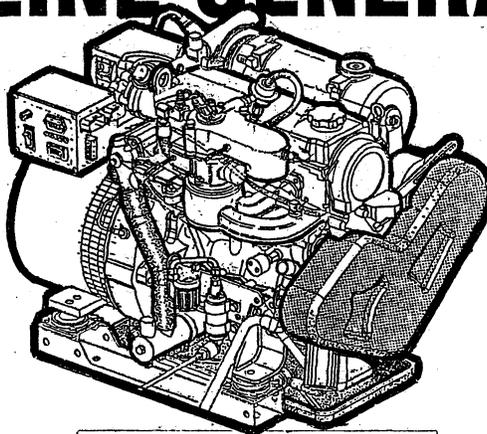




SERVICE MANUAL

8.0KW - 60Hz SBEG / 6.4KW - 50 Hz SBEG
10.0KW - 60Hz SBEG / 8.0KW - 50 Hz SBEG
12.5KW - 60Hz SBEG / 10.0KW - 50 Hz SBEG
14.0KW - 60Hz SBEG / 11.6KW - 50 Hz SBEG

Single Phase GASOLINE GENERATORS



PUBLICATION #055050
JULY 2013



Low Carbon Monoxide Emissions

⚠ WARNING

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

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

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



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

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

**CALIFORNIA
PROPOSITION 65 WARNING**

Marine diesel and gasoline engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Gasoline with an ETHANOL content higher than 10% (E10) is not allowed and may void warranty.



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. Lethal voltage is present at these connections!

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

PREVENT BURNS — HOT ENGINE

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

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

⚠ WARNING: Steam can cause injury or death!

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

PREVENT BURNS — FIRE

⚠ WARNING: Fire can cause injury or death!

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the throttle body, injector, 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 lines, fuel filters, or other fuel system components.
- Do not operate with a Coast Guard Approved flame arrester removed. Backfire can cause severe injury or death.
- Do not operate the engine with the air intake (silencer), or flame arrester/filter screen removed.
- 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 — gasoline is highly flammable.

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 generator 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!

- Turn OFF the DC breaker on the control panel or turn the unit's battery selector switch to OFF before servicing the engine.
- Disconnect the battery cables before servicing the engine/generator. Remove the negative lead first and reconnect it last.
- Make certain all personnel are clear of the engine before starting.
- Make certain all covers, guards, and hatches are re-installed before starting the engine.

BATTERY EXPLOSION

⚠ WARNING: Battery explosion can cause injury or death!

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

BATTERY ACID

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

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

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

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifolds are securely attached and no warping exists. Pay close attention to the manifold, water injection elbow, and exhaust pipe nipple.
- Be sure the unit and its surroundings are well ventilated.
- In addition to routine inspection of the exhaust system, install a **carbon monoxide detector**. Consult your boat builder or dealer for installation of approved detectors.
- For additional information, refer to ABYC T-22 (educational information on Carbon Monoxide).

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

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

Vomiting	Muscular twitching
Dizziness	Intense headache
Throbbing in temples	Weakness and sleepiness

AVOID MOVING PARTS

⚠ WARNING: Rotating parts can cause injury or death!

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

SAFETY INSTRUCTIONS

- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belt's tension while the engine is operating.
- Do not allow any swimming or activity around or near the exhaust discharge opening for the generator while the generator is operating. Carbon Monoxide poisoning or death can occur.

HAZARDOUS NOISE

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

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

 **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 a gasoline engine or generator should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are from a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

H-2 Ventilation of Boats using Gasoline

H-24 Gasoline Fuel Systems

P-1 Installation of Exhaust Systems
for Propulsion and Auxiliary Engines

P-4 Marine Inboard Engines and Transmissions

E-11 AC & DC Electrical Systems on Boats

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

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

ABYC (American Boat and Yacht Council)
"Standards and Technical Information Reports for Small Craft"

Order from:

American Boat & Yacht Council
613 Third Street, Suit 10
Annapolis, MD 21403

Website: www.abycinc.org

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

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

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

Order from:

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

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INSTALLATION

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

CODES AND REGULATIONS

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

SIPHON-BREAK

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

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

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



AVAILABLE FROM
YOUR WESTERBEKE
DEALER

EXHAUST SYSTEM

The exhaust system's hose MUST be certified for marine use. Corrugated Marine Exhaust Hose is recommended. The use of this type of hose allows for extreme bends and turns without the need of additional fitting and clamps to accomplish these bends and turns. In this regard, a single length of corrugated exhaust hose can be used. The system MUST be designed to prevent the entry of water into the exhaust system under any sea conditions and at any angle of vessels heel.

A detailed Marine Installation Manual covering gasoline and diesel, engines and generators, is supplied with each unit. A pdf is available to download from our website at www.westerbeke.com.

INTRODUCTION



ENGINE IDENTIFICATION PLATE

SERIAL NUMBER LOCATION

The engine's model number and engine serial number are found on an I.D. plate affixed to the engine's rocker cover and on I.D. stickers attached to either side of the AC generators housing.

Take the time to enter this information on the blank decal below. This will provide a quick reference when seeking technical information and/or ordering parts.

SPECIFICATION	50 HZ.	60 HZ.
MODEL		
RPM		
KW		
KVA		
VOLTS		
AMPS		
ENG. HP		
ENG. SER. NO.		
GEN. SER. NO.		
PF/PHASE	/	
WIRES		
RATING		
INSUL. CLASS		
TEMP. RISE		
BATTERY		
C.I.D.		

ORDERING PARTS

Whenever replacement parts are needed, always provide the generator and engine model and serial numbers. In addition, include a complete part description and part number for each part needed. Also insist upon WESTERBEKE packaged parts because *will fit* or generic parts are frequently not made to the same specifications as original equipment.

DIAGNOSTIC SOFTWARE

A diagnostic software Kit Pm.#053500 which contains software for all out Low CO models along with our Interface Communication cable needed to connect between the unit's ECU and your laptop is available for purchase from your area's Westerbeke Distributor.

To locate the Westerbeke Distributor in your area, visit our website: www.westerbeke.com.

ENGINE OVERHAUL

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

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

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 worn plugs or low octane fuel. 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 carburetor performance or worn plugs. They are caused also by defective electrical devices such as the battery, alternator or starter. 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.

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.

NOTE: Standard engine compression should be 164 psi at 270 RPM and pressure should not vary by more than 28 PSI (2.0kg/cm²).

MINIMUM COMPRESSION 119 PSI

NOTE: Make certain the engines valve clearances are properly adjusted. An incorrect valve clearance can cause symptoms that might, incorrectly, suggest an engine overhaul (cylinder misfire, white smoke, noise, etc.).

Before preparing for an engine overhaul, adjust the valve clearances to the correct specification, install a new cover gasket and test the engine.

COMPRESSION TEST PROCEDURES

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 and activate the starter solenoid.

1. Start the engine and allow it to warm up to its normal operating temperature. Then shut it down.
2. Open the DC breaker on the unit's control box to disable the ECU. Connect the jumper arrangement on the starter solenoid connections.
3. Close the unit's raw water thru hull opening. This is to prevent the raw water pump from pumping water into the unit's exhaust system during the test as no or very little exhaust pressure will be present during the test to help expel water from the unit's exhaust system during engine cranking.
4. Remove the high tension leads from the spark plugs and remove all the spark plugs.
5. Thread the compression gauge adapter into the spark plug opening of cylinder #1. Connect the compression gauge to the adapter.
6. Activate the starter motor using the push button on the electrical jumper arrangement 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. Stop cranking and record the pressure.
7. Remove the compression gauge and adapter from the #1 spark plug. Open and install it in the #2 cylinder spark plug opening and repeat step #6.
8. Proceed to the next cylinder and repeat step #6 until all the cylinders have been tested and their pressures recorded.

NOTE: A wet test can be performed on cylinders with low compression figures. This will help determine if the low pressure is the result of worn cylinders/rings or worn valve seats/valves or both. Place a few squirts of oil inter the cylinder and then perform the compression test on that cylinder.

- a. A dramatic rise in the recorded compression valve would indicated a worn cylinder/rings.
- b. A minimal rise in the recorded compression valve would indicate bioth cylinder/ring and valve wear.
- c. No appreciable rise in the recorded compression valve would indicate valve/seat wear.

BASIC ENGINE TROUBLESHOOTING

The following troubleshooting tables are based upon certain engine problem indicators and the most likely causes of the problems. When troubleshooting indicates an electrical problem, see the *ELECTRICAL SYSTEM WIRING DIAGRAM* as these may reveal other possible causes of the problem which are not listed below.

NOTE: The engine's DC electrical system is protected by a 30 amp manual reset circuit breaker located on the control box of the generator. There is also an 8 amp buss type fuse on the control panel that protects the LCD Display and Start/Stop.

PROBLEM	PROBABLE CAUSE
*Engine does not crank	<ol style="list-style-type: none"> 1. Battery is low or dead. 2. Loose battery connections. 3. Faulty wire connection. 4. Faulty start switch. 5. Faulty starter solenoid. 6. Raw water filled cylinders. 7. Circuit breaker is off.
*Engine cranks but fails to start	<ol style="list-style-type: none"> 1. Out of fuel. 2. Fuel pump inoperative. 3. Worn or faulty spark plugs. 4. High tension wires grounding. (wet system) 5. Faulty ignition coil. 6. Faulty distributor. 7. Faulty wire connections. 8. Low engine compression. 9. Air in the fuel system. See <i>BLEEDING THE FUEL SYSTEM</i>
*Engine starts, runs and then shuts down	<ol style="list-style-type: none"> 1. Faulty shutdown switch,(oil pressure, coolant or exhaust temperature). 2. High engine water or exhaust temperature. 3. Dirty fuel/water separator filter. 4. Low oil level in sump. 5. Faulty fuel pump. 6. Faulty fuel pump. 7. Air in the fuel system. See <i>BLEEDING THE FUEL SYSTEM</i> 8. Fuel line restriction. 9. Mechanical check valve at the fuel supply is faulty 10. Throttle plate binding. 11. Faulty wire connections. 12. AC generator overload. 13. High exhaust pressure.
Poor performance at rated speed.	<ol style="list-style-type: none"> 1. Low octane gasoline. 2. Incorrect ignition timing. 3. Faulty MAP sensor.

PROBLEM	PROBABLE CAUSE
Engine Overspeeds (LED on Steady)	<ol style="list-style-type: none"> 1. Air in fuel system dirty/faulty speed sensor (MPU). 2. Stepper motor shaft sticking. 3. Faulty motor. 4. ECU faulty.
Engine Under-Speeds (LED on Flashing)	<ol style="list-style-type: none"> 1. Fuel starvation. 2. Amperage overload. 3. Faulty fuel pump.
Engine High Exhaust Temperature (LED ON)	<ol style="list-style-type: none"> 1. Loss of raw water coolant flow. 2. Faulty exhaust temperature switch. 3. Faulty ground connection.
High Oil Pressure	<ol style="list-style-type: none"> 1. Faulty sensor. 2. Dirty oil or wrong SAE type oil in the engine. 3. Relief valve is stuck.
Engine overheats. (LED ON)	<ol style="list-style-type: none"> 1. Coolant loss. Pressure test cooling system. 2. Faulty raw water pump impeller. 3. Belts are loose or broken. 4. Raw water pump worn. 5. Faulty thermostat. 6. Heat Exchanger is clogged. 7. Collapsed hose. 8. Faulty ground. 9. Faulty sensor.
Low oil pressure. (LED ON)	<ol style="list-style-type: none"> 1. Low oil level. 2. Faulty oil pressure sensor. 3. Wrong SAE type oil in engine. 4. Faulty ground. 5. Wrong type oil filter. 6. Relief valve is stuck. 7. Faulty oil pump. 8. Faulty engine bearings.
No DC charge to the starting battery.	<ol style="list-style-type: none"> 1. Loose alternator drive belt. 2. Connections to the alternator are loose or faulty. 3. Faulty alternator. 4. No excitation to the regulator.

* Refer to the *ELECTRICAL TROUBLESHOOTING* guide in this manual for detailed testing of the electric circuits relating to these problems.

NOTE: When unplugging or disconnecting DC electrical components, shut off the panels DC breaker.

SERVICE SPECIFICATIONS

<i>Component</i>		<i>Standard mm (inches)</i>	<i>Limit mm (inches) (repair or replace)</i>
ROCKER ARMS, ROCKER SHAFTS, CAMSHAFT			
CAMSHAFT CAM HEIGHT	Intake (primary)	38.78 (1.527)	38.28 (1.5082)
	Intake (secondary)	38.78 (1.527)	38.28 (1.5082)
	Exhaust	39.10 (1.5405)	38.60 (1.5208)
CAMSHAFT JOURNAL DIAMETER		45.93 - 45.94 (1.8096 - 1.8100)	
CYLINDER HEAD AND VALVES			
FLATNESS OF CYLINDER HEAD GASKET SURFACE		0.05 or less (0.002)	
CYLINDER HEAD GASKET SURFACE GRINDING LIMIT (including grinding of cylinder block gasket surface)			0.2 (0.0078)
CYLINDER HEAD OVERALL HEIGHT		106.9 - 107.1 (4.2118 - 4.2197)	
CYLINDER HEAD BOLT NOMINAL LENGTH			103.2 (4.0660)
VALVE MARGIN	Intake	1.0 (0.0394)	0.5 (0.0197)
	Exhaust	1.5 (0.05910)	1.0 (0.0394)
VALVE STEM DIAMETER		6.6 (0.2600)	
VALVE STEM-TO-GUIDE CLEARANCE	Intake	0.020 - 0.050 (0.0007 - 0.0019)	0.10 (0.0039)
	Exhaust	0.050 - 0.085 (0.0019 - 0.0034)	0.15 (0.0059)
VALVE FACE ANGLE		45° - 45.5°	
VALVE STEM PROJECTION	Intake	43.70 (1.7217)	44.20 (1.7414)
	Exhaust	43.30 (1.7060)	43.80 (1.7257)
OVERALL VALVE LENGTH	Intake	100.75 (3.9695)	100.25 (3.9498)
	Exhaust	101.05 (3.9813)	105.55 (4.1586)
VALVE SPRING FREE HEIGHT	Intake	46.1 (1.8163)	45.6 (1.7966)
	Exhaust	46.8 (1.8439)	46.3 (1.8242)
VALVE SPRING LOADED (installed height)	Intake	226 (40.0)	
	Exhaust	284 (39.6)	
VALVE SPRING SQUARENESS		2°	4°
VALVE SEAT CONTACT WIDTH		0.9 - 0.18 (0.0354 - 0.0512)	
VALVE GUIDE INTERNAL DIAMETER		6.6 (0.260)	
VALVE GUIDE PROJECTION		17.0 (0.6698)	
OIL PUMP AND OIL PAN			
OIL PUMP TIP CLEARANCE		0.06 - 0.18 (0.00236 - 0.0070)	
OIL PUMP SIDE CLEARANCE		0.04 - 0.10 (0.00157 - 0.0039)	
OIL PUMP BODY CLEARANCE		0.10 - 0.18 (0.0039 - 0.0070)	0.35 (0.01379)
PISTONS AND CONNECTING RODS			
PISTON OUTSIDE DIAMETER		075.5 (2.9747)	
PISTON RING SIDE CLEARANCE	No.1 Ring	0.02 - 0.06 (0.00078 - 0.0023)	
	No.2 Ring	0.02 - 0.06 (0.00078 - 0.0023)	
PISTON RING END GAP CLEARANCE	No.1 Ring	0.20 - 0.35 (0.0078 - 0.0137)	0.8 (0.0315)
	No.2 Ring	0.35 - 0.50 (0.0137 - 0.0197)	0.8 (0.0315)
	Oil Ring	0.20 - 0.50 (0.0078 - 0.0197)	1.0 (0.0394)
PISTON PIN O.D.		18.0 (0.7092)	
PISTON PIN PRESS-IN LOAD (at room temperature)		4,900 - 14,700Nm (3,616 - 10,848 ft-lb)	

SERVICE SPECIFICATIONS

<i>Component</i>	<i>Standard mm (inches)</i>	<i>Limit mm (inches) (repair or replace)</i>
PISTONS AND CONNECTING RODS		
CRANKSHAFT PIN OIL CLEARANCE	0.02 - 0.04 (0.00078 - 0.00157)	0.1 (0.0039)
CONNECTING ROD BIG END SIDE CLEARANCE	0.10 - 0.25 (0.00394 - 0.00985)	0.4 (0.0157)
CRANKSHAFT AND CYLINDER BLOCK		
CRANKSHAFT END PLAY	0.05 - 0.18 (0.00197 - 0.00709)	0.25 (0.00985)
CRANKSHAFT JOURNAL DIAMETER	48.0 (1.891)	
CRANKSHAFT PIN DIAMETER	42.0 (1.6548)	
CRANKSHAFT JOURNAL OIL CLEARANCE	0.02 - 0.04 (0.0007 - 0.0015)	0.1 (0.0039)
CYLINDER BLOCK GASKET SURFACE FLATNESS	0.05 OR less (0.00197)	
CYLINDER BLOCK GASKET SURFACE GRINDING LIMIT (including grinding of cylinder head gasket surface)		0.2 (0.00078)
CYLINDER BLOCK OVERALL HEIGHT	256 (10.0864)	
CYLINDER CYLINDRICITY	0.01 (0.00039)	
CYLINDER I.D.	75.5 (2.9747)	
PISTON-TO-CYLINDER CLEARANCE	0.02 - 0.04 (0.0007 - 0.00157)	

REWORK DIMENSIONS

<i>Component</i>	<i>Standard mm (inches)</i>		
CYLINDER HEAD AND VALVES			
	OVERSIZE		
CYLINDER HEAD OVERSIZE	0.05	12.050 - 12.068 (0.47477 - 0.47547)	
VALVE GUIDE HOLE DIAMETER	0.25	12.250 - 12.268 (0.48265 - 0.48335)	
	0.50	12.500 - 12.516 (0.4925 - 0.4932)	
OVERSIZE VALVE SEAT	INTAKE (primary)	0.3	27.300 - 27.325 (1.07562 - 1.07660)
RING HOLE DIAMETER		0.6	27.600 - 27.625 (1.08744 - 1.08842)
	INTAKE (secondary)	0.3	32.300 - 32.325 (1.27262 - 1.2736)
		0.6	32.600 - 32.625 (1.2844 - 1.28542)
	EXHAUST	0.3	35.300 - 35.325 (1.39082 - 1.39180)
		0.6	35.600 - 35.625 (1.4026 - 1.4036)

DISASSEMBLY AND ASSEMBLY PROCEDURES

DISASSEMBLY

- Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
- Drain water, fuel and oil before disassembly.
- Clean or wash the engine exterior.
- 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

ASSEMBLY

- Wash all parts, except for oil seals, O-rings, and rubber gaskets 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, install new gaskets and O-rings.

TORQUING DATA

Parts of the engine use plastic region tightening bolts. The tightening procedure for these is different from that of conventional bolts and is described in this manual. Note that plastic region tightening bolts have fixed service limits. These limits are indicated in this manual and must be strictly observed.

- Plastic region tightening bolts are used for the following applications:
 1. Cylinder head bolts
 2. Connecting rod cap bolts
- The tightening procedure is basically as follows: After tightening a bolt to the specified torque, tighten it by a further $90^\circ + 90^\circ$ or by a further $90-100^\circ$. The exact tightening procedure differs depending on the bolt and is described where it applies in this manual.

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.

Disassembly

The parts assembled with the silicone can be easily disassembled without use of a special method. In some cases, however, the sealant between the joined surfaces may have to be broken by lightly striking with a mallet or similar tool. A flat and thin gasket scraper may be lightly hammered in between the joined surfaces. In this case, care must be taken to prevent damage to the joined surfaces. For removal of the oil pan, use a special "oil pan remover".

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.

Form-in-place Gasket Application

When assembling parts with the silicone gasket, you must observe some precautions but the procedures are very simple as in the case of a conventional precut gasket.

The applied gasket bead should be the specified size and without breaks. Be sure to encircle the bolt hole circumference with a completely continuous bead. The gasket material can be wiped away unless it has hardened. While the gasket is still moist, mount the parts in position. When the parts are mounted, make sure that the gasket is applied to the required area only. Do not apply oil or water to the sealing locations or start the engine until a sufficient amount of time has passed after installation is completed.

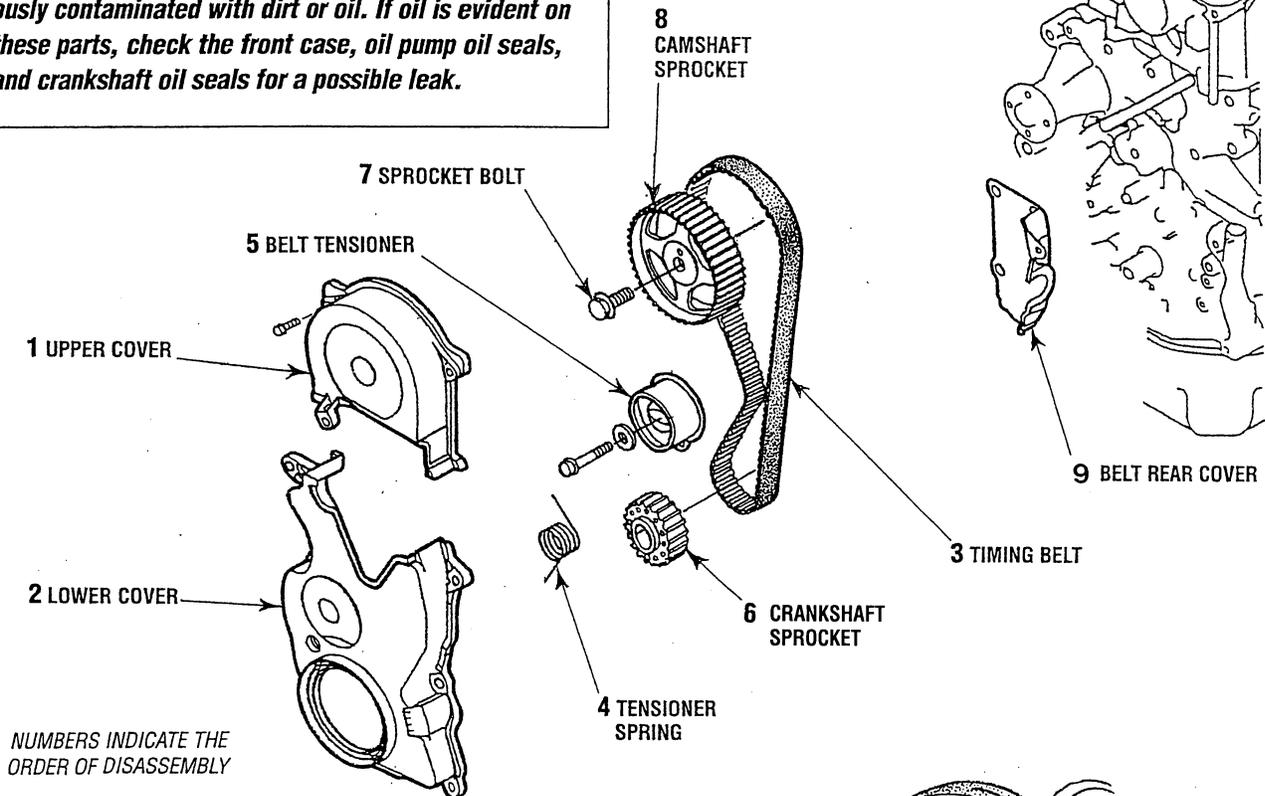
The gasket application procedure may vary on different areas. Observe the procedure described in the text when applying the gasket silicone and follow the directions on the applicator/tube.

DISASSEMBLY, INSPECTION AND ASSEMBLY TIMING BELT

NOTE: In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

TIMING BELT INSPECTION AND REPLACEMENT

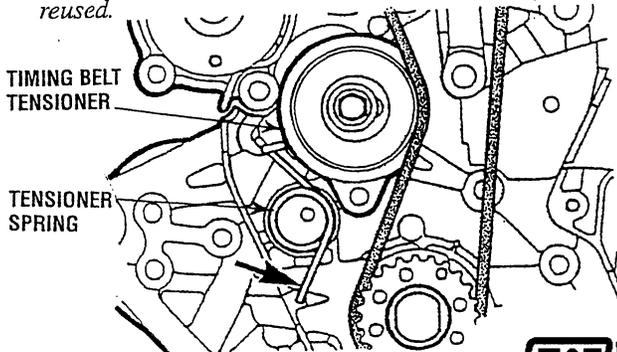
CAUTION: Water or oil on the timing belt severely reduces the service life of the belt. Keep the timing belt sprocket and tensioner free of oil and grease. These parts should never be cleaned. Replace if seriously contaminated with dirt or oil. If oil is evident on these parts, check the front case, oil pump oil seals, and crankshaft oil seals for a possible leak.



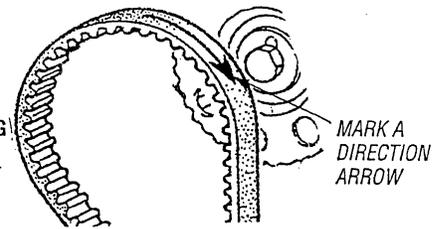
TIMING BELT REMOVAL

Using pliers, grip the tensioner spring projection and remove it from the oil pump case stopper. Then, remove the tensioner spring and the timing belt tensioner.

NOTE: If the timing belt is to be reused, chalk an arrow on the belt to indicate the direction of rotation before removing it. This will ensure the timing belt is fitted correctly when reused.

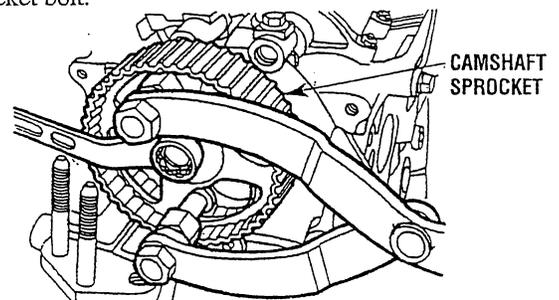


REMOVING THE TIMING BELT



SPROCKET BOLT REMOVAL (CAMSHAFT)

Using the special tools shown in the illustration, lock the camshaft sprocket in position and then loosen the camshaft sprocket bolt.



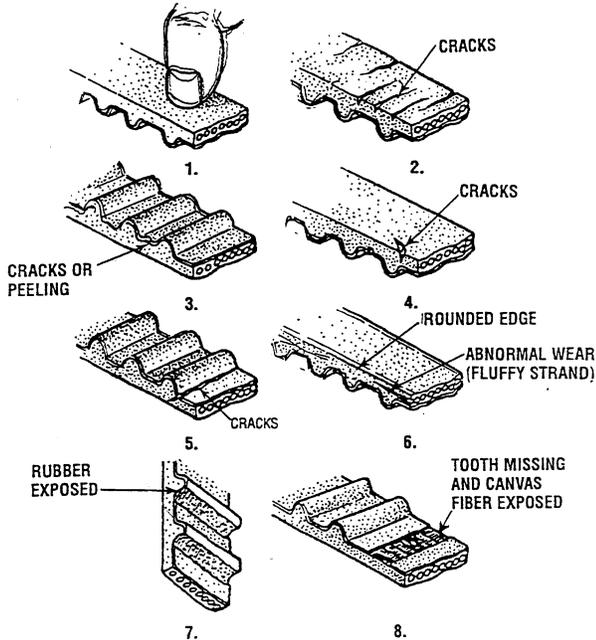
DISASSEMBLY, INSPECTION AND ASSEMBLY TIMING BELT

NOTE: In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

Timing Belt Inspection

Replace the belt if any of the following conditions exist:

1. Hardening of back rubber-back side is glossy, without resilience, and leaves no indent when pressed with fingernail.
2. Cracks on rubber back.
3. Cracks or peeling of canvas.
4. Cracks on tooth bottom.
5. Cracks on belt.
6. Abnormal wear of belt sides. The sides are normal if they are sharp as if cut by a knife.
7. Abnormal wear on teeth.
8. Tooth missing and canvas fiber exposed.

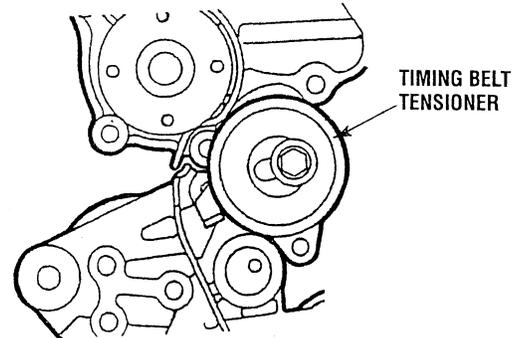


Belt Tensioner Inspection

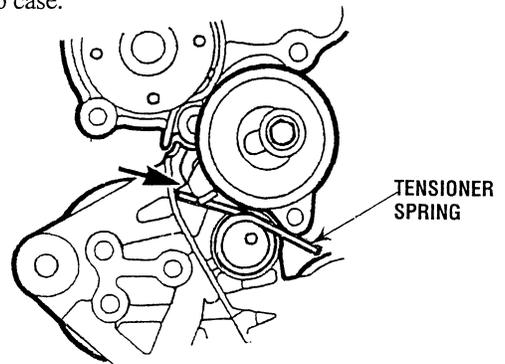
Replace the belt tensioner if it binds, rattles, or is noisy when turned.

Tensioner Spring Installation

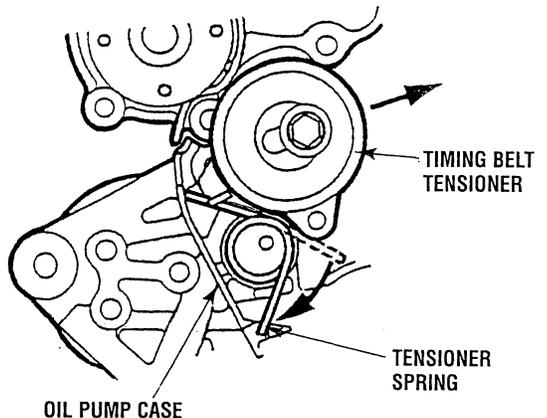
1. Lock the timing belt tensioner in the illustrated position.



2. Fit one of the tensioner spring projections over the hooked portion of the belt tensioner and fit the tensioner onto the oil pump case.

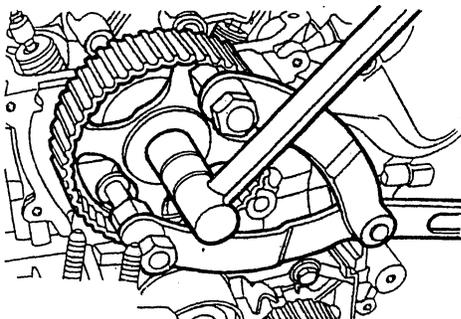


3. Grip the other tensioner spring projection and fit it onto the oil pump case lug as shown in the illustration. Move the timing belt tensioner in the direction shown and temporarily tighten the bolt.



Sprocket Bolt Installation (Camshaft)

Using the special tools shown in the illustration, lock the camshaft sprocket in position and tighten the camshaft sprocket bolt to the specified torque.

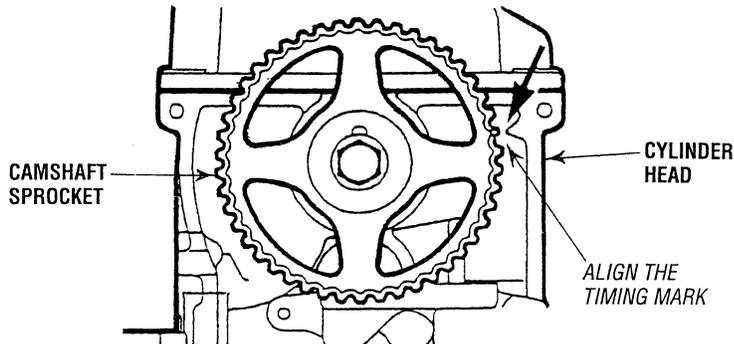


LOCKING THE CAMSHAFT SPROCKET
88Nm (64.9 ft-lb)

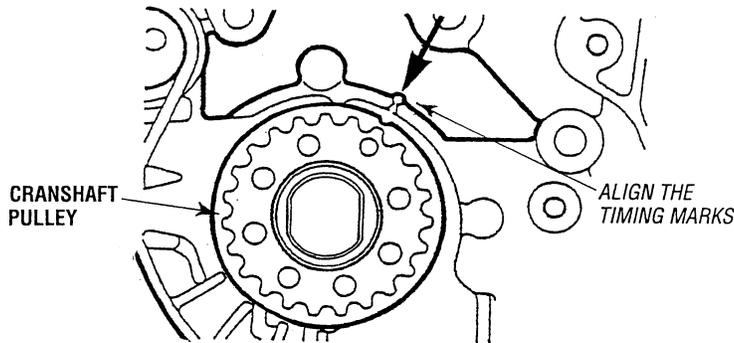
DISASSEMBLY, INSPECTION AND ASSEMBLY TIMING BELT

NOTE: In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

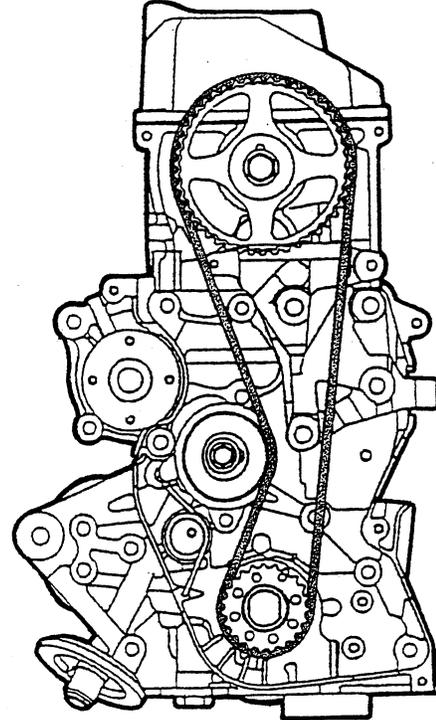
Timing Belt Installation



1. Align the camshaft timing mark with the timing mark on the cylinder head.



2. Align the crankshaft timing mark with the timing mark on the front case.
3. Keeping the tension side of the timing belt tight, fit the timing belt onto the crankshaft sprocket, camshaft sprocket, and tensioner pulley in that order.
4. Loosen the tensioner pulley mounting bolts by 1/4 to 1/2 of a turn and allow the tensioner spring to apply tension to the timing belt.



5. Turn the crankshaft twice in the normal rotating direction (clockwise) and check that the timing marks are correctly aligned.

CAUTION: This procedure utilizes the camshaft's driving torque to apply tension evenly to the timing belt. Be sure to turn the crankshaft as described above. Do not turn the crankshaft in reverse.

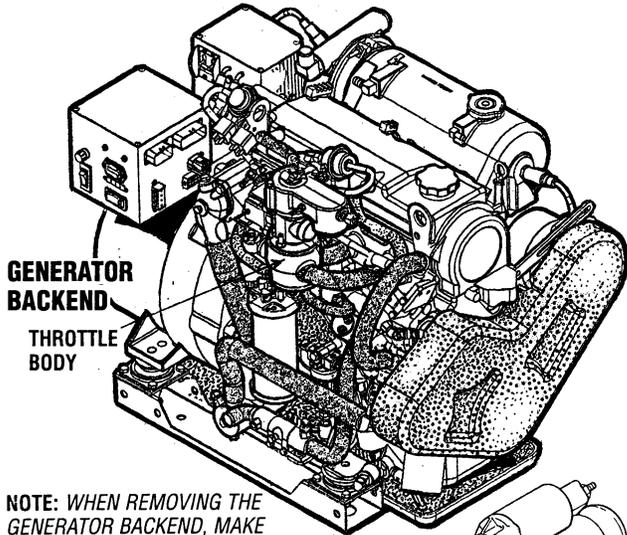
6. Tighten the tensioner pulley mounting bolts.
IDLER PULLEY BOLTS TORQUE 23 Nm (17 ft-lb)
7. Replace the timing belt covers.
TIMING BELT COVER BOLTS TORQUE 11 Nm (8 ft-lb)

ENGINE/GENERATOR DISASSEMBLY

REMOVING EXTERIOR ASSEMBLIES

DISASSEMBLY PROCEDURE

Before mounting the engine on an engine stand, unbolt and remove the generator backend. Make sure the back end is properly supported. Refer to the generator section of this manual for additional information and an exploded view of the generator components. Also remove the engine flywheel before mounting the engine.

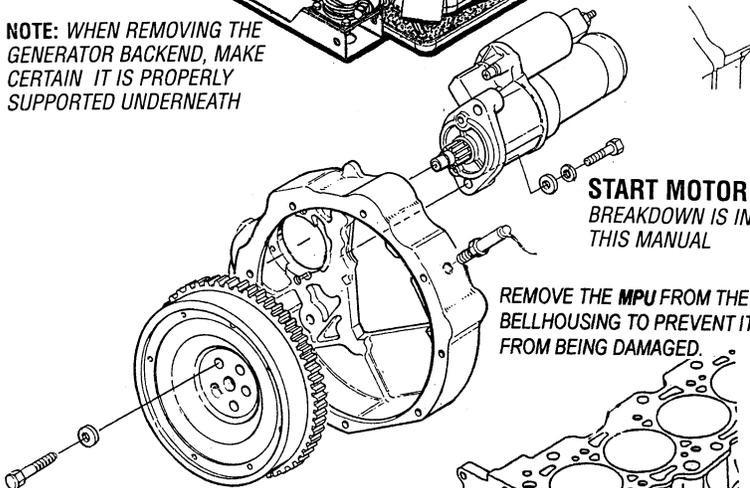
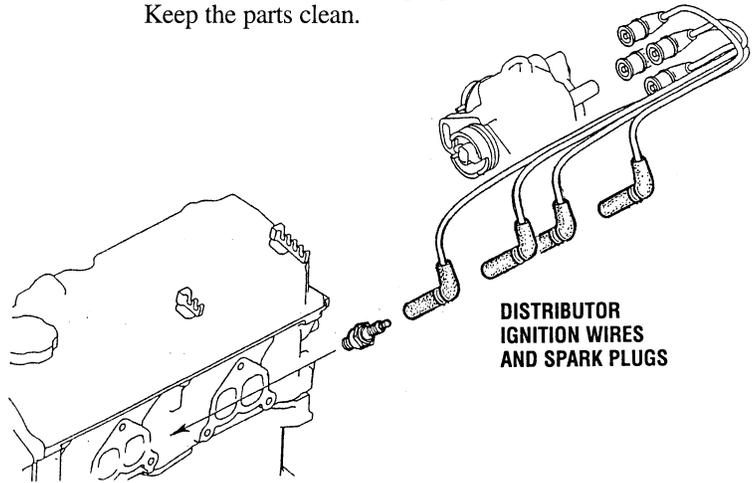


NOTE: WHEN REMOVING THE GENERATOR BACKEND, MAKE CERTAIN IT IS PROPERLY SUPPORTED UNDERNEATH

Mounting the engine on a suitable engine stand and begin removing the exterior engine components.

Note the following when disassemble these components.

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



BELL HOUSING/FLYWHEEL ASSEMBLY

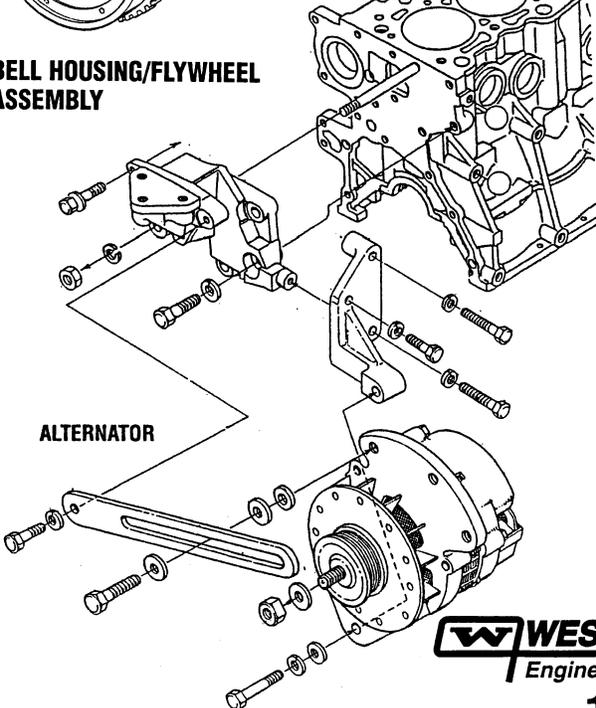
DC Alternator

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

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

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

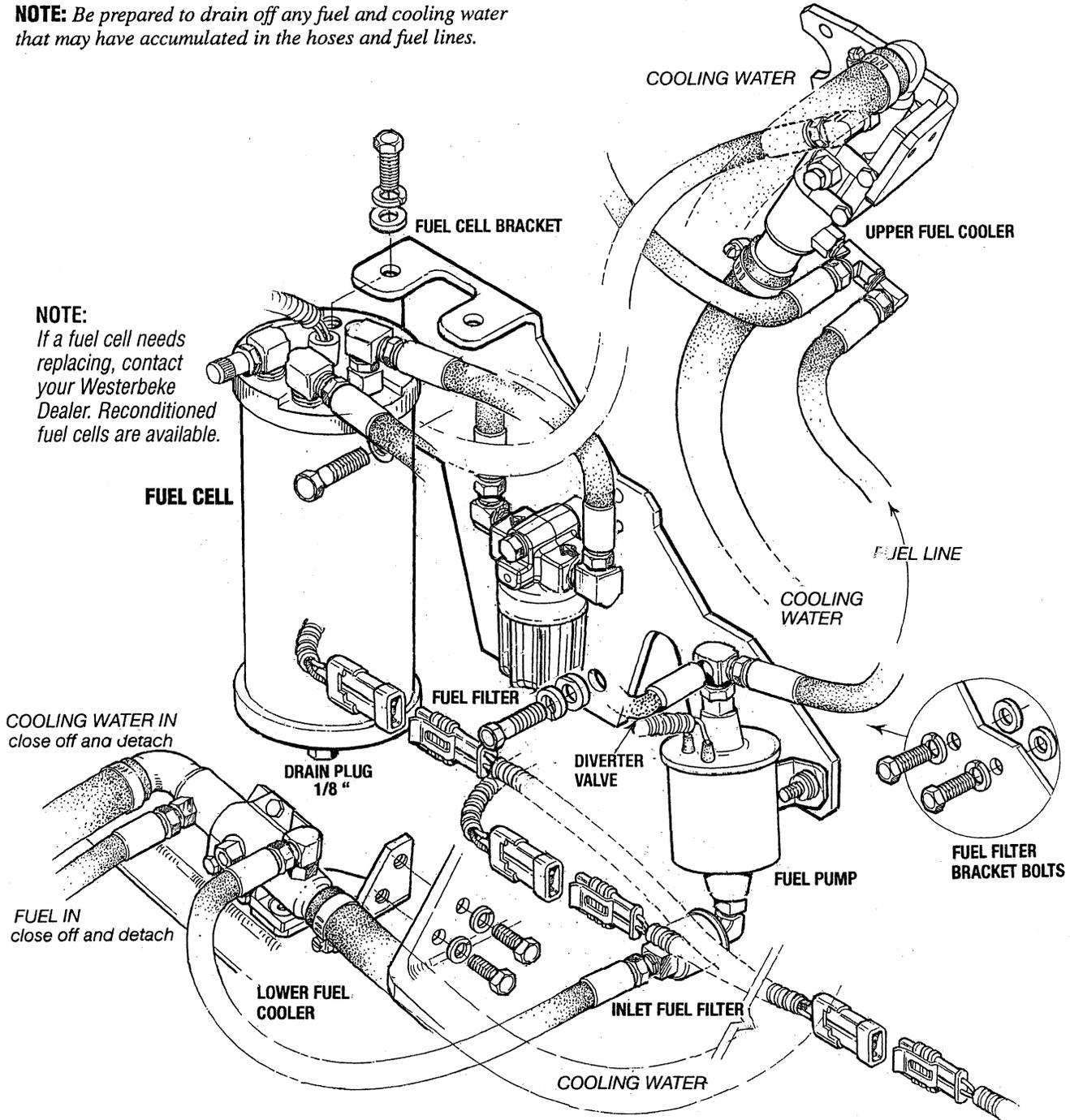
For additional information on alternators, refer to the *ALTERNATOR TROUBLESHOOTING* and *MANDO SERVICE* in this manual.



DISASSEMBLING EFI COMPONENTS

NOTE: Be prepared to drain off any fuel and cooling water that may have accumulated in the hoses and fuel lines.

NOTE:
If a fuel cell needs replacing, contact your Westerbeke Dealer. Reconditioned fuel cells are available.



DISASSEMBLY

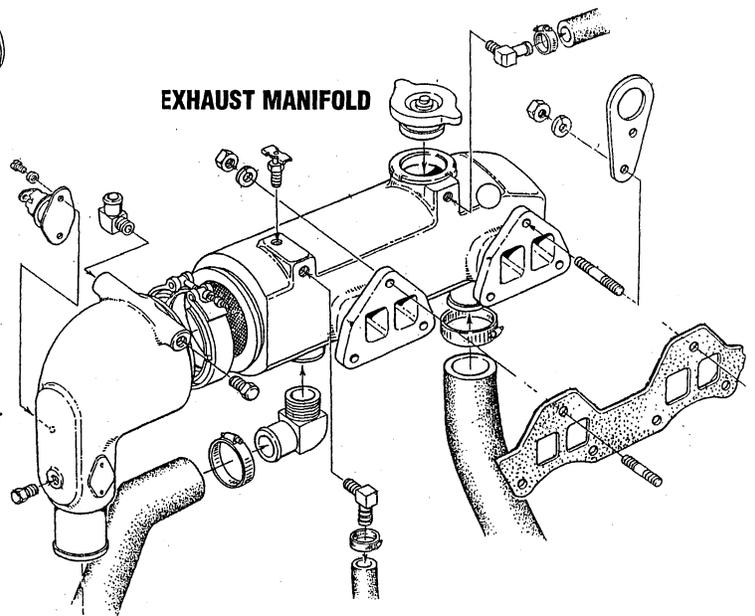
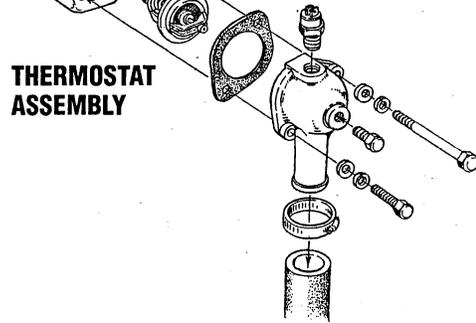
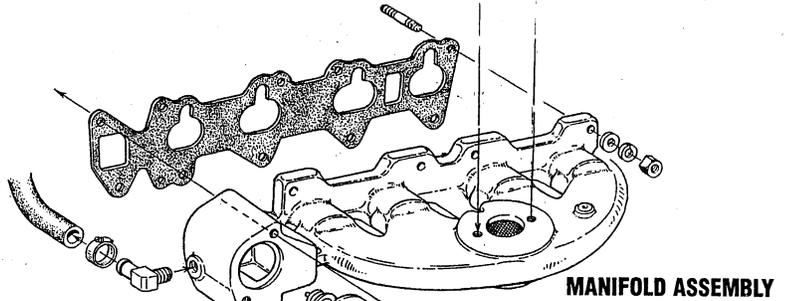
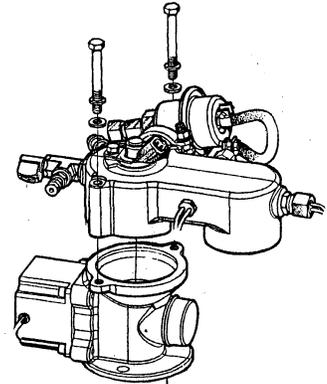
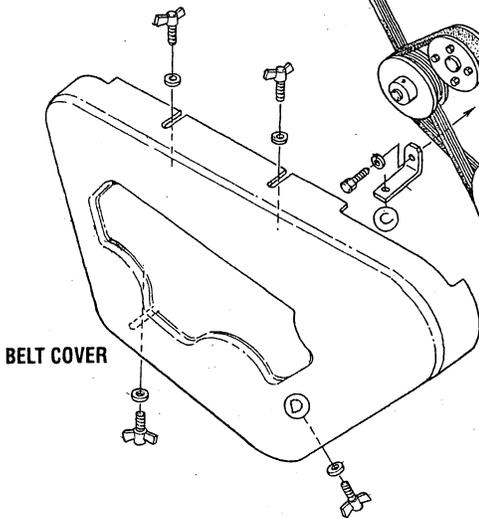
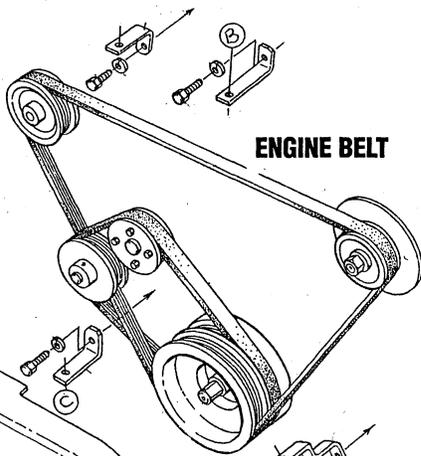
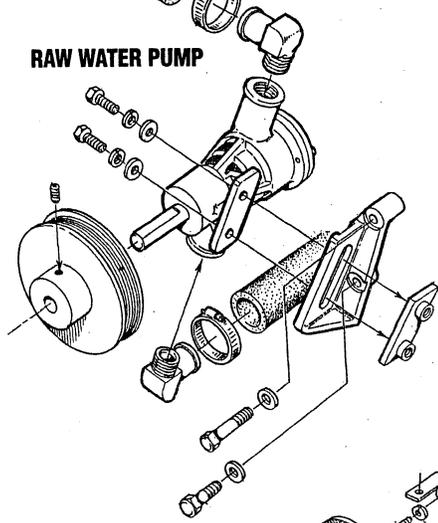
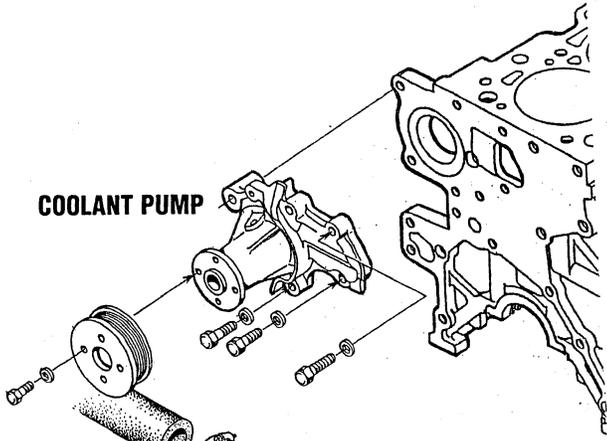
Unplug the wiring harness connections and lift the harness up and off the engine. Disconnect and remove the cooling water hoses. (tag all the hoses and wiring connections for identification when re-assembling).

Disconnect and remove the fuel hoses. The disconnected hoses, connections and wiring harness should be set aside and covered to keep them clean and protected.

With the wiring harness and cooling and fuel hoses removed, the EFI components can be disassembled.

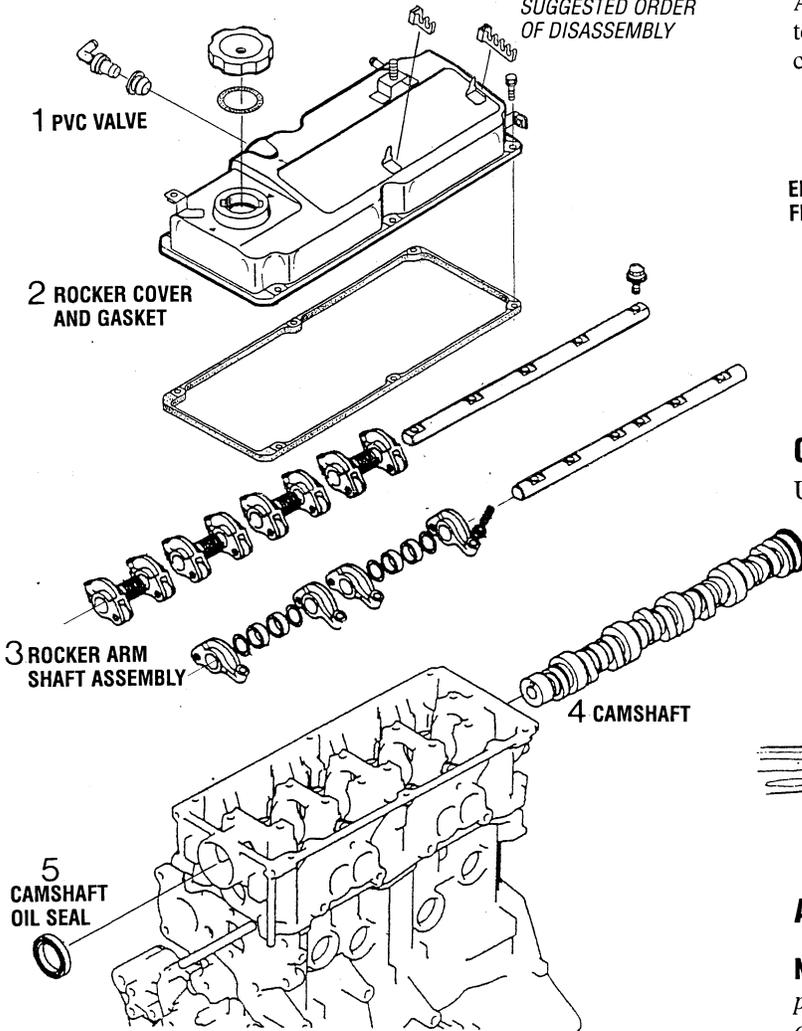
The fuel cell, fuel pump, and fuel filter can be removed together when the large main bracket is disassembled from the engine. All these components should be set aside and covered to keep them clean and protected.

EXTERIOR COMPONENTS DISASSEMBLY



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



ROCKER ARMS AND CAMSHAFT

Camshaft

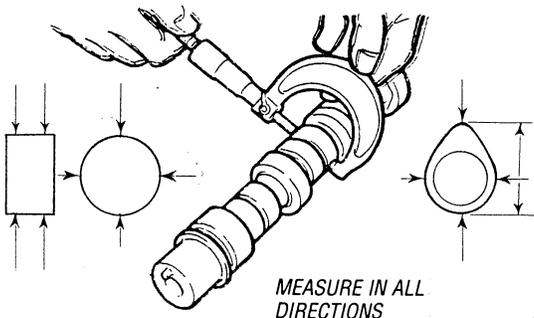
Measure the cam heights and replace the camshaft if any height is less than the specified limit.

STANDARD VALUE:

INTAKE	38.78mm (1.527in)
EXHAUST	39.10mm (1.540in)

LIMIT:

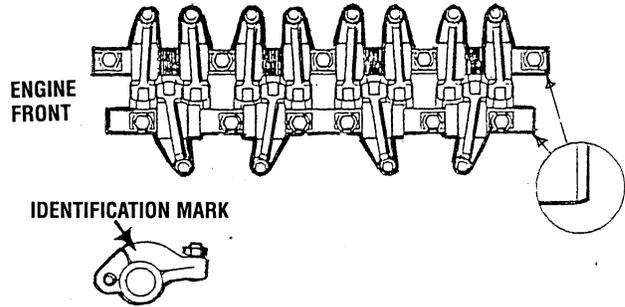
INTAKE	38.28mm (1.508in)
EXHAUST	38.60mm (1.521in)



MEASURE IN ALL DIRECTIONS

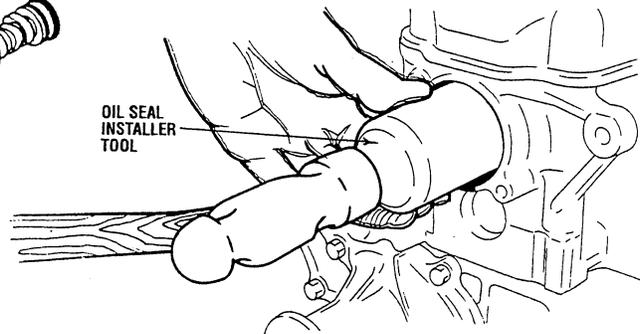
ROCKER ARM /ROCKER ASSEMBLY INSTALLATION

Assembly the rocker arms and rocker shaft, paying attention to the identification marks. Then, mount the assembly on the cylinder head.



CAMSHAFT OIL SEAL INSTALLATION

Using the oil seal installer tool, install the camshaft oil seal.

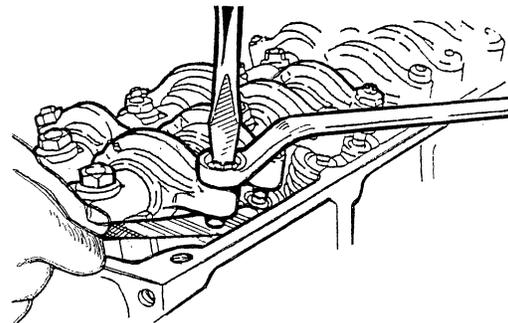


ADJUSTING THE VALVE CLEARANCE

NOTE: Refer to the VALVE CLEARANCE ADJUSTMENT procedure in this manual, however when adjusting the valve clearance on a cold engine, use the following data.

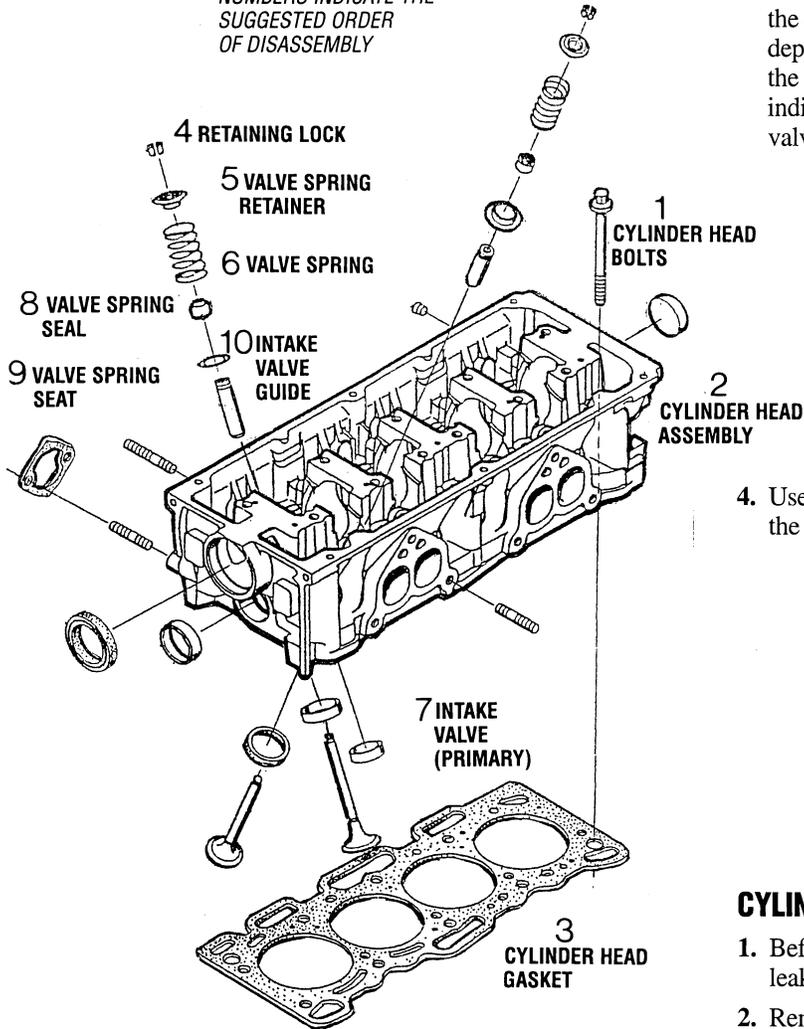
VALVE CLEARANCE ON A COLD ENGINE

INTAKE	0.09mm (0.0035in)
EXHAUST	0.17mm (0.0066in)



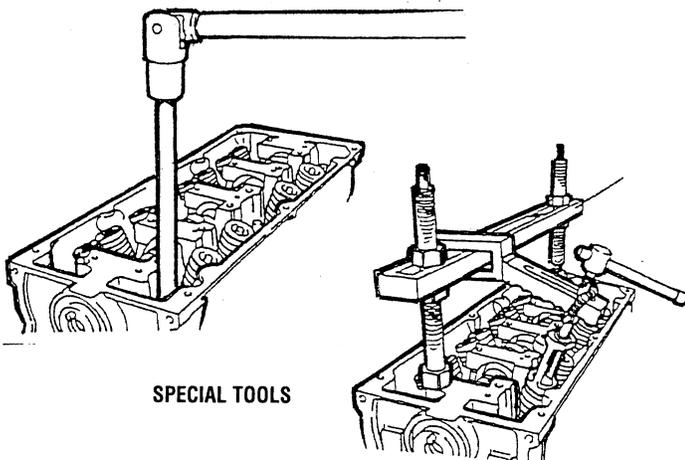
ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



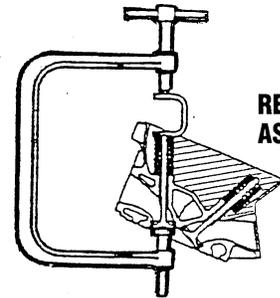
REMOVING THE CYLINDER HEAD FROM THE CYLINDER BLOCK

1. Loosen each of the cylinder head bolts, a little at a time so as to avoid the possibility of distorting the cylinder. repeat several times until the bolts are unfastened.
2. Remove the cylinder head and the cylinder head gasket.



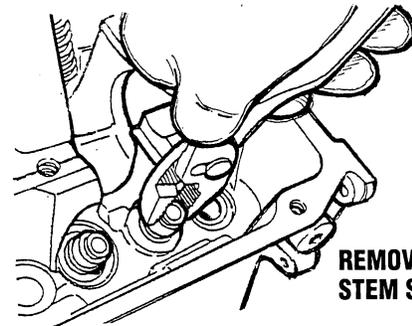
SPECIAL TOOLS

3. Remove the valve retainers, valve springs and valves from the cylinder head. When removing each valve retainer, depress the retainer against the valve spring and remove the retainer lock. Identify each valve by putting a mark indicating the number of the cylinder from which the valve was removed.



REMOVING VALVE ASSEMBLY

4. Use pliers to remove the valve stem seals. Do not reuse the stem seals.



REMOVING VALVE STEM SEALS

CYLINDER HEAD INSPECTION

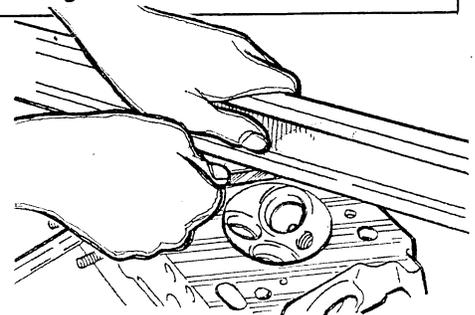
1. Before cleaning the cylinder head, check it for water leaks, gas leaks, cracks, and other damage.
2. Remove all oil, water scale, sealant, and carbon. After cleaning the oil passages, blow air through them to verify that they are not blocked.
3. Check for distortion in the cylinder head gasket surface using a straight edge and thickness gauge. If distortion exceeds the specified limit, grind the gasket surface to specification.

GASKET SURFACE DISTORTION

STANDARD VALVE	0.05mm (.00197in) or less
LIMIT	0.2mm (.00788in)
GRINDING LIMIT	0.2mm (.00788in)

CYLINDER HEAD HEIGHT (SPECIFICATION WHEN NEW)
106.9 - 107.1mm (4.21 - 4.219in)

CAUTION: No more than 0.2mm (.00788in) of stock may be removed from the cylinder head and cylinder block mating surfaces in total.



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

VALVES

1. Check the valve face for correct contact. If contact is uneven or incomplete, reface the valve seat.
2. If the margin is less than specified, replace the valve.

STANDARD VALUE:

INTAKE 1.0mm (.0394in)
EXHAUST 1.5mm (.059in)

LIMIT:

INTAKE 0.5mm (.0197in)
EXHAUST 1.0mm (.0394in)

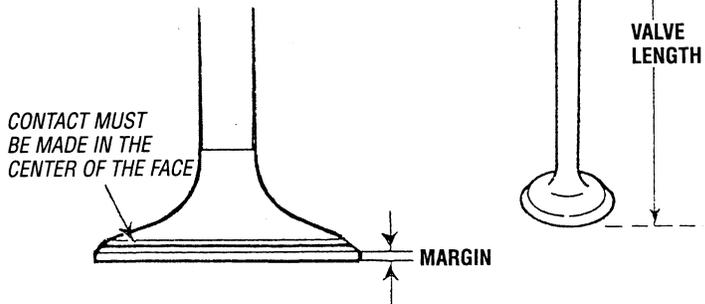
3. Measure the valves total length. If the measurement is less than specified, replace the valve.

STANDARD VALUE:

INTAKE 100.75mm (3.969in)
EXHAUST 101.05mm (3.98in)

LIMIT:

INTAKE 100.25mm (3.95in)
EXHAUST 100.55mm (3.96in)



VALVE SPRINGS

1. Measure the valve springs free height. If the measurement is less than specified, replace the spring.

STANDARD VALUE:

INTAKE 46.1mm (1.81in)
EXHAUST 46.8mm (1.84in)

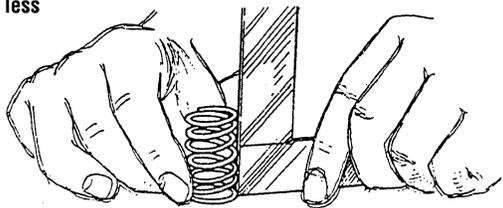
LIMIT:

EXHAUST 46.3mm (1.82in)

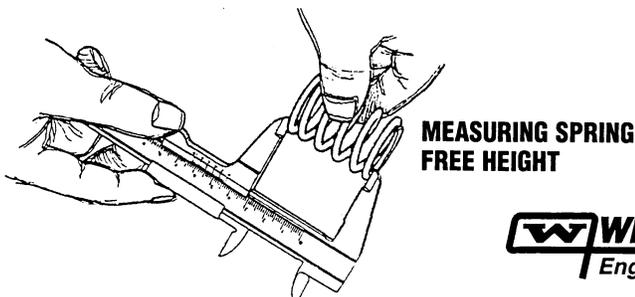
2. Measure the squareness of the spring. If the measurement exceeds the specified limit, replace the spring.

STANDARD VALUE: 2° or less

LIMIT: 2° or less



MEASURING SPRING SQUARENESS



MEASURING SPRING FREE HEIGHT

VALVE GUIDES

1. Measure the clearance between the valve guide and the valve stem. If the clearance exceeds the specified limit, replace either or both components.

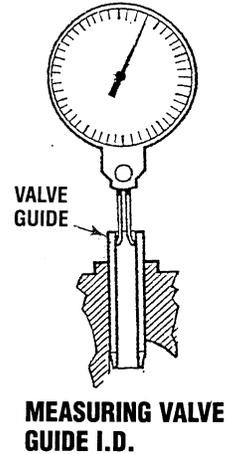
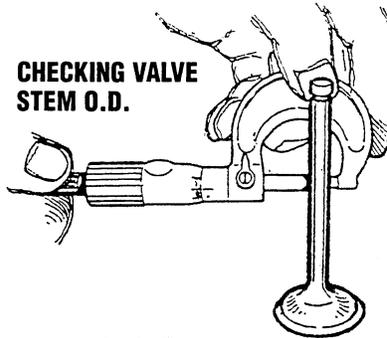
STANDARD VALUE:

INTAKE 0.020 - 0.050mm (.00078 - .00197in)
EXHAUST 0.050 - 0.085mm (.00197 - .0033in)

LIMIT:

INTAKE 0.10mm (0.00394in)
EXHAUST 0.15mm (0.0059in)

CHECKING VALVE STEM O.D.



MEASURING VALVE GUIDE I.D.

VALVE SEATS

1. Assemble the valve, then measure the valve stem projection between the end of the valve stem and the spring seating surface. If the measurement exceeds the specified limit, replace the valve seat.

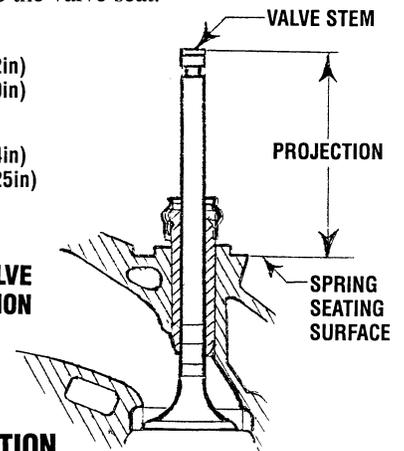
STANDARD VALUE:

INTAKE 43.70mm (1.72in)
EXHAUST 43.30mm (1.70in)

LIMIT:

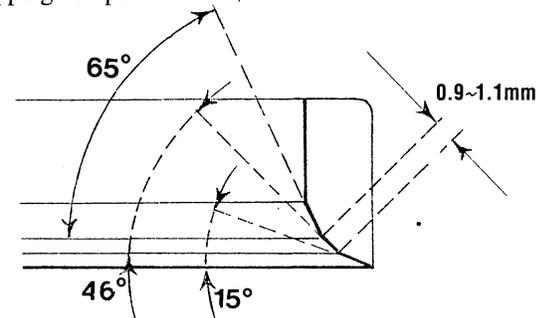
INTAKE 44.20mm (1.74in)
EXHAUST 43.80mm (1.725in)

MEASURING VALVE STEM PROJECTION



VALVE SEAT CORRECTION

1. Before correcting the valve seat, check the clearance between the valve guide and valve. If necessary, replace the valve guide.
2. Using the appropriate special tool or seat grinder, correct the valve seat to achieve the specified seat width and angle.
3. After correcting the valve seat, lap the valve and valve seat using lapping compound. Then, check the valve stem projection.



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

VALVE SEAT REPLACEMENT

1. Cut the valve thickness to be replaced from the inside to reduce the wall thickness. Then, remove the valve seat.
2. Rebore the valve seat hole in the cylinder head to match the selected oversize valve seat diameter.

INTAKE VALVE SEAT HOLE DIAMETERS (0.3 oversize)

PRIMARY 27.300 - 27.325mm (1.075 - 1.076in)
SECONDARY 32.300 - 32.325mm (1.272 - 1.273in)

INTAKE VALVE SEAT HOLE DIAMETERS (0.6 oversize)

PRIMARY 27.600 - 27.625mm (1.087 - 1.088in)
SECONDARY 32.600 - 32.625mm (1.284 - 1.28in)

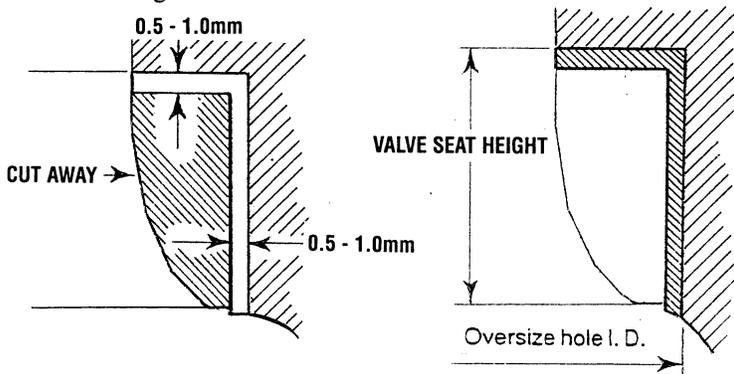
EXHAUST VALVE SEAT HOLE DIAMETERS (0.3 oversize)

35.300 - 35.325mm (1.390 - 1.391in)

EXHAUST VALVE SEAT HOLE DIAMETERS (0.6 oversize)

35.600 - 35.625mm (1.402 - 1.403in)

3. Prevent galling of the cylinder head bore by cooling the valve seat with liquid nitrogen before press-fitting it.
4. Correct the valve seat to achieve the specified width and angle.



VALVE GUIDE REPLACEMENT

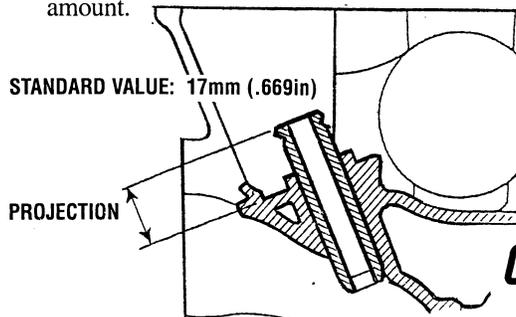
1. Using a press, push the valve guide out toward the cylinder block side.
2. Rebore the valve guide hole in the cylinder head to match the oversize valve guide that is to be fitted.

CAUTION: Do not install a valve guide of the same size again.

VALVE GUIDE HOLE DIAMETERS

0.05 OVERSIZE: 12.050 - 12.068mm (.474 - .475in)
0.25 OVERSIZE: 12.250 - 12.268mm (.482 - .483in)
0.50 OVERSIZE: 12.500 - 12.518mm (.4925 - .4932in)

3. Press-fit the valve guide until it projects by the specified amount.

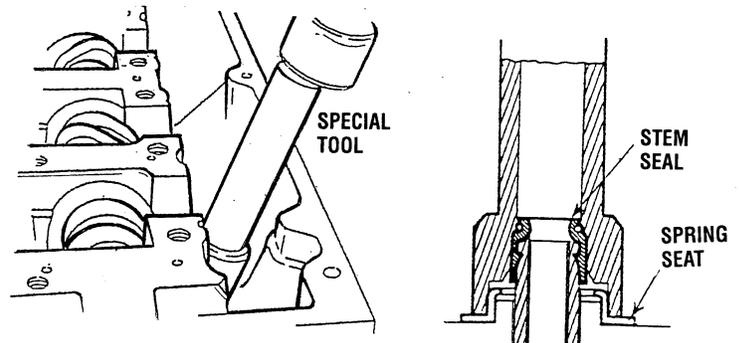


CAUTION: The valve guide must be installed from the upper side of the cylinder head. The valve guides differ in length on the intake and exhaust sides. After press-fitting the valve guide, insert a new valve and check that it slides smoothly.

VALVE STEM SEAL INSTALLATION

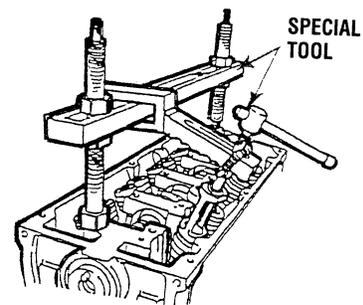
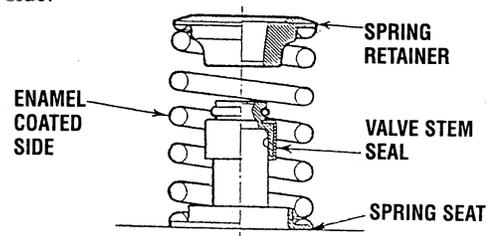
1. Install the valve spring seat.
2. Install a new valve stem seal using the special tool shown.

CAUTION: Valve stem seals cannot be re-used. New valve stem seals must be installed using the correct special tool. Incorrect installation could result in oil leaking past the valve guide.



VALVE SPRING INSTALLATION

1. Install the valve spring with the painted end on the rocker arm side.



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

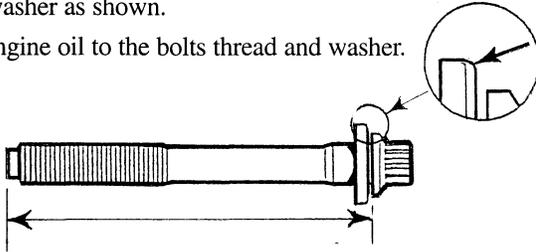
CYLINDER HEAD BOLT INSTALLATION

1. Before re-using the cylinder head bolt, check that its normal length does not exceed the specified limit. Replace the bolt if this measurement exceeds the limit.

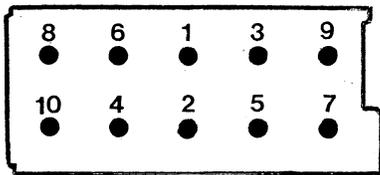
LIMIT: 103.2mm (4.066in)

2. Fit the washer as shown.

3. Apply engine oil to the bolts thread and washer.

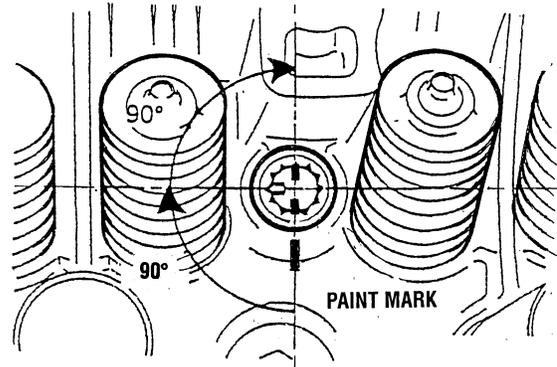


4. Tighten the bolts in the sequence shown until each is torqued to **TORQUE TO 49Nm (36.1 ft-lb)**
5. Completely loosen the bolts.
6. Retighten the bolts in the sequence shown until each is torqued to **TORQUE TO 20Nm (14.7 ft-lb)**



7. Apply paint marks to the cylinder head bolt heads and cylinder head as shown.
8. In accordance with the tightening sequence, tighten each bolt by 90°.
9. Tighten each bolt by a further 90° and check that the paint marks on the bolt head and cylinder head are aligned.

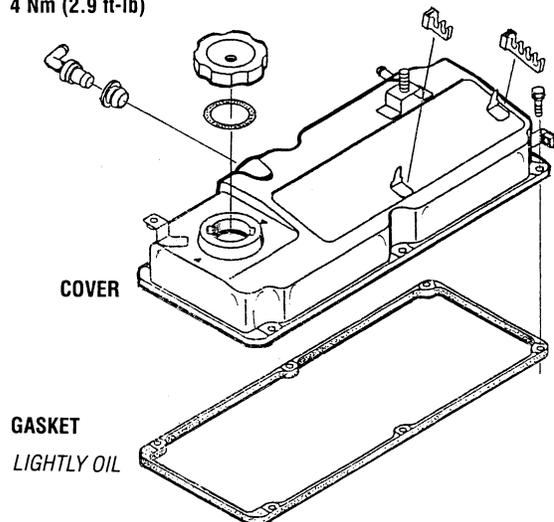
CAUTION: If the bolts are tightened by an angle of less than 90°, they may not hold the cylinder head with sufficient strength. If the bolts are tightened by an angle exceeding 90°, completely remove them and carry out the installation procedure again.



Rocker Cover

Install the rocker cover using a new gasket (slightly coat both sides with clean oil). Gradually tighten the cover bolts to the specified torque making certain the cover gasket is positioned properly.

ROCKER COVER BOLT TORQUE
4 Nm (2.9 ft-lb)

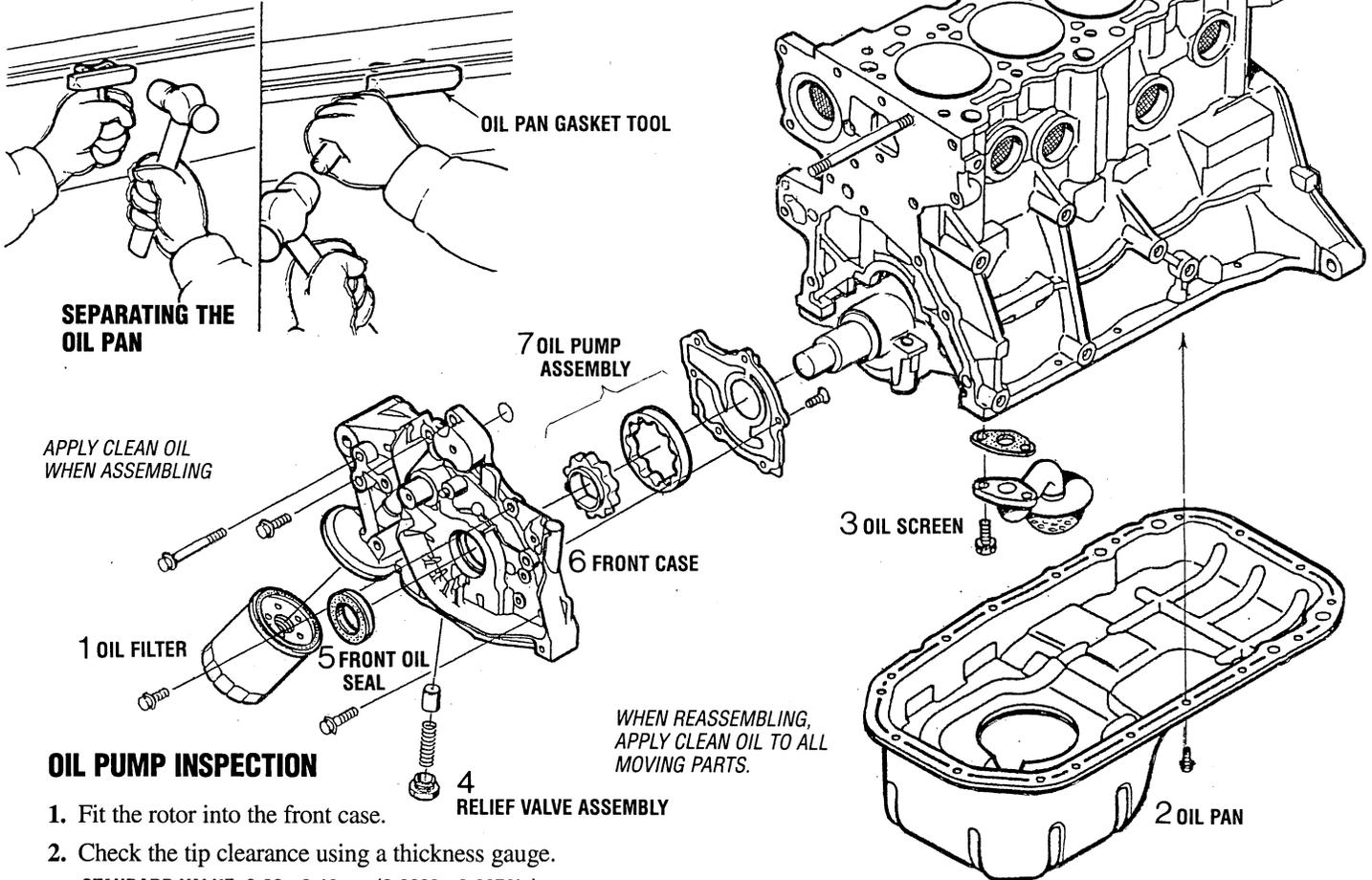


ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

OIL PAN REMOVAL

1. Remove the oil pan mounting bolts.
2. Knock the special tool between the oil pan and cylinder block as shown in the illustration.
3. Tapping the side of the special tool slide the tool along the oil pan/cylinder block seal and remove the oil pan.

NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



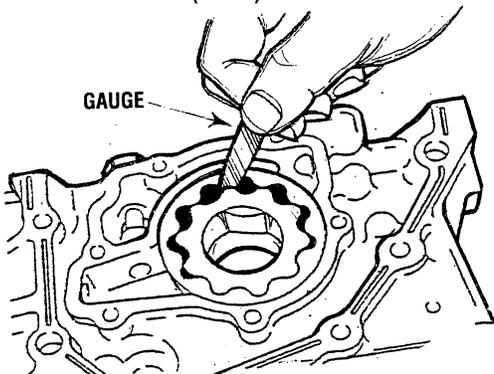
SEPARATING THE OIL PAN

APPLY CLEAN OIL WHEN ASSEMBLING

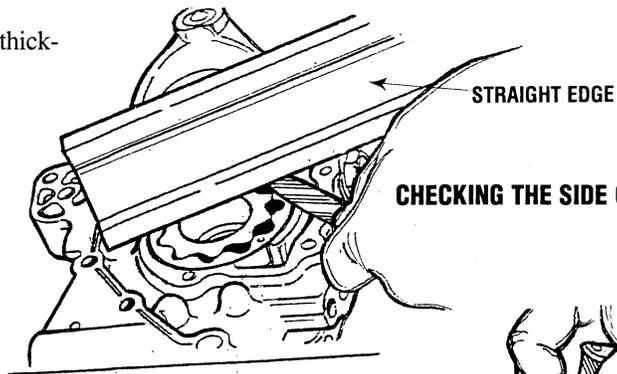
WHEN REASSEMBLING, APPLY CLEAN OIL TO ALL MOVING PARTS.

OIL PUMP INSPECTION

1. Fit the rotor into the front case.
2. Check the tip clearance using a thickness gauge.
STANDARD VALUE: 0.06 - 0.18mm (0.0023 - 0.0070in)
3. Check the side clearance using a straight edge and thickness gauge.
STANDARD VALUE: 0.04 - 0.10mm (0.0015 - 0.0039in)
4. Check the body clearance using a thickness gauge.
STANDARD VALUE: 0.04 - 0.10mm (0.0015 - 0.0039in)
LIMIT: 0.35mm (0.13in)

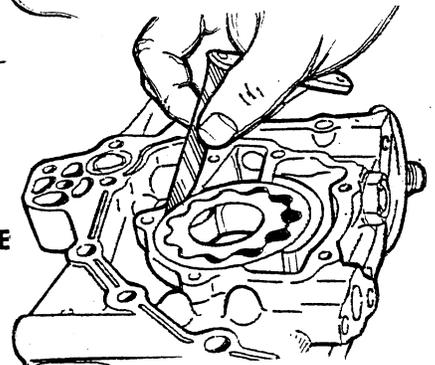


CHECKING THE TIP CLEARANCE



CHECKING THE SIDE CLEARANCE

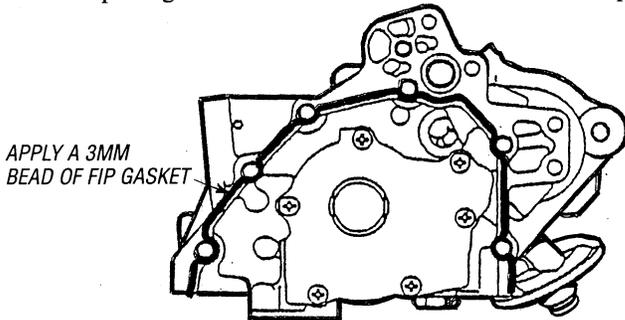
CHECKING THE BODY CLEARANCE



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

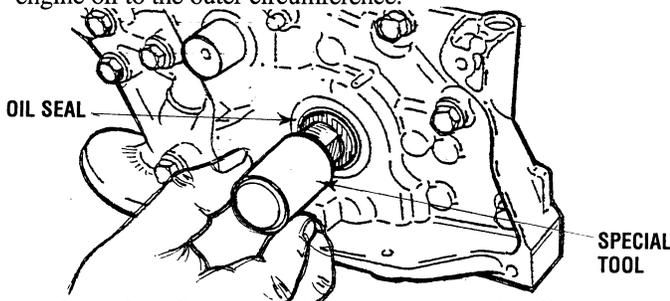
FRONT OIL SEAL CASE INSTALLATION

Clean the sealant application surfaces on the cylinder block and front oil seal case and apply a 3mm bead of form-in-place gasket to the entire circumference of the oil pan flange.

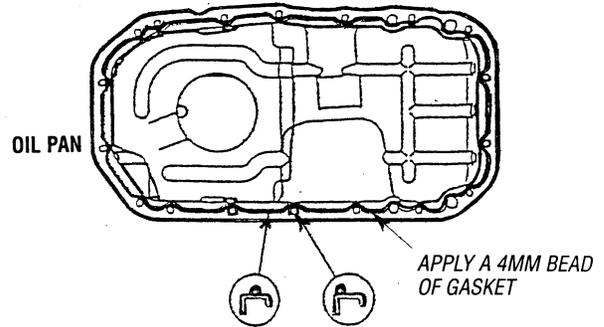
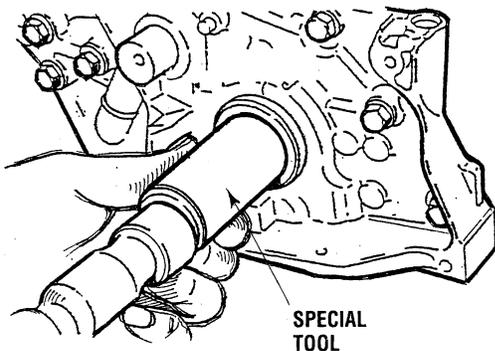


FRONT OIL SEAL INSTALLATION

Place the special tool on the crankshaft front end and apply engine oil to the outer circumference.



Apply engine oil to the oil seal lip, then push the oil seal along the guide by hand until it touches the front case. Tap the oil seal into place using the special tool.



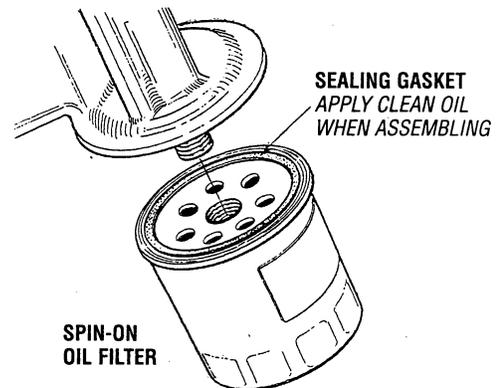
OIL PAN INSTALLATION

Before installing the oil pan, inspect the oil pan drain hose and fittings for cracks and wear, replace if necessary.

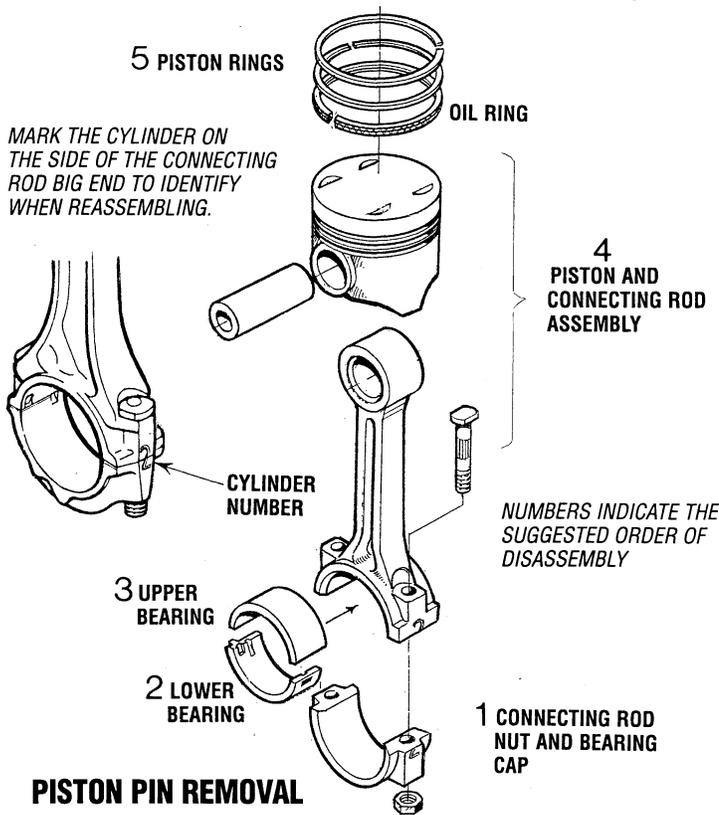
Clean the mating surfaces of the cylinder block and oil pan. Apply a 4mm bead of form-in-place gasket to the outer circumference of the oil pan flange.

INSTALL A NEW OIL FILTER

Screw the oil filter in until the sealing gasket contacts the front case, then tighten 3/4 turn.



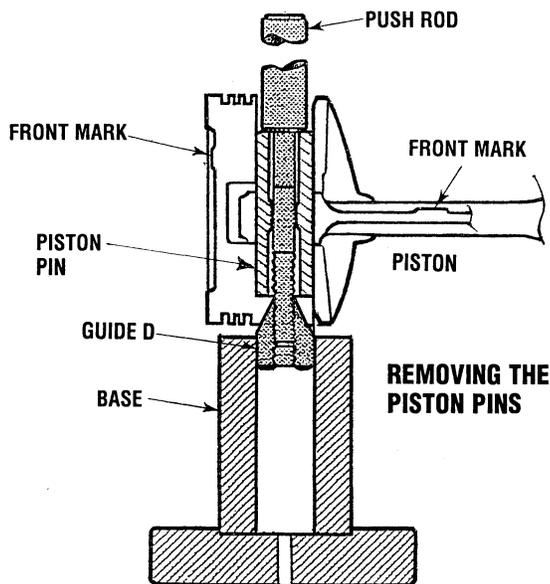
ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY



PISTON PIN REMOVAL

1. Insert the Push Rod (special tool) from the front arrow mark side, then fit guide D.
2. Mount the piston and connecting rod assembly on the Piston Pin Setting Base (special tool) with the piston's front mark pointing upward.
3. Remove the piston pin using a press.

NOTE: After removing the piston pin, keep the piston, piston pin, and connecting rod together. Do not allow pistons, piston pins, and connecting rods from different cylinders to become mixed up.

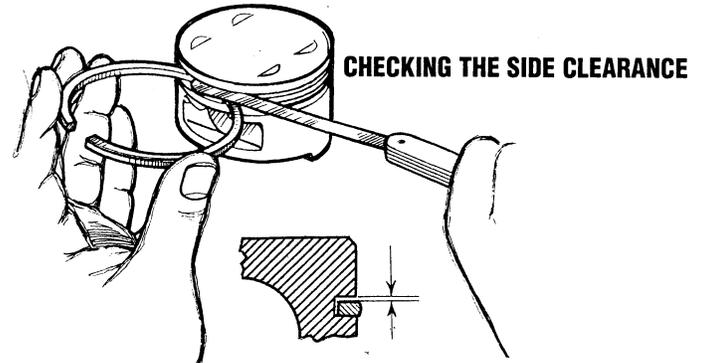


PISTON RINGS - INSPECTION

1. Check the piston ring side clearance. If the clearance exceeds the specified limit, replace the ring or piston, or both.

STANDARD VALUE:

NO.1 RING:	0.03 - 0.07mm (.00118 - .00275in)
NO.2 RING:	0.02 - 0.06mm (.00078 - .00231in)



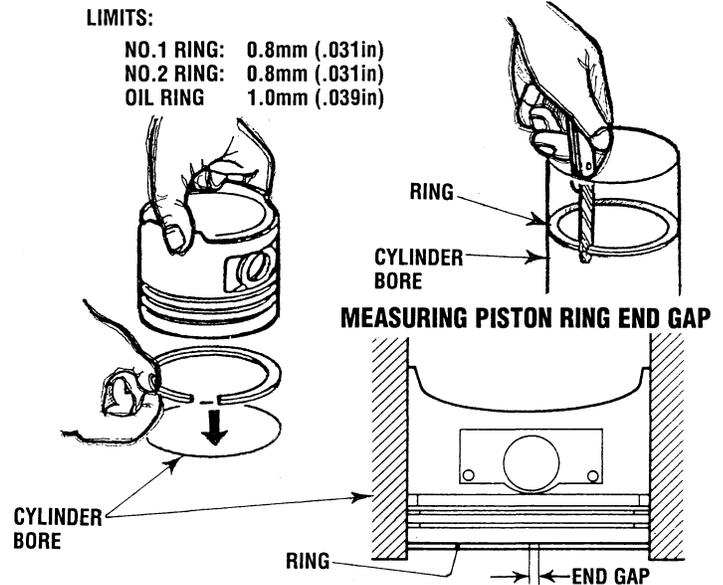
2. Insert the piston ring into the cylinder bore and push it down with a piston. Ensure that the piston's crown is in contact with the ring so that the ring is at 90° to the cylinder wall. Then measure the end gap with a thickness gauge. If the gap is too large, replace the piston ring.

STANDARD VALUE:

NO.1 RING:	0.20 - 0.35mm (.00788 - .013in)
NO.2 RING:	0.35 - 0.50mm (.013 - .019in)
OIL RING:	0.20 - 0.50mm (.00788 - .019in)

LIMITS:

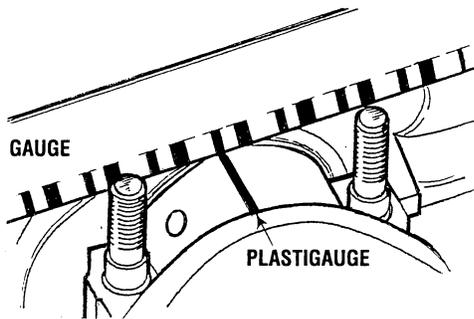
NO.1 RING:	0.8mm (.031in)
NO.2 RING:	0.8mm (.031in)
OIL RING:	1.0mm (.039in)



3. Check the piston rings for damage, wear, seizure and bends, replacing the rings if anything unusual is noted. Always replace the piston rings when installing a new piston.

NOTE: If replacing piston rings, check the piston ring gaps. New rings are packaged with detailed instructions that often supersede the service manual text.

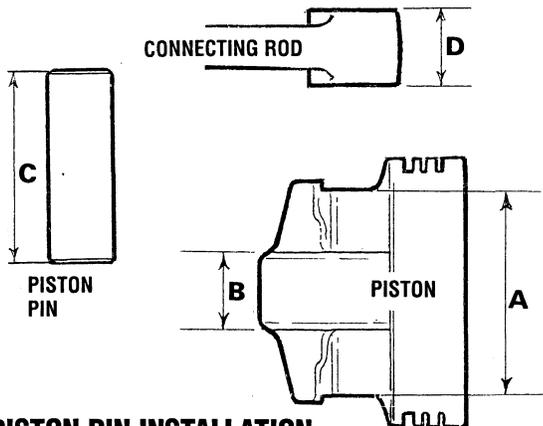
ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY



CRANKSHAFT PIN OIL CLEARANCE (PLASTIC GAUGE METHOD)

1. Wipe all the oil off the crankshaft pin and the connecting rod bearing.
2. On the pin, place a plastic gauge that is cut to the same length as the bearings width. The plastic gauge must be centered on the pin in parallel with the pins axis.
3. Gently place the connecting rod cap in position and tighten the bolts to the specified torque.
4. Remove the bolts and gently remove the connecting rod cap.
5. Measure the compressed part of the plastic gauge at its widest point using the scale printed on the plastic gauge.

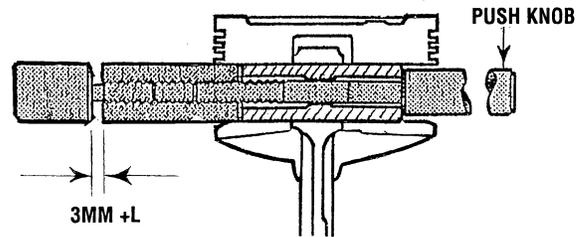
STANDARD VALUE 0.02 - 0.04mm (.000788 - .0015in)
LIMIT 0.1mm (.0039in)



PISTON PIN INSTALLATION

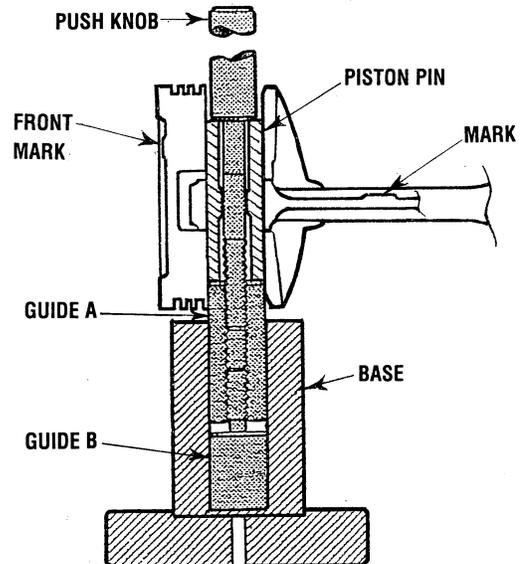
1. Measure the following lengths (as shown):
A: Piston boss-to-piston boss outside dimension.
B: Piston boss-to-piston boss inside dimension
C: Piston pin length.
D: Connecting rod small end eye thickness.
2. Enter the measured values into the following formula:
$$L = \frac{A - C - B - D}{2}$$
3. Insert the Push Rod (special tool) into the piston pin, then fit **guide A** (special tool) as shown.
4. Fit the piston and connecting rod together such that their front marks are on the same side.

5. Apply engine oil to the outside of the piston pin.
6. Into the front-mark side of the piston, insert the **guide A**, piston pin, and Push Rod, starting with **guide A**.
7. Screw **guide B** into **guide A**. Leave a gap between the two guides of 3mm plus the value (L) calculated in step 2.



8. Mount the piston and connecting rod on the Piston Pin Setting Base (special tool) with the pistons front mark pointing upward.
9. Install the piston pin using a press. If the press-fitting load is out of specification, replace the piston pin and piston assembly or the connecting rod, or both.

STANDARD VALUE 4,900 - 14,700 Nm (36,162 - 10,848 ft-lbs)

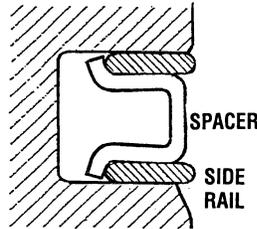
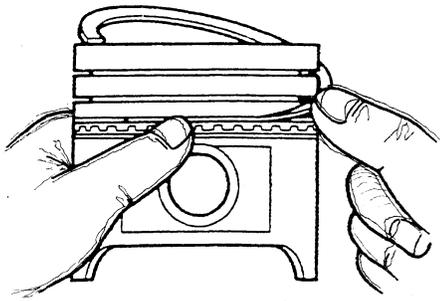


PISTON RINGS INSTALLATION

1. Fit the oil ring spacer into the piston groove. Then, assemble the upper and lower side rails.
2. The spacer and side rails may be fitted in either direction. No distinction is made between top and bottom. The spacer and the side rails sizes are color coded as follows:

SIZE	COLOR
STD	None
0.50mm oversize	Blue
1.00mm oversize	Yellow

ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

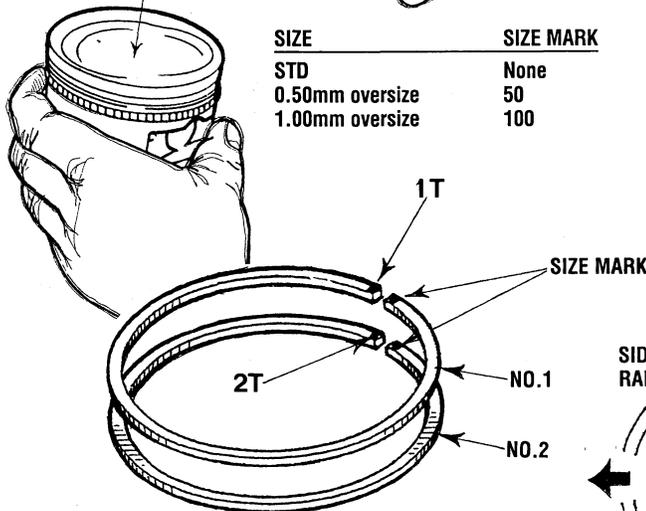
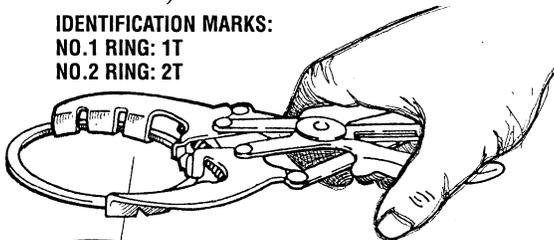


- To install a side rail, fit one end of the rail into the groove then press the rest of the rail into position by hand as shown.

CAUTION: Do not fit side rails using a piston ring expander since they may break.

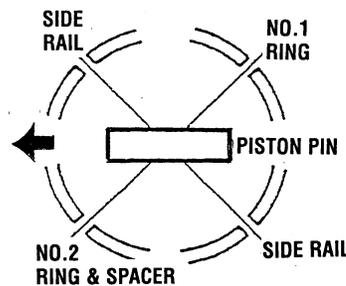
- After installing the side rails, check that they move smoothly in both directions.
- Using a ring expander, fit ring No.2 and ring No.1 with their identification marks facing upward (on the piston crown side).

IDENTIFICATION MARKS:
NO.1 RING: 1T
NO.2 RING: 2T



PISTON AND CONNECTING ROD ASSEMBLY INSTALLATION

- Apply oil to the piston, piston rings, and oil ring.
- Align the gaps of the piston rings and oil ring (side rails and spacer) as shown.
- With the piston crowns front arrow mark pointing toward the timing belt side, press the piston and connecting rod assembly into the cylinder from the top of the cylinder.



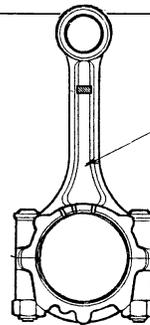
- Compress the piston rings tightly with a suitable ring compression tool, then press the piston and connecting rod fully into the cylinder. Do not strike the piston hard since the piston rings may break and the crank pin may be nicked.



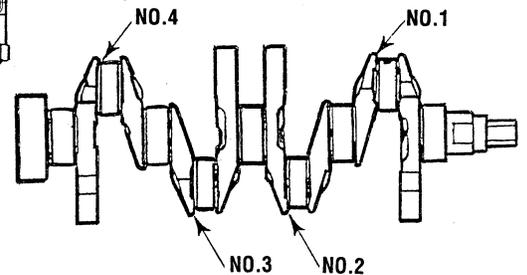
CONNECTING ROD BEARING INSTALLATION

Select bearings according to the crankshaft and connecting rod identification marks or color codes, referring to the following table.

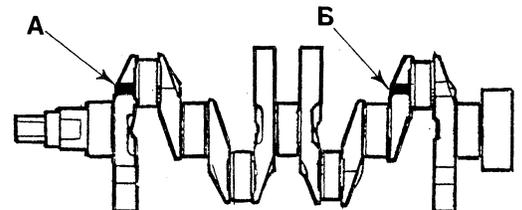
CRANKSHAFT IDENTIFICATION MARK	CONNECTING ROD IDENTIFICATION COLOR	BEARING IDENTIFICATION MARK
I, YELLOW	WHITE	1
	NONE	1
	YELLOW	2
II, NONE	WHITE	1
	NONE	2
	YELLOW	3
III, WHITE	WHITE	2
	NONE	3
	YELLOW	3



COLOR CODE POSITIONS



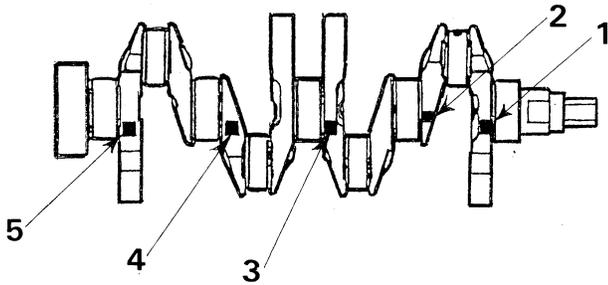
CRANKSHAFT



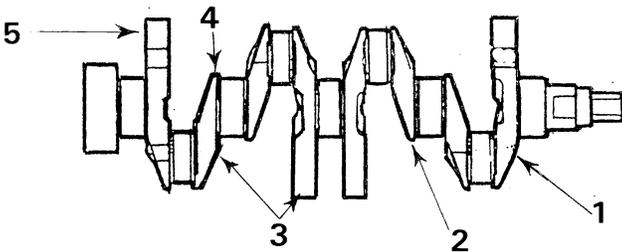
IDENTIFICATION MARK S

ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

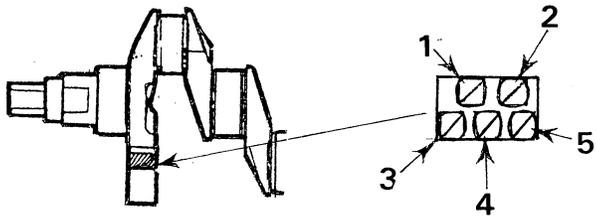
COLOR CODE POSITIONS (TYPE 1)



COLOR CODE POSITIONS (TYPE 2)



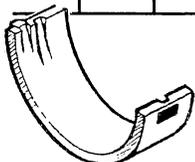
IDENTIFICATION MARK POSITIONS



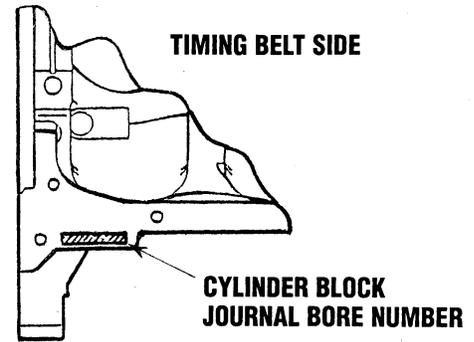
CRANKSHAFT BEARING INSTALLATION

1. Select bearings according to the crankshaft identification marks or color codes, referring to the following chart. If they are not identifiable, measure the crankshaft journals and choose bearings to match the measurements.

CRANKSHAFT JOURNAL			CYLINDER BLOCK BEARING BORE DIAMETER	BEARING	
RANGE	COLOR CODE	IDENT. MARK		JOURNAL DIAMETER MM(IN)	IDENT. MARK
1	YELLOW	1	47.995-48.000 (1.8910-1.8912)	0	1
				1	2
				2	3
2	NONE	2	47.985-47.995 (1.8906-1.8910)	0	2
				1	3
				2	4
3	WHITE	3	47.980-48.985 (1.8904-1.93)	0	3
				1	4
				2	5



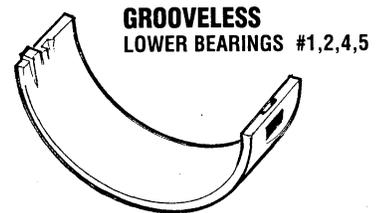
INDENT MARK



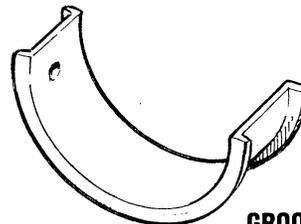
2. Identification marks showing the cylinder block bearing bore diameter are stamped in the position shown, with No.1 at the front of the engine. Bearings must be selected and installed in accordance with these identification marks.
3. Based on the identification markings verified in steps 1 and 2, select bearings from the chart. Note the following example:
If the measured crankshaft journal diameter is 48,000mm, this corresponds to classification 1 in the above table.
If the identification mark on the cylinder block bearing hole is "1", select a bearing with an identification mark of "2".
4. Except for the center bearing, all the upper bearings are grooved. the center bearings are grooveless and have flanges. The center bearings are the same at the top and bottom.
5. The lower bearings are all grooveless.



GROOVES
UPPER BEARINGS #1,2,4,5



GROOVELESS
LOWER BEARINGS #1,2,4,5



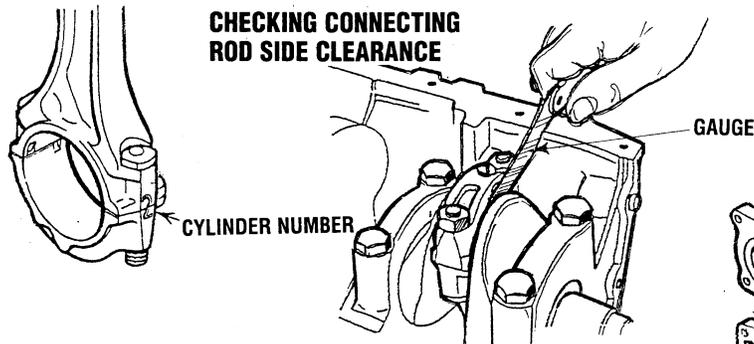
GROOVELESS/FLANGED
UPPER AND LOWER
BEARINGS #3 (CENTER)

ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

CONNECTING ROD CAP INSTALLATION

1. Align the marks made during disassembly and fit the bearing cap onto the connecting rod. If the connecting rod is new and has no index mark, ensure that the bearing locking notches are both on the same side.
2. Check that the connecting rod big end side clearance conforms with the specifications.

STANDARD VALUE	0.10 - 0.25mm (.00394 - .00985in)
LIMIT	0.4mm (.015in)



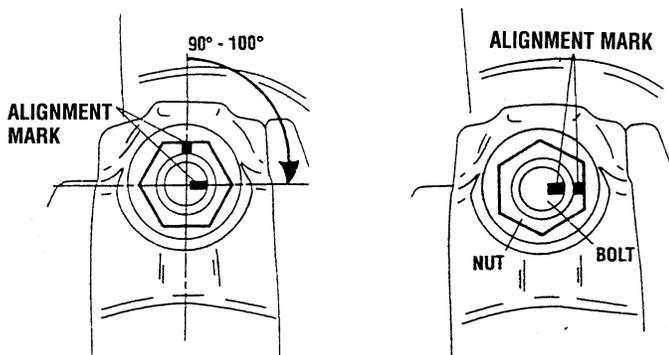
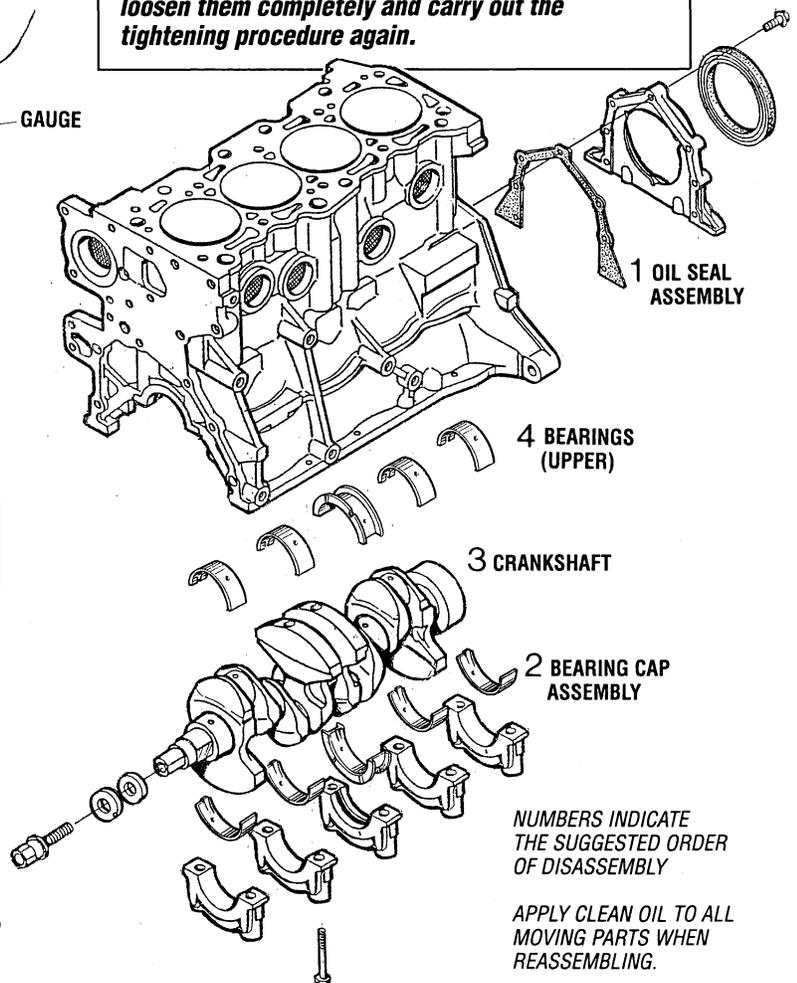
5. Make a paint mark on the top of each nut as shown.
6. Make paint marks on the bolts 90° to 100° clockwise from the paint marks on the nut.
7. Turn the nuts until their paint marks align with the paint marks on the bolts.

CAUTION: If the nuts are turned by less than 90°, the cap may not be held on with sufficient strength. If the nuts are turned by more than 100°, loosen them completely and carry out the tightening procedure again.

CONNECTING ROD CAP NUT INSTALLATION

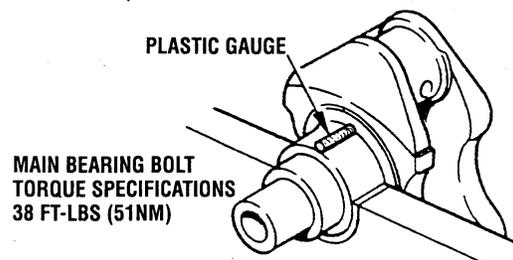
CAUTION: To fit the connecting rod cap nuts with the cylinder head in place, first remove the spark plugs.

1. The connecting rod bolts and nut utilize the plastic region tightening method. the bolts must therefore be checked for stretching before reuse. To check a bolt for stretching, screw the nut down the entire length of the thread by hand. Unless the nut turns smoothly all the way, the bolts threaded section is stretched and the bolt must be replaced.
2. Before fitting the nuts, apply engine oil to their threads and seating surfaces.
3. Fit the nuts onto the bolts and turn them until they are finger tight. The nuts must then be tightened alternately to ensure the correct fitting of the cap.
4. Tighten the nuts to a torque of 17Nm (12.5 ft-lb).

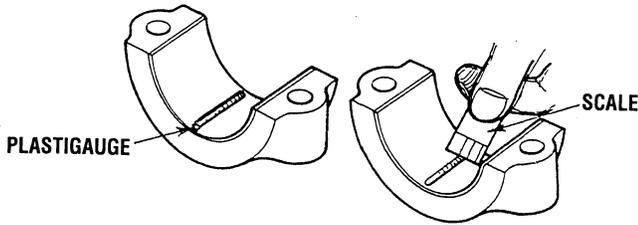


CONNECTING ROD BEARING INSTALLATION

The crankshaft oil clearance can be measured easily using a plastic gauge. To check the crankshaft oil clearance with a plastic gauge, carry out the following procedure:

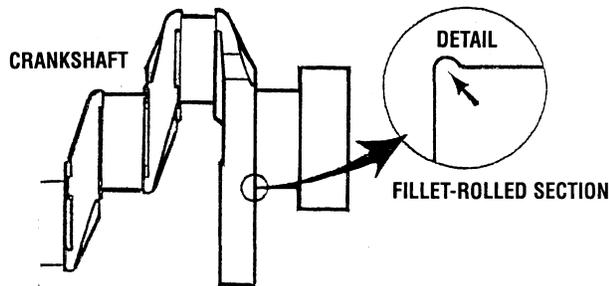


ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY



1. Wipe all oil off the crankshaft journal and the bearings inside surfaces.
2. Install the crankshaft.
3. Cut the plastic gauge such that its length matches the width of the bearing, then place it on the journal along the journals axis.
4. Gently fit the crankshaft bearing cap and tighten the bolts to the specified torque.
5. Remove the bolts and gently remove the crankshaft bearing cap.
6. Using the scale printed on the plastic gauge bag, measure the plastic gauges crushed section at its widest point.

STANDARD VALUE 0.02 - 0.04mm (.000788 - .00157in)
LIMIT 0.1mm (.00394in)

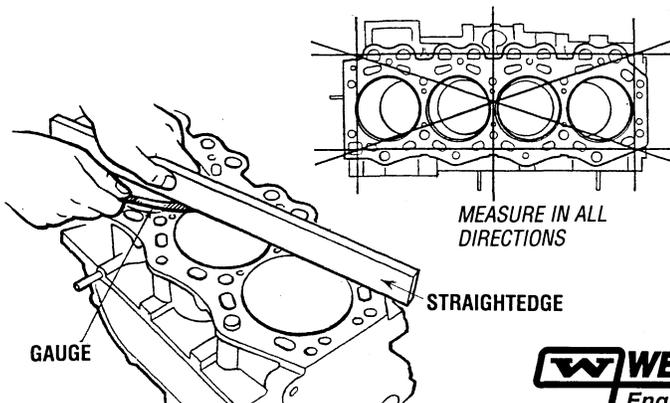


NOTE: The crankshaft pins and journals are fillet-rolled and must not be machined to undersize dimensions.

CYLINDER BLOCK

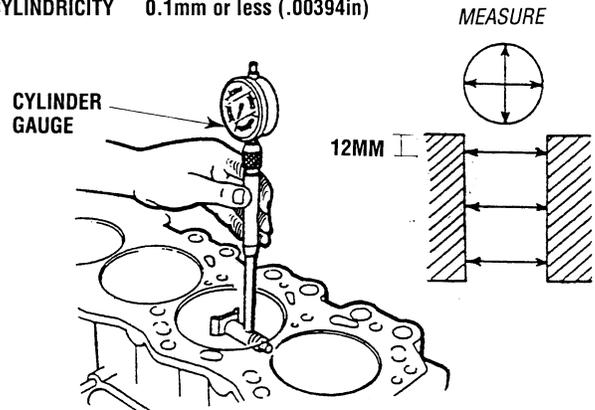
1. Visually check for cracks, rust and corrosion and inspect the cylinder block using a flaw detecting agent. Rectify defects where possible or replace the cylinder block.
2. Ensure that the top surface is free of gasket chips and other foreign material. Check the cylinder blocks top surface for distortion using a straight edge and thickness gauge.

STANDARD VALUE 0.05mm (.00197in)
LIMIT 0.1mm (.00394in)



3. Check the cylinder walls for cracks and seizure marks. If defects are evident, bore all the cylinders to oversize or replace the cylinder block.
4. Using a cylinder gauge, measure each cylinders bore and cylindricity. If any cylinder is severely worn, bore all the cylinders to oversize and replace the piston and piston rings accordingly. Take measurements at the points shown.

STANDARD VALUE:
CYLINDER BORE 75.5mm (2.97in)
CYLINDRICITY 0.1mm or less (.00394in)



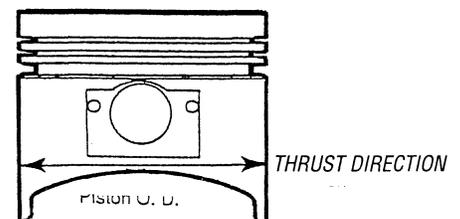
BORING CYLINDERS

1. Oversize pistons to be used should be determined on the basis of the cylinder with the largest bore.
2. Oversize pistons are available with the following oversize dimensions: 0.25mm, 0.50mm, 0.75mm and 1.00mm. Measure the diameter of the piston to be used. Boring must be carried out such that the piston-to-cylinder clearance complies with the standard value. The pistons diameter should be measured at the points shown.
3. Calculate the boring finish dimension based on the piston diameter dimension.
BORING FINISH DIMENSION = PISTON O.D. + PISTON-TO-CYLINDER CLEARANCE (0.02 - 0.04mm (.000788 - .00157in)) - HONING MARGIN (0.02MM)
4. Bore each cylinder to the calculated boring finish dimension.

CAUTION: To prevent distortion caused by heat increased during boring, bore the cylinders in the following order: No.2, No.4, No.1 and No.3.

5. Hone the cylinders to the final finish dimension (piston O.D. + piston-to-cylinder clearance).
6. Check the clearance between the pistons and cylinders.

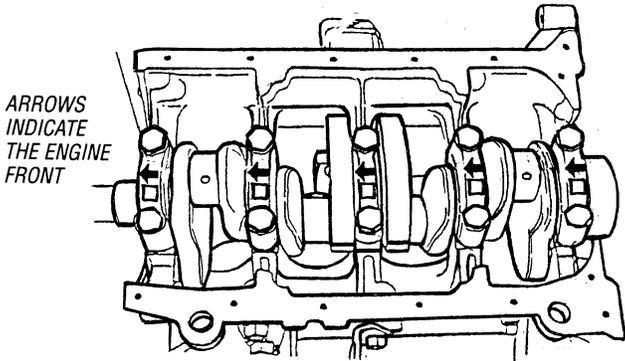
STANDARD VALUE 0.02 - 0.04mm (.000788 - .00157in)



ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

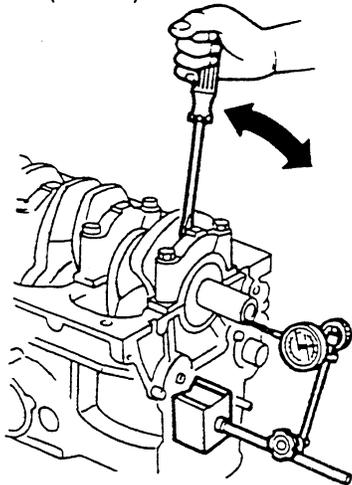
BEARING CAP INSTALLATION

1. On the bottom surface of each bearing cap is the caps number and an arrow. Starting at the timing belt side, fit the bearing caps in numerical order. Ensure that the arrows point toward the timing belt side.



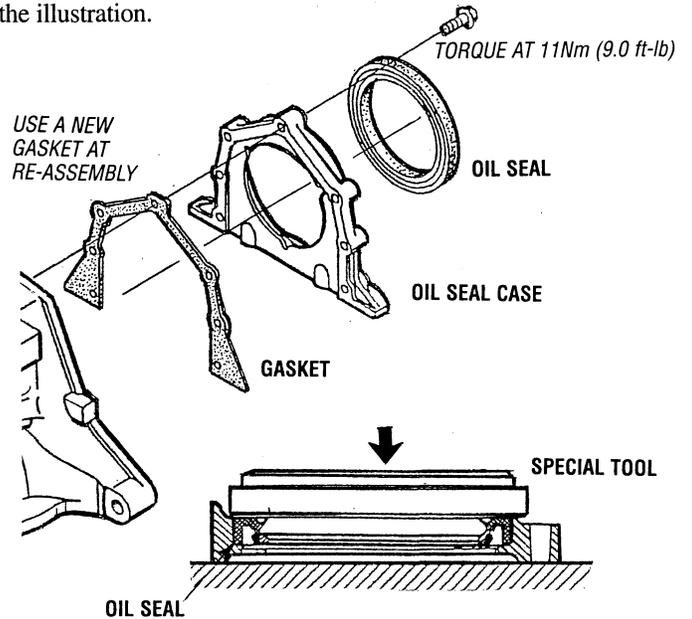
2. After fitting the bearing caps, measure the end play in the crankshaft. If the measurement exceeds the specified limit, replace the crankshaft bearings.

STANDARD VALUE 0.05 - 0.18mm (.00197 - .0070in)
LIMIT 0.25mm (.00985in)



REAR OIL SEAL INSTALLATION

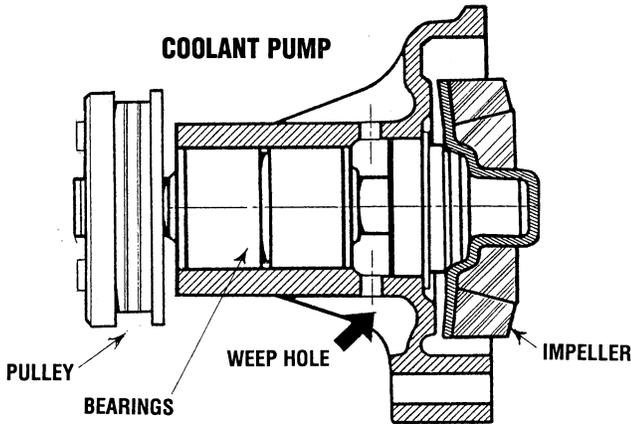
1. Press-fit the rear oil seal using the special tool shown in the illustration.



COOLANT CIRCULATING PUMP

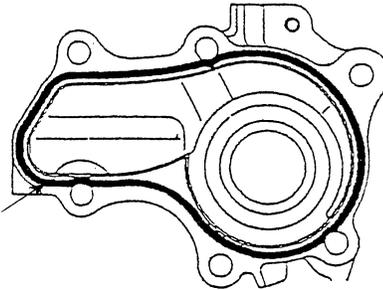
REMOVING THE COOLANT PUMP

1. Loosen the belt guards thumbscrews and remove the engine's belt guard from its brackets at the front of the engine.
2. Ease the belt tension by releasing the raw water pump and remove the engine drive belt (on carburetor models it will be necessary to remove the governor belt).
3. Unscrew the bolts that hold the pump to the engine and remove the coolant pump.



INSPECTION

Carefully check the pump body and impeller for cracks and damage. Inspect the weep holes for signs of water leakage and rust that would indicate a faulty seal. The pulley should turn the shaft (and impeller) smoothly, without noise or sluggish rotation and the pulley edges should be smooth and undamaged.



WATER PUMP INSTALLATION

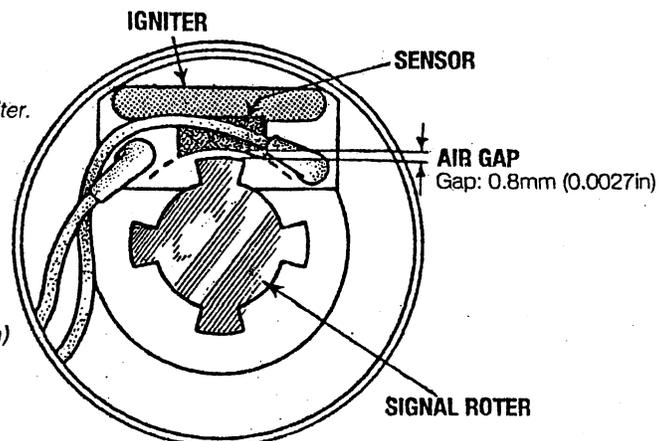
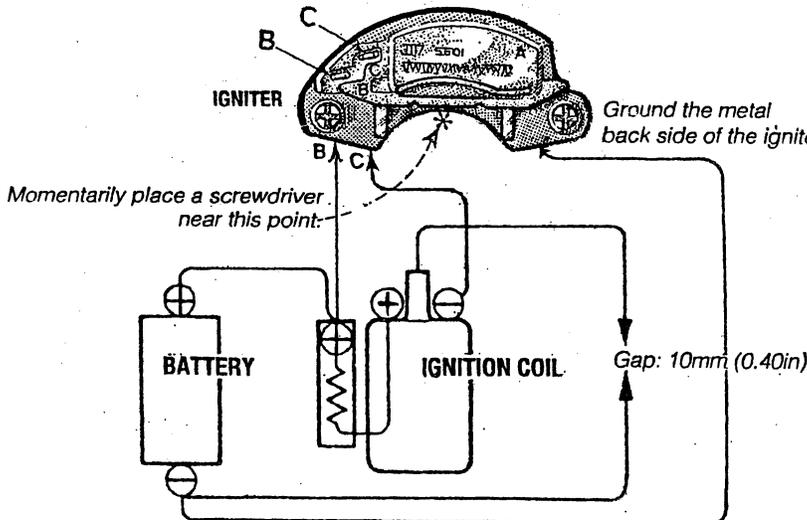
Apply a 3mm bead of form-in-place gasket to the mounting surface.

Tighten the mounting bolts a little at a time.

TORQUE AT 13Nm (9.59 ft-lb)

TESTING THE IGNITER

Reference the illustration below. Using AWG#16 wire, connect the igniter through a 12 VDC battery as shown. Momentarily place the tip of a metal screwdriver near the middle of the pick-up of the igniter. Each time this is done, a spark should jump the gap. This will indicate a serviceable igniter.

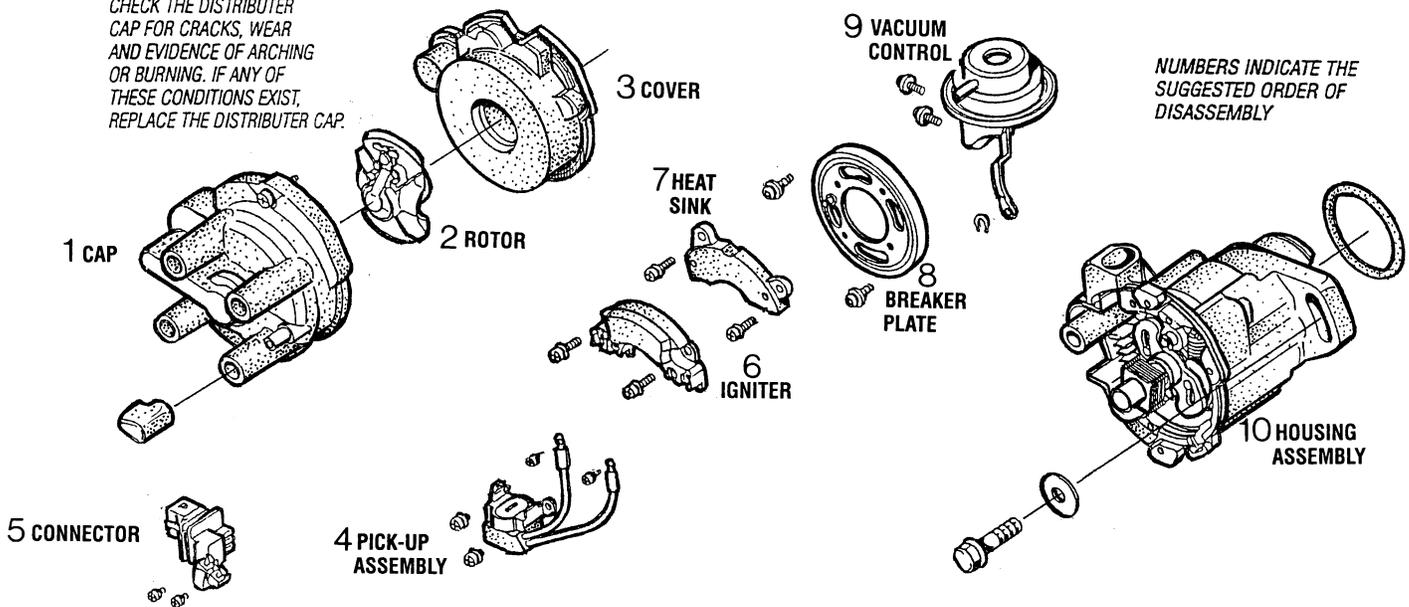


Do not mix up the wire connections to terminals B and C as that would damage the igniter.

If the distributor is operated with the external resistor left shorted, the igniter and coil will overheat.

DISTRIBUTER

CHECK THE DISTRIBUTER CAP FOR CRACKS, WEAR AND EVIDENCE OF ARCHING OR BURNING. IF ANY OF THESE CONDITIONS EXIST, REPLACE THE DISTRIBUTER CAP.



IGNITION COIL INSPECTION

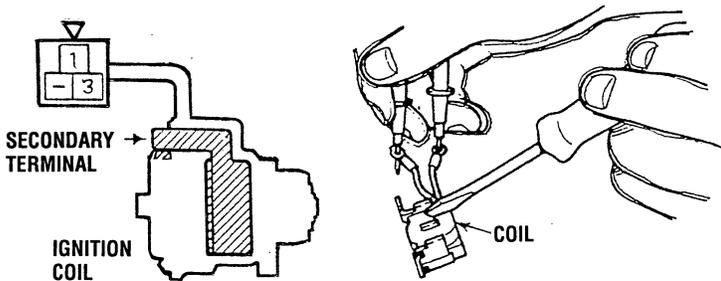
Use a tester to measure the primary and secondary coil resistance.

Primary coil resistance between terminals 1 and 3.

STANDARD VALUE 0.9 - 1.2Ω

Secondary coil resistance between terminals 1 and 3 and secondary terminal.

STANDARD VALUE 20 - 29kΩ

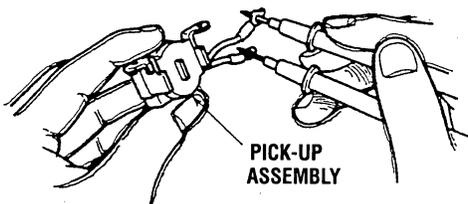


PICK-UP ASSEMBLY

Use a tester to measure pick-up coil resistance.

STANDARD VALUE 420 - 540kΩ

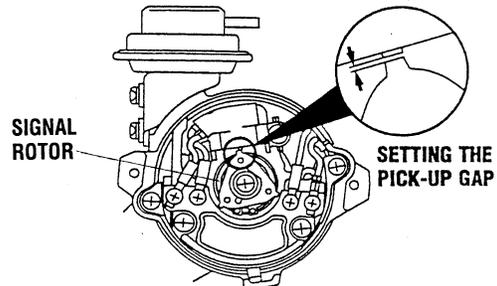
Check that when a screwdriver is passed near the iron core of the pick-up assembly the needle of the tester deflects.



INSTALLATION OF PICK-UP ASSEMBLY

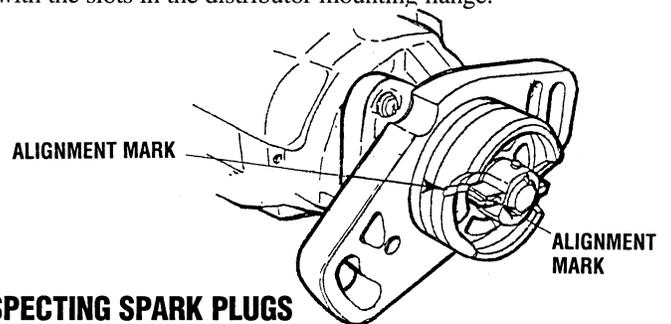
Adjust the gap between the signal rotor and the pick-up assembly.

STANDARD VALUE 0.05mm (.00197in)



DISTRIBUTOR INSTALLATION

1. Turn the crankshaft clockwise until the No.1 cylinder is a TDC on its compression stroke.
2. Align the alignment marks on the distributor housing and coupling.
3. Fit the distributor onto the engine, aligning the stud bolts with the slots in the distributor mounting flange.



INSPECTING SPARK PLUGS

Check the plugs for carbon build-up and burning. Check the plug gap.

SPARK PLUG GAP 0.7 - 0.8mm (0.028 - 0.031in)

EXHAUST MANIFOLD / HEAT EXCHANGER

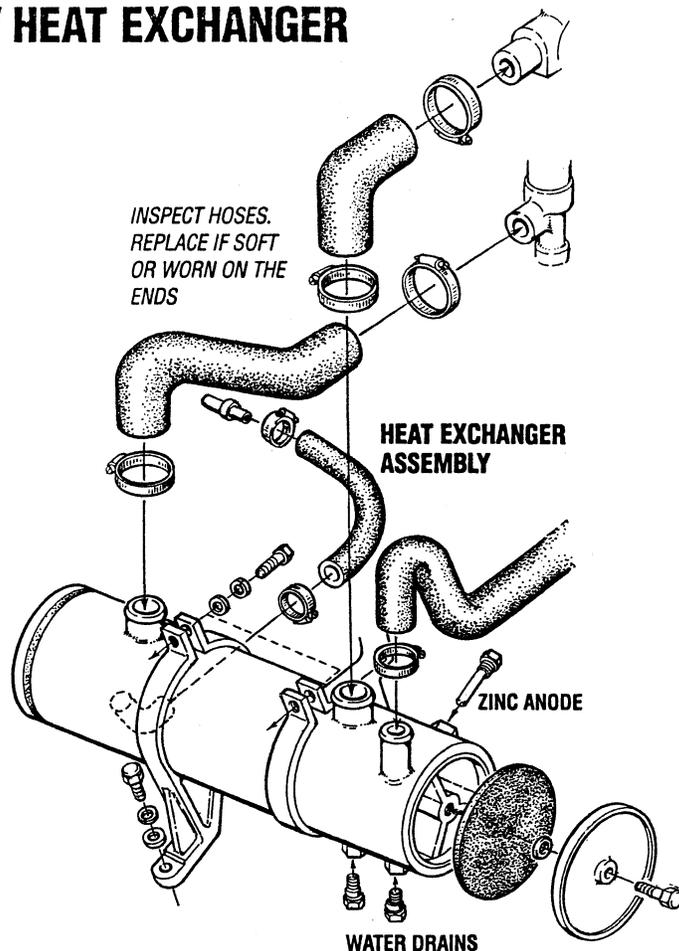
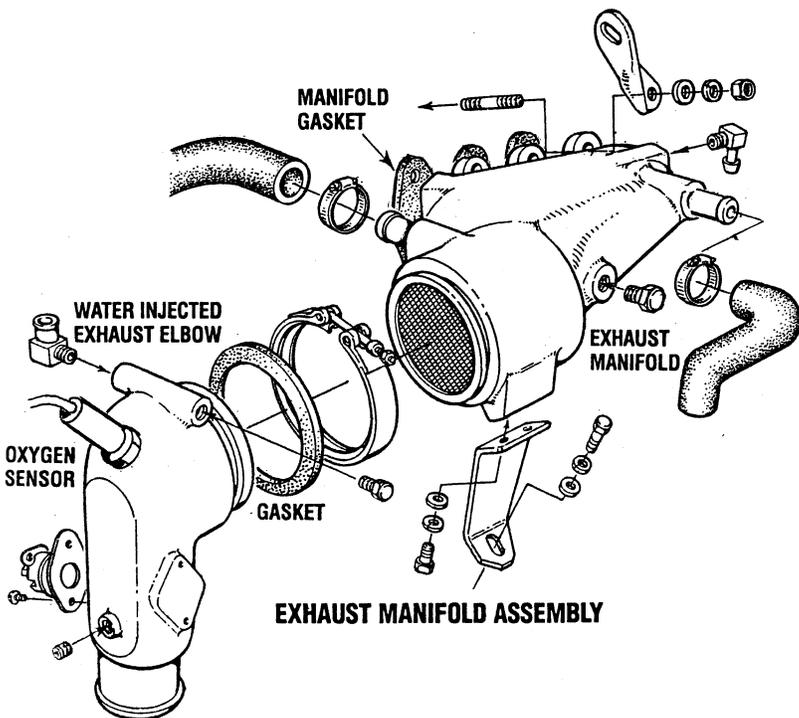
EXHAUST MANIFOLD

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

1. Remove the exhaust elbow from the manifold. Scrape off and discard the old gasket. Inspect the exhaust elbow for corrosion and damage, replace if necessary.
2. If the exhaust elbow passes inspection, remove the high temperature sensor and clean and re-paint the elbow with WESTERBEKE heat resistant enamel.
3. Carefully inspect the exhaust manifold, remove the hose connections noting the location of each for proper alignment at reassembly. Clean the exterior and interior manifold. If the manifold can be reused, repaint with WESTERBEKE heat resistant enamel.

ASSEMBLY

1. If the manifold was removed as an assembly and left intact, it can be replaced on the cylinder head in the reverse order of removal. Install a new gasket.
MANIFOLD MOUNTING BOLTS TORQUE 12 - 17 ft-lb (16 - 23 Nm)
2. Attach the hose connections to the manifold and the exhaust elbow. Once the engine has been re-installed and running, carefully check these assemblies and hose connections for leaks.



HEAT EXCHANGER

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

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

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

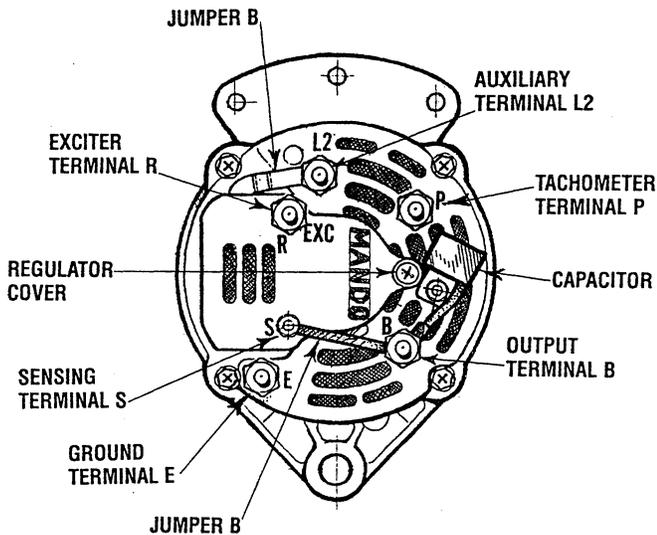
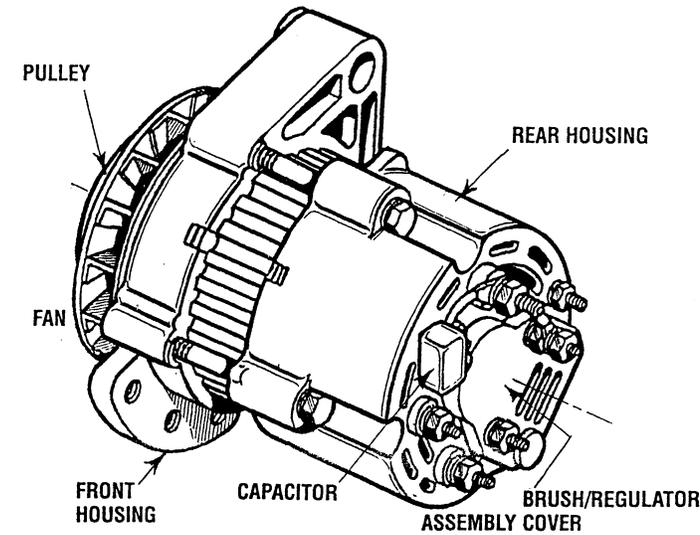
6. Repaint the assembled heat exchanger with WESTERBEKE heat resistant spray enamel

HEAT EXCHANGER ASSEMBLY

Reinstall the heat exchanger. Tighten down the holdown brackets and once the engine is running, check the heat exchanger and hose connections for leaks.

WESTERBEKE 51A MANDO ALTERNATOR

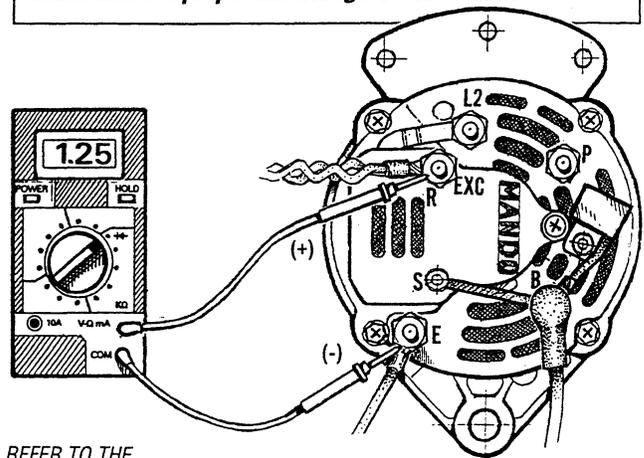
DISASSEMBLY AND TESTING



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

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

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



REFER TO THE WIRING DIAGRAMS FOR THE ABOVE WIRING HARNESS CONNECTIONS

TESTING THE OUTPUT CIRCUIT

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

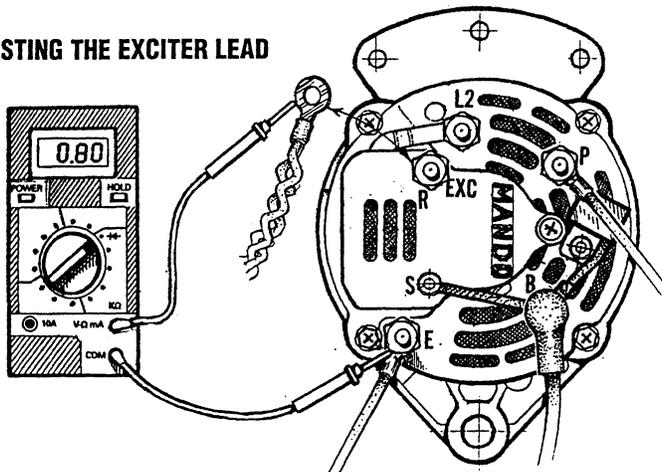
NOTE: Prior to any alternator testing, inspect the entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly battery cable clamps and battery terminals. Inspect the alternator drive belt for excessive wear and replace if necessary. Also adjust for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

TESTING THE EXCITATION CIRCUIT

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

MANDO ALTERNATOR SERVICE

TESTING THE EXCITER LEAD



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

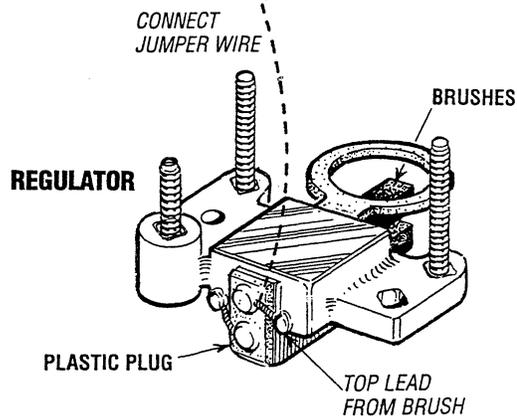
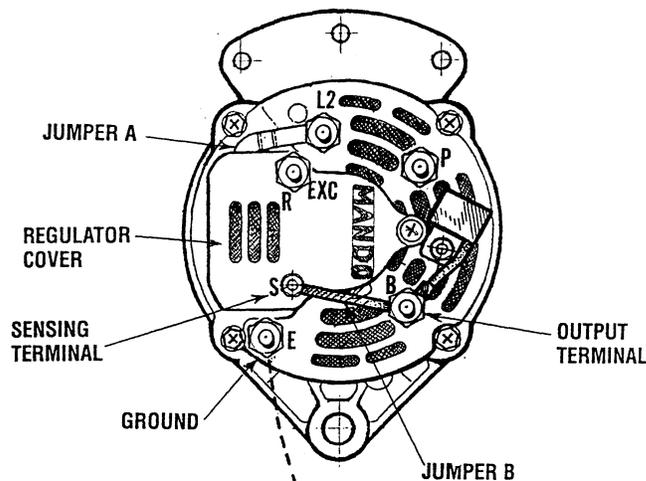
TEST VOLTAGE REGULATOR

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

NOTE: The battery *must* be fully charged to obtain a proper voltage reading in this test. If necessary, charge the battery with a battery charger or 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.

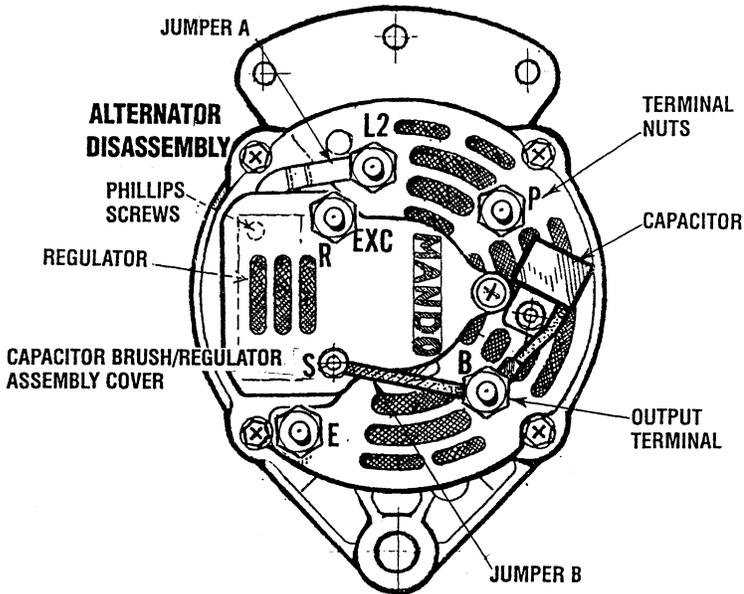


- i. Repeat steps 1 and 2.
- NOTE:** Do not let the voltage exceed 16 volts.
- j. If a voltmeter reading of 14.5 volts or above is now obtained, the voltage regulator is faulty and must be replaced. If the voltmeter reading is below 14.5 volts, inspect the brushes and slip rings for wear, dirt or damage. 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

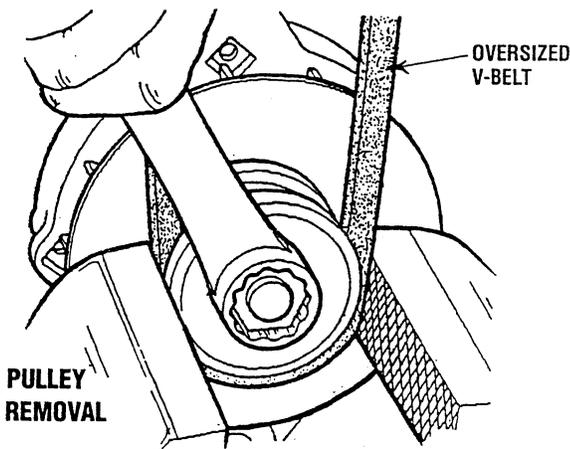
REMOVE ALTERNATOR

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.

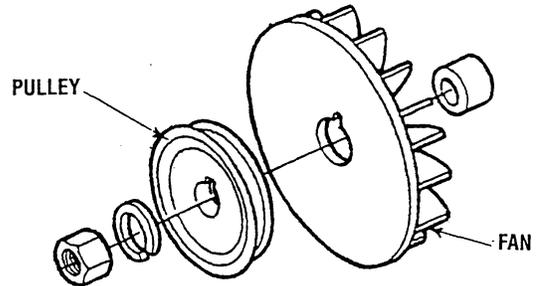


DISASSEMBLE ALTERNATOR

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.

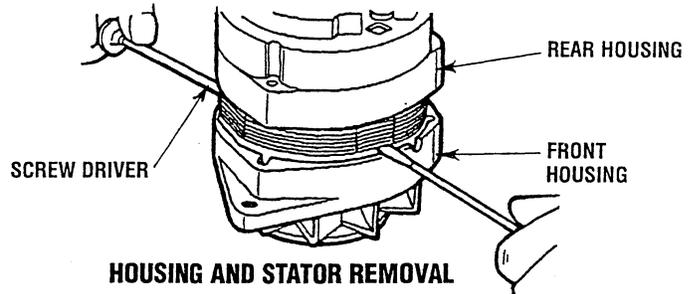


PULLEY AND FAN COMPONENTS

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

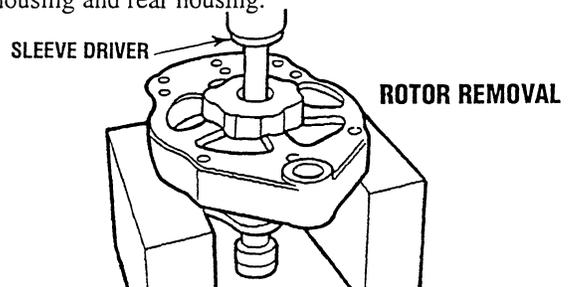
NOTE: Score the stator, and the front and rear housings so the unit may be reassembled correctly.

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



HOUSING AND STATOR REMOVAL

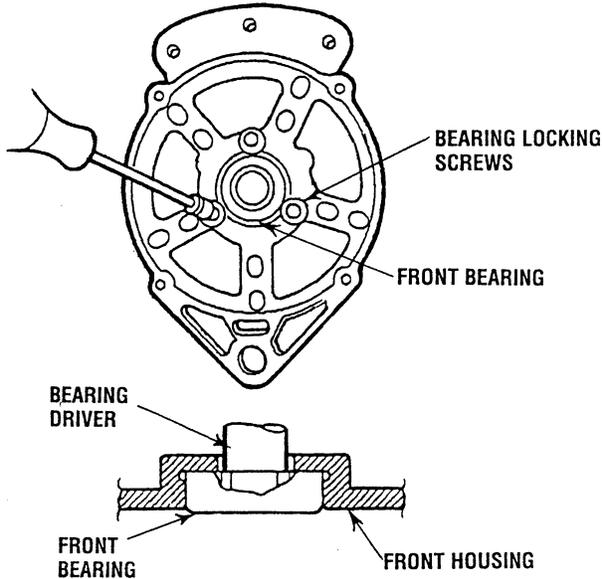
14. Carefully push the rotor assembly out of the front housing and rear housing.



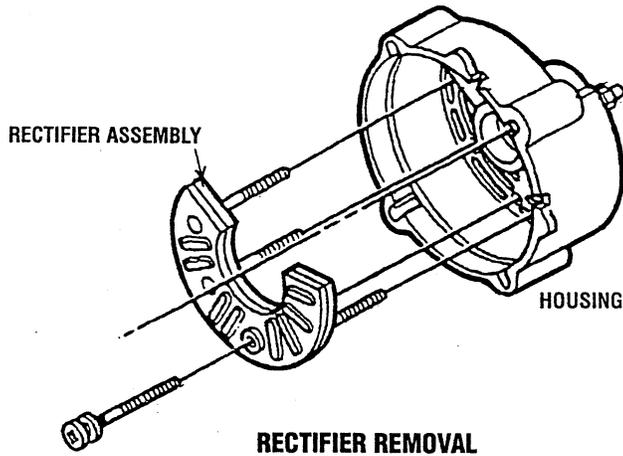
NOTE: If the bearing is removed from the housing, a new bearing must be installed.

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

MANDO ALTERNATOR SERVICE



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

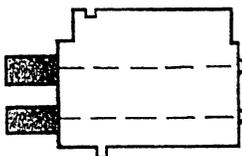


RECTIFIER REMOVAL

CLEAN AND TEST ALTERNATOR COMPONENTS

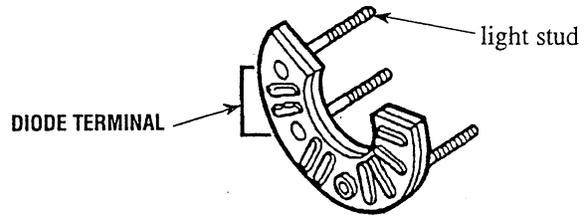
1. Inspect and test the brush/regulator assembly. The brush set may be reused if the brushes are 1/4 in. (6 mm) or longer. The brushes must not be oil soaked, cracked or grooved.

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.



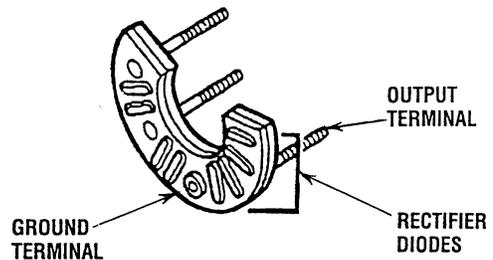
TESTING BRUSH ASSEMBLY

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 output 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.

MANDO ALTERNATOR SERVICE

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.

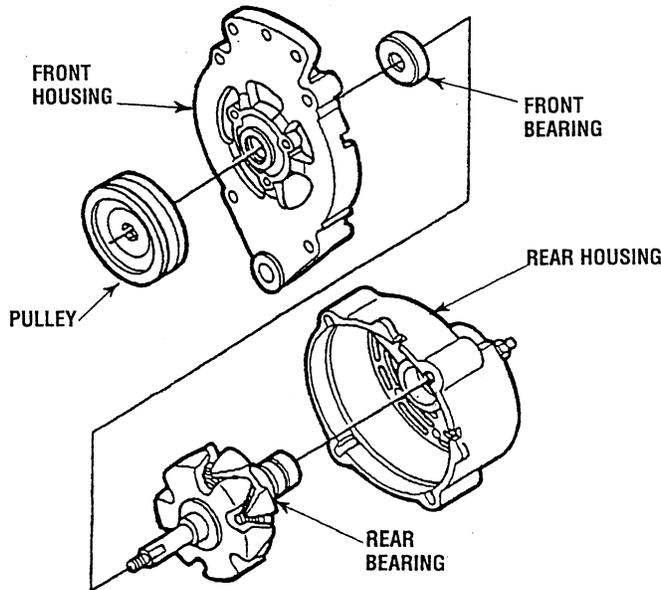
5. Clean and inspect the rotor shaft bearings:

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

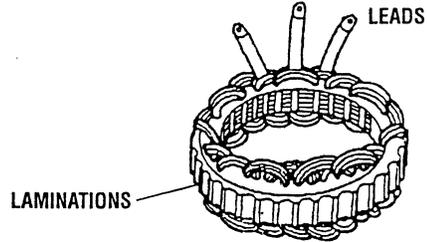
- a. The bearings should be wiped clean with a lint-free cloth containing a moderate amount of commercial solvent. Do not immerse a bearing in solvent, or use pressurized solvent or air.
- b. Check the bearings for obvious damage, looseness or rough rotation. Replace a bearing if any doubt exists as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



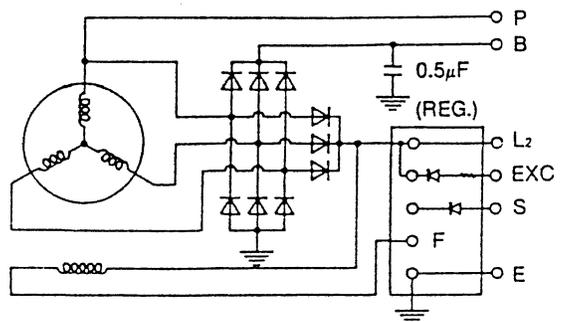
7. Test the stator windings as follows:
 - a. Using an ohmmeter or test lamp, check for continuity between all three leads (1, 2, and 3). A low ohm reading or lit test lamp should be observed.



- 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:

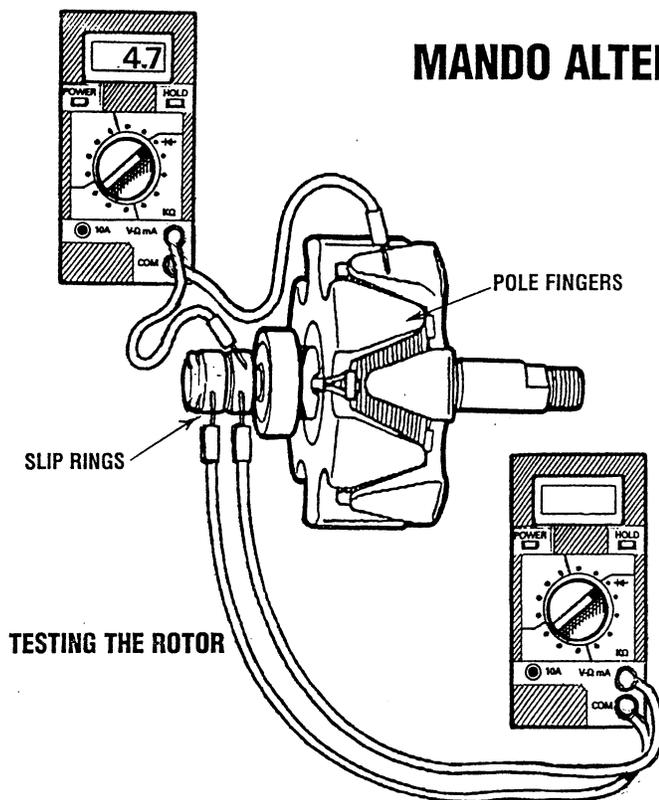
NOTE: If slip rings need to be replaced, you must replace the entire rotor.

- 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.



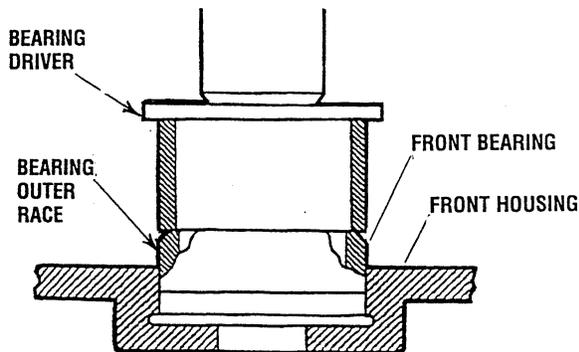
INTERNAL CIRCUIT WIRING

MANDO ALTERNATOR SERVICE

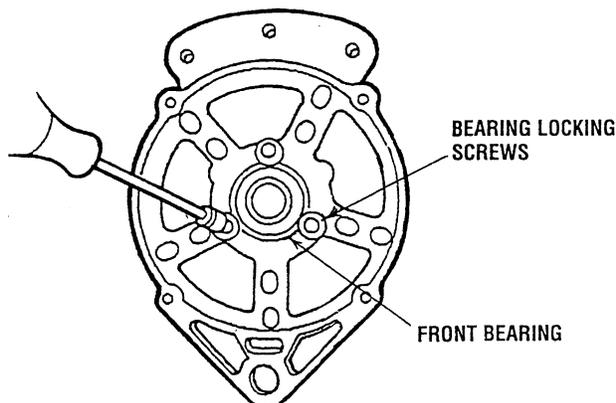


ASSEMBLE ALTERNATOR

- 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)

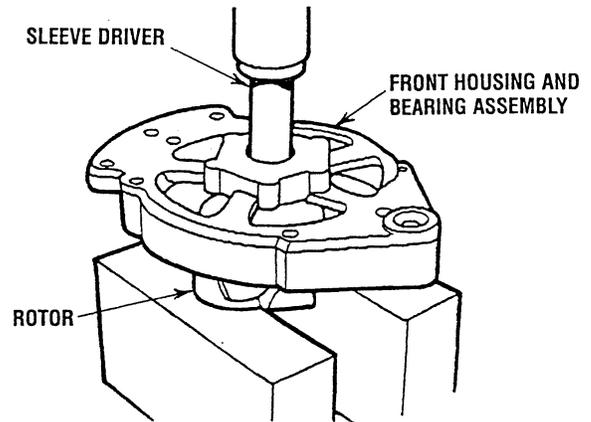


FRONT BEARING ASSEMBLY



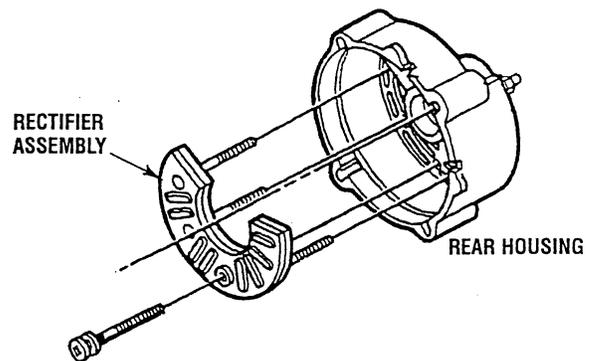
ASSEMBLING THE BEARINGS

- Place the rotor (pulley end up) on the bed of an arbor press, on two steel blocks.
- 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

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

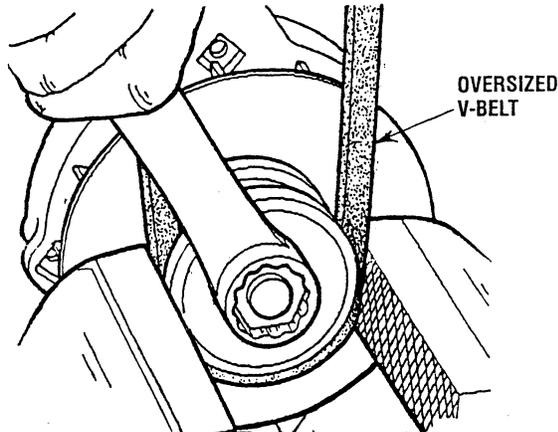


- Assemble the front and rear housings as follows:
 - Put the stator winding in the front housing with the stator leads away from the front housing and the notches in the stator laminations aligned with the four through-bolt holes in the housing.
 - Align the scribe marks you made in the stator, and front and rear housings during disassembly.
 - 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.
 - 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.

MANDO ALTERNATOR SERVICE

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 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

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.

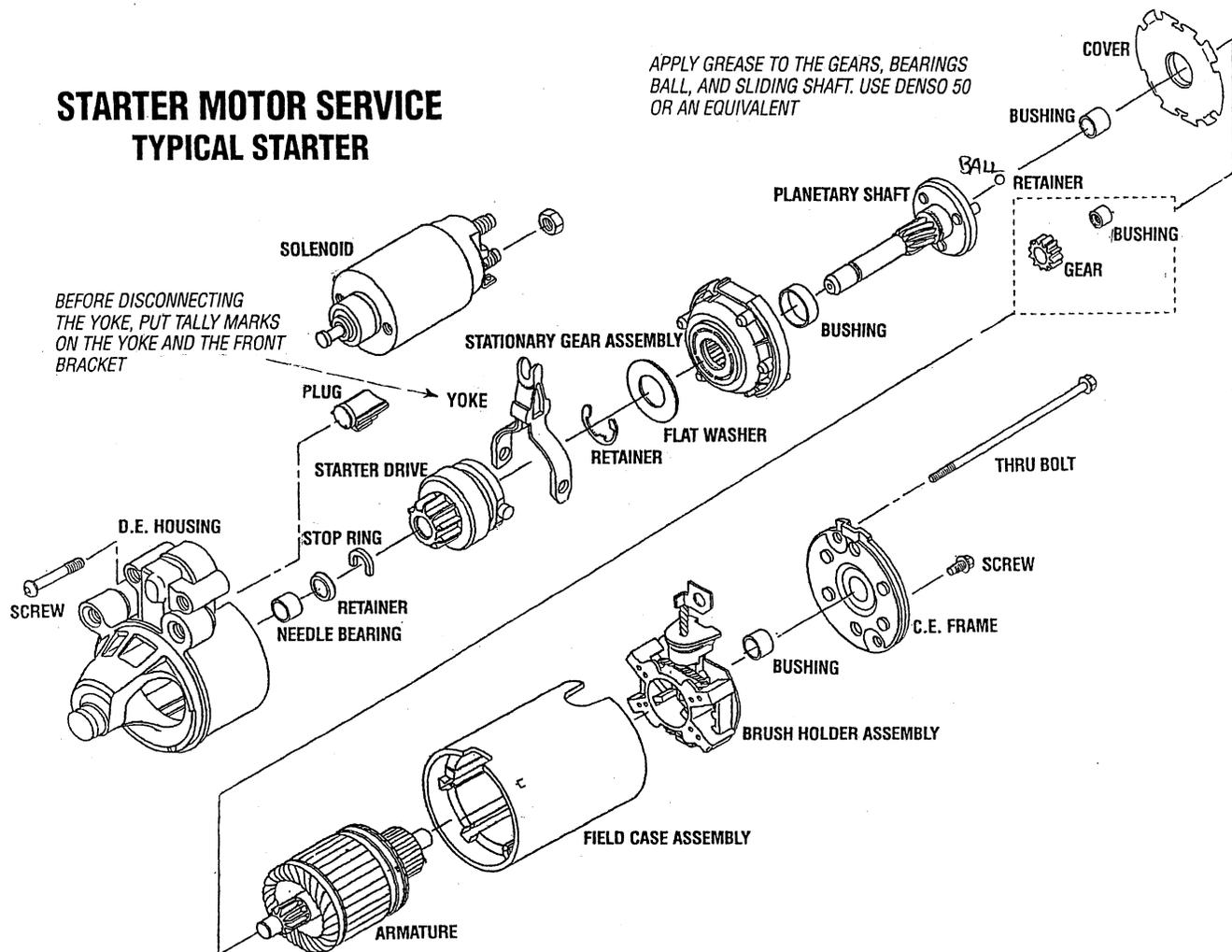
DISASSEMBLING THE MAGNETIC SWITCH

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

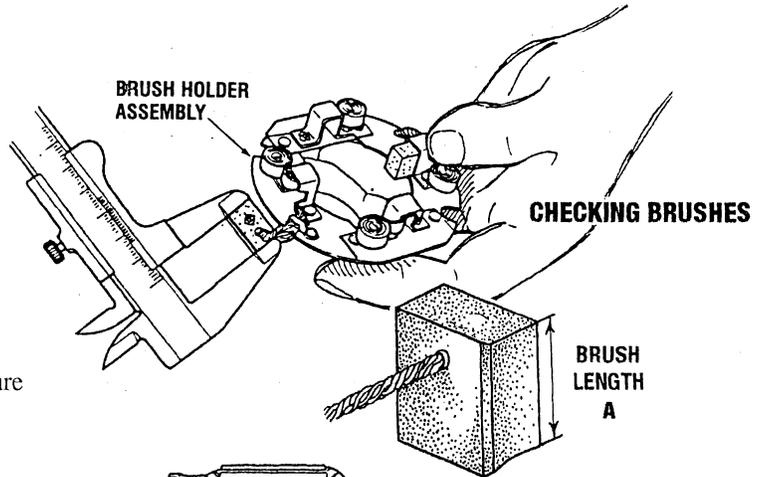


STARTER MOTOR SERVICE

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 vernier calipers.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

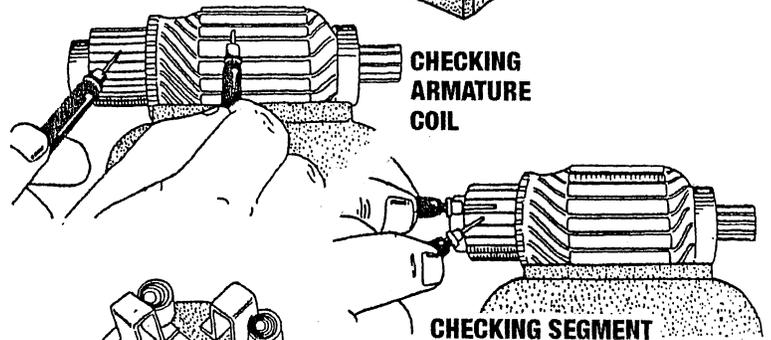
BRUSH LENGTH (A) 18.0MM (0.7086IN)
LIMIT 11.0MM (0.4331IN)



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.

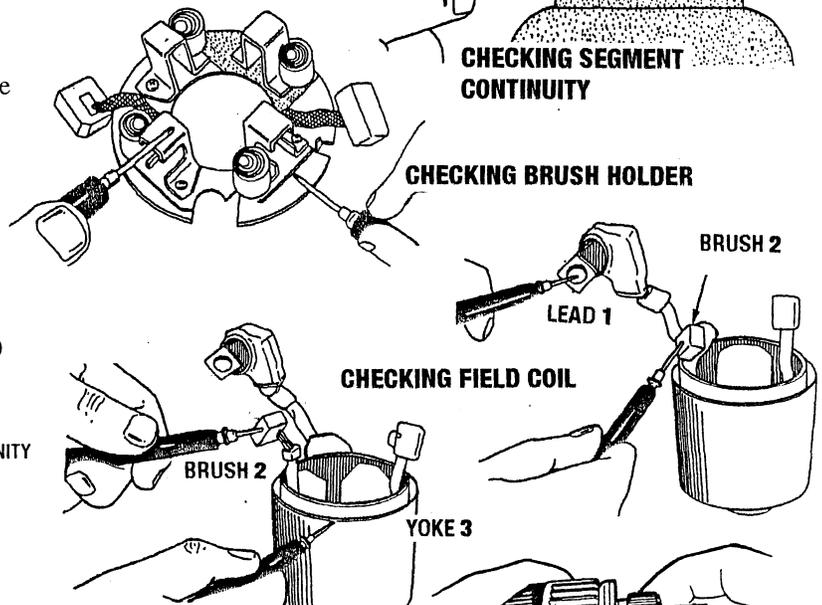
RESISTANCE: COMMUTATOR ARMATURE COIL - INFINITY
COMMUTATOR SEGMENT - 0Ω



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

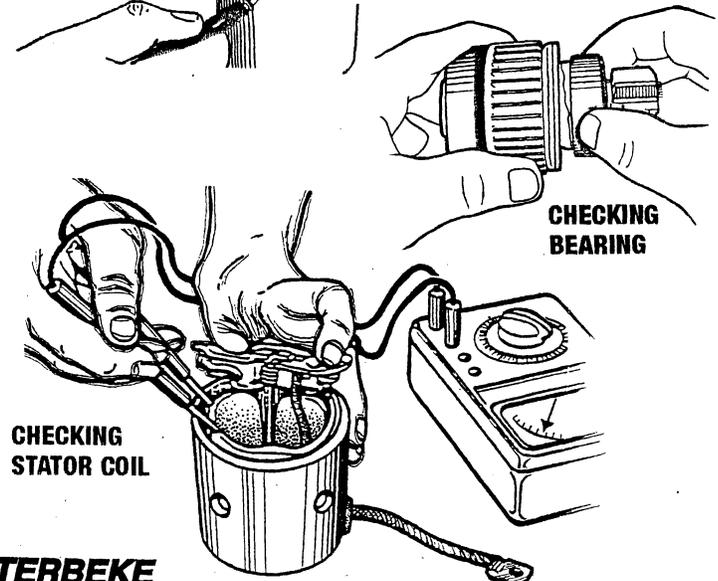
BEARING

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 is not indicated, replace it.

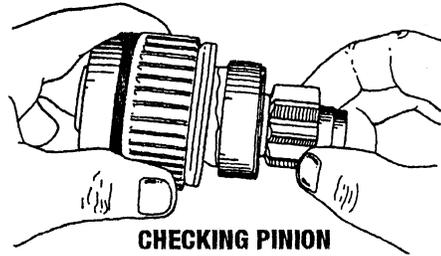
RESISTANCE: LESS THAN 1.0Ω



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.



COMMUTATOR AND MICA

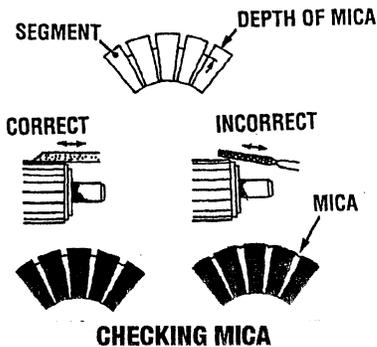
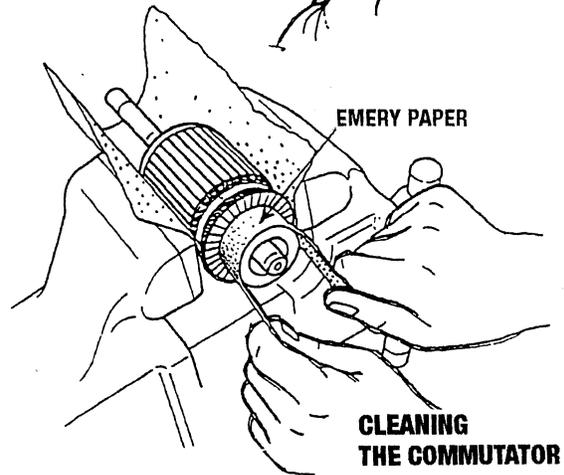
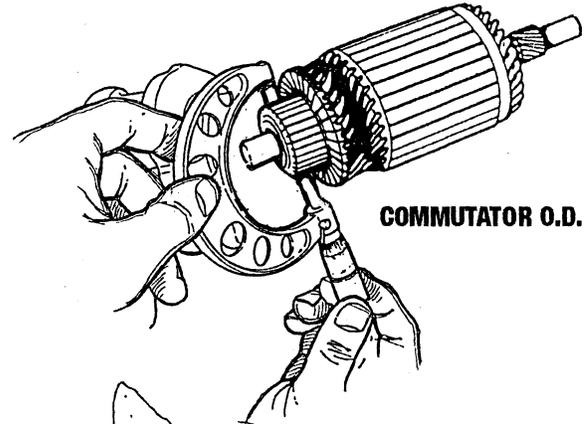
1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the 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)



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.

SERVICE

WESTERBEKE uses a standard starter motor which can be serviced or rebuilt at any starter motor automotive service center. Starter motors used on marine gasoline units must be ignition protected.

If replacing the starter motor, make certain the new motor is certified for marine use. Automotive starters do not meet USCG standards. If in doubt, contact your WESTERBEKE dealer.

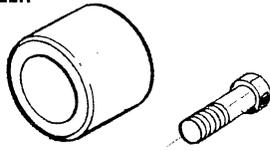
ENGINE TORQUE SPECIFICATIONS

<i>Component</i>	<i>Nm</i>	<i>Ft-lb</i>	<i>Component</i>	<i>Nm</i>	<i>Ft-lb</i>
ALTERNATOR/IGNITION SYSTEM			CYLINDER HEAD COVER	4	3
WATER PUMP PULLEY BOLT	9	6.6	CYLINDER HEAD AND VALVES		
OIL LEVEL GAUGE GUIDE	23	16.9	CYLINDER HEAD BOLT	20	
CRANKSHAFT BOLT				turn +90°-90°	
SPARK PLUG	25	18.5	<i>(Tighten to 49Nm (36 ft-lb), then loosen and retighten as described)</i>		
DISTRIBUTOR	11	8.2	OIL PUMP/OIL PAN		
TIMING BELT			OIL PAN	7	5.1
TIMING BELT COVER	11	8.2	DRAIN PLUG	39	28.7
TIMING BELT TENSIONER	23	16.9	OIL SCREEN	18	13.2
ENGINE SUPPORT BRACKET (left)	35	25.8	FRONT CASE	13	9.5
IDLER PULLEY	35	25.8	RELIEF PLUG	44	32.4
CAMSHAFT SPROCKER BOLT	88	64.9	OIL PUMP COVER	10	7.38
WATER PUMP			PISTONS/CONNECTING RODS		
ENGINE HANGER	11	8.2	CONNECTING ROD NUT	17	12.5
COVER	12	8.8		turn +90°-100°	
WATER PUMP	13	9.5	CRANKSHAFT/CYLINDER BLOCK		
ROCKER ARMS, ROCKER SHAFTS AND CAMSHAFT			REAR OIL SEAL CASE	11	8.2
ROCKER COVER	4	2.9	BEARING CAP BOLT	51	37.6
ROCKER SHAFT ASSEMBLY	31	22.8	FLYWHEEL TO CRANKSHAFT	81	60
ADJUSTING SCREW	15	11			
BEARING CAP	24	17.7	BELLOUSING TO BLOCK	20	15
BEARING CAP BOLT	11	8.2	CRANKSHAFT BOLT 12mm 128-137Nm 94-101		
			NOTE: ENGINES MANUFACTURED AFTER AUGUST 2003 HAVE A LARGER DIAMETER CRANKSHAFT BOLT. CONTACT YOUR WESTERBEKE DEALER WITH YOUR ENGINE SERIAL NUMBER IF IN DOUBT.		
			CRANKSHAFT BOLT 176-186Nm 129-137		
			(AFTER 8/2003) 14mm		

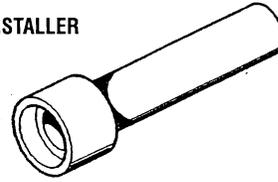
SPECIAL TOOLS

NOTE: These special tools are available from your local Mitsubishi Automotive Dealer.

CAMSHAFT OIL SEAL INSTALLER
MD 998713



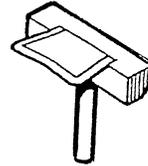
VALVE STEM SEAL INSTALLER
MD 998760



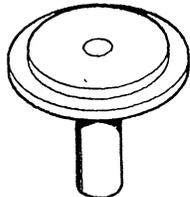
CRANKSHAFT OIL SEAL INSTALLER
For installing the front oil seal
MD 998305



OIL PAN GASKET CUTTER
For removing the oil pan to
break the oil pan seal.
MD 998727

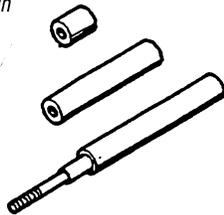


CRANKSHAFT REAR OIL SEAL INSTALLER
For installing the rear oil seal.
MD 998011

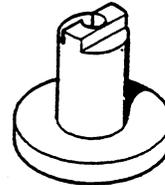


VALVE SPRING COMPRESSOR
MD 998772

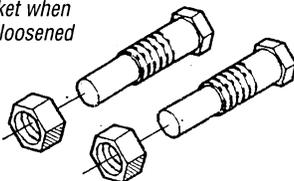
PUSH ROD AND PIN SET GUIDE
Used to pull-out and press in
the piston pin.
MD 999584



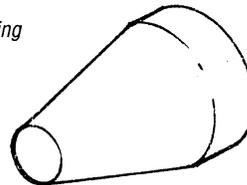
PISTON PIN SET TOOL
For press fitting piston pins
MD 998780



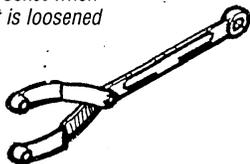
PIN
For supporting the sprocket when
the camshaft sprocket is loosened
or tightened.
MD 998715



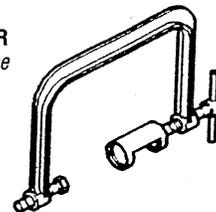
GUIDE D
For removing and pressing
piston pins
MD 991659



END YOKE HOLDER
For supporting the sprocket when
the camshaft sprocket is loosened
or tightened.
MD 990767



VALVE SPRING COMPRESSOR
For removing and installing the
valve springs.
MD 998735

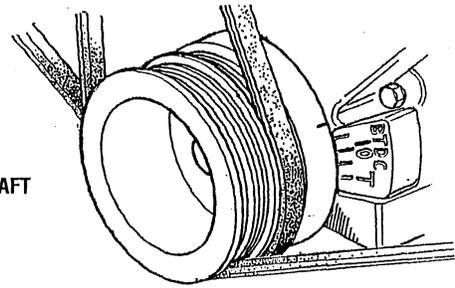


ENGINE ADJUSTMENTS

VALVE CLEARANCE AND ADJUSTMENT

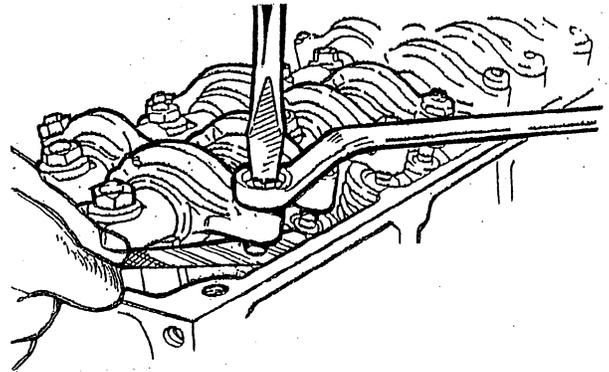
1. Start the engine and allow it to warm up until the engine coolant reaches operating temperature.
2. Remove all the spark plugs to allow ease in rotating the engine crankshaft and to allow viewing of the piston movement.
3. Rotate the engine crankshaft to position No.1 piston at TDC of its compression stroke. Observe intake and exhaust valve movement to indicate compression stroke. Align the timing mark on the crankshaft pulley with the T mark on the gear case timing indicator. This places No.1 piston at TDC of its compression stroke. Observe the piston through the spark plug opening.
4. **Note:** When measuring the valve clearance, if the valve clearance is not as specified, loosen the rocker arm lock nut and adjust the clearance using a feeler gauge by turning the adjusting screw. While holding the adjusting screw with a screwdriver to prevent it from turning, tighten the lock nut to the specified torque of 15 Nm.
5. Adjust the intake and exhaust valves for Cylinder No. 1.
6. Rotate the crankshaft, bringing piston #3 up to TDC of its compression stroke. This can be observed through the spark plug opening. Adjust the valves for cylinder #3. Do the same for cylinder #4 and then #2.
7. Install the rocker cover.
8. Install the spark plugs, placing a small amount of Anti-Seize on the thread of the plug. Tighten to 25 Nm.

CRANKSHAFT PULLEY



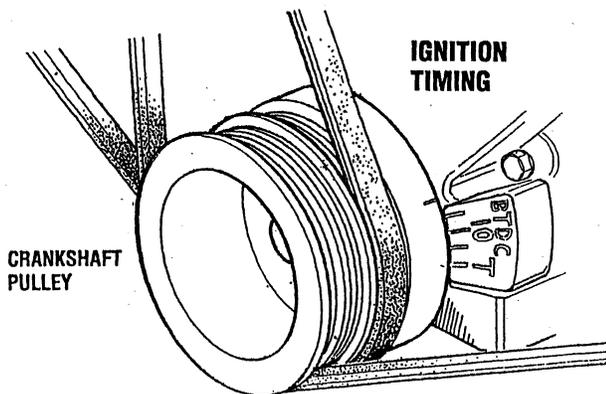
VALVE CLEARANCE (ENGINE HOT)

INTAKE 0.20 MM (0.0079 IN)
EXHAUST 0.25 MM (0.0098 IN)
FIRING ORDER 1-3-4-2



IGNITION TIMING

1. Attach a timing light to the #1 spark plug and mark the front crankshaft timing groove and the timing mark on the scale embossed on the engine's front cover. Each timing mark represents 5°.



2. Start the engine and warm the engine to its normal operating temperature.
3. Using the timing light, align the timing groove in the front crankshaft pulley with the proper timing mark on the ignition timing scale embossed on the engine's front cover. Do this by loosening and slowly rotating the distributor body. refer to the timing specification:

IGNITION TIMING AT 1800 RPM:
15° BTDC ± 1° STATIC (NO VACUUM ADVANCE)

ENGINE ADJUSTMENTS

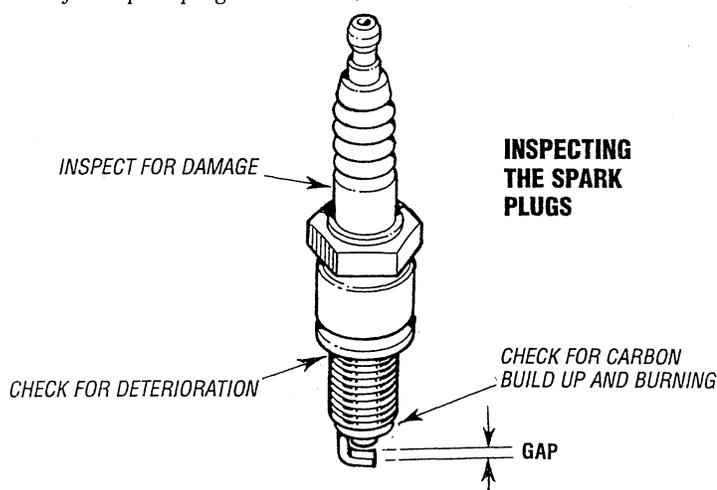
SPARK PLUGS

The spark plugs should be cleaned and regapped after the first 50 hour break-in period, then inspected every 250 hours thereafter and replaced as needed.

WARNING: Do not remove the spark plugs while the engine is hot. Allow the engine to cool before removing them.

SPARK PLUG GAP 0.7 - 0.8mm (0.028 - 0.031in)
SPARK PLUG TORQUE 25Nm (18.45 FT LB)

NOTE: Loctite Anti-Seize applied to the threaded portion of the spark plugs will retard corrosion, making future removal of the spark plugs easier.

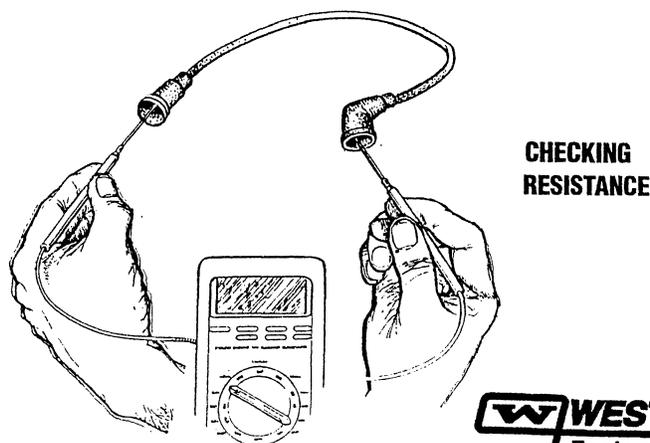


HIGH TENSION CORDS (IGNITION WIRES)

Check the ignition wires every 500 operating hours as engine compartment heat can deteriorate the wires.

Check the resistance of each wire. Do not pull on the wire because the wire connection inside the cap may become separated or the insulator may be damaged. When removing the wires from the spark plugs, grasp and twist the molded cap, then pull the cap off the spark plug.

The resistance value is 410 ohm per inch of wire.



DRIVE BELT ADJUSTMENT

The drive belts must be properly tensioned. Excessive drive belt tension can cause rapid wear of the belts and reduce the service life of the fresh water pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures.

This generator has two drive belts, one drives the governor and alternator and the other drives the raw water pump. The tension adjustment procedure for both belts is as follows:

1. Remove the belt guard.
2. To adjust the governor/alternator drive, loosen the two governor mounting bolts.
3. With the belt(s) loose, inspect for wear, cracks and frayed edges and replace if necessary.
4. To loosen or tighten the alternator drive belt, slide the alternator in or out as required, then retighten its mounting bolts.

To adjust the raw water pump/fresh water pump drive belt, loosen the two raw water pump mounting bolts.

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

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

6. Operate the engine for about 5 minutes, then shut down the engine and recheck the belts tension.
7. Replace the belt guard.

FUEL SYSTEM

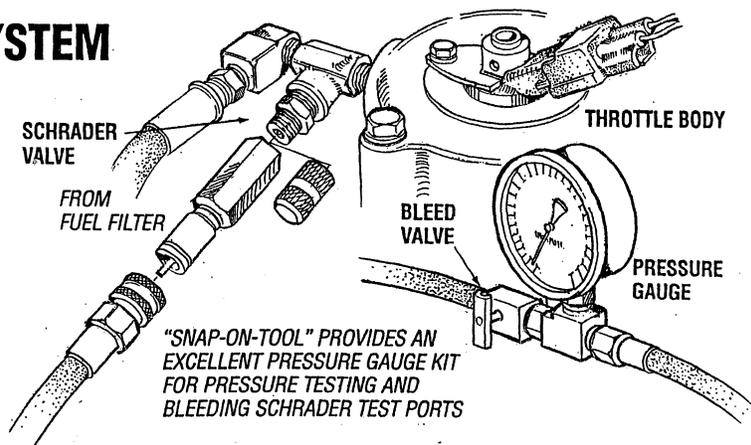
BLEEDING THE FUEL SYSTEM

1. Insure that the fuel cell *is not* connected to the wiring harness, and that the lift pump *is* connected.
2. Attach Snap On MT337B, OTC 7211 or equivalent fuel pressure gauge set to the Schrader valve on fuel cell.

CAUTION: Follow manufacturer's instructions for safe use of the gauge sets to purge a high-pressure fuel system.

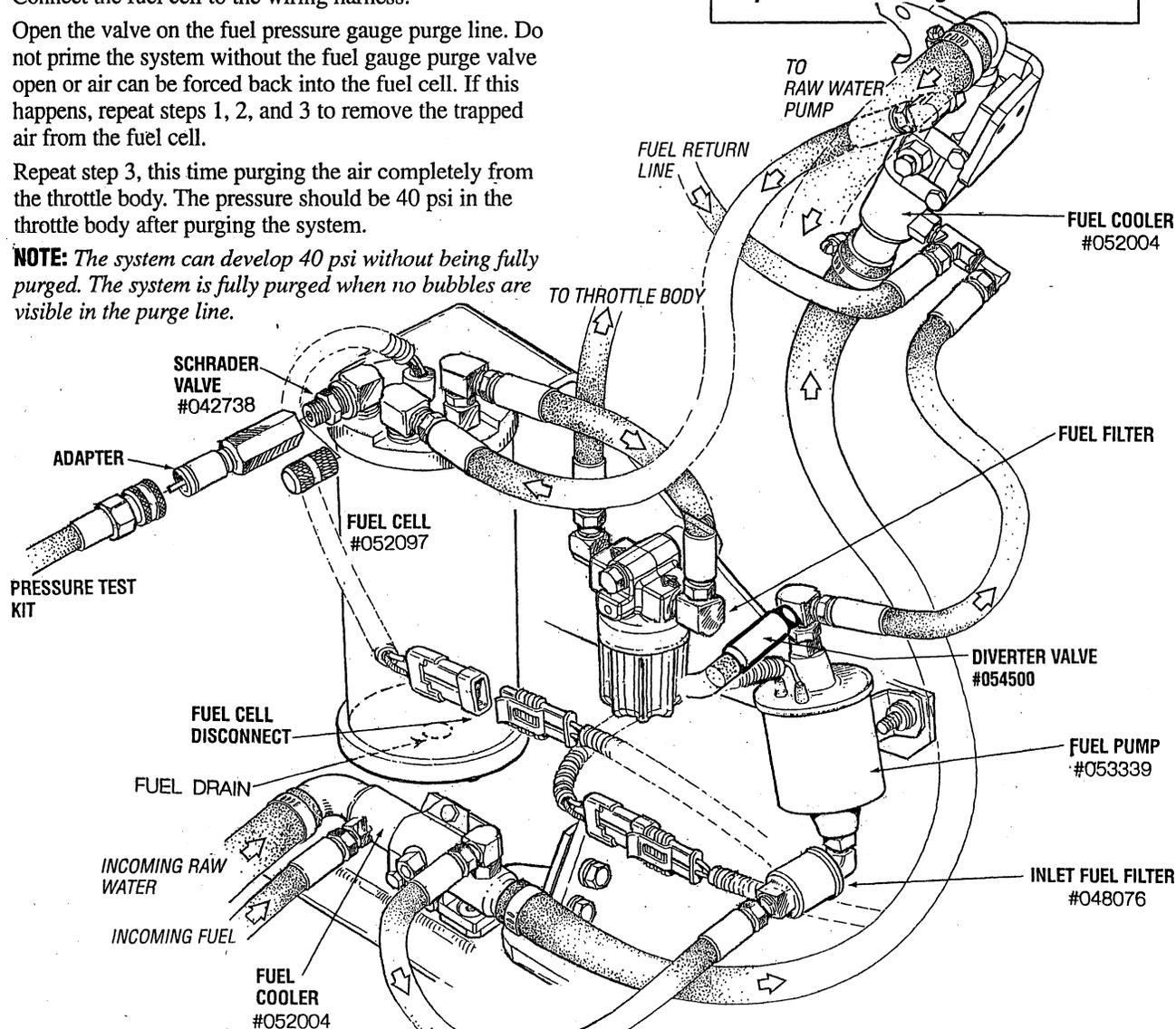
3. While holding the stop switch in the (prime) depressed position, purge the air from the fuel cell. The fuel cell is purged when no air bubbles are visible escaping from the drain line attached to the Schrader valve. Pressure should typically be 3-4 psi.
4. Remove the pressure gauge set from the fuel cell and connect it to the Schrader valve on the throttle body.
5. Connect the fuel cell to the wiring harness.
6. Open the valve on the fuel pressure gauge purge line. Do not prime the system without the fuel gauge purge valve open or air can be forced back into the fuel cell. If this happens, repeat steps 1, 2, and 3 to remove the trapped air from the fuel cell.
7. Repeat step 3, this time purging the air completely from the throttle body. The pressure should be 40 psi in the throttle body after purging the system.

NOTE: The system can develop 40 psi without being fully purged. The system is fully purged when no bubbles are visible in the purge line.



8. Remove the pressure gauge set, and cap all Schrader valves.
9. Insure that all wire connections are secure and that there are no leaks in the fuel system.

WARNING: Take care to catch any fuel that may be spilled and properly dispose of the fuel rags.



ENGINE ADJUSTMENTS

DESCRIPTION

The lubricating system is a pressure feeding system using an oil pump. The engine oil is drawn from the oil sump by the oil pump, which drives the oil, under pressure, through the oil filter, oil cooler and various lubricating points to the engine. The oil then returns to the oil sump to repeat the continuous cycle. When the oil pressure exceeds the specific pressure, the oil pushes open the relief valve in the oil pump and returns to the oil sump, keeping the oil pressure within its specific range.

LOW OIL PRESSURE

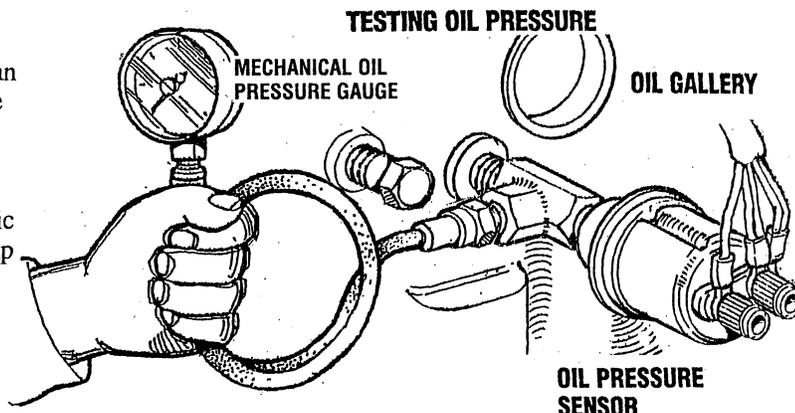
The specified safe minimum oil pressure is 4.3 + 1.4 psi (0.3 - 0.1 kg/cm²). A gradual loss of oil pressure usually indicates worn bearings. For additional information on low oil pressure readings, see the engine troubleshooting chart.

TESTING OIL PRESSURE

To test the oil pressure, remove the hex plug from the oil manifold and install a mechanical oil pressure gauge in its place. After warming up the engine, set the engine speed at 1800 rpm and read the oil pressure.

OIL PRESSURE BETWEEN 50 AND 60 PSI AT 1800 RPM

NOTE: A newly started (cold) engine may have an oil pressure up to 70 or 80 psi. A warmed engine can have an oil pressure as low as 30 psi. Oil pressure will vary depending on the load placed on the generator.

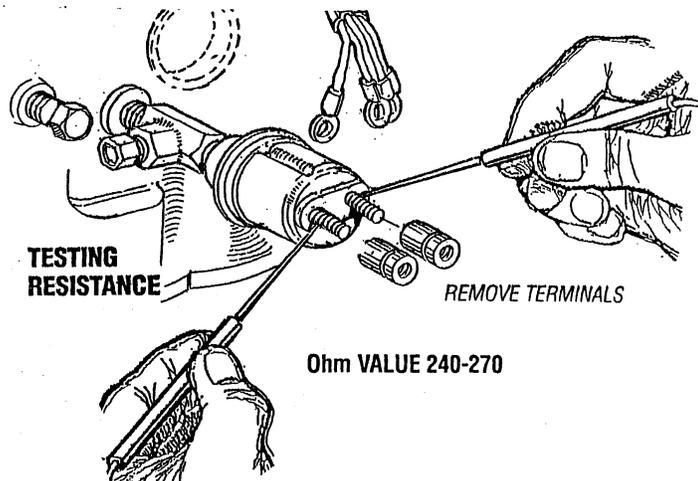


OIL PRESSURE SENDER

An oil pressure sender #049197 is fitted to the engine oil gallery. This sends a voltage signal to the control ECU that it interprets as oil pressure. Should this voltage signal fall to a present value, the ECU will shut the unit down and illuminate the oil pressure LED on the control panel.

Test the sensor by checking resistance (at rest):

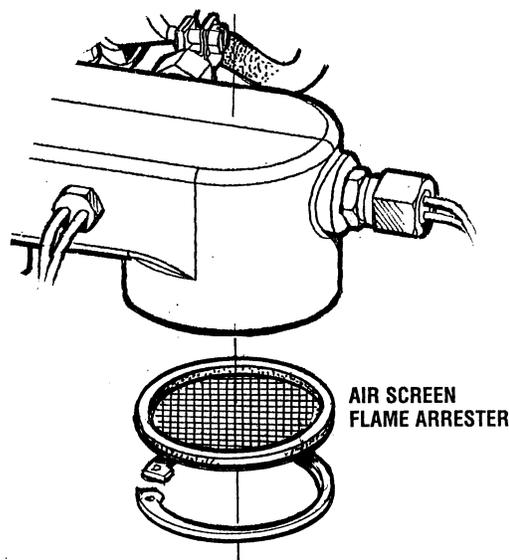
SENSOR AND SWITCH TORQUE 9 - 13 ft-lb (1.2 - 1.8 m-kg)



AIR SCREEN / FLAME ARRESTER

The air screen/ flame arrester should be inspected and cleaned. Inspect the rubber sealing and replace if worn or cracked. Clean the screen in a water soluble cleaner such as gunk.

WARNING: The generator should never be started or operated without the airtight/flame arrester in place.



ENGINE OPERATING SYSTEM

DESCRIPTION

The engine/generator is equipped with an electronic speed-regulated, fuel injected control system. Engine speed is maintained constant by varying the amount of air induced past a throttle plate into the intake manifold. The throttle plate position is controlled by a rotary proportional actuator energized from a closed loop control circuit whose signal input is from a magnetic pickup-type speed sensor.

Fuel is metered to the engine intake manifold by a central port-type fuel injector system where the amount of fuel injected is primarily determined by the engine speed, the engine load, the engine temperature and the intake air temperature. Fuel is delivered to the engine by a high pressure fuel pump. The fuel pressure drop across the injector is maintained constant by a fuel pressure regulator which is ported to the intake manifold to compensate for pressure variations as a result of engine load changes.

Air-fuel management as well as engine operational functions are performed by an embedded electronic control unit (ECU). Engine/generator control functions (starting and stopping) are inputted from a remote control panel or from the engine START/OFF switch to the ECU. The ECU then sets the required operational parameters necessary for the running of the engine.

The output driver in the ECU which controls the relays (K1, K2) and the control panel indicator lamp(s) is one which has internal current limiting capability of its outputs, and will turn itself off should such an over-current condition occur. Therefore, the engine status indicator lamps are of the 12V LED type.

The ROM of the MCU contains the program from which the engine is controlled. The MCU measures and monitors the status of the engine through various inputs and then sets accordingly the outputs which control the engine. The MCU has direct control of the amount of the fuel injected as well as some control of the throttle position. The actual position of the throttle plate actuator for speed control however, is determined by a proportional, integral and derivative (PID) analog closed loop control circuit. The MCU monitors the engine speed and will shut down the engine in case an overspeed condition should ever occur. In addition, the ECU has a safety backup overspeed circuit in the unlikely event that the MCU fails to respond.

This manual provides detailed testing procedures of the operating system and its components including a troubleshooting chart and wiring schematics of four EFI generators.

THROTTLE BODY

The throttle body, mounted on the intake manifold, is an assembly of the principal components of the EFI (Electronic Fuel Injection System).

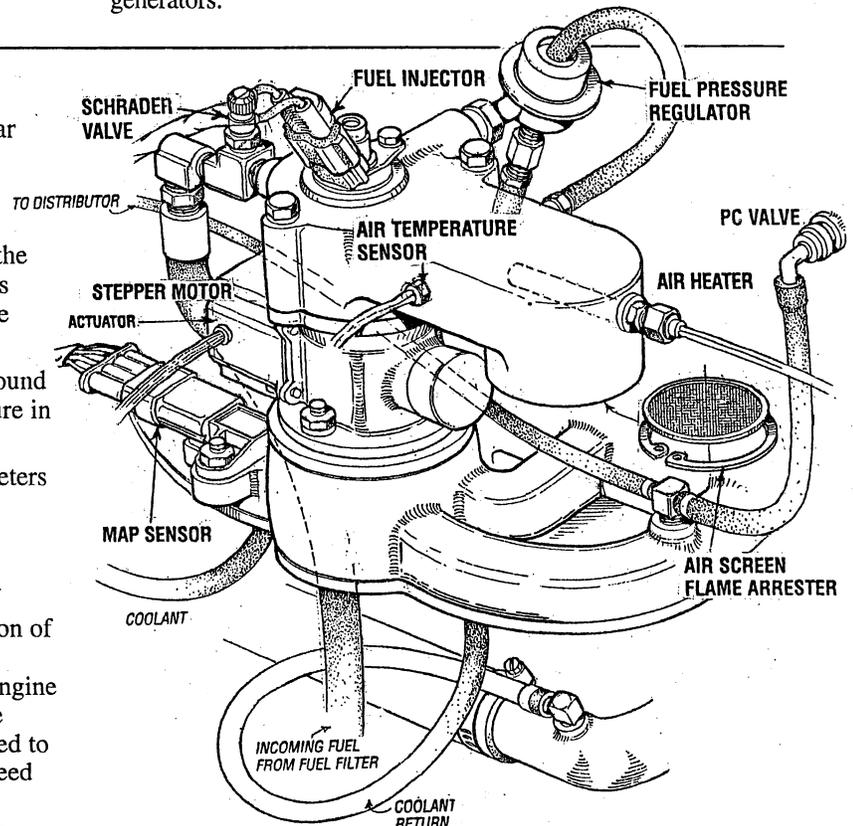
The EFI is controlled by the ECU (Electronic Control Unit) which interprets data from sensors that monitor the vital parts of the engine. The ECU uses this continuous flow of data to determine the appropriate injector pulse rate and throttle opening position.

A high pressure fuel pump supplies fuel to the area around the injector and the regulator maintains the fuel pressure in that area at 35 - 40 PSI.

The injector is a solenoid operated pintle valve that meters fuel into the intake manifold depending on engine operating conditions and generator amperage load as determined by the ECU.

Air flow into the intake manifold is through the flame arrester/air filter and is controlled by the ECU operation of the throttle plate via the actuator (stepper motor). The throttle plate positioning for proper air flow into the engine is accomplished through the ECU interpretation of the engine operating conditions. The Schrader valve is used to monitor the fuel pressure at the fuel injector and to bleed air after fuel system servicing.

On some models an air intake heater is positioned in the intake to heat the incoming air during a cold start.



ELECTRONIC CONTROL UNIT (ECU)

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.

CONTROL CIRCUIT OPERATION

DESCRIPTION

When the engine start/stop switch and the remote start/stop switch are in their center positions and the green LED is not illuminated and the generator is not running, the ECU and all the engine electrical components are in an off state.

When the start switch is actuated (momentarily depressed), the ECU is powered up and a start is assumed. The green LED will illuminate. The K2 run relay will energize turning on the ignition and the fuel pump. After a time delay of approximately 4 seconds, the K1 relay will energize, which in turn energizes the starter solenoid and an engine cranking sequence will result - starting the engine.

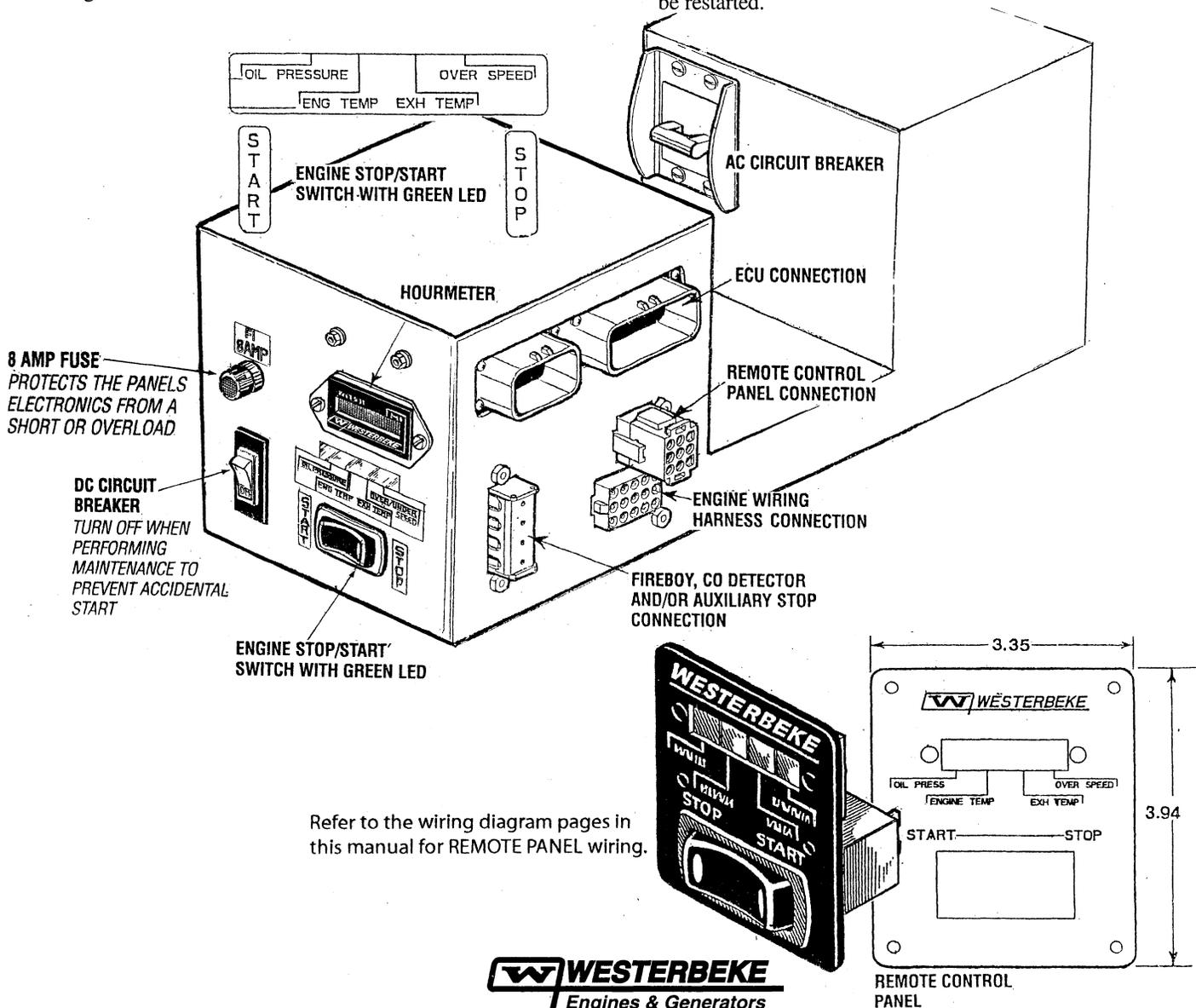
Should the engine fail to start within approximately 6-8 seconds, the start sequence will be terminated and the ECU will go to the off state and the green LED light will go out and the underspeed LED fault light will illuminate.

When the engine starts, the starter will automatically disengage (start relay K1 is de-energized). The green LED light on the switch is on and circuit power to the ECU is latched on. The generator will come up to speed and the engine is now under the control of the ECU.

When a stop is initiated by momentarily depressing the stop switch, the ECU will take this command and then de-energize the K2 run relay. This removes DC power to the ignition, the fuel pump, and the injector, shutting down the engine. Once the ECU senses zero rpm engine speed (no MPU AC signal) it then releases the latch, which holds the circuit power on. The green LED light will go out and the ECU will revert to an off state.

Should a fault occur to initiate an engine shutdown as a result of low oil pressure, high water injected exhaust elbow temperature, high engine antifreeze coolant temperature, high engine rpm or low engine rpm, the ECU will acknowledge this as a valid stop command. The stop sequence will be as previously described except that the circuit power will remain on and the fault LED board will register the fault cause by illuminating the related fault LED. This fault LED will remain on and will not allow the engine to be restarted.

To reset the ECU and turn off the fault LED, the DC circuit breaker must be turned off, then back on. The reset action must be initiated before the ECU will permit the engine to be restarted.



ELECTRONIC CONTROL UNIT (ECU)

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.

Program dipswitches are in the OFF position and should not be disturbed.

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 software.

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 60Hz 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)

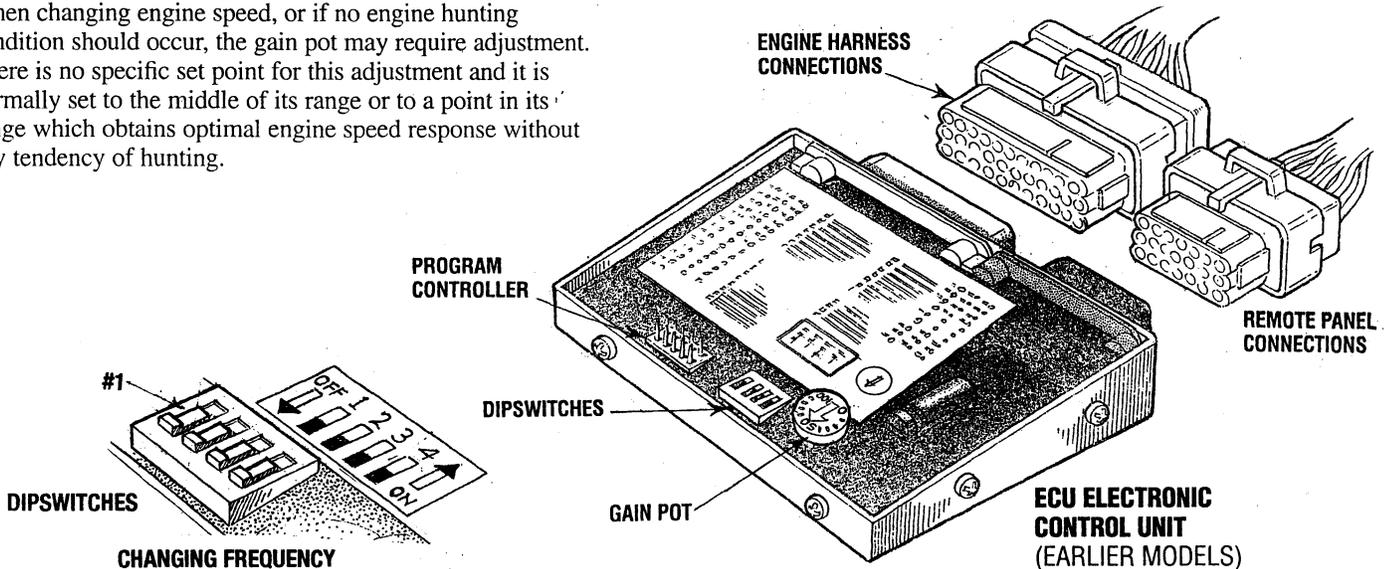
When changing engine speed, or if no engine hunting condition should occur, the gain pot may require adjustment. There is no specific set point for this adjustment and it is normally set to the middle of its range or to a point in its range which obtains optimal engine speed response without any tendency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

Setting/Changing Engine Speed

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

1. Open the control box on the generator. Shut OFF the DC breaker on the control box.
2. Locate the dipswitches on the ECU (Electronic Control Unit).
3. Move the #1 dipswitch as shown in the illustration below to the position corresponding to the operating hertz as selected.
4. Turn the DC breaker on the control box ON. Turn OFF the control panel AC breaker.
5. Start the generator and monitor the operating hertz using an appropriate meter and AC output voltage. Adjust the AC output voltage as needed using the voltage adjustment pod on the voltage regulator.
6. Once the hertz and AC voltage have been verified, close the panel box AC breaker and load test the generator.

NOTE: The GAIN adjustment on earlier ECU's may need to be adjusted should a hertz variation occur when an amperage load is applied. Reduce the GAIN adjustment to a lower number until a stable hertz is achieved.



DIPSWITCH #1 IS USED FOR CHANGING THE FREQUENCY, ON IS FOR 50HZ, OFF IS FOR 60HZ. THE REMAINING SWITCHES #2,#3, AND #4 SERVE NO FUNCTION.

REPLACING THE ECU

Remove the control box cover. Before attempting to remove the ECU, disconnect its power by removing the fuse from the front of the control panel. With the engine harness connections unplugged, unscrew the four side screws and remove the ECU from its holder.

INSTALLING THE NEW ECU

To install the new ECU, reverse the above procedure.

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 #053500) 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:

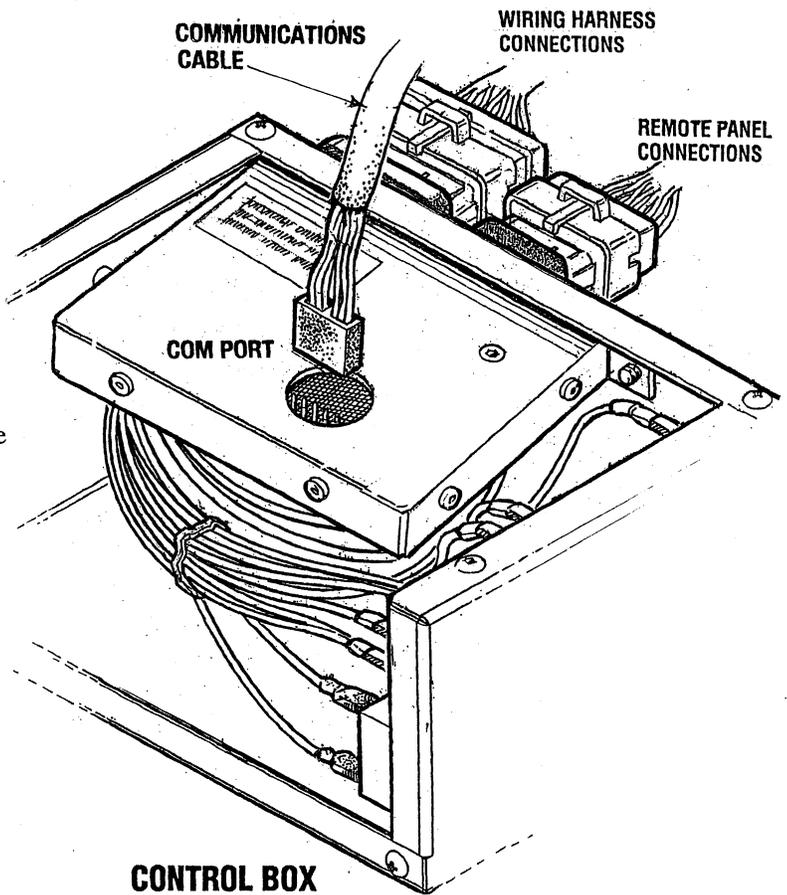
1. Open the control box on the generator. Shut OFF the DC breaker on the control.
2. Access the opening on the ECU by removing the plug. Connect your laptop (with the software installed) using the communications cable included in the kit to the ECU and turn the laptop ON.

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 connected 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. Start the generator and monitor the AC output voltage. Adjust the voltage as needed using the voltage adjustment pod on the voltage regulator.
6. With the speed/hertz verified and the AC output voltage adjusted, close the AC breaker and load test the generator.



EFI GENERATOR ELECTRICAL TESTING VALUES

DEVICE AND CONDITION	GENERATOR MODELS			
	All Models	5.0/6.5Kw	8,10,12.5.14Kw	20/22Kw EFI
Speed Sensor-Voltage (while cranking) (AC Volts)		1.33	0.98	1.26
Speed Sensor-Resistance (at rest) (in Ohms)	950-1000Ω			
Distributor-Voltages (in AC volts)				
Red (ECU) and Black/White (+)		0.55	0.447	0.253
Red (ECU) and Blue (-)		0.44	0.44	0.177
Blue (-) and Black/White (+)		0	0	0
Black/White (+) and Engine Ground		0.072	0.011	0
Blue (-) and Engine Ground		0	0	0
Red (ECU) and Engine Ground		0.60	0.45	0.277
Distributor-Resistance (in Ohms)				
Red (ECU) and Black/White (+)	None (open)			
Red (ECU) and Blue (-)	None (open)			
Blue (-) and Black/White (+)	None (open)			
Black/White (+) and Engine Ground	None (open)			
Blue (-) and Engine Ground	None (open)			
Red (ECU) and Engine Ground	None (open)			
Map Sensor-Voltages (in DC Volts)				
Pin 4 (sig) to Ground (at rest)		0	0	0
Pin 4 (sig) to Ground (prime delay in start mode)		4.089	4.05	4.056
Pin 4 (sig) to Ground (running 1800 rpm no AC load)		1.73*	1.25*	1.300*
Pin 3 (+5V) to Ground (at rest)		0	0	0
Pin 3 (+5V) to Ground (prime delay in start mode)		4.997	4.997	4.999
Pin 3 (+5V) to Ground (running 1800 rpm no AC load)		5.005*	5.003*	5.014*
Map Sensor-Resistance (in Ohms)				
Pin 1 (grnd) to Pin 2	1.9Ω			
Pin 1 (grnd) to Pin 3	5.9Ω			
Pin 1 (grnd) to Pin 4	5.3Ω			
Intake Heater Element in Ohms	1.5 - 2.5Ω			
Air Temperature Sensor (room temp.)in Ohms	10,000Ω			
Water Temperature Sensor (room temp.)in Ohms	10,000Ω			
Oil Pressure Sensor (at rest)in Ohms	245Ω			
Stepper Motor (at rest)in Ohms				
Black and Green	2.61Ω			
Red and Blue	2.61Ω			
Stepper Motor-Resistance (in Ohms)				
Purple: Part #42221				14.55Ω
Blue: Part #48921			14.55Ω	
Black: Part #49556		12.50Ω		
K1, 2, or 3 Relay (between terminal 86 and 85)in Ohms			86Ω	86Ω
Mando Alternator-part #39139 (in DC Volts)				
B+ (typical at rest)			12.7	12.7
B+ (typical while running)			14.1	14.5
At Excitation (typical while running)			13.4	13.6
At Excitation (at rest)			0	0
Fuel Pump in Ohms				
Low Pressure	1.5 - 2.0Ω			
High Pressure	9.0 - 13.0Ω			

Note: * Approximate Voltages

ELECTRICAL TROUBLESHOOTING CHART (STATIC TESTING)

The following test procedures will require the use of a multimeter and the engine's wiring diagram (in this manual). Also refer to the relay testing page. WESTERBEKE recommends that these tests be performed by a qualified technician.

PROBLEM	TESTING (12 VDC is battery + voltage measured to ground)	INSPECTION/SOLUTION
Engine does not crank.....	Test for B+ (12v) at the circuit breaker to the PC board terminal T4. If OK ↓	Check for bad connections at the engine harness connector P1, Pin 1, the #14 red wire, or at the battery + on the starter. Check the connections at the PC board terminal 4 and at the circuit breaker
	Test for B+ (12v) at the circuit breaker to the panel fuse end and to the PC board terminal T1. If OK ↓	Look for a bad connection from the circuit breaker to the fuse or at the PC board terminal T1. Replace the circuit breaker.
	Test for B+(12v) from the fuse end to the PC board terminal T2. If OK ↓	Inspect the connections at the fuse or PC board terminal T2. Replace the fuse.
	Test for B+(12v) at the crank relay K1 terminal 30. If OK ↓	Check for a bad connection at the engine harness connector P1, pin #3. Check the DC voltage at terminal #30 at the K1, K2, K3 and K4 relays.
	Test for B+ (12v) at the start/stop switch terminals 2 and 10. If OK ↓	Look for bad connections at the panel connector S2, pin 1, white/black/red wire to the terminal PC board or at the start/stop switch terminals 2 and 10.
	Test for B+ (12v) at the start switch terminal 1 when the switch is activated. If OK ↓	Replace the start switch.
	Test for B+ (12v) at crank relay K1, terminal 86. If OK ↓	Check bus fuse (8 amp).
	Test for B+(12v) at crank relay K1 terminal 85. Activate the start switch and after a few seconds the voltage should drop below .5 volts. If OK ↓	Inspect for a bad connection at relay K1 terminal 8 orange wire or at ECU connector J2, Pin #8
	Activate the start switch, after 4-5 seconds B+(12v) should be present at terminal 87 on relay K1. If OK ↓	Look for a bad connection at relay K1.
	Activate the start switch, after 4-5 seconds check for B+(12v) at the start solenoid. If OK ↓	Look for a bad connection at crank relay K1, terminal 85 orange wire or at the ECU connector J2, pin #8.
	Inspect the starter.	Check the connections at crank relay K1 terminal 87, yellow/red wire or at the start solenoid.

NOTE: The engine's electrical system is protected by a manual reset circuit breaker located on the control box on the generator. If an overload occurs, this breaker will need to be reset.

ELECTRICAL TROUBLESHOOTING CHART (STATIC TESTING)

The following test procedures will require the use of a multimeter and the engine's wiring diagram (in this manual). Also refer to the relay testing page. WESTERBEKE recommends that these tests be performed by a qualified technician.

PROBLEM	TESTING (12 VDC is battery + voltage measured to ground)	INSPECTION/SOLUTION
Engine cranks but fails to start...	Test for B+ (12v) at terminals 30 and 86 on the K2 run relay If OK ↓	Check for bad connections at both terminals. Replace the K2 relay.
	Test for B+ (12v) at run relay K2, terminal 85 and activate the start switch. Voltage should be less than 5 volts. If OK ↓	Inspect the connections at relay K2, terminal 85, or at the ECU connector J2, pin 19.
	Activate the start switch, test for B+(12v) at relay K2 run relay, terminal 87. NOTE: For other possible causes (failure to start) such as fuel pump, speed sensor (MPU), ignition, etc, refer to the these sections in this manual.	Replace the K2 relay.
Engine starts, runs but shuts down.....	Test for voltage across the oil pressure sensor terminals, with the engine running voltage should be less than 1.0 volts. If OK ↓	Faulty oil pressure sensor. Replace sensor/switch.
	Test for voltage across the exhaust temperature switch, when the engine shuts down, it should read zero (0) volts. If OK ↓	Faulty exhaust temperature switch. Replace switch. Loss of coolant thru exhaust elbow. High exhaust temperature.
	The engine temperature sensor maybe faulty. If OK ↓	Test sensor, refer to component testing in this manual.
	Fireboy suppression circuit maybe faulty.	By-pass Fireboy connection at terminal block. Install a jumper between #4 and #3.

IMPORTANT

CONTINUED →

SYSTEM MONITORING SOFTWARE AND DATA LOGGING

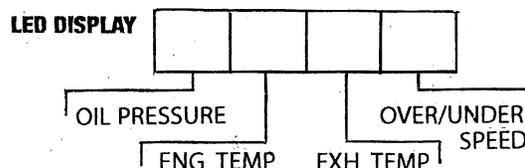
A diagnostic Software Kit #055410 is available through your Westerbeke Master Distributor. The Master Distributor can be located on the Westerbeke website at www.westerbeke.com. An interconnect cable is provided with the kit to connect between the ECU in the generator's control box and your laptop to use this software.

The software will be a very important tool for monitoring system operation to ensure the system is operating at its optimum. Also for locating any operating issue and for the very important task of Data Logging used to help determine a cause for engine/system malfunction. For the models listed in this manual, the engine **MUST** be running for the software to communicate with the system ECU. When troubleshooting an engine/system malfunction, start data Logging as soon as the engine is started and running. Then view the data being displayed in the various boxes on the PC Interface.

The Data file can be opened in most spreadsheet forms such as Microsoft Excel.

After installing the PC Interface Software on your laptop, shut OFF the DC breaker on the generator's control box. Attach one end of the communications cable to one of your laptop ports and attach the other end to the 10 pin connector on the ECU. Make sure the **arrow** on the communications cable plug is facing towards the ECU harness connection plugs.

Turn ON your laptop and the DC breaker on the control box.



DATA LOGGING (TROUBLESHOOTING AID)

Test procedures for Data Logging with Gasoline Diagnostic Software-PC Interface

DESCRIPTION

The Diagnostic software is a valuable tool in diagnosing engine problems. It should not replace basic troubleshooting techniques or common sense. Some of our products such as the 5.0 and 6.5 SBEG and 8.0 to 14.0 SBEG, along with non-OBD 20.0 and 22.5 SBEG do not have an idle mode. That means that the engine must be running before the PC interface can begin communication. Models such as the OBD versions like 20.0 and 22.5 SBEGA do have an idle mode and PC interface can begin communications before the engine is actually running. Once you have determined which type you have, the following procedures will help gather valuable information.

Start off by collecting data from the time that the engine is started. If you have a genset that has the idle mode, start the PC interface communicating and data logging before you start the engine. If you have an engine that does not have an idle mode, start the PC Interface as soon as possible after the engine is running. Let the engine warm up for about 10 to 15 minutes before trying to apply an AC load. Monitor and record AC volts and amps if possible.

After the engine is warmed up, start applying an AC load by turning on various devices. Let the unit run at each load change for a couple of minutes so that the unit is stable. Monitor and record AC volts and amps if possible at each load site. Continue to add AC load until the unit is at or near full power rating. Power is determined by multiplying the AC voltage times the AC amperage. This will determine if the unit is overloaded or not.

After loading up the genset, begin to reduce the AC load. Allow the unit run at each load site for a couple of minutes to stabilize. Continue to reduce the AC load and monitor voltage and amperage until there is no AC load on genset. This will give a technician a baseline of what is happening when the engine is running under a controlled load condition.

Finally, after running the controlled baseline test, this might sound strange, but sometimes the customer might know a particular scenario that will cause a problem for the unit. Sometimes we hear customers say that the unit runs fine for awhile and when my air conditioner shuts off something happens. Try repeating the scenario that the customer mentions. Always start by recording date from the start up for at least a couple of minutes with no load on the generator to get a starting point. Then continue to record data until the problem shows up.

If you have a unit with no *idle mode*, and the unit shut down under some kind of fault, the data log will automatically stop and save the file. If you have a unit with an *idle mode*, and the unit was to shut down under some kind of fault, you will have to manually stop the data log to save it. Or in the case of shutting of the DC circuit breaker, this will also cause the data log to stop and save itself.

USING THE DATA

All of the data that is being recorded is also being displayed on the PC Interface in the various boxes. The following information applies whether you are looking at the data file after it has been recorded or watching it live in the PC Interface. The data file can be opened in most spreadsheet software such as Microsoft Excel.

The data that is being collected is self explanatory and simple to follow. For example, the engine temp, air temp, oil pressure, and battery volts would be easy to understand, other items may be less familiar.

Speed

Simple enough, this is the speed that the engine is running. If the genset is set up to operate at 60 Hz, then the engine needs to run at 1800 rpm (belt driven units may be different). If the unit is set up for 50 Hz operation then the engine speed will be 1500 rpm.

When a genset is governing properly, you should see reading slightly above and below the desired speed. Even a well tuned engine will vary a little. The point is you should see readings above and below the desired speed. If you see speed readings remain more than 20 rpm above or below the desired speed for a prolonged period of time, there could be a problem, especially if this is noticed with no AC load applied.

If the speed is too high with no AC load applied, check the data box labeled Stepper Pos. (steps). The throttle is controlled by a stepper motor. Usually the step count for the engine running with no AC load is typically in the 20-30 steps range. A couple of steps above or below this range does not indicate a problem. However, if the step count is in the single digit numbers or even showing a zero, the problem maybe that the throttle body assembly may be out of calibration or not functioning properly. The stepper motor can only go to a position that it thinks is zero. If the calibration is off, the stepper cannot move the throttle closed enough to slow the engine down. An engine that has this problem will run at the proper speed once some AC load has been added. However, when that load is dropped, the speed will be too high, and in some cases may cause the engine to over-speed and shut down.

If the engine speed is too low with no AC load applied, there is probably a totally different problem. Again, look at the Stepper Position. Is the speed low but steps are high? This would mean that the throttle is being opened to compensate for loss of speed but the speed is not coming up. Check to make sure that the fuel level is full in the fuel system (no air) and that the fuel is good and the filters are clear. Check to make sure that the air intake screens are clean. Check to make sure that the spark plugs have not fouled. Bleed the fuel system to remove any air.

DATA LOGGING (TROUBLESHOOTING AID)

If the engine speed is okay when running with no AC load, but once underway with some AC load being applied the speed drops and stays below the desired speed, first check the AC power by multiplying the total AC amperage times the AC volts to get the kilowatts. If this number is higher than what the unit is rated for, then it is overloaded., Shut off some of the devices until the speed returns to normal and check the power again. If there is only a small AC load applied and the speed cannot maintain, follow the same suggestions from the previous paragraph.

Pressure (kPa)

This is the pressure that exists in the intake manifold. At no-load, the kPa will be lower than at full load. The wider the throttle plate is open, the closer it gets to atmosphere which is about 100 kPa. Typically a genset running at no-load will see a kPa value around 30, while at full load it would be around 90 kPa. If the kPa is stuck at 70 and never moves then there is a problem with either the MAP sensor or the wiring to the MAP sensor, as 70 is a default value that is in the code.

WB Heater Set-point

This is the set-point in millivolts of the heater temperature in the Wideband O2 Sensor. Currently in all the units that do not have an *idle mode*, the set point is 893. In other units the set-point will vary but will be displayed in this box.

WB Current Temp

This is the actual value in millivolts of the heater temperature in the Wideband O2 Sensor. If the heater is working properly, you will typically see values stay within 20 millivolts of the set-point. The higher the number is, the colder the heater is. Typically a reading in the 4000 area means that the heater is not working at all. If the value is swinging dramatically above and below the set-point, the sensor is probably failing. The sensor should be replaced.

Lambda

Lambda represents the ratio of the amount present in a combustion chamber compared to the amount that should have been present in order to obtain "perfect" combustion. Thus, when a mixture contains exactly the amount of oxygen required to burn the amount of fuel present the ratio will be one to one and lambda will equal 1,000. If the mixture contains too much oxygen for the amount of fuel (a lean mixture), lambda will be greater than 1,000. If a mixture contains too little oxygen for the amount of fuel (a rich mixture), lambda will be less than 1,000.

Perfect combustion requires an air/fuel ratio of approximately 14.7:1 (by weight) under normal conditions. Thus a lean air/fuel ratio of, say, 16:1 would translate to a lambda value of 1.088. (To calculate, divide 16 by 14.7.) A lambda of .97 would indicate an air/fuel ratio of 14.259:1 (derived by multiplying .97 by 14.7).

In these applications lambda readings should be 1,000. Because of the combustion involved this number will constantly be changing, ideally you should see the value of lambda fluctuating slightly above and below the 1,000 target.

Immediately after a startup, it is typical to see a rich readings for lambda. This is part of the startup process and usually takes a couple of minutes for sensors to warm up and take control of the air fuel mixture.

If you see a problem in this area first check the Wideband heater values to make sure that the heater is working. Remember that it takes about three minutes after starting an engine for it to be totally in control. Physically remove the sensor and check it for corrosion and build up of deposits from the water being injected through the exhaust. Salt water deposited on the sensor will be very damaging. If there is any evidence of build up, replace the sensor. Determine the cause for raw water getting on this sensor.

After checking the sensor and the genset is running too rich, check the air intake screens and spark plugs to make sure they are clean and functioning properly. If the genset is running too lean, check the fuel levels and the quality of the fuel. Water in the gas is no good and will cause the genset to run lean.

Ip Current

Is the electrical value equivalent of the lambda reading. There is not much to learn from this number.

Lambda PW Trim

Is the fueling trim percentage that the wideband oxygen sensor is contributing. In most cases 15% is the maximum.

Wideband P, I & D Term

These values are the Wideband Sensor Heater Temperature control terms. These values will be constantly changing. It is more important to look at the WB Current Temp value.

Lambda P & I Term

These values are the lambda value controlling terms. Their job is to keep the lambda reading at 1,000 enriching or leaning the fueling.

NB STT (Narrowband Short Term Trim)

If your genset is equipped with a narrowband oxygen sensor, this will be the value of its contribution. Maximum contribution is 1%.

Stepper Pos (steps)

The throttle shaft is controlled by a stepper motor. The value displayed is in steps, zero steps being the closed position. Most units will run at no load in the 20 to 30 steps range, these values will vary from engine to engine.

Pulse Width

This is the fueling duration in milliseconds (ms). The value will be lower at no load than at full load.

Main Fuel Comp (%)

This is the fueling compensation that is derived from a value in the fuel table, which is based on the engine rpm and the MAP pressure.

DATA LOGGING (TROUBLESHOOTING AID)

Air Temp and Engine Temp Comp (%)

This is the fueling compensation based on the air temperature and engine temperature. This value can be both positive and negative. This value is added or subtracted from the main fuel compensation value.

Speed P, I & D Terms

These values reflect the engine speed governing process. These values are constantly changing and it is very hard to get any information from them, you should see these values constantly changing. If for some reason there are all zeroes in these columns than the engine is probably not running.

De-rated P Term

This code provided for the P(Proportional) Term, in the speed PID control, to be de-rated right after start-up for a short period of time. This allows the engine to warm up without having an aggressive P value which could cause hunting or instability when the engine is cold. On some older units there is also a trim pot on the top on the EUC that can manually de-rate the P value. This will be reflected in this box.

Frequency Option

This the value of the speed selector on the ECU, whether it is 50 or 60 Hz. Some interfaces may not show this column but will display the Frequency Option in the Title area at the top on the data log.

The Generator Frequency

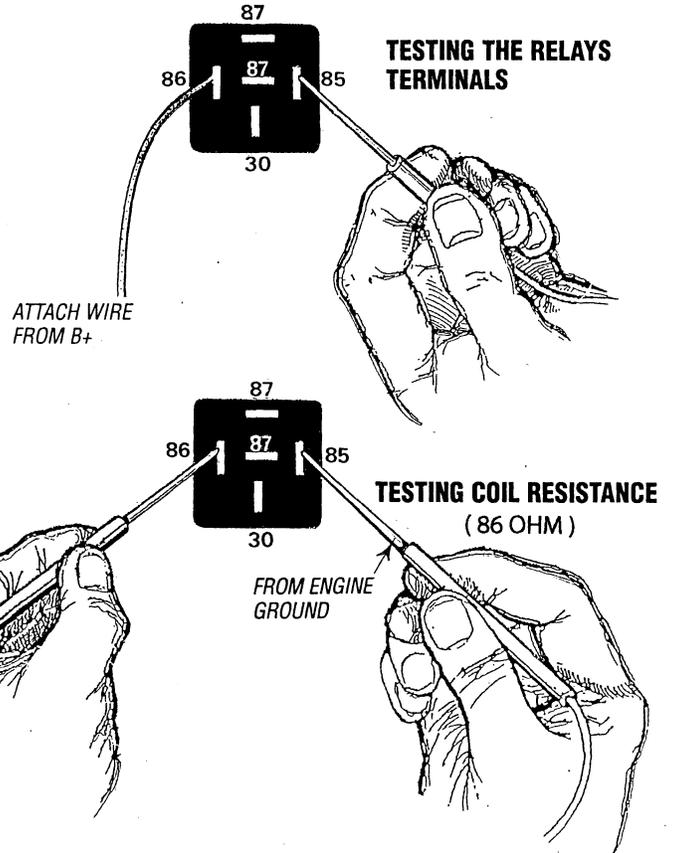
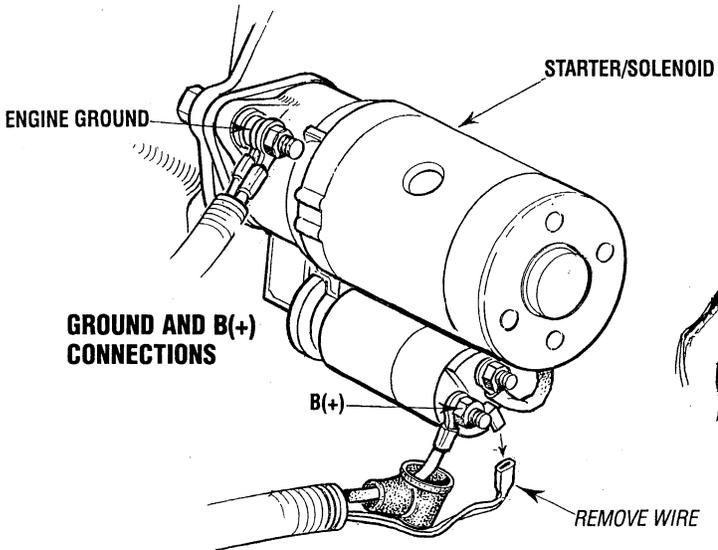
The Generator Frequency is a function of engine speed. For most applications, 50 Hz operation is with an engine speed of 1500 rpm, while 60 Hz operation is with an engine speed of 1800 rpm.

COMPONENT TESTING

GENERAL

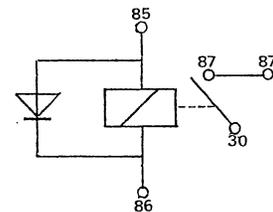
All DC voltage measurements are made to the engine battery negative ground point unless specified otherwise. In making test measurements, make sure that a good ground for the meter is established, preferably the point where the negative battery is connected to the engine. Battery positive voltage is indicated as B+ and should measure no less than 11.5 volts.

AC voltage measurements should be made with a true RMS AC meter to insure accuracy.

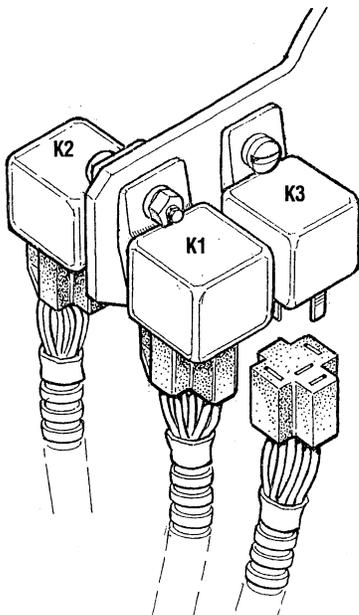


RELAYS

The relays used in the control system have coils which are polarized by the fact that they have internal free wheeling suppression diodes across them. Relay coil terminal 86 must be maintained (+), terminal 85(-). The relay coil is rated 12V DC, and the coil resistance is typically 85 ohms. With B+ on terminal 86, direct grounding of terminal 85 is permissible for testing purposes.



RELAY INTERNAL DIAGRAM



RELAYS
TYPICAL RELAY ARRANGEMENT

COMPONENT TESTING

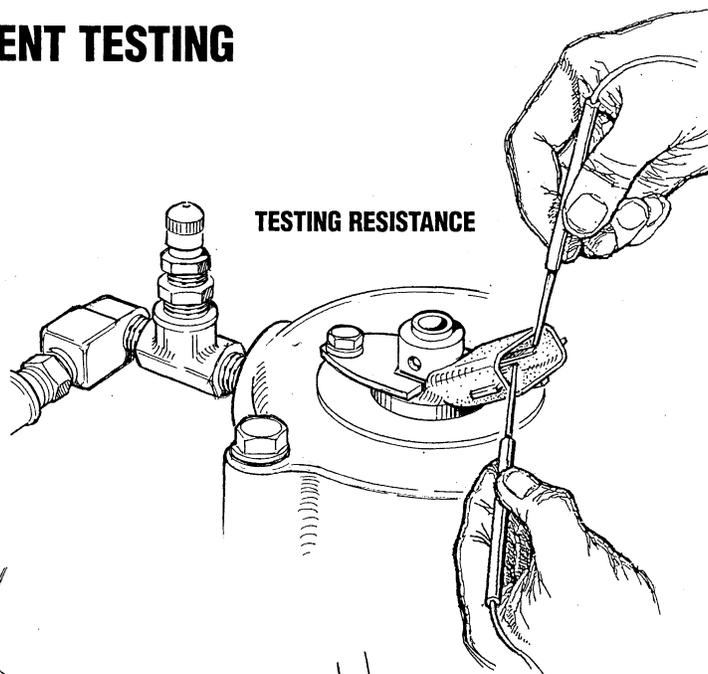
STEPPER MOTOR

The throttle plate rotary stepper motor operates on a low DC voltage supplied from the ECU. There are two independent operating coils in the stepper motor. Each coil resistance is typically 2.61 ohms.

A resistance value test only should be performed on the stepper motors two coils. Do not apply 12VDC to these coils as it will damage the coils.

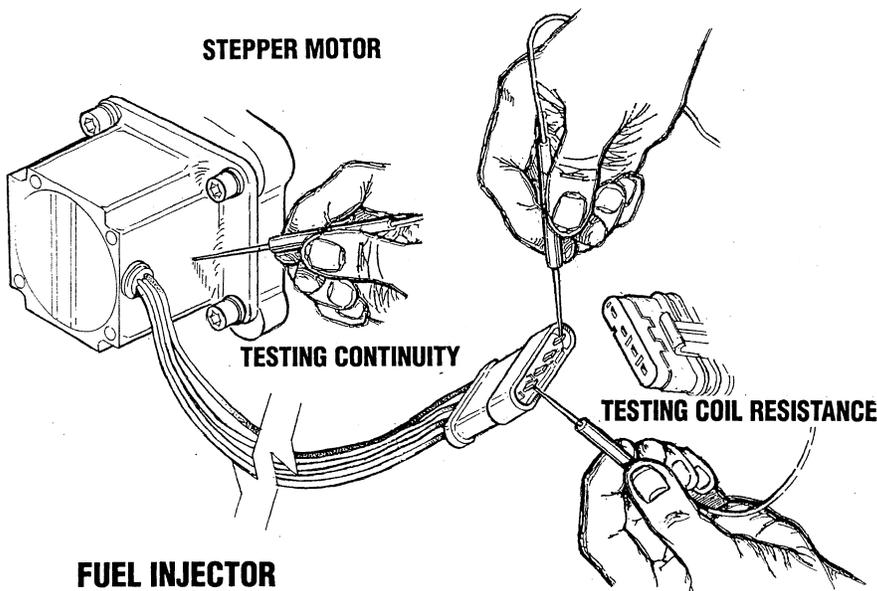
Check the resistance value of each coil between coil #1 (blue and red) and coil #2 (black and green).

There should be no continuity found between any of the coil connectors and the metal case of the stepper body.



TESTING RESISTANCE

STEPPER MOTOR

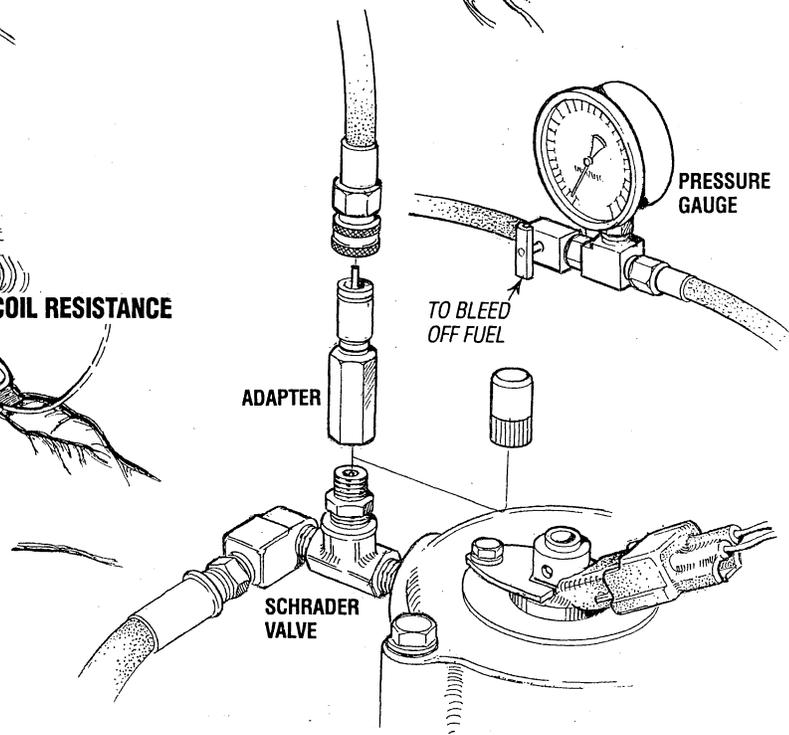


TESTING CONTINUITY

TESTING COIL RESISTANCE

FUEL INJECTOR

The fuel injector has no polarity and operates on 12 VDC. The coil resistance is typically in the order of 14 to 16 ohms. The positive wire to the injector is supplied power through the contacts of relay K2, which is off when the engine is not running. To test the injector, disconnect its cable connector and connect a ground wire to one of its input pins. Connect a wire from a point of B+ and repeatedly touch the other input pin. When touched, a low audible click should be perceptible; if not, resistance test the coil. If okay, the injector may be assumed to be functioning electrically. However it could be clogged. If in doubt, replace the injector.



PRESSURE GAUGE

TO BLEED OFF FUEL

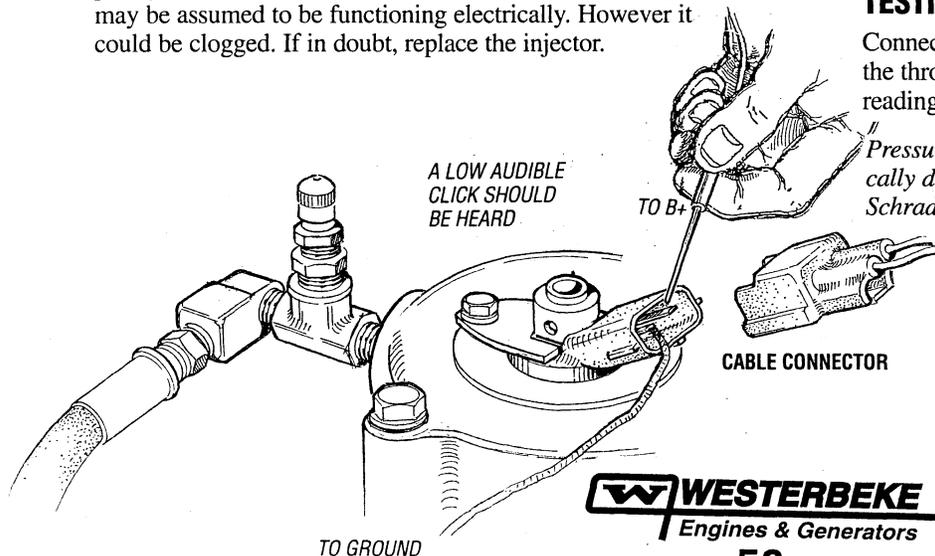
ADAPTER

SCHRADER VALVE

TESTING SYSTEM FUEL PRESSURE

Connect a fuel pressure test gauge to the Schrader valve on the throttle body as shown and run the engine. Pressure readings should indicate 35 - 40 psi.

Pressure gauge kit MT 337B "SNAP -ON-TOOL" is specifically designed for fast accurate testing of fuel pressure for Schrader test ports.



A LOW AUDIBLE CLICK SHOULD BE HEARD

TO B+

CABLE CONNECTOR

TO GROUND

COMPONENT TESTING

TESTING THE MAGNETIC PICK UP COIL

Test the magnetic pick-up AC voltage output while cranking. Voltages are listed below.

Test the magnetic pick-up coil winding in a static mode. Resistance values are shown below. If the AC output voltage is not present or lower than listed and the resistance value of the coil winding is correct, debris may be insulating the MPU tip end. Remove the MPU and examine and clean the tip end of debris.

Coil winding resistance being lower or not present would damage the MPU.

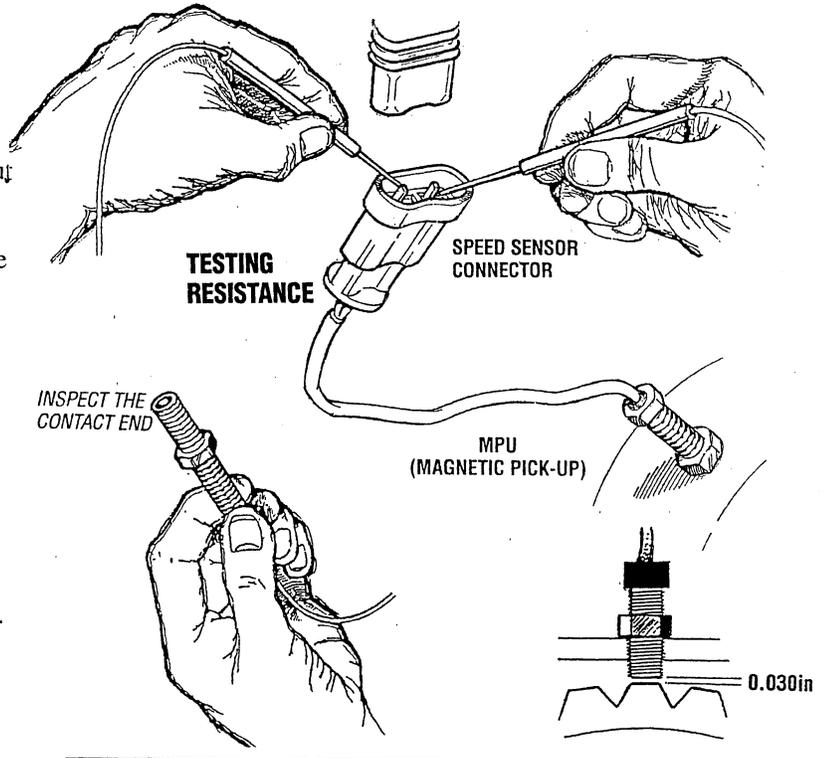
NOTE: Carefully follow the installation instructions provided with the new MPU.

Speed Sensor Test Values Voltage (while cranking)

8, 10, 12.5, 14 Kw EFI - 0.98 VAC

Resistance (at rest) - 950-1000Ω (all models)

NOTE: The AC signal produced by the MPU will be greater the closer the MPU is positioned to the flat of the ring gear tooth and weaker the farther away from the tooth.



TESTING THE FUEL PRESSURE PUMP

Testing the fuel pumps in a static mode. Check for integrity of the pump winding. Unplug each pump from the engine harness and check the resistance value of the winding.

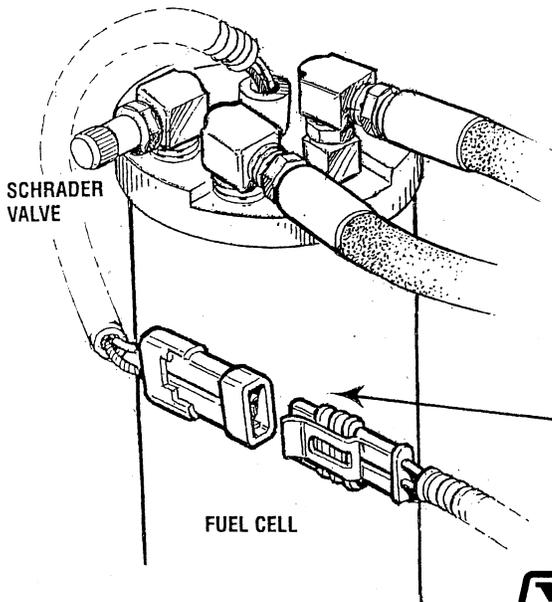
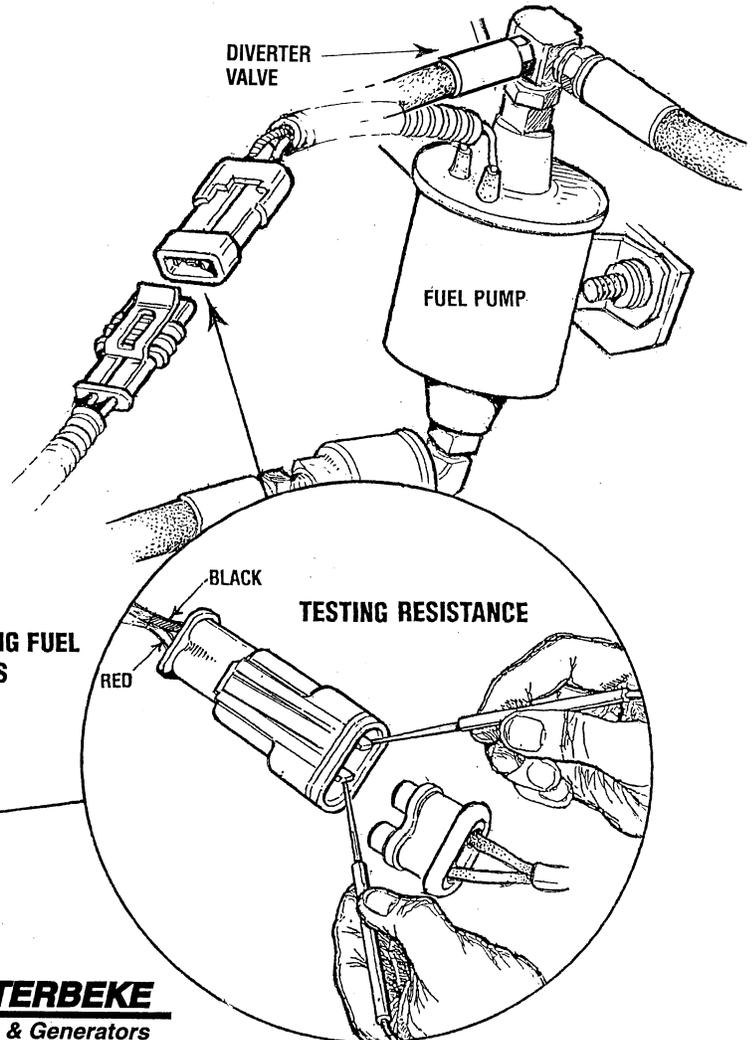
The lower pressure pump should produce 8-10 psi of pressure when operating measured at the Schrader valve on the fuel cell. The high pressure pump should produce 35-40 psi of pressure when operating measured at the Schrader valve on the throttle body.

Fuel Pump Resistance (at rest) 3.5 - 14.5 Ohms

High Pressure 1.5 - 2.0 Ohms

Low Pressure 9.0 - 13.0 Ohms

There should be no continuity between the metal case and either terminal of the plug connector.



COMPONENT TESTING

TESTING OXYGEN SENSORS

Two oxygen sensors are used in the EFI system. A narrow band sensor on the exhaust inlet side of the catalyst and a wide band sensor on the exhaust discharge side of the catalyst. These sensors monitor engine operation that the ECU interprets and adjusts air/fuel ratios accordingly.

TESTING THE OXYGEN SENSORS IN A STATIC MODE

Narrow Band Sensor: Unplug the sensor from the engine harness. Locate the 2 white pin leads, measure across these two pins with an ohm meter.

Resistance Value 2.0 - 4.0 OHM (approximately)

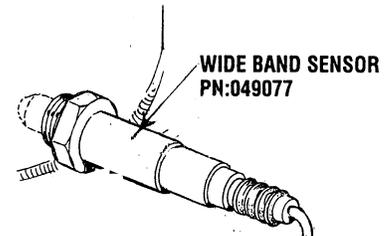
There should be no continuity between either of the two white lead pins and the black or grey lead pins.

Wide Band Sensor: Unplug the sensor from the engine harness. Locate the red pin lead and the vacant black pin lead. Measure across these two pins with an ohm meter.

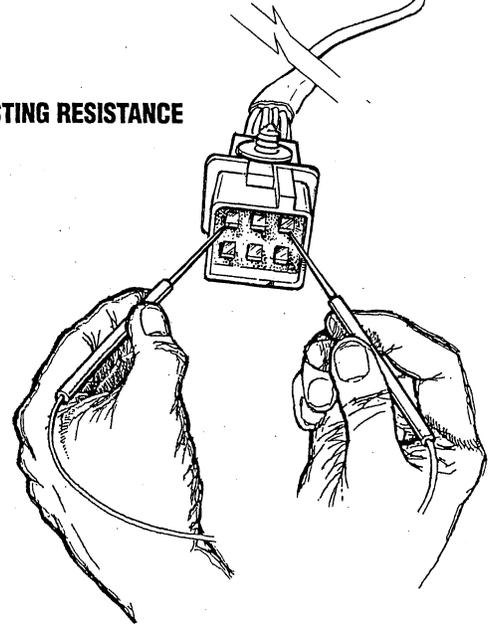
Resistance Value 110.0 - 130.0 OHM (approximately)

No continuity should be found between these two pins and any of the other four.

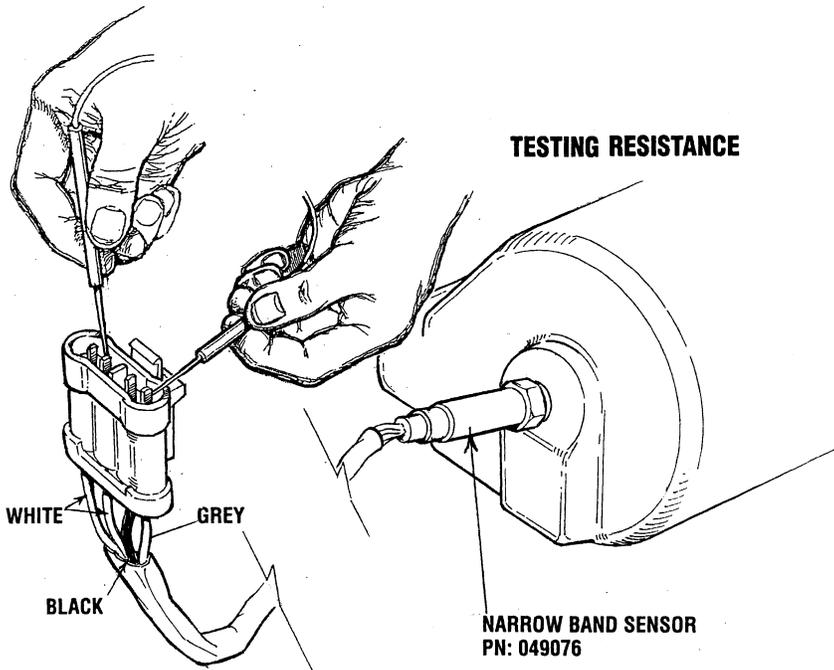
Sensors not meeting these tests are presumed faulty. Care should be taken when installing a replacement sensor. Do not scratch, damage, or handle the sensor end in any way.



TESTING RESISTANCE



TESTING RESISTANCE

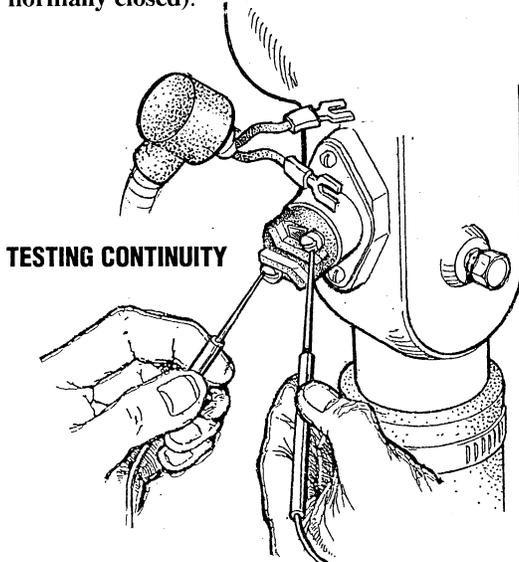


COMPONENT TESTING

TESTING THE EXHAUST TEMPERATURE SWITCH

An exhaust temperature switch is located on the water injected exhaust elbow. Normally closed, this switch will open and the ECU will interpret this as a high exhaust temperature and open the K2 run relay stopping the generator. The exhaust temperature LED on the panel will illuminate. The switch opens at 260 - 270°F (127 - 132°C). This switch resets (contacts close) at approximately 225°F (107°C).

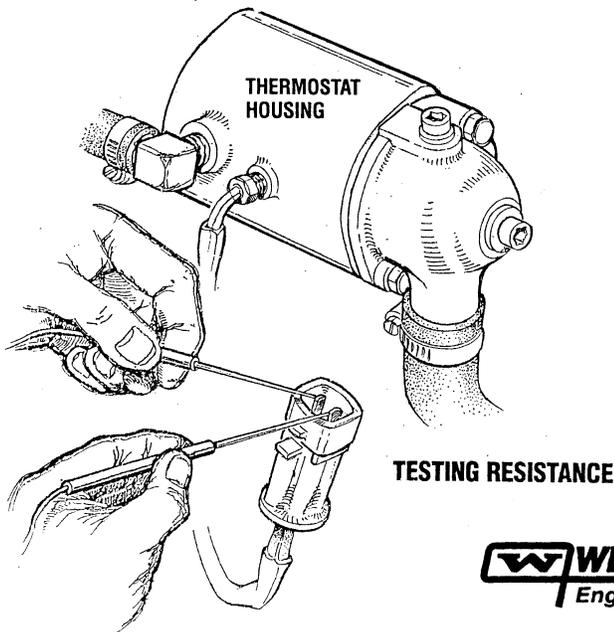
When testing, continuity should be found (switch is normally closed).



COOLANT (WATER) TEMPERATURE SENSOR

A temperature sensor is located at the thermostat housing. This sensor sends a DC voltage to the ECU that it interprets as engine (antifreeze) coolant temperature. Should this voltage reach a set value, the ECU will interpret this as a high temperature and open the K2 run relay, stopping the generator. The overheat LED on the panel will then illuminate.

Test the sensor as shown. Resistance at room temperature should indicate 10,000 Ohms.

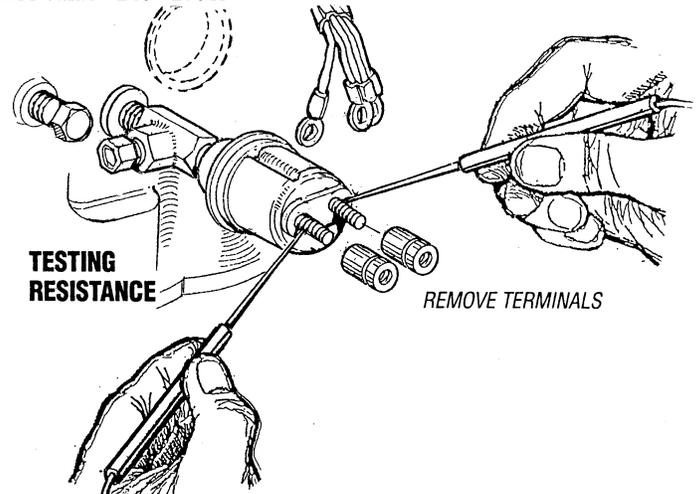


TESTING THE OIL PRESSURE SENSOR

The oil pressure sensor sends a DC voltage to the ECU that the ECU interprets as oil pressure. Should this voltage fall below a certain level, the ECU will shut the generator down and illuminate the oil pressure LED.

Test the sensor by checking resistance (at rest):

Ohm Value - 240 - 270 Ω



ENGINE DC CIRCUIT BREAKER

The generator's engine DC circuit is protected by a rocker type DC 20 amp breaker mounted on the control box (this also serves as an Emergency Stop Switch). Excessive DC current draw or DC electrical overload anywhere in the instrument panel wiring or engine wiring will cause the breaker to trip to the OFF position. In this event, the DC power to the ECU will be interrupted, stopping the generator. No panel LED will illuminate. Check and repair the source of the problem. After repairing the fault, reset the breaker and restart the generator.

HIGH/LOW RPM SHUTDOWN

The ECU monitors engine speed by the AC voltage produced by the MPU. Should this voltage reach a preset value, the ECU will interpret this as an engine overspeed (2175 rpm approximately) and open the K2 relay, stopping the generator. The panel Overspeed LED will illuminate. Should the MPU produce a low AC voltage that the ECU interprets as an underspeed condition, the ECU will open the K2 relay and stop the generator. The Overspeed LED will then blink.

COMPONENT TESTING

AIR, COOLANT, AND WATER HEATER TEMPERATURE SENSORS

These three sensors contain as their sensing elements identical negative temperature coefficient (NTC) thermistors whose internal resistance inversely changes to a change in temperature (i.e., temperature increase, resistance decrease). The thermistors nominal resistance value at 77° F (25° C) is 10,000 ohms. When the ECU is in an on state, the thermistors (-) lead is connected to ground, and its (+) lead is connected to the ECU and then through a fixed series 10,000 ohm resistor to the +5V power source. Therefore, the voltage at the thermistors (+) lead should be approximately +2.5 volts at a temperature of 77° F and decreases to a voltage of approximately +.25V at 220° F. The voltage - temperature relationship however, is not linear over this range and therefore it should only serve as an indicator that the thermistor is functioning.

Resistance Values (at room temperature)

Air Temperature Sensor - 10,000Ω

Coolant Temperature Sensor - 10,000Ω

Generally, the thermistor may be assumed to be good if there is a perceptual resistance change for a corresponding temperature over the indicated range, otherwise replace the sensor.

INTAKE HEATER ELEMENT

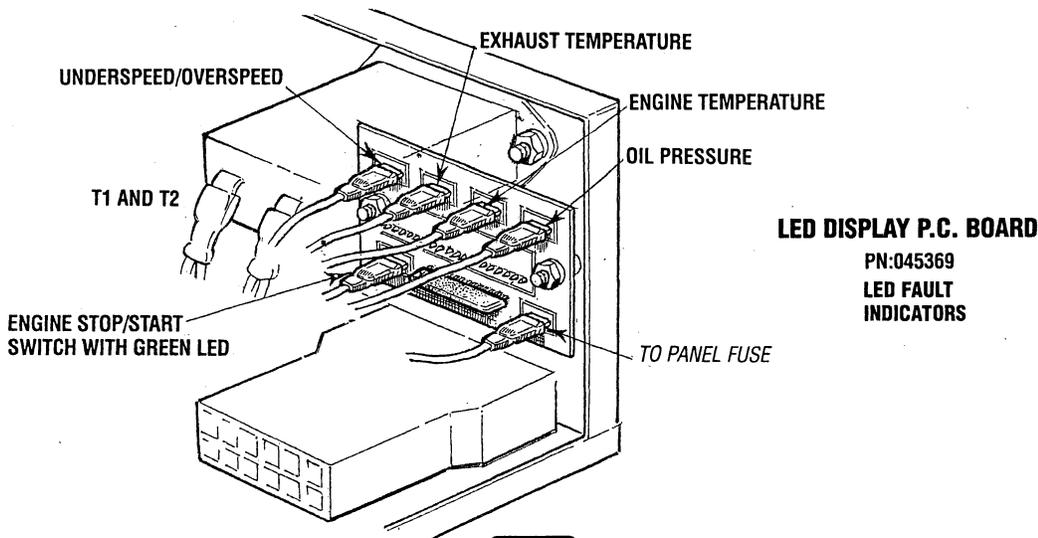
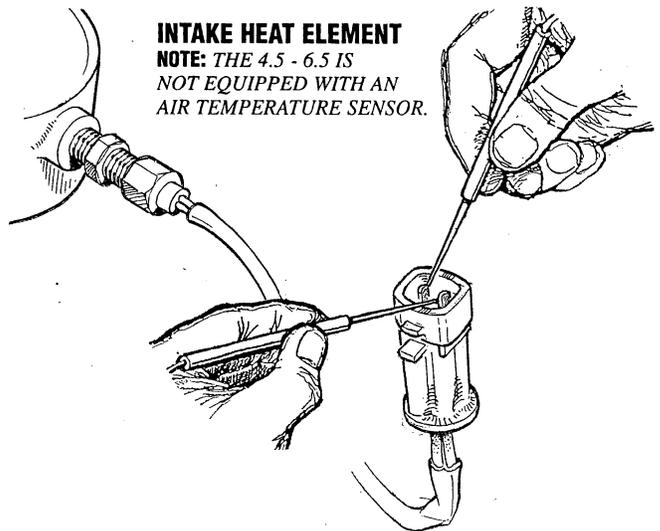
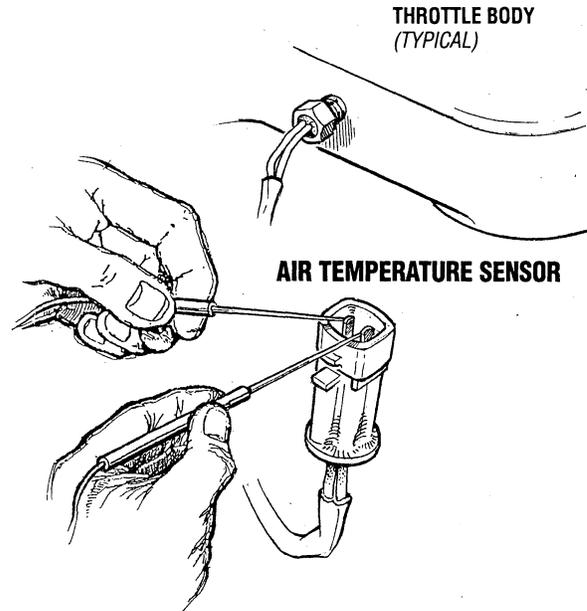
An intake heater is located in the air inlet area of the throttle body on all four cylinder models. the heater operates to warm incoming air on a cold engine start and in adverse cold operating conditions.

Testing (static) the Heater Element

Unplug the heater from the engine harness. Put the ohmmeter probes across the two heater plug pin contacts.

Resistance Value 1.5 - 2.5 OHM (approximately)

There should be no continuity between either of the two pin contacts and the metal case of the element.



COMPONENT TESTING

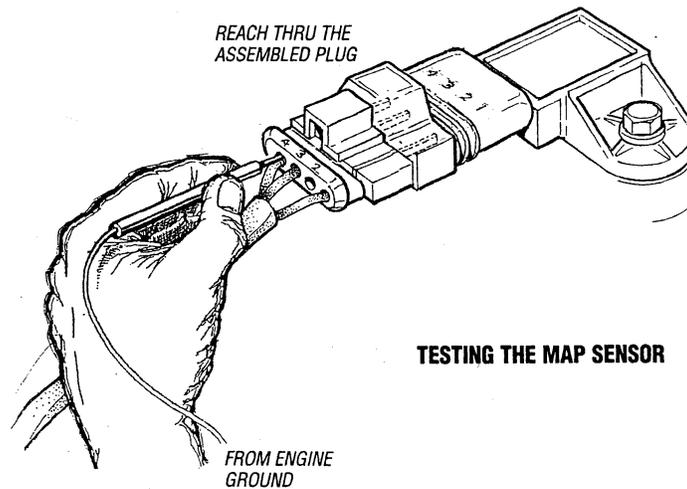
MAP SENSOR

The Manifold Absolute Pressure (MAP) sensor is a solid state pressure transducer which measures the intake manifold pressure (vacuum). It derives its operating power (+5V, Pin 4; Gnd, Pin 1) from the ECU and receives power only when the ECU is in an *on* state. Its output (Pin 3) is measured to ground.

Typical output voltages are as follows:

		EFI Generators 8,10,12.5 14Kw
Map Sensor -- Voltages		
Pin 4 (sig) to Grnd (at rest)	_____	0 VDC
Pin 4 (sig) to Grnd (prime delay in start mode)	_____	4.05 VDC
Pin 4 (sig) to Grnd (running 1800 rpm no AC load)	_____	1.25 VDC (typical)
Pin 3 (+5V) to Grnd (at rest)	_____	0 VDC
Pin 3 (+5V) to Grnd (prime delay in start mode)	_____	4.997 VDC
Pin 3 (+5V) to Grnd (running 1800 rpm no AC load)	_____	5.003 VDC (typical)

		EFI Generators All Models
Map Sensor -- Resistances		
Pin 1 (grnd) to Pin 2	_____	1.9Ω
Pin 1 (grnd) to Pin 3	_____	5.9Ω
Pin 1 (grnd) to Pin 4	_____	5.3Ω



WESTERBEKE 8.0/6.4KW TO 14/11.6KW SBEG ENGINE SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	Gasoline, four-cycle, four-cylinder, fresh water-cooled, Vertical, in-line overhead mechanism		
Governor	Electronic Control Unit		
Combustion Chamber	Semi-spherical type		
Bore & Stroke	2.97 x 3.23 inches (75.5 x 82.0 mm).		
Piston Displacement	89.6 cubic inches (1468 cubic centimeters)		
Firing Order	1 - 3 - 4 - 2		
Direction of Rotation	Clockwise, when viewed from the front		
Compression Ratio	9.0:1		
Inclination	Continuous 20° Temporary 30° (not to exceed 15 minutes)		
Fuel Consumption	8.0Kw	1.0 gph	6.4Kw (3.0 lph) 10.0Kw 1.1gph 8.0Kw (3.5 lph) 12.5Kw 1.3 gph 10.0Kw (4.0 lph) 14.0Kw 1.4 gph 11.6Kw (4.5 lph)
Weight	8.0/6.4Kw	438 lbs (199 kgs)	
	8.0/10.0Kw	463 lbs (210 kgs)	
	10.0/12.5Kw	495 lbs (225 kgs)	
	11.6/14.0Kw	522 lbs (237 kgs)	

TUNE-UP SPECIFICATIONS

Compression Pressure (Limit of difference between cylinders)	165 psi at 300 rpm 14 psi (0.98 Kg/cm ²)
Valve Seat Angle	Intake 45° Exhaust 45°
Valve Clearance (engine hot)	Intake 0.08 inches (0.20 mm) Exhaust 0.09 inches (0.25 mm)
Engine Timing (1800 RPM)	15° BTDC (no vacuum advance connected)
Horsepower OutPut All models 60Hz (50Hz)	24 hp (19 hp)

EXHAUST EMISSIONS SYSTEMS

Emission Control Systems	EMC, OAS, TWC
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LUBRICATION SYSTEM

General	Forced lubrication by geared pump
Oil Filter	Full flow, spin-on replaceable type
Sump Capacity (not including filter)	3.5 U.S. qts (3.3 liters) plus filter/cooler assembly
Operating Oil Pressure (engine hot)	20-60 psi
Oil Grade	API Specification of SJ, SL, SM or SN

ELECTRICAL SYSTEM

Starter Battery	12-Volt, reduction gear/solenoid
Starter	12-Volt, (-) negative ground
DC Cold Cranking Amps	150-175 (cold engine)
DC Charging	12- VDC belt driven alternator.
Battery Capacity	800-1000 Amps

IGNITION SYSTEM

General	Battery ignition 12V negative ground. Distributor with ignition module and igniter. Ignition coil and spark plug.
Distributor	Equipped with auto timing controller, ignition coil built-in breakerless type
Spark Plug Thread Size	14mm X 1.25 pitch
Throttle Body	Electronic fuel injection with Electronic Governor.
Spark Plug Gap	.030 inches (0.8mm)
Ignition Timing	15° BTDC ± 1

FUEL SYSTEM

General	Throttle body fuel injection
Fuel	Unleaded gasoline with an octane rating of 89 or higher.
Fuel Filter (on engine)	Replaceable cartridge-screw on
Air Cleaner (flame arrester)	Metal screen type - cleanable
Air Flow (engine combustion)	1800 rpm 48 cfm (1.3 cmm) 1500 rpm 39 cfm (1.1 cmm)
Fuel Hose Size	1/4" I.D. minimum - 3/8" I.D. maximum

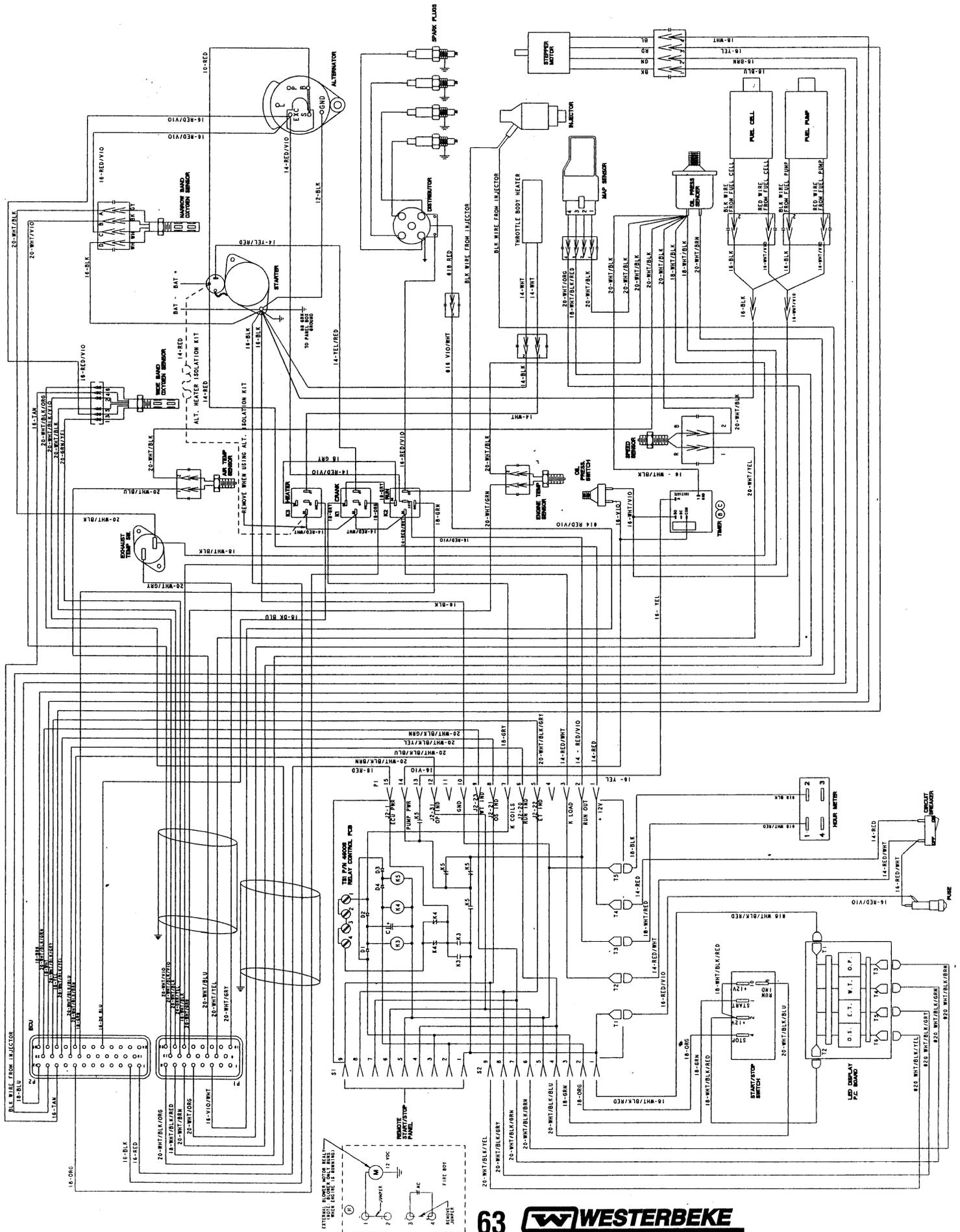
COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, belt driven
Raw Water Flow, at 1800 rpm	5.5 gpm (5.2 lpm) approx.
System Capacity (coolant)	6.0 qts (5.7 liters)

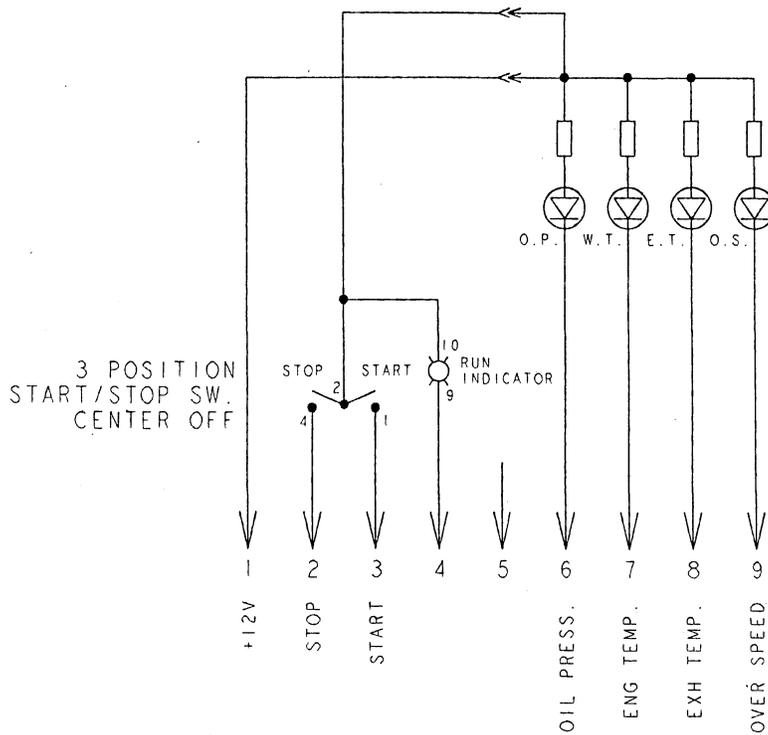
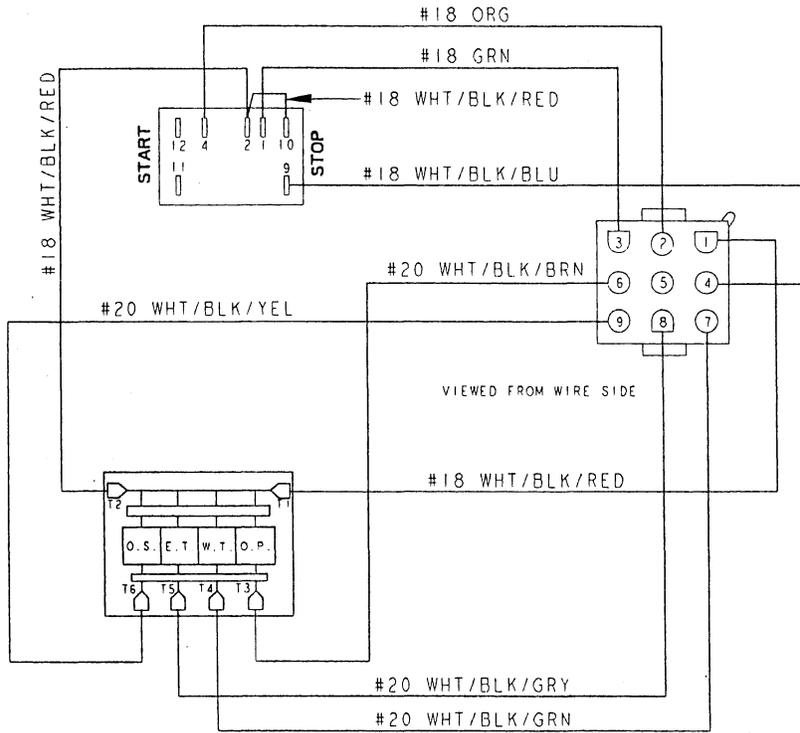
AC GENERATOR (SINGLE PHASE)

General-Single Phase	Brushless four pole, revolving field. Sealed lubricated single bearing design. Reconnectable single phase with solid state voltage regulator	
Voltage - Single Phase	120 Or 120/240 volts - 60 hertz 230 volts - 50 hertz	
Voltage Regulation	± 2% no load to full load.	
Frequency Regulation	± 1% no load to full load.	
Rating (Volts AC)		
8.0 /6.4Kw	120/240 volts - 66/33	230 volts -27 amps
10.0/8.0Kw	120/240 volts - 83/41	230 volts -34 amps
12.5/10.0Kw	120/240 volts - 104/52	230 volts -43 amps
14.0/11.6Kw	120/240 volts -116/58	230 volts -50 amps
<i>Note: Forced ventilation MUST be provided to maintain generator compartment temperatures below 122° F (50° C)</i>		
Generator Cooling	200 - 300 cfm (5.6 - 8.4 cmm)	
Air Requirements	(60 Hertz at 1800 rpm)	
<i>Note: Increase air supply 15% for 50 hertz operation (1500 rpm)</i>		
Engine Compartment Cooling Requirements	100 - 200 cfm (2.83 - 5.66 cmm)	

WIRING DIAGRAM 8,10,12.5 AND 14KW SBEG #53549



REMOTE STOP/START PANEL WIRING DIAGRAM DISPLAY BOARD SCHEMATIC



BE GENERATOR

DESCRIPTION

This is a four pole brushless generator. The exciter provides residual magnetism which guarantees the self excitation of the generator on start-up. (The residual voltage is about 10% of nominal AC voltage). The Automatic Voltage Regulator (AVR) converts this AC voltage to DC voltage and supplies this DC voltage to the exciter windings. This DC voltage indirectly controls the main rotating field by means of the sequence exciter rotor-diode bridges-main rotating field. The AVR has a plus or minus voltage precision of 1% in the generators working range with distortion free loads. The AVR controls and keeps the voltage constant on one phase. The AVR monitors generator frequency, if the frequency should drop below a factory set point, excitation from the AVR can be modulated to remove any voltage output instability that may arise.

Generator: The generator design is based on a multilaminated magnetic circuit with salient poles on the rotor. The rotor is of a special compact construction with an integral damper cage and a field winding section conductor wound directly on the rotor. A special interpole fixation combined to the mechanical compactness of the winding ensures a highly efficient generator.

Exciter: The exciter is a six-pole synchronous generator with salient poles on the stator and a cylindrical armature on the rotor. The exciter rotor and the rotating rectifier are mounted on the shaft with the main generator rotor.

Excitation System: The system is excited automatically by means of residual magnetism of the magnetic circuits of the generator and exciter and stabilized by the permanent magnet in one of the exciter poles.

Winding Connections: The single-phase synchronous generator has 4 stator leads and can be configured to 120 or 240 volt output.

Bearings: The bearings are sealed type and permanently greased requiring no maintenance during their working life (approx. 30,000 hours).

CIRCUIT BREAKER

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

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.
- In addition to periodic cleaning, the generator should be inspected for tightness of all connections, evidence of overheated terminals and loose or damaged wires.
- The drive discs on single bearing generators should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.
- The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.
- Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. If side motion is detectable, bearings are wearing or wear on shaft of bearing socket outside bearing has occurred. Repair must be made quickly or major components will rub and cause major damage to generator.

Carbon Monoxide Detector

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

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

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

AC VOLTAGE REGULATOR (CURRENT MODELS)

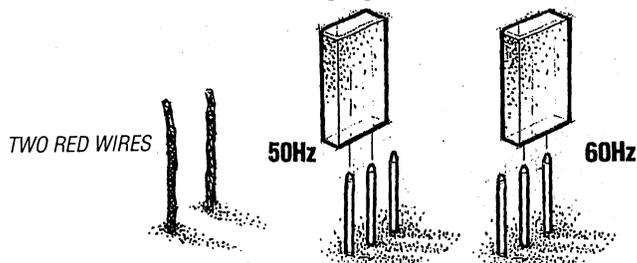
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VOLTAGE POTENTIOMETER

The output voltage of the generator can be adjusted using the potentiometer with the generator running at its selected speed (frequency) by turning the adjustment until the desired voltage is obtained. **NOTE:** If the voltage is set higher than selected rated voltage, the generator may be damaged.

FREQUENCY

A jumper is found on earlier regulators that is connected to two of the three pins as illustrated below for either 50 or 60 hertz. On newer regulators, there are two red wires. These are left separate for 60 hertz and electrically joined for 50 hertz. The ECU must then be programmed for the hertz change.

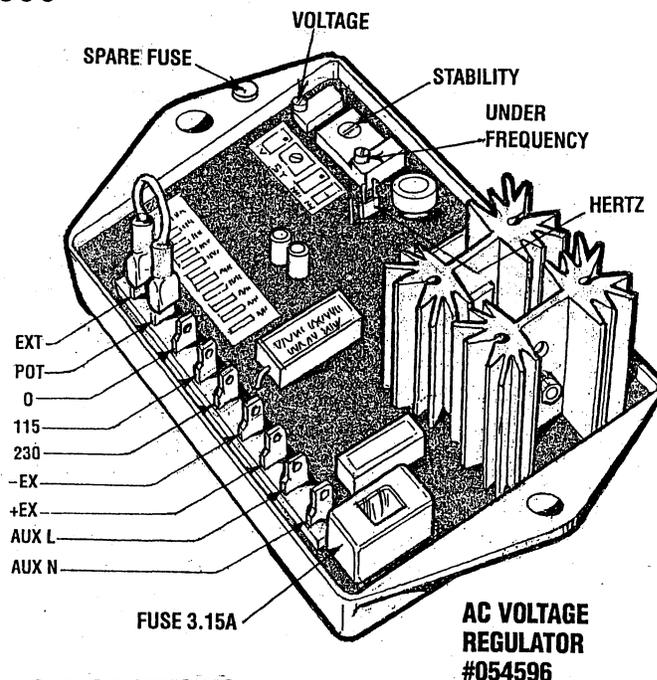


STABILITY

If at no-load or while under load with steady engine speed, AC output voltage fluctuation is experienced. Adjust the **stability** potentiometer. This modulates the reaction time of the regulator to external inputs, thereby eliminating any instability in the AC generator load system.

UNDER FREQUENCY

With the generator running at rated speed and producing desired voltage, reduce the engine speed using the mechanical governor by 4 hertz. Adjust the under frequency potentiometer until the AC output voltage of the generator starts to drop. Then restore the engine speed to the original rated speed.



VOLTAGE SENSING

The voltage sensing connections are *0* and *115* when selected output voltage is between *100V* and *140V*. Connect between *0* and *230* when selected output voltage is between *200V* and *280V*. Newer regulator models may have a 400 volt connection. This is not used with any of the generator models in this manual.

EXCITER WINDING

Proper polarity in this circuit **must** be maintained. **Black** to **- Ex** and **red** to **+ Ex**. Failure to do so may damage the regulator.

AUXILIARY WINDING

Connect the correct color wires to the terminals. Green or gray to **Aux L** and blue and brown to **Aux N**.

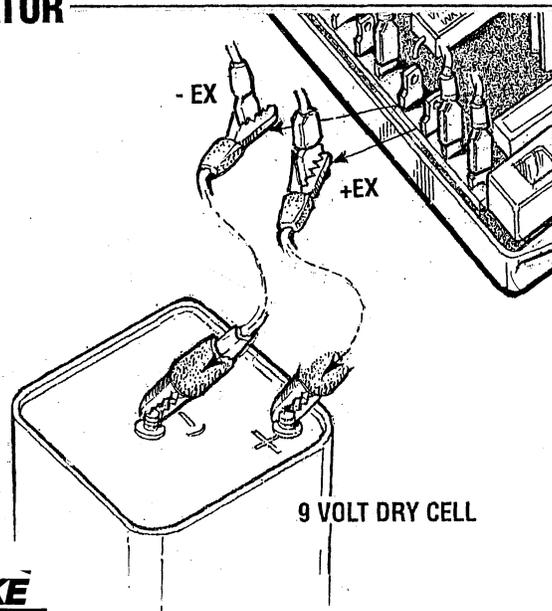
EXCITING THE GENERATOR

Exciting the generator using an external DC source can be performed when troubleshooting a generator/AC voltage output issue.

The following procedure should be followed:

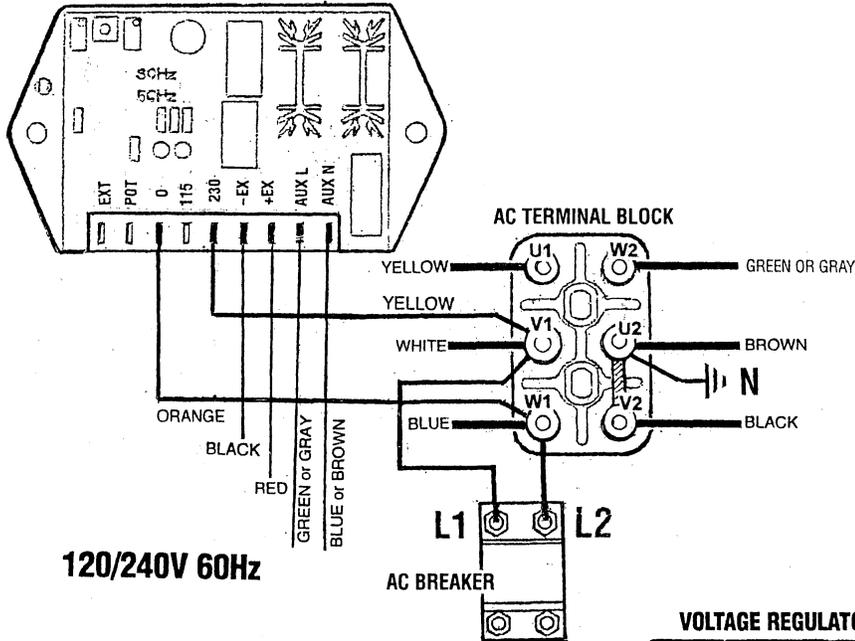
1. The generator should not be operating. Remove the **-Ex** and **+Ex** electrical connections off the regulator.
2. Maintaining polarity. Connect the + (plus) from a 9 volt dry cell battery to the **+Ex** (red) electrical lead coming from the generator and the - (negative) to the **-Ex** (black) electrical lead coming from the generator.
3. Start the generator and observe the reaction and voltage output from the generator and react accordingly.

The troubleshooting booklet for the BE style generator will help you determine the cause of a generator AC voltage output issue by the AC voltage found being produced by the generator and the reaction of the generation to excitation.

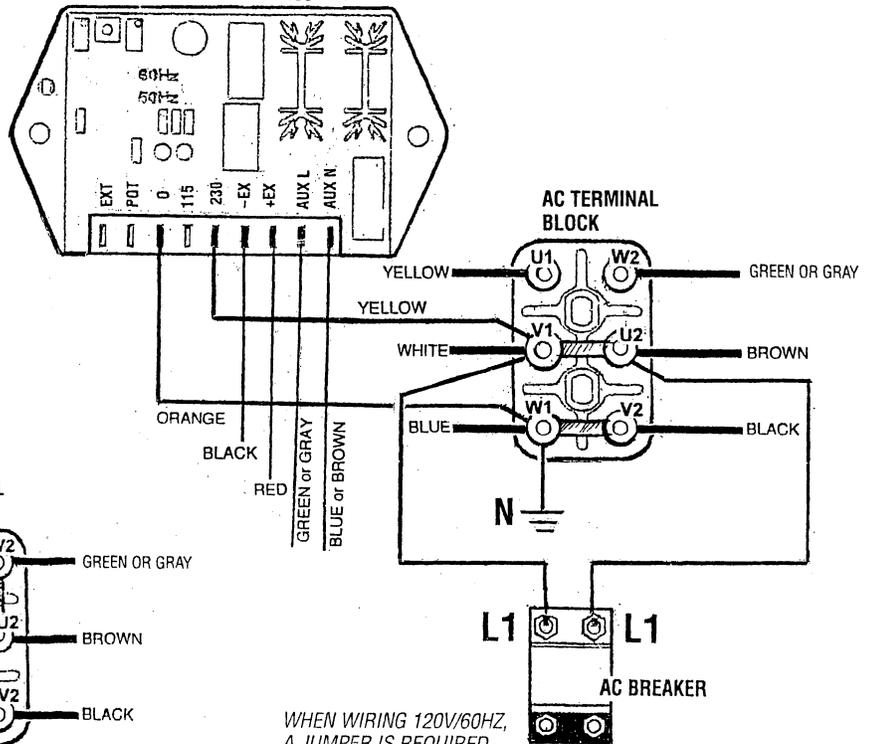


AC VOLTAGE REGULATOR (CURRENT MODELS) #054596

VOLTAGE REGULATOR #054596

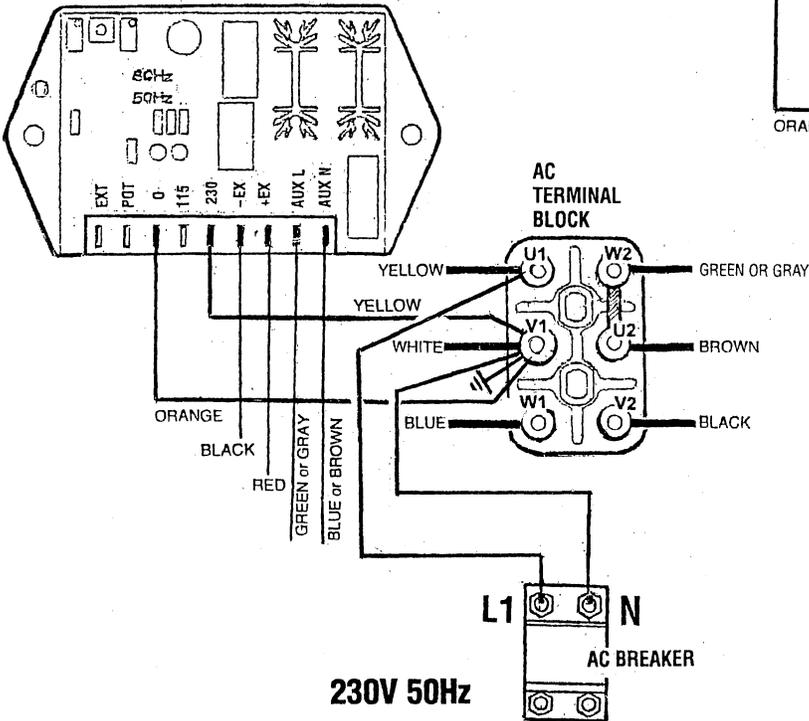


VOLTAGE REGULATOR #054596

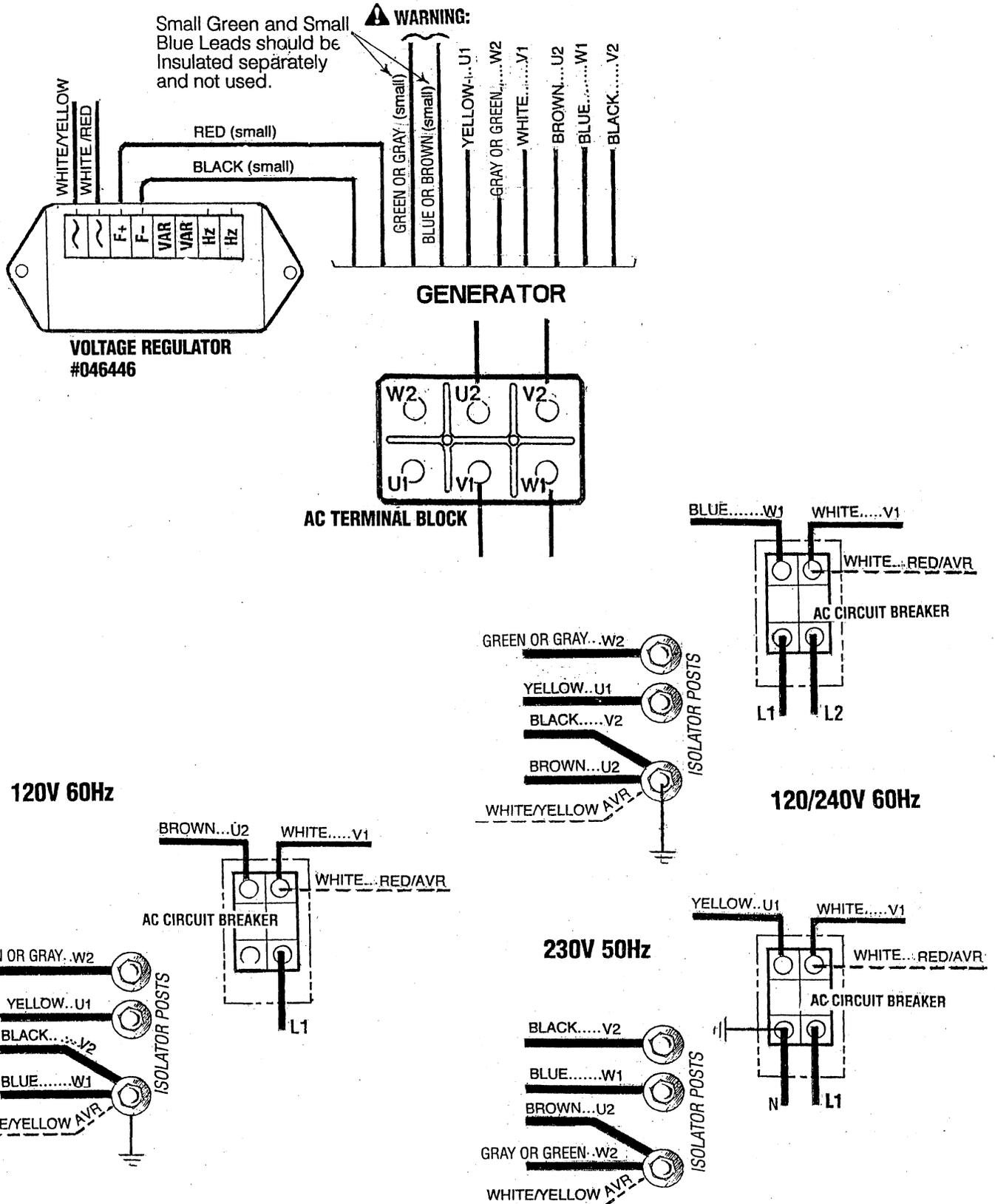


WHEN WIRING 120V/60HZ,
A JUMPER IS REQUIRED
BETWEEN LOAD CONNECTIONS

VOLTAGE REGULATOR #054596



BE GENERATOR (EARLIER MODELS) WITH VOLTAGE REGULATOR #046446



BE GENERATOR (EARLIER MODELS) WITH VOLTAGE REGULATOR #046446

EXCITATION OF THE GENERATOR TO DETERMINE FAULT

1. Disconnect the F+ lead from the voltage regulator.
2. Disconnect the F- lead from the voltage regulator.

NOTE: Be sure to maintain DC polarity.

3. Connect the 12 DC+ to the F+ lead
4. Connect the 12 DC- to the F- lead.
5. Leave the 12VDC connected for 5 minutes.
Disconnect and reconnect F+ and F- leads to the regulator.
6. Start the generator and observe the voltage build-up.
If the voltage build-up does not occur, repeat steps 1 thru 5.

NOTE: Steps 1 thru 4 are performed when flashing the exciter field (stator) to determine the cause of a fault in the generator.

Step 5: Start the generator and observe/note the reaction of the generator while applying 12VDC to the exciter stator. Record the AC voltage output/generator.

Step 6: Stop the generator. and remove the 12VDC lead from F+ and F- and reconnect it to the regulator board.

If a short exists the excitation will produce a load on the drive engine. A growling noise will be produced by the AC generator. The short will produce heat affecting the windings adjacent to it and smoke may be produced.

If a short is not found but rather an open is indicated, the two main stator windings will have to be electrically isolated and the windings checked with an ohm meter. Test between V12 and U1 for an open circuit or check for an open between V22 and U2.

VOLTAGE REGULATOR

Normal DC voltage to exciter stator winding generator at no load.

F+ F- → 8 - 9 VDC

Normal AC input voltage to regulator. 120 VAC - 60Hz
~ → ~ 230 VAC - 50Hz

RESTORING RESIDUAL MAGNETISM TO THE GENERATOR

The initial excitation of the generator is assured by the permanent magnet built in one of the exciter stator poles. Trouble with the initial excitation can occur after prolonged storage or after a service repair that dismantles the exciter. In some rare instances, it may be the result of rough transport or handling. To restore the residual magnetism necessary to begin the voltage build-up, excite the generator with 40 - 60VDC by following the procedure below:

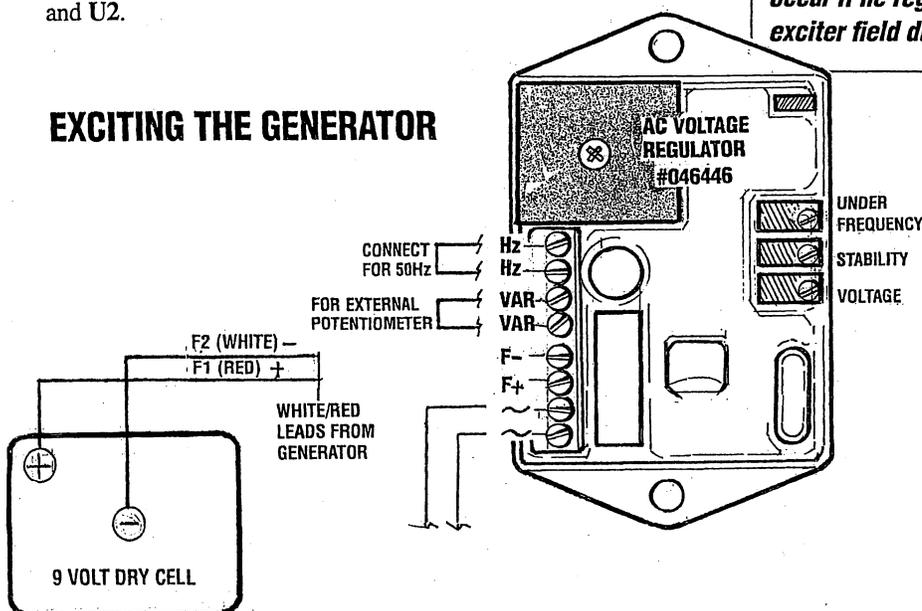
1. Disconnect the F+ lead from the voltage regulator.
2. Disconnect the F- lead from the voltage regulator.

NOTE: Be sure to maintain DC polarity.

3. Connect the 40 - 60VDC+ to the F+ lead
4. Connect the 40 - 60VDC- to the F- lead.
5. Leave connected for 2 -3 seconds.
Disconnect and reconnect F+ and F- leads to the regulator.
6. Start the generator and observe the voltage build-up.
If the voltage build-up does not occur, repeat steps 1 thru 5.

CAUTION: Damage to the voltage regulator will occur if the regulator is not disconnected from the exciter field during flashing.

EXCITING THE GENERATOR



BE GENERATOR (EARLIER MODELS) WITH VOLTAGE REGULATOR #046446

VOLTAGE POTENTIOMETER

The output voltage of the generator can be adjusted using the potentiometer with the generator running at its selected speed (frequency) by turning the adjustment until the desired voltage is obtained. **NOTE:** *If the voltage is set higher than selected rated voltage, the generator may be damaged.*

FREQUENCY

A jumper on the regulator is connected to two of the three pins for either 60 hertz or 50 hertz operation. **NOTE:** *This does not automatically change the engine speed. Engine speed change is performed using the adjustment on the belt driven mechanical governor.*

STABILITY

If at no-load or while under load with steady engine speed, AC output voltage fluctuation is experienced. Adjust the stability potentiometer. This modulates the reaction time of the regulator to external inputs, thereby eliminating any instability in the AC generator load system.

UNDER FREQUENCY

With the generator running at rated speed and producing desired voltage, reduce the engine speed using the mechanical governor by 4 hertz. Adjust the under frequency potentiometer until the AC output voltage of the generator starts to drop. Then restore the engine speed to the original rated speed.

VOLTAGE SENSING

The voltage sensing connections are 0 and 115 when selected output voltage is between 100V and 140V. Connect between 0 and 230 when selected output voltage is between 200V and 280V.

EXCITER WINDING

Proper polarity in this circuit **must** be maintained. White to F- and red to F+. Failure to do so may damage the regulator.

AUXILIARY WINDING

Connect the correct color wires to the terminals. Green or gray to Aux L and blue and brown to Aux N.

AC VOLTAGE CONNECTIONS

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

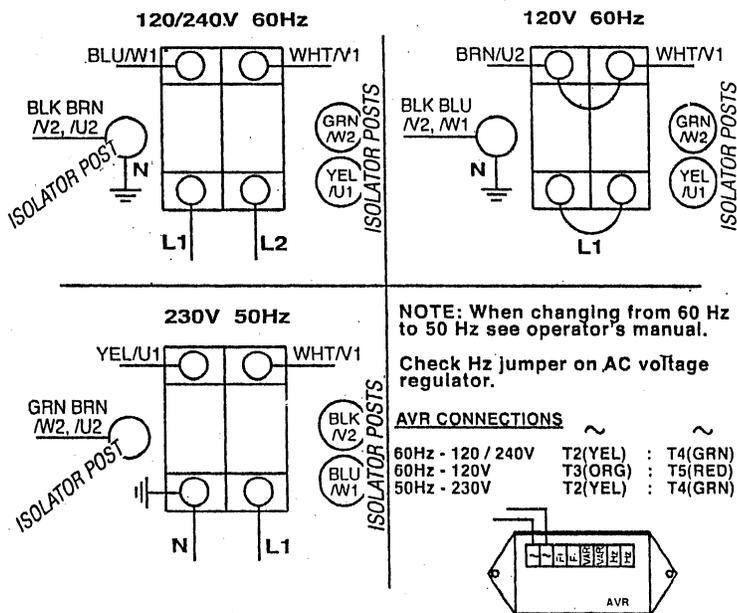
Generator Frequency

1. Frequency is a direct result of engine/generator speed:
1800 rpm = 60 hertz; 1500 rpm = 50 hertz.
2. To change generator frequency, follow the steps below:
Configure the AC terminal block for the desired voltage frequency as shown. Ensure that the case ground wire is connected to the correct terminal block neutral ground stud.
3. Remove or install the jumper on the automatic regulator (depending on frequency). Refer to *BE GENERATOR*.

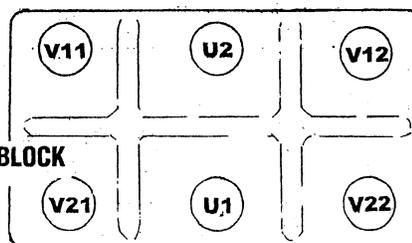
NOTE: *The green ground wire may be removed in those installations where the AC circuit has a separate neutral and ground circuit. This will prevent the unit from being a ground source in the vessel.*

4. Open the AC circuit breaker.
5. Start the generator and adjust the engine speed to the correct no-load hertz, then adjust the voltage rheostat on the regulator to the corresponding AC output.

AC TERMINAL BLOCK CONNECTIONS



VOLTAGE REGULATOR #046446 EARLIER MODELS



AC TERMINAL BLOCK

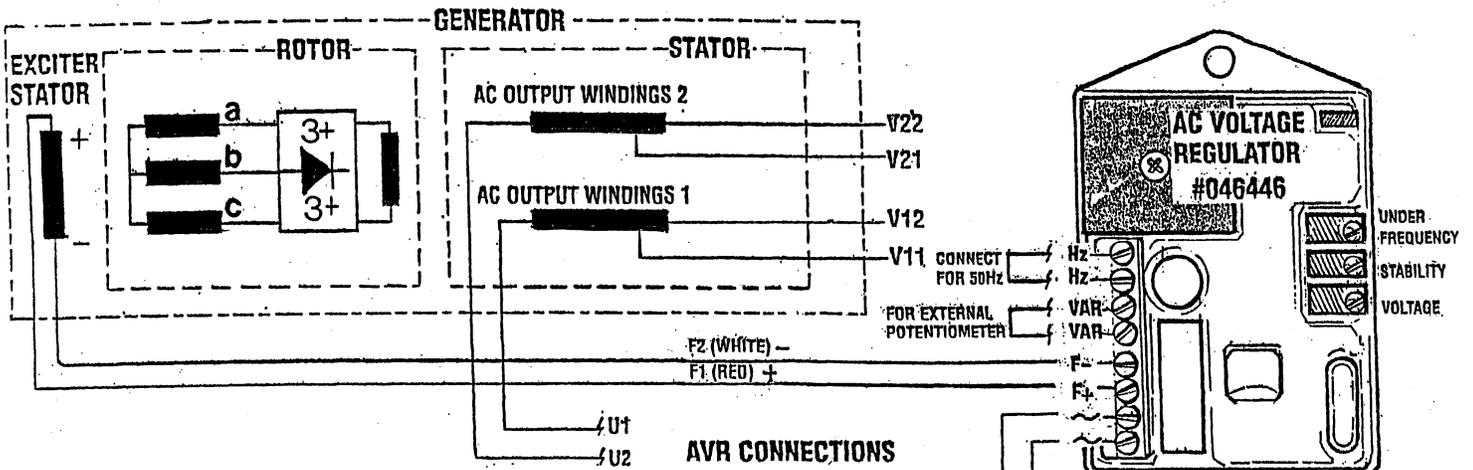
BE GENERATOR (EARLIER MODELS) WITH VOLTAGE REGULATOR #046446

Voltage Adjustments

The potentiometer is used to adjust output voltage. At proper engine operating speed the output voltage should be held at $\pm 2\%$ from a no-load condition to a full rated generator output and from power factor 1.0 with engine drive speed variations up to .5Hz (1%).

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

Once the generator has been placed into operation and as break-in is/has taken place. A no-load AC voltage adjustment maybe needed along with a "GAIN" adjustment. See voltage adjustment and ECU adjustments in this manual.



INTERNAL WIRING SCHEMATIC

AVR CONNECTIONS

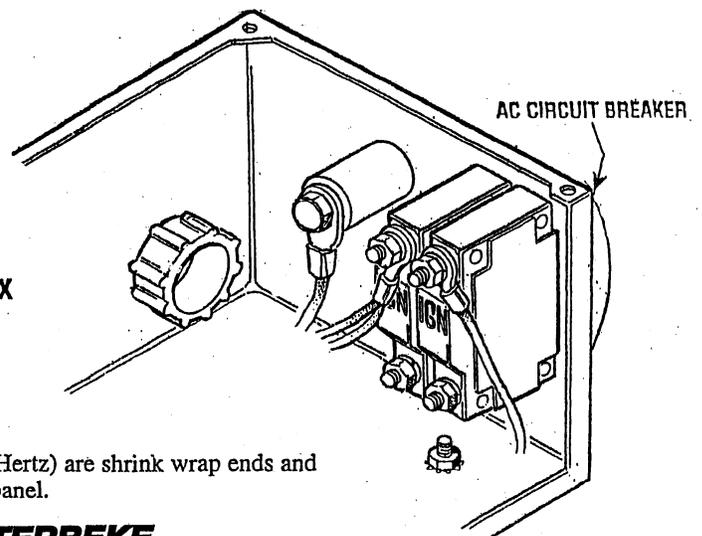
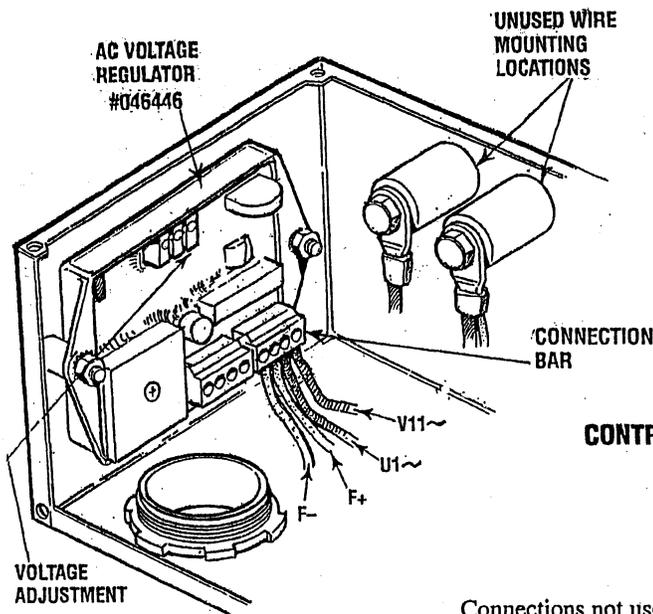
60 HZ - 120 VOLTS U1 ; V11
60HZ - 120/240 VOLTS U1 ; V11
50HZ - 230 VOLTS U1 ; V12

AVR CONNECTIONS

60 HZ - 120 VOLTS T3 ; T5
60HZ - 120/240 VOLTS T2 ; T4
50HZ - 230 VOLTS T2 ; T4

WIRE COLOR CODE

T2 - YELLOW
T3 - ORANGE
T4 - LIGHT GREEN
T5 - LIGHT RED



Connections not used (50 Hertz) are shrink wrap ends and are tied off in the control panel.

BE GENERATOR ALL MODELS

TROUBLESHOOTING

In some cases, it is difficult to find out on the basis of the existing indications on which part of the generator the fault has occurred. For this reason, it is recommended to follow the step by step procedure below:

1. Inspect visually the condition of all connections, terminal boards, terminals and the excitation system components.
2. Inspect visually for indications of damage to the windings on the generator.
3. Check the operation of the voltage regulator. Check if the voltage regulator is connected correctly and properly adjusted.

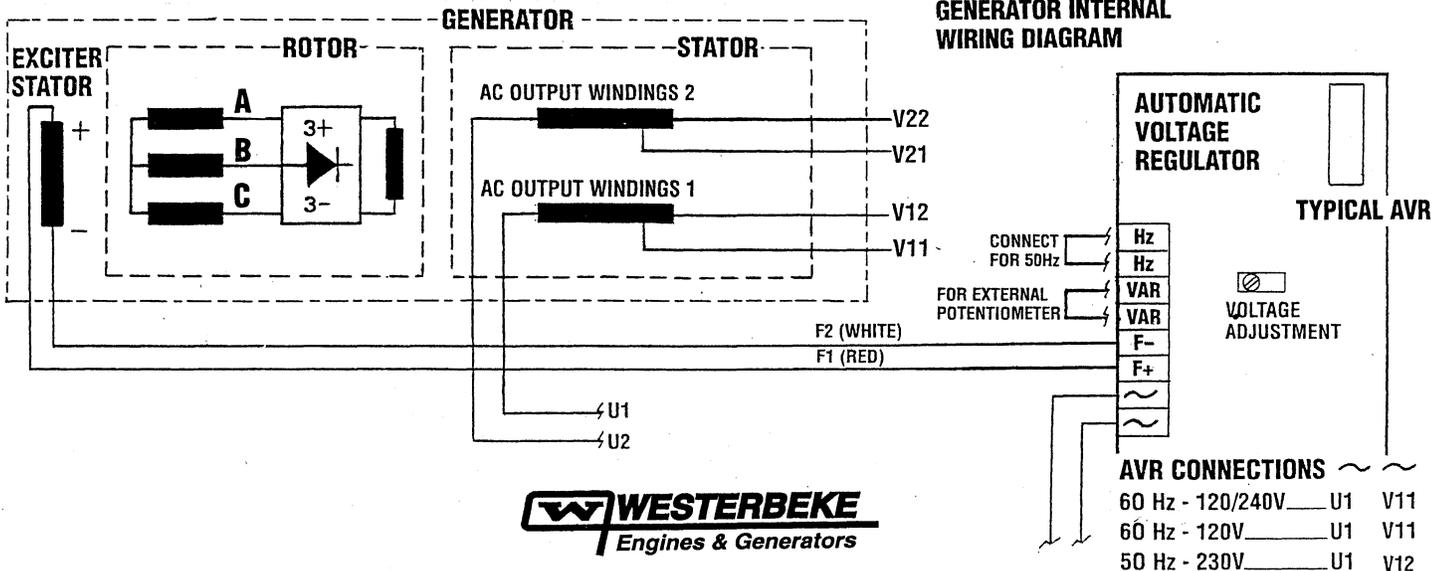
4. In case of a faulty regulator operation, the trouble may lie also in the generator. This can be easily verified by checking the generator operation with separate excitation. For this check it is necessary to follow the *EXCITATION MAGNETIZATION PROCEDURE* outlined in this manual.
5. A burning smell or signs of smoke would indicate a short in the windings or a mechanical failure.

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

FAULT	PROBABLE CAUSE
NO AC VOLTAGE OUTPUT AT NO LOAD	<ol style="list-style-type: none"> 1. Short or open in the main stator winding. 2. Four or more shorted or open diodes on exciter rotor. 3. Open in exciter stator winding. 4. Open in rotating field winding. 5. Shorted suppressor.
RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.	<ol style="list-style-type: none"> 1. Faulty voltage regulator. 2. Short or open in the AC wiring to the voltage regulator.
LOW AC VOLTAGE OUTPUT AT NO LOAD 60 - 100 VAC.	<ol style="list-style-type: none"> 1. Reset voltage potentiometer. 2. Shorted diodes in exciter rotor 1 to 3 diodes. 3. Shorted exciter rotor winding. 4. Faulty voltage regulator. 5. Short in exciter stator windings. 6. Short in rotating field winding.
HIGH AC OUTPUT VOLTAGE 150 VAC OR HIGHER.	<ol style="list-style-type: none"> 1. Reset voltage potentiometer. 2. Faulty voltage regulator.
UNSTABLE VOLTAGE OUTPUT. (ENGINE SPEED STEADY)	<ol style="list-style-type: none"> 1. The potentiometer on the voltage regulator needs adjusting. 2. Faulty voltage regulator.
AC VOLTAGE DROP UNDER LOAD 60 - 100 VOLTS AC.	<ol style="list-style-type: none"> 1. Diode(s) on exciter rotor breaking down when load is applied (inductive) 1-3 diodes.
VERY LOW AC OUTPUT VOLTAGE 4 - 10 VAC	<ol style="list-style-type: none"> 1. Loss of residual magnetism.

RESISTANCE VALUES (IN OHMS)

	GENERATORS			
	8.0Kw	10.0Kw	12.5Kw	14.0Kw
Exciter Stator	23.5	25.1	25.5	26.6
Main Stator				
V22 to U2	0.3	0.3	0.4	0.4
V12 to U1	0.3	0.3	0.4	0.4
Exciter Rotor				
A to B	1.2	0.6	0.6	0.4
B to C	1.2	0.6	0.6	0.4
C to A	1.2	0.6	0.6	0.4
Rotor Field	2.2	2.4	2.8	3.0
Suppressor	NO RESISTANCE			



BE TROUBLESHOOTING

TO ACCESS THE ROTOR ASSEMBLY FOR TROUBLESHOOTING

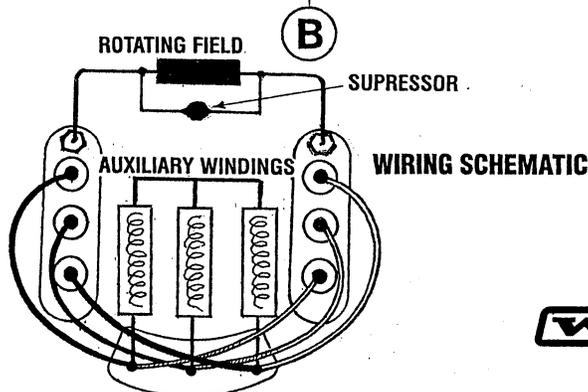
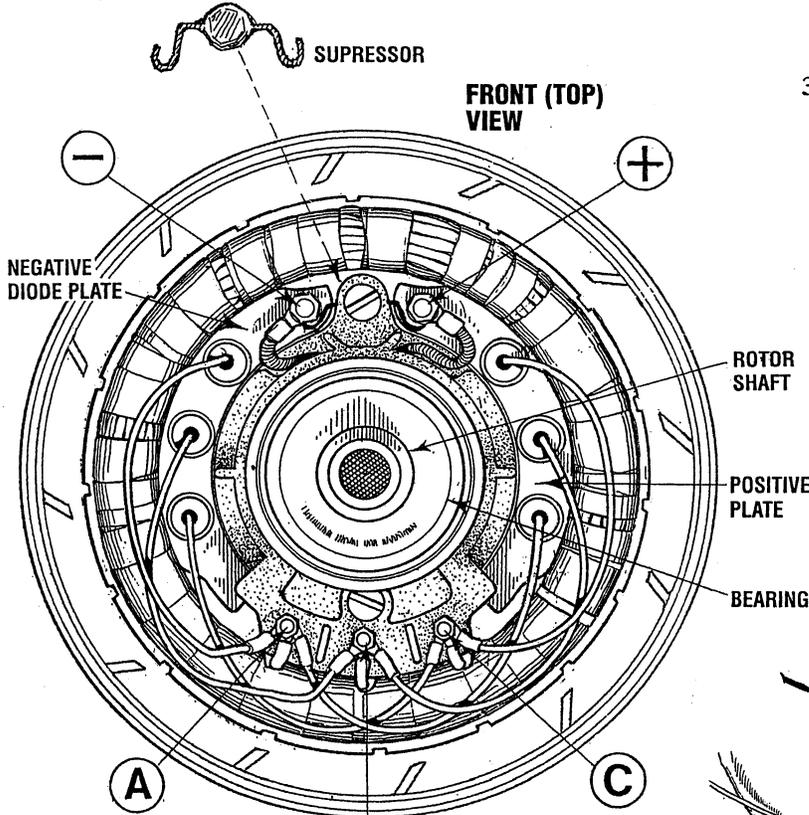
1. Remove the six (5mm) allen head screws that hold the end cover to the generator housing.
2. At the 9:00 and 3:00 O'clock position are threaded bosses. Thread a bolt (8mm - 1.5 x 50mm) into these two bosses. This will push the end cover off the housing exposing the rotor assembly.

When re-installing: Place a small amount of petroleum jelly on the rotor bearing "O"-ring located in the cover boss.

Position the cover onto the bearing and thread the six (5mm) allen head screws back in place (finger tight).

Tighten the screws in a criss-cross manner drawing the end cover onto the bearing. When fully on, tighten the screws securely.

NOTE: A transient voltage suppressor is connected between the (+) and (-) terminals of the rotating field windings (underneath).



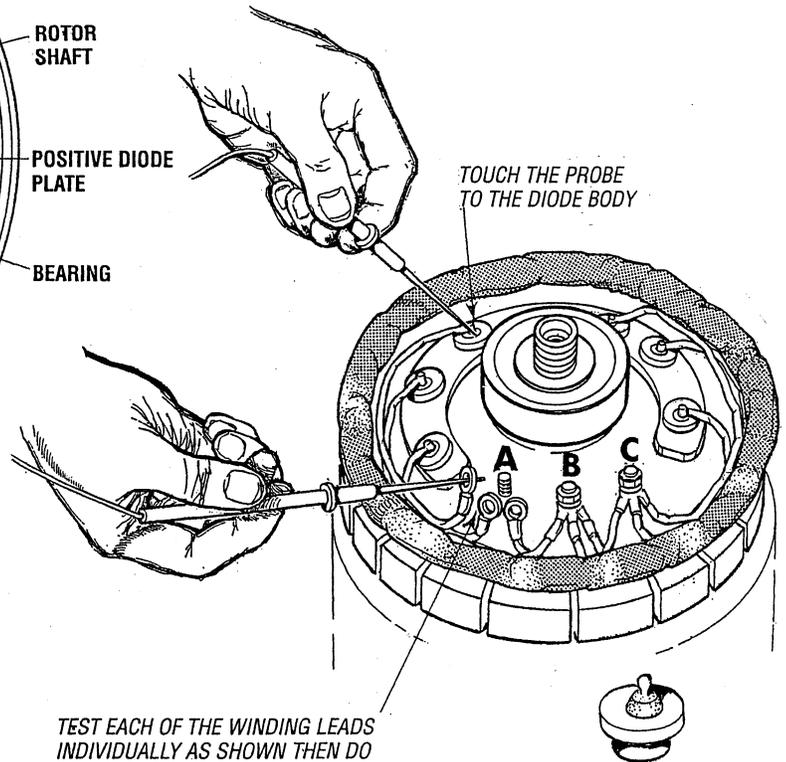
ROTOR TROUBLESHOOTING (Low voltage Output)

Rotating Field Winding

1. Position the rotor as shown above with the (+) and (-) connections at 12 O'clock.
2. Place the ohm meter leads across the (+) and (-) connections and record the ohm value. Also check that there is no continuity between either the (+) or the (-) connections and the rotor shaft.

Diodes and Auxiliary Windings

1. Test the diodes on the (+) and (-) sides by lifting the leads from the auxiliary winding studs A, B, and C as illustrated. Test each diode for an open or short.
- NOTE:** The three pairs of windings should have the same ohm values.
2. Test the auxiliary windings in pairs. Check the ohm values between A and B, B and C, A and C and record. Check that there is no continuity between the rotor shaft and windings A, B, and C.
 3. Test each diode individually. A resistance value should be found through the diode in one direction and, with the meter probes reversed, show no ohm value. The ohm value found for each diode should be approximately the same.



TEST EACH OF THE WINDING LEADS INDIVIDUALLY AS SHOWN THEN DO THE SAME WITH B AND C.

A FAULTY DIODE CAN BE PRESSED OUT AND REPLACED

BE GENERATOR

GENERATOR DISASSEMBLY

The generator layout should be studied carefully before disassembly.

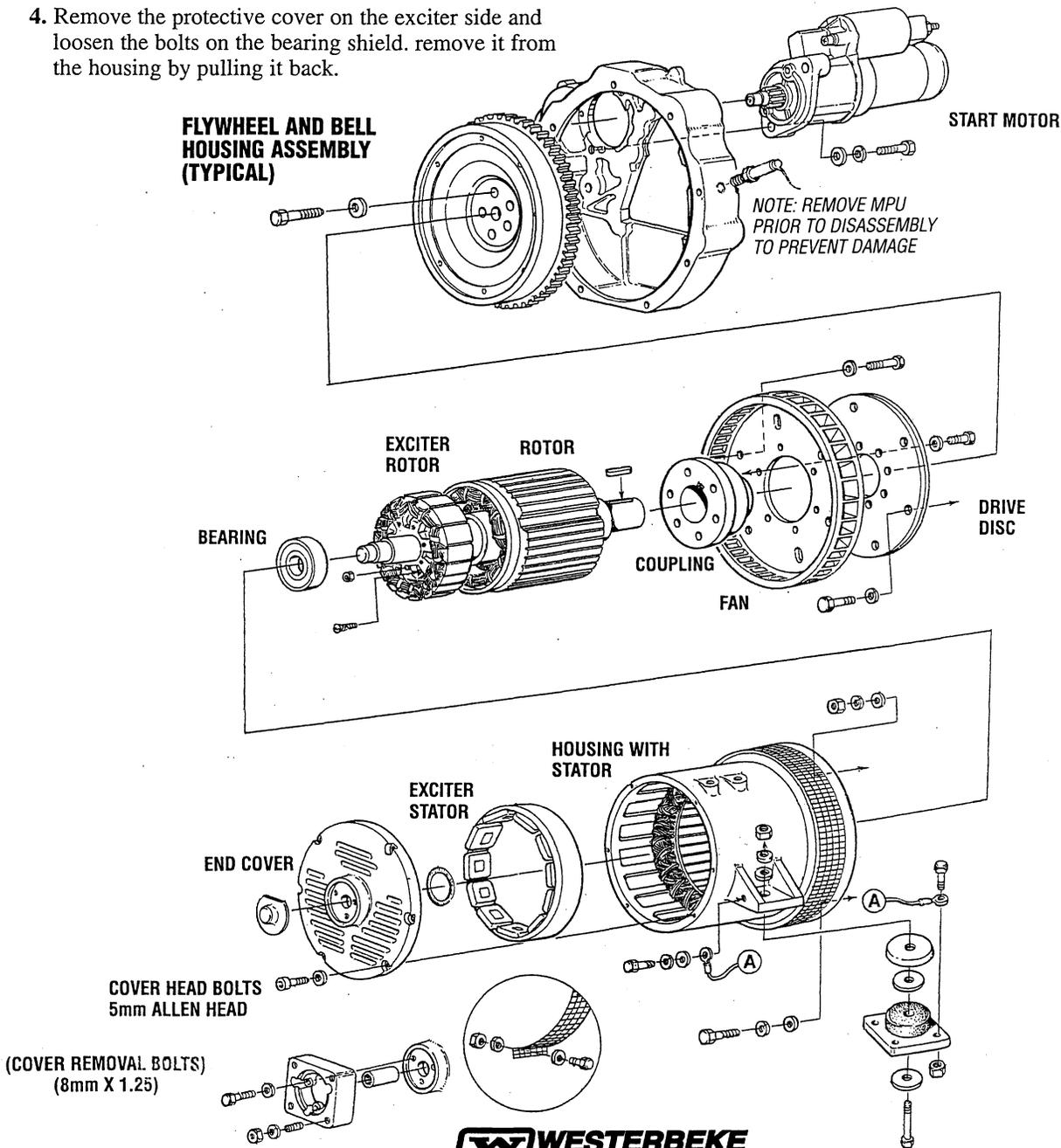
1. Remove terminal box cover. Disconnect the wire leads from the generator. If necessary, disassemble the voltage regulator support (if the Automatic Voltage Regulator is mounted in the terminal box) and the box complete.
2. Disconnect the voltage regulator leads and the leads from the exciter stator **F+** and **F-** to the voltage regulator.
3. Remove the fastening bolts to the generator and disassemble the generator from the prime mover by disconnecting the adapter housing and the coupling disc from the flywheel.
4. Remove the protective cover on the exciter side and loosen the bolts on the bearing shield. remove it from the housing by pulling it back.

5. Remove the rotor horizontally through the flange end of the generator.
6. When the rotating rectifier is to be removed, the bearing should be pulled out first.

NOTES: During the transport of the single bearing generator, the rotor of the generator should be fixed to the housing with the coupling disc on the flange.

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 gently.



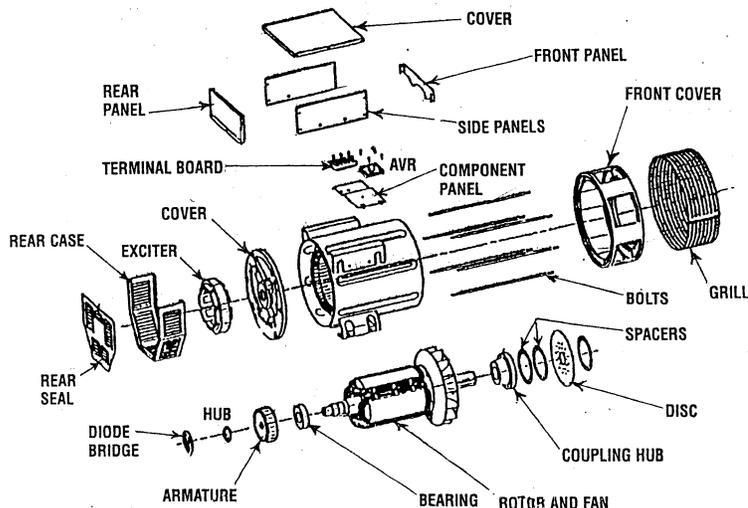
GENERATOR MAINTENANCE

WARNING: Prior to performing any maintenance, make certain that the generator is shutdown, switches are off and the unit is at room temperature.

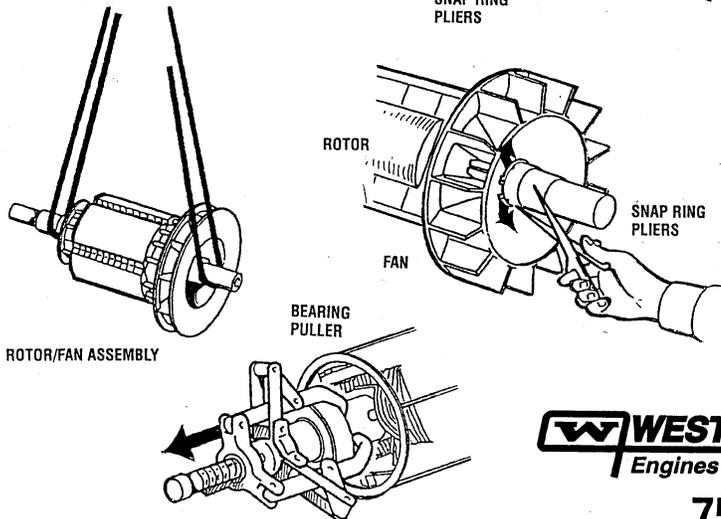
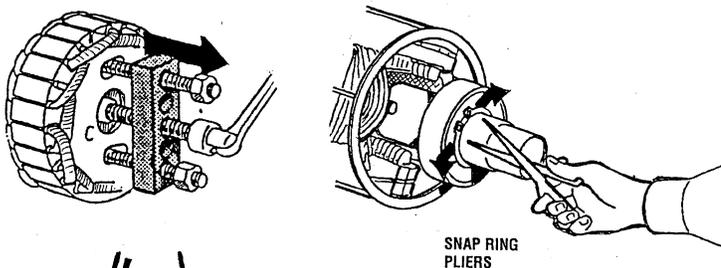
DISASSEMBLY

If it becomes necessary to disassemble the stator/rotor assembly, use the following text as a guide.

1. Insert a suitable puller (which can be easily made) and remove the exciter.
2. Extract the rotor using a hoist with soft ropes of sufficient strength. Carefully remove the rotor and place it on a prepared work area. It may be necessary to remove the front cover to extract the rotor due to the diameter of the fan.

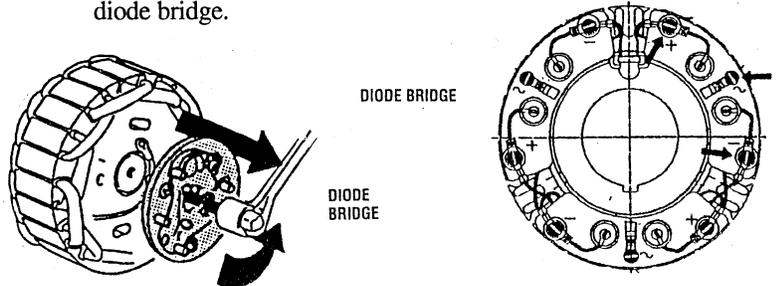


3. Remove the seager rings with snap ring pliers.
4. Remove the bearings with a proper bearing puller.



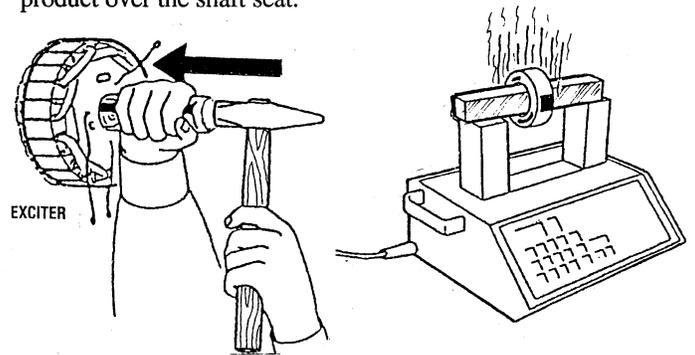
Rotation Diode Bridge

1. Disconnect the five wires of the rotating diode bridge.
2. Remove the blocking bolt and pulling gently, remove the diode bridge.

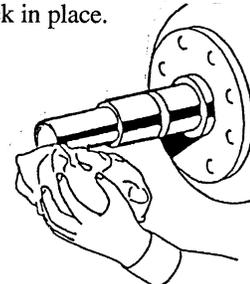


REASSEMBLY

1. Heat the bearing with a special magnetic device and using insulated gloves, assemble the bearings to the shaft.
2. Put the seager rings back into place. Thoroughly clean the shaft and spread a thin layer of Permabond or similar product over the shaft seat.



3. Reassemble the exciter carefully, making sure the diode connecting cables are turned toward the outside.
4. Install the rotor and completely reassemble the generator with all the covers back in place.



CLEANING

Use compressed air to clean the exterior of the generator. Do not use liquids or water. Do not use compressed air on interior components as this could cause short circuits.

MAINTENANCE

To clean the windings, use solvents like oil of turpentine or "Solvesso" solvent. Cleaning with such substances, which contain a high evaporation level, will not damage the isolation level of the windings. When cleaning is over, please look out for any overheating or carbonization signs.

We also recommend drying the windings at 60 - 80°C and if you notice that the varnish of the windings is not in good shape, then have them varnished again.

CARBON MONOXIDE "CO"/LOW-CO GENERATORS

IMPORTANT INFORMATION

DESCRIPTION

Carbon monoxide "CO" is a component of engine exhaust. It is a colorless, tasteless, odorless, lighter than air poisonous gas that can kill you without any warning. CO poisoning is one of the major safety risks associated with boating. It is a threat that must not be underestimated.

Westerbeke Low-CO generators are designed to reduce normal levels of CO in the engine exhaust by approximately 99%.

Several standards for CO have been published, expressed in parts per million "ppm" and hours of exposure:

Regulator	CO ppm	Exposure Hours
EPA	9	8
ACGIH	25	8
EPA	35	1
NIOSH	35	8
OSHA	50	8
ACGIH	125	0.5
NIOSH	200	0.0
NIOSH (IDLH)	1200	0.0

1200 ppm is the so-called IDLH concentration - IMMEDIATELY DANGEROUS TO LIFE AND HEALTH.

A city in California characterizes the effect of CO concentration this way:

Parts per Million	Responses
25	Permissible exposure level, no apparent toxic symptoms.
100	No poisoning for long period. Allowable for several hours.
200	Should not be exposed above this level for any period of time. A possible mild frontal headache in two to three hours.

Even though the generator normally produces very low levels of CO, an exhaust leak of untreated exhaust would be extremely dangerous. For this reason it is extremely important to install a CO detector near the generator and to be sure it is always turned on and functioning properly. If this detector sounds, do not turn it off, assuming it is a false signal. You can not taste, smell, or otherwise detect CO. Leave the detector on, turn off all engines and generators, evacuate the boat leaving ports and hatches open, and seek professional help.

As soon as CO leaves the exhaust outlet, the level is subject to dilution in the open air. The closer a person is to the exhaust outlet, the higher the concentration of CO.

In a closed space, such as the engine compartment, the boat, or underneath a stern swim platform, concentrations will potentially rise to the undiluted level emanating from the exhaust system due to a lack of fresh air to dilute the exhaust gas. Therefore, one should never rely on dilution of the exhaust to provide a margin of safety.

Westerbeke Low-CO generators achieve a very low reduction of typical CO by precise control of the engine's air/fuel ration coupled with after treatment in a special catalyst. CO emissions are not the same for every model because each engine is different. Also, certain fuel system components are commonized across several engine models being adequate for some and extra-adequate for others, thus producing different CO levels for different models.

The fuel system which accomplishes the required precise air/fuel ratio control is comprised of many different components: purchased sub-assemblies, machined castings, sensors, electronics and others. Because of the extreme level of CO reduction, any variability in the functioning of any these components can and will cause variability of the CO output.

CO concentration also varies with load. Usually, but not always, the worst case CO concentration occurs at maximum load.

INSPECTION

The catalyst is critical to optimizing CO levels. Any water intrusion into the exhaust system will likely quickly compromise the proper operation of the catalyst. Westerbeke's exhaust system installation instructions dated on or after February 2004 must be adhered to.

NOTE: *Water intrusion is not a product defect and is not covered under warranty, neither Westerbeke's normal product warranty nor the emissions specific warranty mandated by various regulating authorities such as EPA and CARB.*

Maintenance of any components affecting the flow of air or the flow of fuel to the engine is critically important, such as fuel filters and air filters (if any).

Inspection of the catalyst at the prescribed intervals is critically important. The exhaust elbow is removed by loosening the metal clamp to provide a view of the output surface of the catalyst. Any visual irregularity of the normal flush, honeycomb appearance is most likely a result of water intrusion. The cause of the irregularity must be identified and addressed. If there is irregularity, the catalyst and gasket must be replaced. Upon careful reassembly of the catalyst, exhaust elbow gasket, and exhaust elbow, check for the presence of CO while the engine is running. This must be performed with a CO analyzer.

CARBON MONOXIDE "CO"/LOW-CO GENERATORS

IMPORTANT INFORMATION

Catalyst performance will degrade over time. As the generator accumulates operating hours, CO concentrations will increase. **The catalyst must be replaced every 2,000 hours of engine operation.**

Verification of satisfactory CO levels must be done seasonally or each 1,000 hours (which ever occurs first). Verification involves actual sampling of exhaust gas with an appropriate CO analyzer.

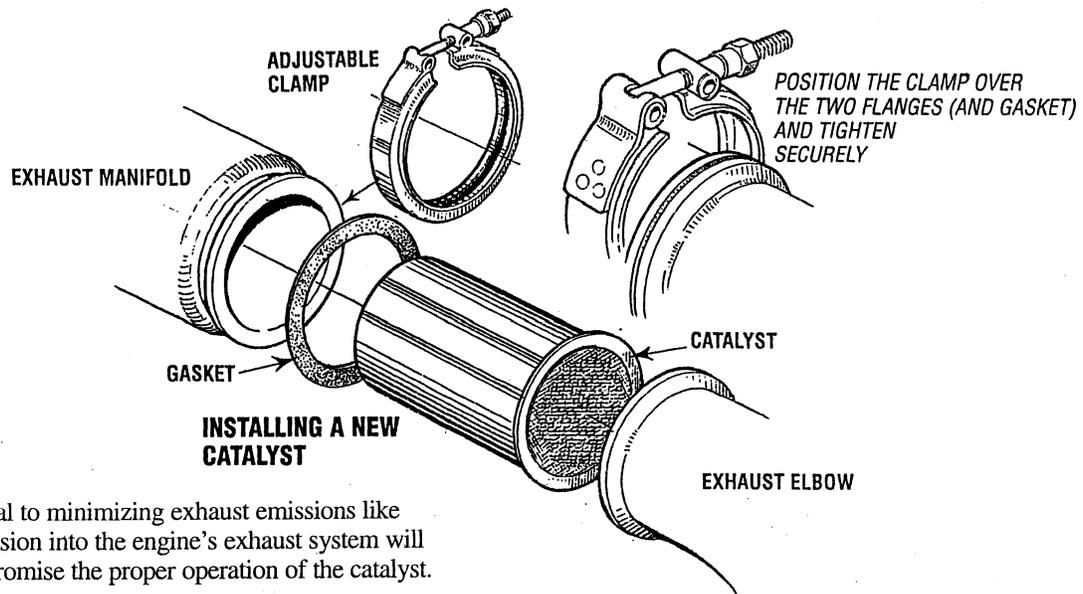
There are two locations where exhaust gas can be sampled. Dry, but hot, exhaust can be sampled at the plugged tapped hole in the exhaust elbow intended for back pressure measurements. Measurements at this location may not be practical in all instances due to the high exhaust temperature, temperature limits of the analyzer, safety concerns over temperatures involved or the possibility of high levels of CO. The other location is the boat's exhaust outlet, which contains entrained cooling water (except dry stack exhaust systems). Only analyzers with probes should be used at this location and it is critical that the probe not ingest water. Probe-type analyzers have an air pump drawing a gas sample through the probe. As a result, they tend to ingest water when it is present. Be sure to aim the probe downwards with the opening pointed in the direction of the water flow and just out of the flow. Position the analyzer as high as possible with the tubing leading to the probe running continuously downhill. Observe the usually translucent tubing between the probe and the analyzer and be sure no water is being ingested. If any water is ingested into the analyzer, it must be repaired or replaced and recalibrated.

When measuring CO at the exhaust outlet be aware of the ambient CO level by also measuring CO away from and upwind of the exhaust outlet, especially in marinas. the CO level at the exhaust will be influenced upwards by the ambient level.

Whenever taking the time to verify proper CO concentration from the exhaust with a CO analyzer, always take the opportunity to use the analyzer to "sniff" around the engine looking for CO from exhaust leaks. Pay close attention to the connection of the cylinder head to the exhaust manifold, the exhaust manifold to the water injected exhaust elbow, and all subsequent downstream exhaust components and hoses. Remember, exhaust gas that has not yet passed through the catalyst is raw, untreated exhaust and is very high in CO content.

Analyzers usually require periodic calibration. Follow the instructions that come with the analyzer very carefully regarding calibration.

The following are manufacturers that offer CO analyzers: Extech, TIF, Testo, TSI, Bacharach, Fluke, Monoxor, Fyrite, Zellweger Analytics, Industrial Scientific Corp, GFG, TPI, Teledyne and others. Westerbeke recommends analyzers with a probe connected to the analyzer by a length of transparent tubing. They are slightly more expensive than those with the sensor built into one end of the analyzer, but they allow you to sample the exhaust coming out of the boat's exhaust outlet.



DESCRIPTION

The catalyst is critical to minimizing exhaust emissions like CO. Any water intrusion into the engine's exhaust system will likely quickly compromise the proper operation of the catalyst.

Westerbeke's exhaust system installation dated May 2004 2nd Edition or later must be adhered to.

EMISSIONS

This genset meets the requirements of California's Exhaust Emissions Standards as stated on the nameplate.

California users of this genset should be aware that unauthorized modifications or replacement of fuel, exhaust, air intake, or speed control system components that affect engine emissions are prohibited. Unauthorized modification, removal or replacement of the engine label is prohibited.

Federal Emissions Compliance Period: The Federal Emissions Compliance Period referred to on the nameplate indicates the number of operating hours for which the engine has been shown to meet Federal Emissions requirements.

Catagory C= 250 hrs, B=500 hrs,m A =1000.hrs.

You should carefully review operator (Owner) Installation and other manuals and information you receive with your genset. If you are unsure that the installation, use, maintenance or service of your genset is authorized, you should seek assistance from an approved WESTERBEKE dealer.

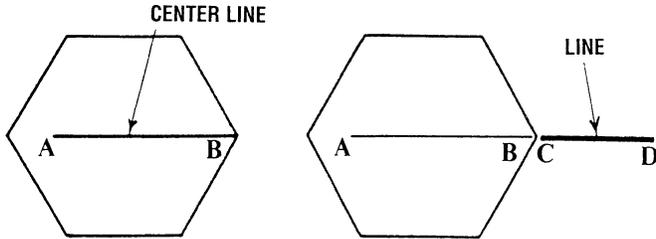
California genset users may use the table below as an aid in locating information related to the California Air Resources Board requirements for emissions control.

EMISSIONS CONTROL INFORMATION TABLE

Emissions Warranty Information	The California emissions control warranty statement is located in the same packet, if information as this manual when the genset is shipped from the factory.
Engine Fuel Requirements	The engine is certified to operate on unleaded gasoline. See <i>FUEL RECOMMENDATIONS</i> .
Engine Valve Adjustment	See <i>MAINTENANCE SCHEDULE</i> .
Engine Ignition Timing	See <i>MAINTENANCE SCHEDULE</i> .
Engine Lubricating Oil Requirements	See <i>ENGINE OIL RECOMMENDATIONS</i> .
Engine Adjustments	ECU.
Engine Emission Contol System	The engine emission control system consists of engine design and precision manufacture.
Catalyst	See <i>MAINTENANCE SCHEDULE</i> .
Oxygen Sensor	See <i>MAINTENANCE SCHEDULE</i> .
Back Pressure	See <i>MAINTENANCE SCHEDULE</i> .

ANGULAR NUT AND BOLT TIGHTENING METHOD

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

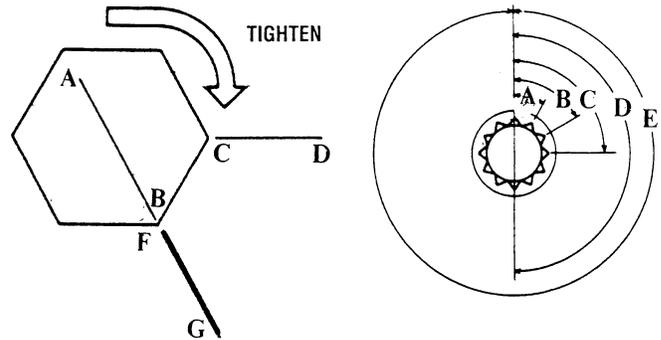
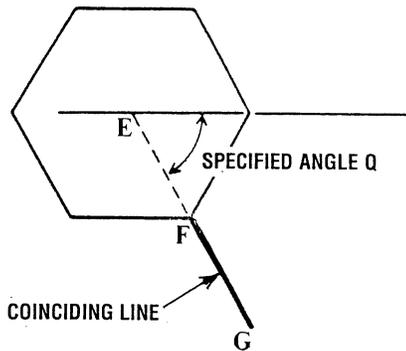


- Draw another line (F-G) on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center (E) of the nut or bolt.
- Use a socket wrench to tighten each nut or bolt to the point where the line (A-B) is aligned with the line (F-G).

Example: Specified Angle and Tightening Rotation

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

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



NEW TIGHTENING METHOD USING PLASTIC REGION TIGHTENING BOLTS

Parts of the engine use plastic region tightening bolts. The tightening procedure for these is different from that of conventional bolts and is described in this manual.

NOTE: The plastic region tightening bolts have fixed service limits. These limits are indicated where they occur in this manual and must be strictly observed.

Plastic region tightening bolts are used for the following applications:

- Cylinder Head Bolts
- Connecting Rod Cap Bolts

The tightening procedure is as follows:

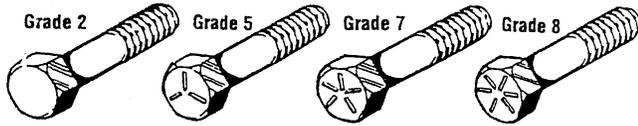
After tightening a bolt to the specified torque, tighten it by a further 90° + 90° or by a further 90° to 100°. The exact tightening procedure differs depending on the bolt and is described as it occurs in this manual.

STANDARD HARDWARE

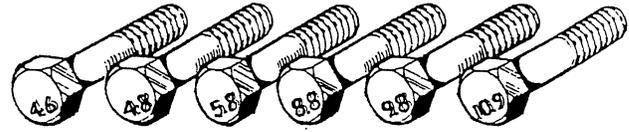
BOLT HEAD MARKINGS

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

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



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



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

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

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

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

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

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

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

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

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

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

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

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

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

BOLTS & FASTENERS/ASSEMBLIES

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

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

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

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

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

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 .621 = Miles

DISTANCE EQUIVALENTS

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

VOLUME

Cubic Inches (in³) x 16.387 = Cubic Centimeters x .061 = in³
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 (H₂O) x .07355 = Inches of Mercury x 13.783 = H₂O
Inches of Water (H₂O) x .03613 = psi x 27.684 = H₂O
Inches of Water (H₂O) x .248 = Kilopascals (kPa) x 4.026 = H₂O

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

REMOTE OIL FILTER (OPTIONAL) (PN.034129)

INSTALLATION

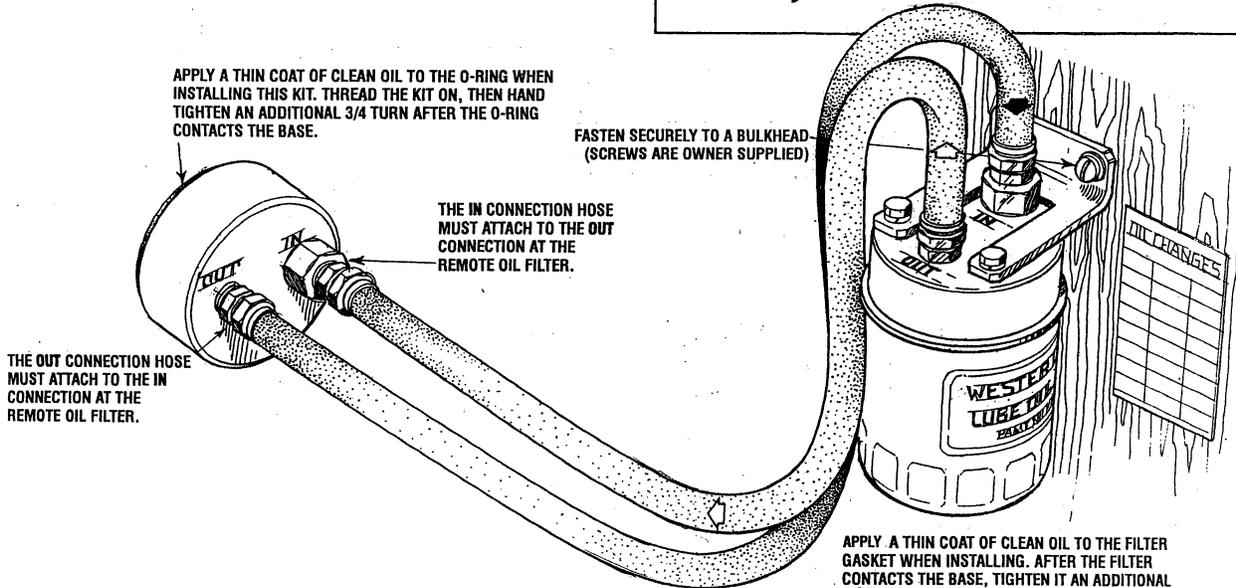
This popular accessory is used to relocate the engine's oil filter from the engine to a more convenient location such as an engine room bulkhead.

NOTE: Refer to *ENGINE OIL CHANGE* in this manual for instructions on removing the oil filter.

To install, simply remove the engine oil filter and thread on WESTERBEKE's remote oil filter kit as shown. Always install this kit with the oil filter facing down as illustrated. Contact your WESTERBEKE dealer for more information.

NOTE: Westerbeke is not responsible for engine failure due to incorrect installation of the Remote Oil Filter.

CAUTION: It is vital to install the oil lines correctly. If the oil flows in the reverse direction, the bypass valve in the filter assembly will prevent the oil from reaching the engine causing an internal engine failure. If there is no oil pressure reading, shutdown immediately and check the hose connections.



MEASURING EXHAUST BACK PRESSURE

Exhaust systems normally produce resistance to the flow of exhaust gases, causing back-pressure. Back-pressure must be kept within a certain limit. Check the back-pressure before the generator is put back into service.

To test exhaust pressure, connect either a water column or PSI tube to the test part on the exhaust elbow as shown.

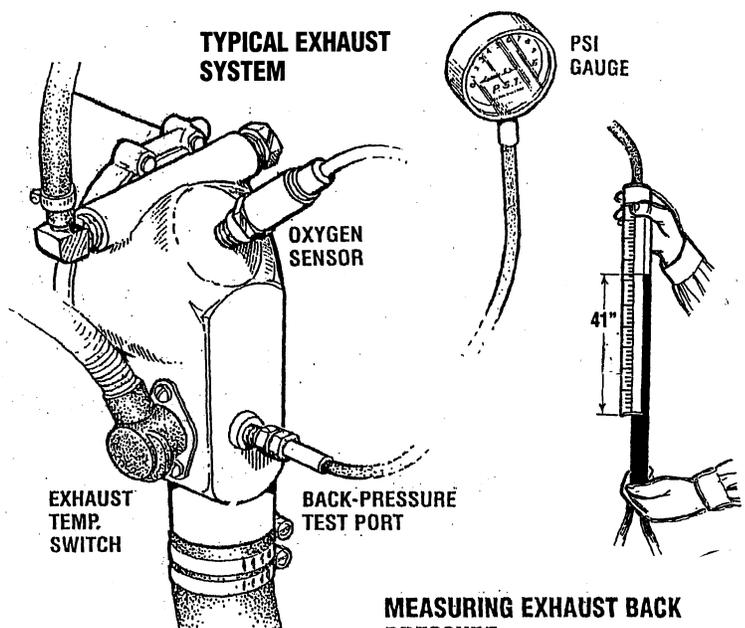
Check the exhaust back-pressure before the generator is put into service. Measure the back-pressure after the engine has reached its normal operating temperature, and at the point where it is about to reach its rated load at either 1500 rpm (for 50Hz applications) or 1800 rpm (for 60Hz applications). Back-pressure should not exceed 1.5 psi (0.11 kg/cm²).

A water column can be made by taping one end of a clear plastic tube along a yardstick and fitting the other end of the tube with a 1/4" NPT pipe fitting.

Back pressure should not exceed 41 in. (104cm) of water in the column.

OXYGEN SENSORS

There are two oxygen sensors, one at the location on the exhaust manifold where the engine exhaust enters the catalyst and the other where the exhaust gas exits the catalyst. These signal the ECU regarding CO levels being discharged with the exhaust.



MEASURING EXHAUST BACK PRESSURE



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