)	Metric (mm)	Fractions of an inch	Decimal (in.)	Metric (mm)
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.175	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	21.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

STANDARD AND METRIC CONVERSION DATA

LENGTH-DISTANCE

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

DISTANCE EQUIVALENTS

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

VOLUME

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

MASS-WEIGHT

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

PRESSURE

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

TORQUE

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

VELOCITY

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

POWER

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

FUEL CONSUMPTION

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

TEMPERATURE

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

LIQUID WEIGHTS

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

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