OPERATORS MANUAL

WESTERBEKE MARINE DIESEL GENERATORS

15.0 KW BTDA - 60 Hz | 12.0 KW BTDA - 50 Hz
15.0 KW BTDB - 60 Hz | 12.0 KW BTDB - 50 Hz

Single and Three Phase

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WESTERBEKE

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CALIFORNIA

PROPOSITION 65 WARNING

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

SAFETY INSTRUCTIONS

INTRODUCTION

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

PREVENT ELECTRIC SHOCK

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

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

PREVENT BURNS — HOT ENGINE

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

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

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

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

PREVENT BURNS — FIRE

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

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

PREVENT BURNS — EXPLOSION

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

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

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

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

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

BATTERY EXPLOSION

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

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

BATTERY ACID

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

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

TOXIC EXHAUST GASES

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

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

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

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

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

AVOID MOVING PARTS

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

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

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

HAZARDOUS NOISE

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

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

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

OPERATORS MANUAL

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

ENGINE INSTALLATIONS

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

Sections of the ABYC standards of particular interest are:

H-2 Ventilation
P-1 Exhaust systems
P-4 Inboard engines
E-9 DC Electrical systems

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

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

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

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

Order From:

ABYC
15 East 26th Street
New York, NY 10010

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

Order From:

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

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

Order From:

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


WESTERBEKE
Engines & Generators

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INTRODUCTION

This WESTERBEKE Diesel Generator is a product of WESTERBEKE's long years of experience and advanced technology. We take great pride in the superior durability and dependable performance of our engines and generators. Thank you for selecting WESTERBEKE.

In order to get the full use and benefit from your generator it is important that you operate and maintain it correctly. This manual is designed to help you do this. Please, read this manual carefully and observe all the safety precautions throughout. Should your generator require servicing, contact your nearest WESTERBEKE dealer for assistance.

This is your operators manual. A parts catalog is also provided and a technical manual is available from your WESTERBEKE dealer. If you are planning to install this equipment contact your WESTERBEKE dealer for WESTERBEKE'S installation manual.

WARRANTY PROCEDURES

Your WESTERBEKE Warranty is included in a separate folder. If, after 60 days of submitting the Warranty Registry form you have not received a customer identification card registering your warranty, please contact the factory in writing with model information, including the unit's serial number and commission date.

Customer Identification Card

WESTERBEKE
Engines & Generators

Customer Identification
MR. GENERATOR OWNER
MAIN STREET
HOMETOWN, USA
Model 15BTDB Ser. #U0000-D702
Expires 4/4/98

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

PRODUCT SOFTWARE

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

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

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

NOTES, CAUTIONS AND WARNINGS

As this manual takes you through the operating procedures, maintenance schedules, and troubleshooting of your marine engine, critical information will be highlighted by NOTES, CAUTIONS, and WARNINGS. An explanation follows:

NOTE: *An operating procedure essential to note.*

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

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

INTRODUCTION

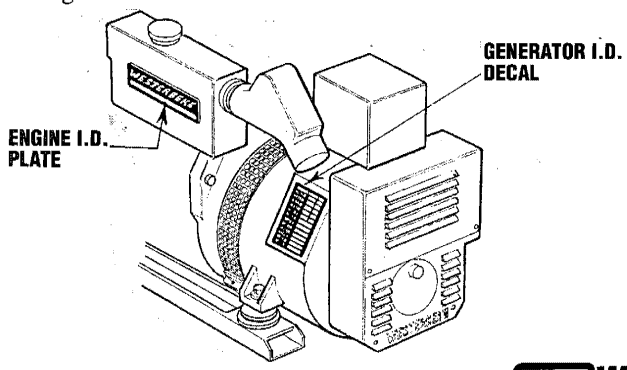
SERIAL NUMBER LOCATION

The engine and generator serial numbers and model numbers are located on a decal on the generator housing. Take the time to enter the information on the blank decal provided below as this will provide a quick reference when seeking technical information and/or ordering repair 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.		

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

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



NOTE: *A carbon monoxide warning decal has been provided by WESTERBEKE. Affix this decal in a visible position in the engine room.*

UNDERSTANDING THE DIESEL ENGINE

The diesel engine closely resembles the gasoline engine, since the mechanism is essentially the same. The cylinders are arranged above a closed crankcase; the crankshaft is of the same general type as that of a gasoline engine; and the diesel engine has the same type of valves, camshaft, pistons, connecting rods and lubricating system.

Therefore, to a great extent, a diesel engine requires the same preventive maintenance as a gasoline engine. The most important factors are proper ventilation and proper maintenance of the fuel, lubricating and cooling systems. Replacement of fuel and lubricating filter elements at the time periods specified is a must, and frequent checking for contamination (that is, water, sediment, etc.) in the fuel system is also essential. Another important factor is the use of the same brand of high detergent diesel lubrication oil designed specifically for diesel engines.

The diesel engine does differ from the gasoline engine, however, in its method of handling and firing of fuel. The carburetor and ignition systems are done away with and in their place is a single component – the fuel injection pump – which performs the function of both.

ORDERING PARTS

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

SPARES AND ACCESSORIES

Certain spares will be needed to support and maintain your WESTERBEKE generator. Your local WESTERBEKE dealer will assist you in preparing an inventory of spare parts. See the *SPARE PARTS* page in this manual. For Engine and Generator Accessories, see the *ACCESSORIES* brochure.

CONTROL PANELS

MAIN PANEL

This manually-controlled WESTERBEKE diesel generator is equipped with toggle switches on the engine's control panel and, optionally, at a remote panel. All three switches are momentary contact type and serve the following functions:

1. PREHEAT: The PREHEAT toggle switch is a double-pole, single-throw switch. The switch serves two purposes: pre-heating the engine for easy starting and defeating or bypassing the engine's protective oil pressure switch. The defeat function activates the fuel solenoid, instrument power, alternator excitation, electronic governor and provides power to the START switch.

2. START: The START toggle switch is a double-pole, single-throw switch. The switch, when activated, energizes the starter solenoid for starting the engine. *This switch will not operate electrically unless the* PREHEAT *switch is depressed and held at the same time.*

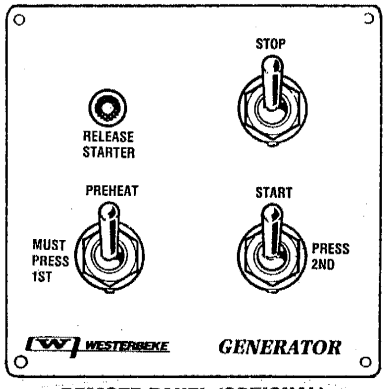
3. STOP: The STOP toggle switch is a single-pole, single-throw, normally closed switch. This switch provides power to the fuel solenoid, instrument cluster and alternator excitation, after the oil pressure switch has closed upon engine starting. Opening of this switch opens the power circuit to the fuel solenoid, thereby stopping the fuel flow to the injection pump and stopping the engine.

NOTE: *When the engine is shut down, the water temperature gauge and the oil pressure gauge will continue to register the last temperature and oil pressure readings displayed. They will return to zero once electrical power is restored.*

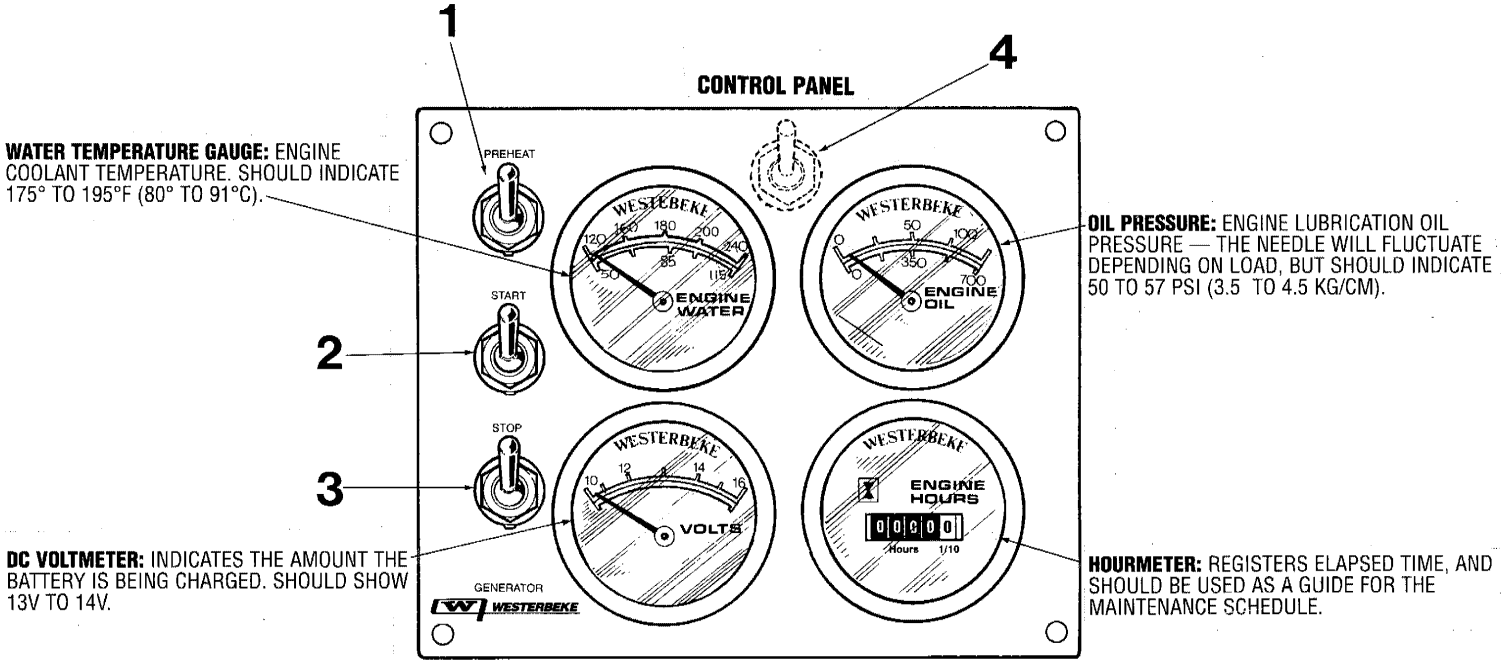
4. EMERGENCY STOP: The EMERGENCY stop switch at the rear of the control box is normally closed. When depressed, it will open the DC circuit to the control panel and shut the engine down. As the switch is not toggled it can be used when performing maintenance.

REMOTE PANEL

For remote operation of the generator system, the same three switches are used. The PREHEAT and START switches are connected in parallel with the gauge panel's switches and serve the same functions as in the gauge panel. The STOP switch is in series with the gauge panel's STOP switch and serves the same function.



REMOTE PANEL (OPTIONAL)



WATER TEMPERATURE GAUGE: ENGINE COOLANT TEMPERATURE. SHOULD INDICATE 175° TO 195°F (80° TO 91°C).

OIL PRESSURE: ENGINE LUBRICATION OIL PRESSURE — THE NEEDLE WILL FLUCTUATE DEPENDING ON LOAD, BUT SHOULD INDICATE 50 TO 57 PSI (3.5 TO 4.5 KG/CM).

DC VOLTMETER: INDICATES THE AMOUNT THE BATTERY IS BEING CHARGED. SHOULD SHOW 13V TO 14V.

HOURMETER: REGISTERS ELAPSED TIME, AND SHOULD BE USED AS A GUIDE FOR THE MAINTENANCE SCHEDULE.

NOTE: *Should you suspect a faulty gauge refer to the trouble shooting section of this manual.*

DIESEL FUEL, ENGINE OIL AND ENGINE COOLANT

DIESEL FUEL

Use fuel that meets the requirements or specification of Class 2-D (ASTM), and has a cetane rating of #45 or better.

Care Of The Fuel Supply

Use only clean diesel fuel! The clearance of the components in your fuel injection pump is very critical; invisible dirt particles which might pass through the filter can damage these finely finished parts. It is important to buy clean fuel, and keep it clean. The best fuel can be rendered unsatisfactory by careless handling or improper storage facilities. To assure that the fuel going into the tank for your engine's daily use is clean and pure, the following practice is advisable:

Purchase a well-known brand of fuel.

Install and regularly service a good, visual-type filter/water separator between the fuel tank and the engine. The Raycor 500 FG or 900 FG are good examples of such filters.

ENGINE OIL

Use a heavy duty engine oil with an API classification of CF or CG-4 or better. Change the engine oil after an initial 50 hours of break-in operation, and every 100 hours of operation thereafter. For recommended oil viscosity, see the following chart:

Operating Temperature	Oil Viscosity
Above 68°F (20°C)	SAE 30, 10W-30 or 15W-40
41°-68°F (5-20°C)	SAE 20, 10W-30 or 15W-40
Below 41°F (5°C)	SAE 10W-30 or 15W-40

⚠ CAUTION: ***Do not allow two or more brands of engine oil to mix. Each brand contains its own additives; additives of different brands could react in the mixture to produce properties harmful to your engine.***

Oil Pressure

The engine's oil pressure, during operation, is indicated by the oil pressure gauge on the instrument panel. During normal operation, the oil pressure will range between 35 and 65 psi.

NOTE: *A newly started, cold engine can have an oil pressure reading upwards of 65 psi. A warmed engine can have an oil pressure reading as low as 35 psi. These readings will vary depending upon the temperature of the engine and the load placed on the generator.*

ENGINE COOLANT

WESTERBEKE recommends a mixture of 50% antifreeze and 50% distilled water. Distilled water is free from the chemicals that can corrode internal engine surfaces.

The antifreeze performs double duty. It allows the engine to run at proper temperatures by transferring heat away from the engine to the coolant, and lubricates and protects the cooling circuit from rust and corrosion. Look for a good quality antifreeze that contains Supplemental Cooling Additives (SCAs) that keep the antifreeze chemically balanced, crucial to long term protection.

The distilled water and antifreeze should be premixed before being poured into the cooling circuit.

NOTE: *Look for the new environmentally-friendly long lasting antifreeze that is now available.*

Antifreeze mixtures will protect against an unexpected freeze and they are beneficial to the engine's cooling system. They retard rust and add to the life of the circulating pump seal.

ANTIFREEZE PROTECTION

Antifreeze concentration	23%	30%	35%	50%
Freezing Temperature	14°F (-5°C)	8°F (-13°C)	-4°F (-20°C)	-40°F (-40°C)

Coolant Recovery Tank

A coolant recovery tank kit is supplied with each WESTERBEKE diesel engine. The purpose of this recovery tank is to allow for engine coolant expansion and contraction during engine operation, without the loss of coolant and without introducing air into the cooling system. This kit is provided and must be installed before operating the engine.

PREPARATIONS FOR INITIAL STARTUP

PRESTART INSPECTION

This section of the manual provides the operator with preparation, initial starting, break-in, starting (warm or cold) and stopping procedures. Follow the procedures as presented for the conditions indicated and your WESTERBEKE generator set will give reliable performance and long service life.

Before starting your generator set for the first time or after a prolonged layoff, check the following items:

- ☐ Check the engine oil level. Add oil to maintain the level at the high mark on the dipstick.
- ☐ Check the fuel supply and examine the fuel filter/separator bowls for contaminants.
- ☐ Check the DC electrical system. Inspect wire connections and battery cable connections.
- ☐ Check the coolant level in both the plastic recovery tank and at the manifold.
- ☐ Visually examine the unit. Look for loose or missing parts, disconnected wires, unattached hoses, and check threaded connections.
- ☐ Check load leads for correct connection as specified in the wiring diagrams.
- ☐ Examine air inlet and outlet for air flow obstructions.
- ☐ Be sure no other generator or utility power is connected to load lines.
- ☐ Be sure that in power systems with a neutral line that the neutral is properly grounded (or ungrounded) as the system requires, and that generator neutral is properly connected to the load neutral. In single phase and some 3-phase systems an incomplete or open neutral can supply the wrong line-to-neutral voltage on unbalanced loads.
- ☐ Make sure the mounting installation is secure.
- ☐ Make sure that the generator is properly grounded.

⚠ CAUTION: ***When starting the generator, it is recommended that all AC loads, especially large motors, be switched OFF until the engine has come up to speed and, in cold climates, starts to warm up. This precaution will prevent damage caused by unanticipated operation of the AC machinery and will prevent a cold engine from stalling.***

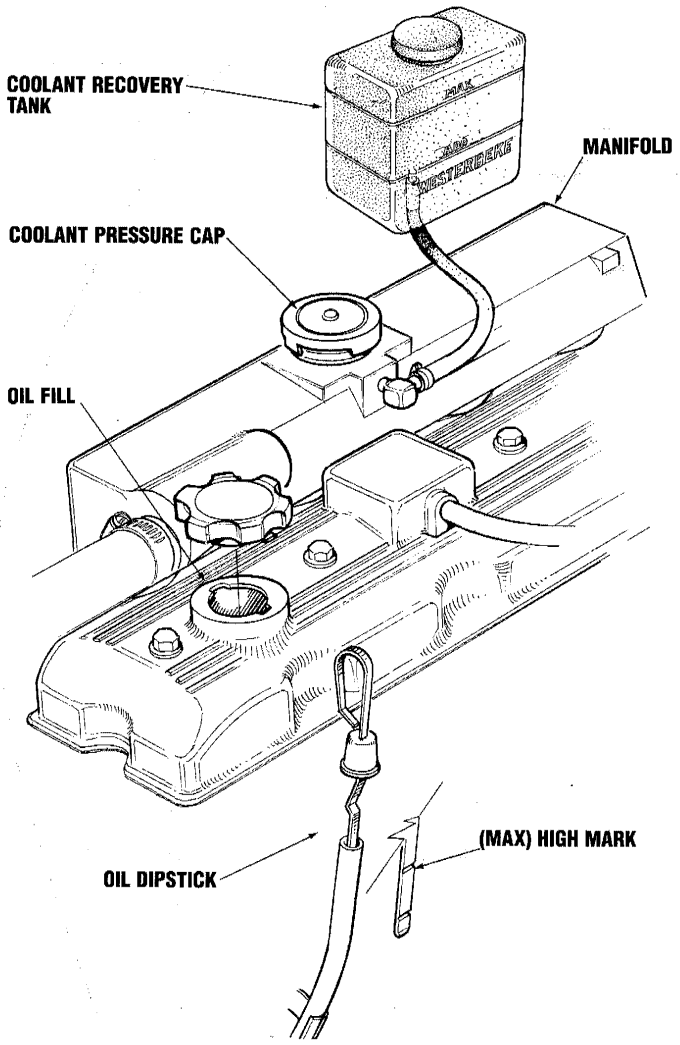
GENERATOR VOLTAGE

The speed of the generator engine is adjusted at the factory, however, it is advisable to verify.

To supply 60 HZ, the speed should be 1800 RPM at no load, and should not fall below 1800 RPM by more than .3 percent at full load.

To supply 50 HZ, speed should be 1500 RPM at full load.

Generator voltage should build to its rated value within 5 seconds after rated speed is attained. Record or observe voltage of generator at no load and at full load (hot). The voltages are easily adjusted to optimum values no load and full load (refer to *VOLTAGE ADJUSTMENT* in this manual). If possible, apply actual service load or test load of the same power factor as the load to be used in service. If voltage cannot be adjusted to suitable values and some fault seems evident, contact your authorized WESTERBEKE service dealer.



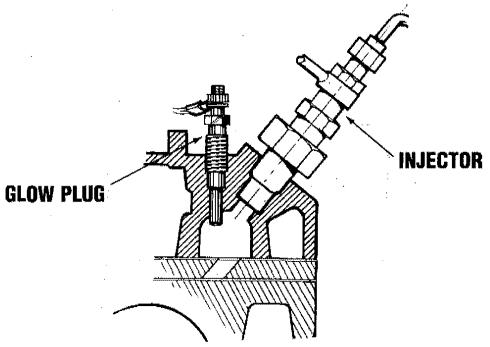
STARTING/STOPPING PROCEDURE

THE STARTING SYSTEM

Westerbeke diesel generators use electric starters assisted by glow plugs for both normal and cold weather starting. The illustration below shows a cross-sectional view of one cylinder. The glow plug is located in the combustion chamber so that its tip is in the injector nozzle's spray path. When the glow plug is energized by the PREHEAT button, the plug glows red at the tip and assists in igniting the fuel. The result is a rapid start with less wear on the starter.

This system is common to WESTERBEKE diesels. The start circuitry is designed so that the PREHEAT button must be depressed for the time specified in the preheat chart. Then, while keeping the PREHEAT button engaged, the START button is depressed to crank the engine.

NOTE: *The START switch will not energize unless the PREHEAT switch is depressed. Depressing the PREHEAT switch activates the glow plugs in the cylinder head so use the PREHEAT intermittently to avoid overheating the glow plugs.*



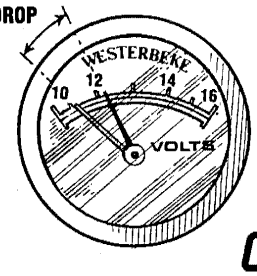
PREHEAT: Depress the PREHEAT switch. The voltmeter and panel lights, gauges and meters will be activated. The PREHEAT switch should be depressed in accordance with the following chart:

Temperature/Preheat

Atmospheric Temperature	Preheating Time
+41°F(+5°C) or higher	Approx. 10 seconds
+41°F(+5°C) to 23°F (-5°C)	Approx. 15 seconds
+23°F(-5°C) or lower	Approx. 20 seconds
Limit of continuous use	30 seconds before cranking

START: While still depressing the PREHEAT switch, depress the START switch. This will engage the starter solenoid. Upon engine starting, release the START switch. Do not release the PREHEAT switch until the oil pressure reaches 15 psi. Then as long as the high water temperature and low oil pressure protective circuits do not activate, the engine will remain energized and continue to run.

NOTE: *When starting: A voltage drop will occur when the preheat switch is depressed.*



Should the engine not start when the START switch is depressed for 10 to 20 seconds, release both switches and wait 30 seconds; repeat the procedure above and preheat longer. **Never run the starter for more than 30 seconds.**

> ⚠ **CAUTION:** ***Prolonged cranking intervals without the engine starting can result in the engine exhaust system filling with raw water. This may happen because the pump is pumping raw water through the raw water cooling system during cranking. This raw water can enter the engine's cylinders by way of the exhaust manifold once the exhaust system fills. Prevent this from happening by closing the raw water supply through-hull shut-off, draining the exhaust muffler, and correcting the cause of the excessive engine cranking. Engine damage resulting from raw water entry is not a warrantable issue; the owner/operator should keep this in mind.***

Remote Starting Procedure

The remote start panel is the same as the engine-mounted start panel except that it has a green LED light and no guages. When starting at a remote location, the green LED lights when the generator is running at approximately 600 rpm. This indicates when the START switch can be released since the starting of the generator may not be audible.

A. When the PREHEAT switch is depressed at the remote start/stop panel the LED light will illuminate. When the START switch is depressed and the starter cranks the engine this LED light will dim. When the engine starts the LED light will brighten signaling to release the START switch. Continue to hold the PREHEAT depressed for a few seconds to allow oil pressure to build up which closes the oil pressure safety switch that is in the series path for 12V B+ to the fuel run solenoid.

B. After the generator is started and the START switch is released, the generator's starter will not crank until the PREHEAT switch is operated first because this switch supplies voltage to the START switch.

Once the engine starts, check the engine's instruments for proper oil pressure and battery charging voltage. Apply a light load to the generator and allow the engine's operating temperature to come up to 140-150°F (60-66°C) before applying heavy loads.

NOTE: *Some unstable running may occur in a cold engine. Depressing the PREHEAT switch for 10-15 second intervals will help stabilize the engine RPM until the operating temperature reaches the 140-150°F and a load is applied to the engine. When the engine is running and the PREHEAT switch is depressed, a charging load on the DC alternator will be discernible.*

STARTING/STOPPING PROCEDURE

Starting Under Cold Conditions

Make sure the lubricating oil conforms with the ratings for the prevailing temperature. Check the table in the *ENGINE OIL* section in this manual.

The battery should be fully charged to minimize voltage drop.

Use a sufficient amount of preheat to aid in starting. See the *Temperature/Preheat* chart elsewhere in this section.

STOPPING PROCEDURE

1. Remove the AC electrical load from the generator and allow the generator to run for three to five minutes to stabilize its operating temperatures.
2. Depress the STOP switch and hold it until the generator is completely stopped.
3. Now release the STOP switch.

Remote Stopping Procedure

To stop the generator, depress the STOP switch which opens the normally closed B+ path for voltage to the engine's run circuit. The STOP switch must be held open until the generator comes to a complete stop. Remote start panels may be connected to the generator as indicated. A jumper has to be removed between the T-1 and T-2 connections at the panel connection terminal board. (Refer to the wiring diagram in the DC ELECTRICAL SYSTEM section of this manual for remote start/stop panel connections.)

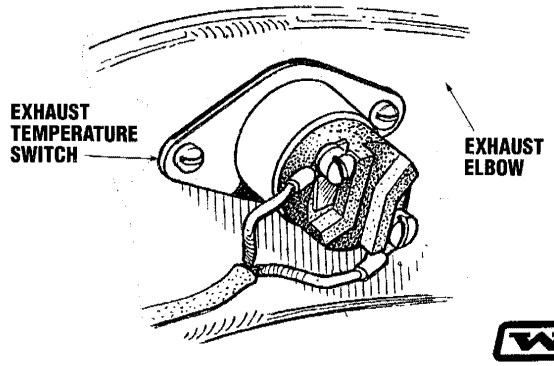
SAFETY SHUTDOWN SWITCHES

The engine is protected by three automatic shutdown switches. Should shutdown occur, ***do not attempt to restart without finding and correcting the cause. Refer to the heading "Engine Stops" in the*** **TROUBLESHOOTING** ***section of this manual.***

The following is a description of these automatic shutdown switches:

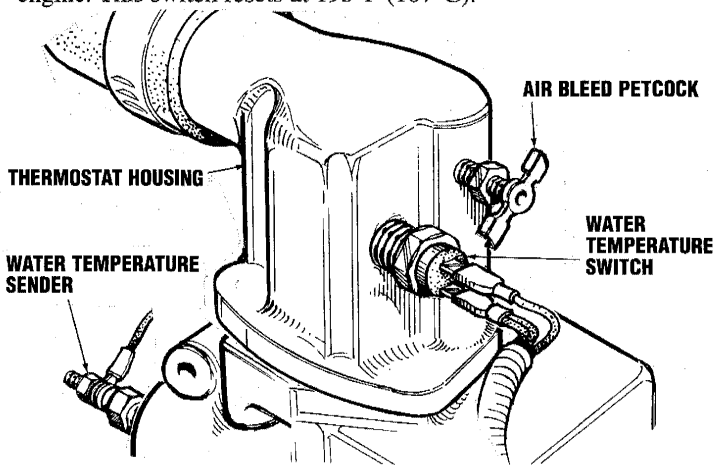
High Exhaust Temperature Switch

An exhaust temperature switch is located on the exhaust elbow. Normally closed, this switch will open and interupt the DC voltage to the fuel solenoid on the injection pump (shutting OFF the engine) should the switch's sensor indicate an excessive exhaust temperature (an inadequate supply of raw water causes high exhaust temperatures). This switch opens at 260-270°F (127-132°C). This switch resets at approximately 225°F (107°C).



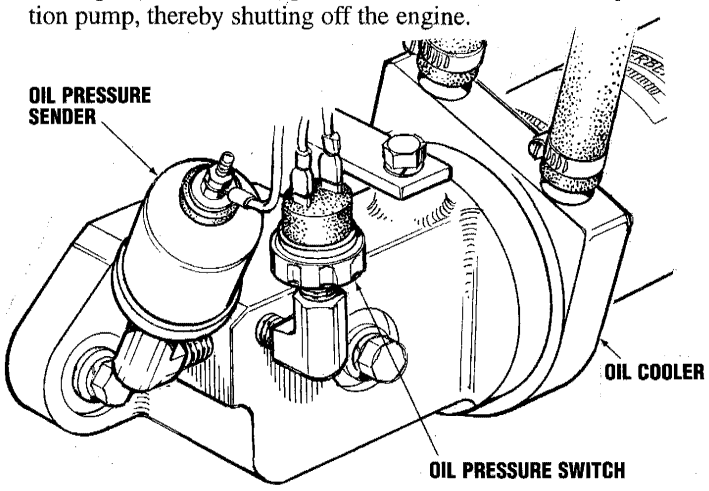
High Water Temperature Switch

A high water temperature switch is located on the thermostat housing. Normally closed, this switch, should the fresh water coolant's operating temperature reach approximately 210°F (99°C), will open and interrupt the DC voltage to the fuel solenoid on the injection pump, thereby shutting off the engine. This switch resets at 195°F (107°C).



Low Oil Pressure Switch

A low oil pressure shutdown switch is located off the engine's oil gallery. Normally open in a static state, this switch's sensor monitors the engine's oil pressure. Should the engine's oil pressure fall to 5-10 psi, this switch will open interrupting the DC voltage to the fuel solenoid on the injection pump, thereby shutting off the engine.



Engine Circuit Breaker

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

GENERATOR BREAK-IN PROCEDURE

DESCRIPTION

Although your engine has experienced a minimum of one hour of test operations at the factory to make sure accurate assembly procedures were followed and that the engine operated properly, a break-in time is required. The service life of your engine is dependent upon how the engine is operated and serviced during its initial hours of use.

Breaking-in a new engine basically involves seating the piston rings to the cylinder walls. Excessive oil consumption and smoky operation indicate that the cylinder walls are scored, which is caused by overloading the generator during the break-in period.

Your new engine requires approximately 50 hours of initial conditioning operation to break in each moving part in order to maximize the performance and service life of the engine. Perform this conditioning carefully, keeping in mind the following:

Start the engine according to the *STARTING PROCEDURE* section. Run the engine while checking that all systems (raw water pump, oil pressure, battery charging) are functioning.

AFTER START-UP

Once the generator has been started, check for proper operation and then encourage a fast warm-up. Run the generator between 20% and 60% of full load for the first 10 hours.

> ⚠ **CAUTION:** ***Do not attempt to break-in your generator by running without a load.***

After the first 10 hours of the generator's operation, the load can be increased to the full-load rated output, then periodically vary the load.

Avoid overload at all times. An overload is signaled by smoky exhaust with reduced output voltage and frequency. Monitor the current being drawn from the generator and keep it within the generator's rating. Since the generator operates at 1800 RPM to produce 60 hertz (or at 1500 RPM to produce 50 Hertz), control of the generator's break-in is governed by the current drawn from the generator.

CHECK THE FOLLOWING

☐ Monitor the control panel gauges.

☐ Check for leaks of fuel and engine oil.

☐ Check for abnormal noise such as knocking, friction, vibration and blow-back sounds.

NOTE: *The engine may be a little unstable when started cold. Intermittent use of the preheat will help overcome this. The engine, at normal operating temperature with no load, should be smooth and relatively quiet. Under load, a fuel detonation knock will be discernible.*

☐ Confirm exhaust smoke:
When the engine is cold – White Smoke.
When the engine is warm – almost Smokeless.
When the engine is overloaded – some Black Smoke.

To protect against unintentional overloading of the generator, the generator's output leads should be routed through a circuit breaker that is rated at the rated output of the generator.

NOTE: *Be aware of motor starting loads and the high current draw required for starting motors. This starting amperage draw can be 3 to 5 times normal running amperage. See* GENERATOR INFORMATION *in this manual.*

GENERATOR ADJUSTMENTS

Once the generator has been placed in operation, there may be adjustments required for engine speed (hertz) during the engine's break-in period (first 50 hours) or after this period. A no-load voltage adjustment may also be required in conjunction with the engine's speed adjustment. See *GENERATOR INFORMATION* in this manual.

THE DAILY ROUTINE

CHECK LIST

Each day before starting your generator, take a few moments to run this check list:

- ☐ Record the hourmeter reading in your log (engine hours relate to the maintenance schedule.)
- ☐ Visually inspect the generator for fuel, oil, or water leaks.
- ☐ Check the oil level (dipstick).
- ☐ Check the coolant level in the coolant recovery tank.
- ☐ Check your diesel fuel supply.
- ☐ Look for clean fuel in the fuel/separator transparent bowl.
- ☐ Check for loose wires at the alternator.
- ☐ Check the starting batteries (weekly).
- ☐ Check drive belts for wear and proper tension (weekly).

START THE GENERATOR

(See *STARTING PROCEDURES* on previous pages). Allow the engine to warm up for 5 to 10 minutes to reach operating temperatures of 140° to 150°F (60°-66°C) before applying AC loads, apply loads systematically allowing the generator to adjust to each load before applying the next. Check the gauges for proper oil pressure, operating temperature, and DC voltage.

NOTE: *Some unstable running may occur in a cold engine. This condition should abate as normal operating temperature is reached and loads are applied.*

> ⚠ **CAUTION:** ***Do not operate the generator for long periods of time without a load being placed on the generator.***

STOPPING THE GENERATOR

Remove the major AC loads from the generator one at a time. Allow the generator to run for a few minutes to stabilize the operating temperature and depress the stop switch. (See *STOPPING PROCEDURES* elsewhere in this manual.)

MAINTENANCE SCHEDULE

> ⚠ **WARNING:** ***Never attempt to perform any service while the engine is running. Wear the proper safety equipment such as goggles and gloves, and use the correct tools for each job. Disconnect the battery terminals when servicing any of the engine's DC electrical equipment.***

NOTE: *Many of the following maintenance jobs are simple but others are more difficult and may require the expert knowledge of a service mechanic.*

SCHEDULED MAINTENANCE	CHECK EACH DAY	HOURS OF OPERATION							EXPLANATION OF SCHEDULED MAINTENANCE
		50	100	250	500	750	1000	1250	
Fuel Supply	☐								Diesel No. 2 rating of 45 cetane or higher.
Fuel/Water Separator	☐								Check for water and dirt in fuel (drain/replace filter if necessary).
Engine Oil Level	☐								Oil level should indicate between MAX. and LOW on dipstick.
Coolant Level	☐								Check at recovery tank; if empty, check at manifold. Add coolant if needed.
Drive Belts	☐ weekly								Inspect for proper tension (3/8" to 1/2" depression) and adjust if needed. Check belt edges for wear.
Visual Inspection of Engine	☐	**NOTE:** *Please keep engine surface clean. Dirt and oil will inhibit the engine's ability to remain cool.*							Check for fuel, oil and water leaks. Inspect wiring and electrical connections. Keep bolts & nuts tight. Check for loose belt tension.
Fuel Filter		☐		☐		☐		☐	Initial change at 50 hrs, then change every 250 hrs.
Starting Batteries (and House Batteries)	☐ weekly								Every 50 operating hours check electrolyte levels and make sure connections are very tight. Clean off excessive corrosion.
Engine Oil (and filter)		☐							Initial engine oil & filter change at 50 hrs., then change both every 100 hours.
Generator		☐	☐	☐	☐	☐	☐	☐	Check that AC connections are clean and secure with no chafing. See *GENERATOR MAINTENANCE* for additional information.
Heat Exchanger Zinc Anode		☐	☐	☐	☐	☐	☐	☐	Inspect zinc anode, replace if needed, clear the heat exchanger end of zinc anode debris.
Fuel/Water Separator			☐	☐	☐	☐	☐	☐	Change every 200 hours.
Electronic Governor Control (if applicable)		☐				☐			Check and or adjust the no-load speed in the panel, required (hertz) and the regulator board adjustment as needed. **NOTE:** *These adjustment are not a warrantable adjustment during or after the unit's break-in.*
Exhaust System		☐		☐		☐		☐	Initial check at 50 hrs., then every 250 hrs. Inspect for leaks. Check anti-siphon valve operation. Check the exhaust elbow for carbon and/or corrosion buildup on inside passages; clean and replace as necessary. Check that all connections are tight.
Engine Hoses			☐	☐	☐	☐	☐	☐	Hose should be hard & tight. Replace if soft or spongy. Check and tighten all hose clamps.

MAINTENANCE SCHEDULE

NOTE: *Use the engine hour meter gauge to log your engine hours or record your engine hours by running time.*

SCHEDULED MAINTENANCE	CHECK EACH DAY	HOURS OF OPERATION							EXPLANATION OF SCHEDULED MAINTENANCE
		50	100	250	500	750	1000	1250	
Raw Water Pump				☐		☐		☐	Remove pump cover and inspect impeller for wear; replace if needed. Also replace gasket. Lubricate both when reassembled.
Coolant System					☐			☐	Drain, flush, and refill cooling system with appropriate antifreeze mix.
Electric Fuel Lift Pump Filter (if applicable)		☐		☐	☐	☐	☐	☐	Initial filter change at 50 hours, then change filter every 250 hours.
DC Alternator				☐		☐		☐	Check DC charge from alternator. Check mounting bracket; tighten electrical connections.
***Fuel Injectors**						☐			Check and adjust injection opening pressure and spray condition (see *ENGINE ADJUSTMENTS*).
***Starter Motor**					☐			☐	Check solenoid and motor for corrosion. Remove and lubricate. Clean and lubricate the starter motor pinion drive.
***Preheat Circuit**					☐			☐	Check operation of preheat solenoid. Remove and clean glow plugs; check resistance (4-6 ohms). Reinstall with anti seize compound on threads.
***Engine Cylinder Compression**					☐			☐	Check compression pressure and timing (see *Engine Adjustments*).
***Torque Cylinder Head Hold-down bolts**		☐			☐		☐		At first 50 hours, then every 500 hours (see *ENGINE ADJUSTMENTS*).
***Adjust the Valve Clearances**		☐			☐		☐		Adjust Valve Clearances (see *ENGINE ADJUSTMENTS*).
***Heat Exchanger**							☐		Remove, have professionally cleaned and pressure tested.
***Internal Water Pump**									Change water pump grease every 4000 hours (BESOO L-2).

*WESTERBEKE recommends this service be performed by an authorized mechanic.

ENGINE COOLING CIRCUIT

DESCRIPTION

Westerbeke marine diesel generators are designed and equipped for fresh water cooling. Heat produced in the engine by combustion and friction is transferred to fresh water coolant which circulates throughout the engine. This circulating fresh water coolant cools the engine block and its internal moving parts. The heat is transferred externally from the fresh water coolant to raw water by means of a heat exchanger; similar in function to an automotive radiator. Raw water flows through the tubes of the heat exchanger while fresh water coolant flows around the tubes; engine heat transferred to the fresh water coolant is conducted through the tube walls to the raw water which is then pumped into the exhaust system where finally it is discharged overboard. In other words, the engine is cooled by fresh water coolant, this coolant is cooled by raw water, and the raw water carries the transferred heat overboard through the exhaust system. The fresh water coolant and raw water circuits are independent of each other. Using only fresh water coolant within the engine allows the cooling water passages to stay clean and free from harmful deposits.

Fresh Water Circuit

NOTE: *Refer to* ENGINE COOLANT *paragraphs in this section for the recommended antifreeze and water mixture to be used as the fresh water coolant and for information on filling the fresh water system.*

Fresh water coolant is pumped through the engine by a belt-driven circulating pump, absorbing heat from the engine. The fresh water coolant circulates through the engine's block absorbing heat, then passes through the thermostat into the exhaust manifold, to the heat exchanger where it is cooled, and then is returned to the engine block through the suction side of the fresh water circulating pump. When the engine is started cold, external coolant flow is prevented by the closed thermostat (although some coolant flow is bypassed around the thermostat to prevent the exhaust manifold from overheating). As the engine warms up, the thermostat gradually opens, allowing full flow of the engine's coolant to flow unrestricted to the external portion of the cooling system.

Coolant Recovery Tank

A coolant recovery tank allows for engine coolant expansion and contraction during engine operation, without any significant loss of coolant and without introducing air into the cooling system. This tank should be located at or above the engine manifold level and should be easily accessible.

CHANGING COOLANT

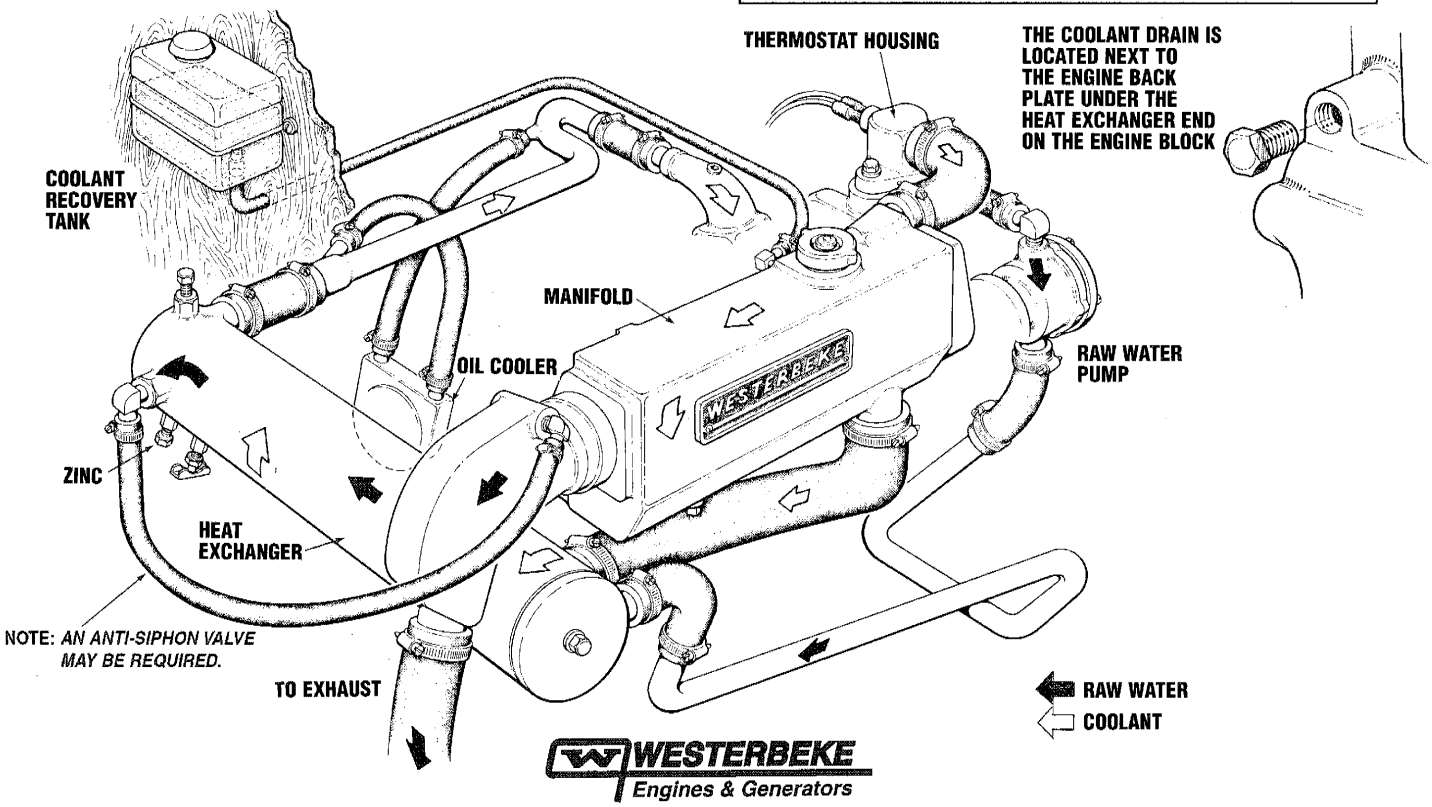
The engine's coolant must be changed according to the *MANTENANCE SCHEDULE*. If the coolant is allowed to become contaminated, it can lead to overheating problems.

> ⚠ **CAUTION:** ***Proper cooling system maintenance is critical; a substantial number of engine failures can be traced back to cooling system corrosion.***

Drain the engine coolant by loosening the drain plug on the engine block and opening the manifold pressure cap. Flush the system with fresh water, then start the refill process.

NOTE: *The petcock on the heat exchanger can also be used to drain engine coolant.*

> ⚠ **WARNING:** ***Beware of the hot engine coolant. Wear protective gloves.***



To Refill With Coolant

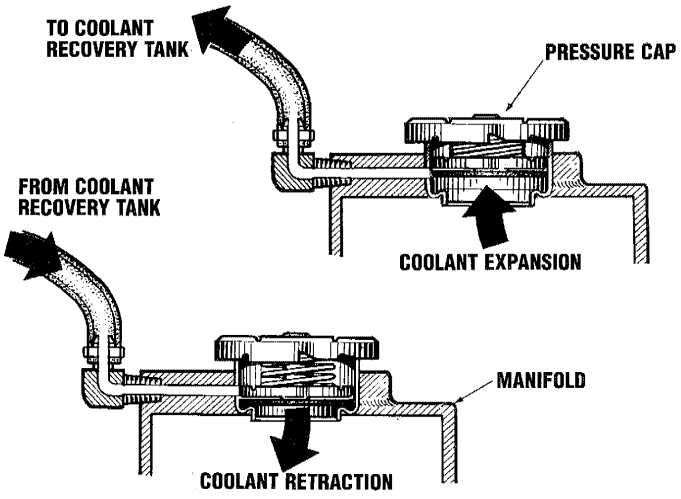
With the engine running in idle, slowly pour clean, premixed coolant into the manifold.

NOTE: *Open the air bleed petcocks near the thermostat housing and heat exchanger to help remove air from the system. When a steady flow of coolant appears at the drain plug opening, close the water drain plug and fill the system until the manifold remains full. Close the petcock on the heat exchanger when antifreeze flows from it.*

Monitor the coolant in the manifold and add as needed. Fill the manifold to the filler neck and install the manifold pressure cap. The petcock on the thermostat housing should be opened when refilling to allow trapped air to escape.

Remove the cap on the coolant recovery tank and fill with coolant mix to halfway between LOW and MAX and replace the cap. Run the engine, close all petcocks and observe the coolant expansion flow into the recovery tank.

After checking for leaks, stop the engine and allow it to cool. Coolant should draw back into the cooling system as the engine cools down. Add coolant to the recovery tank if needed. Clean up any spilled coolant.



NOTE: *Periodically check the condition of the manifold pressure cap. Ensure that the upper and lower rubber seals are in good condition and check that the vacuum valve opens and closes tightly. Carry a spare cap.*

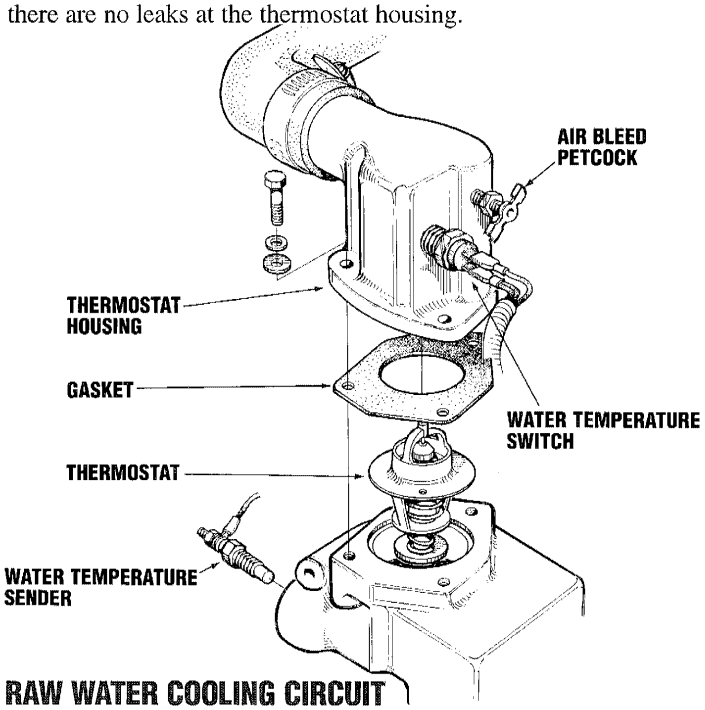
THERMOSTAT

A thermostat, located near the manifold at the front of the engine, controls the coolant temperature, as it continuously flows through the closed cooling circuit. When the engine is first started the closed thermostat prevents coolant from flowing (some coolant is by-passed through a hole in the thermostat to prevent the exhaust manifold from overheating), as the engine warms up the thermostat gradually opens. The thermostat is accessible and can be checked, cleaned, or replaced easily. Carry a spare thermostat and gasket.

To Replace the Thermostat

Remove the three cap screws and disassemble the thermostat housing as shown. When installing the new thermostat and gasket apply a thin coat of sealant on both sides of the gasket before pressing it into place. Do NOT over-tighten the cap screws.

Run the engine and check for normal temperatures and that there are no leaks at the thermostat housing.



RAW WATER COOLING CIRCUIT

The raw water flow is created by a positive displacement impeller pump. This pump draws water directly from the ocean, lake, or river through a hose to the water strainer. The raw water passes from the strainer through the heat exchanger (through the heat exchanger tubes) where it cools the engine circulating fresh water coolant. The raw water is then discharged into the water injected exhaust elbow, mixing with and cooling the exhaust gasses. This mixture of exhaust gas and raw water is pushed overboard.

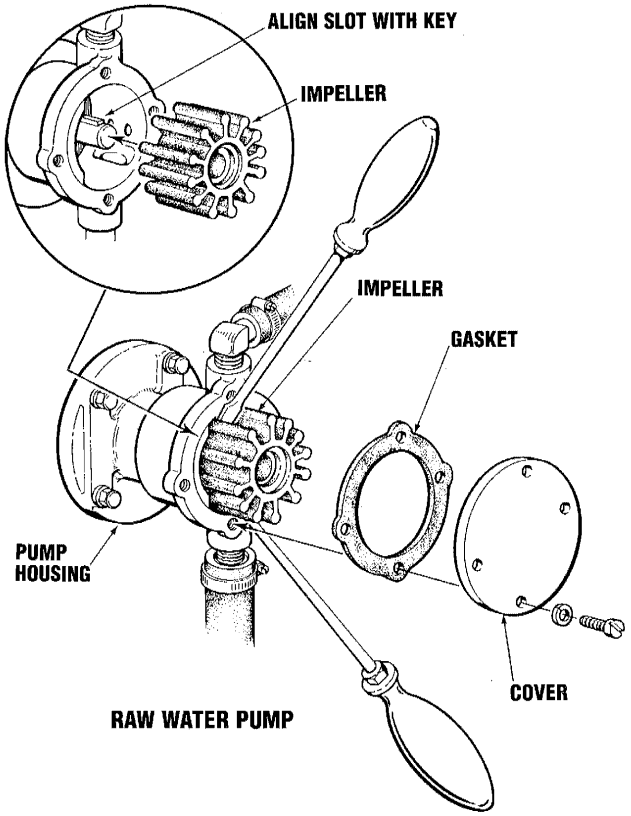
Raw Water Pump

The raw water pump is a self-priming, rotary pump with a non-ferrous housing and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate within the impeller housing, producing the pumping action. On no account should this pump be run dry as water acts as a lubricant for the impeller. There should always be a spare impeller and impeller cover gasket aboard (an impeller kit). Raw water pump impeller failures occur when lubricant (raw water) is not present during engine operation. Such failures are not warrantable, and operators are cautioned to make sure raw water flow is present at start-up.

NOTE: *Should a failure occur with the pump's internal parts (seals and bearings) it may be more efficient to purchase a new pump and rebuild the original pump as a spare..*

Changing the Raw Water Pump Impeller

Close the raw water intake valve. Remove the impeller with the aid of two small screwdrivers, as illustrated, and carefully pry the impeller out of the pump. Install the new impeller and gasket by positioning the hub pin to align with the slot in the drive shaft. Move the blades to conform to the curved cam plate and push the impeller into the pump's housing. When assembling, apply a thin coating of lubricant to the impeller and gasket. Open the raw water intake valve.



RAW WATER PUMP

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

Heat Exchanger

The heat exchanger is a copper tube which encloses a number of small copper tubes. Raw water is pumped through the small copper tubes and the freshwater coolant from the engine is circulated around the copper tubes. The raw water removes heat from the freshwater coolant.

Zinc Anode

A zinc anode, or pencil, is located in the raw water cooling circuit within the heat exchanger. The purpose of the zinc anode is to sacrifice itself to electrolysis action taking place in the raw water cooling circuit, thereby reducing the effects of electrolysis on other components of the system. The condition of the zinc anode should be checked monthly and the anode cleaned or replaced as required. Spare anodes should be carried on board.

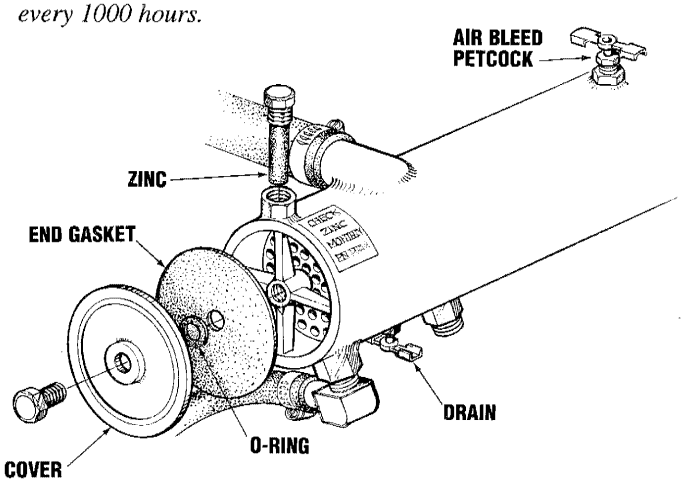
NOTE: *Electrolysis action is the result of each particular installation and vessel location; not that of the generator.*

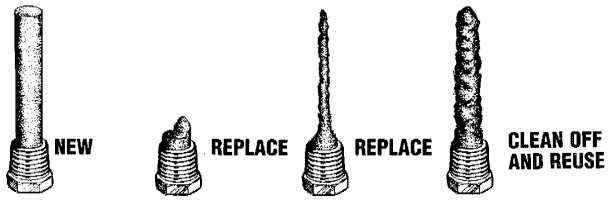
If the zinc pencil needs replacement, hold the hex boss into which the zinc pencil is threaded with a wrench while loosening the anode with another wrench. This prevents the hex boss from possibly tearing off the exchanger shell. After removing the zinc, note the condition of it. If the zinc is in poor condition, there are probably a lot of zinc flakes within the exchanger. Remove the end of the heat exchanger and clean the inside of all zinc debris. Always have a spare heat exchanger end gasket in case the present one becomes damaged when removing the end cover. Replace the gasket (refer to your engine model's heat exchanger end gasket part number), o-ring, cover, and install a new zinc pencil.

Heat Exchanger Service

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

NOTE: *Operating in silty and/or tropical waters may require that a heat exchanger cleaning be performed more often than every 1000 hours.*





ZINC ANODES

DIESEL FUEL

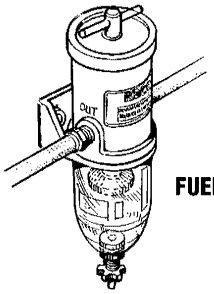
Use No. 2 diesel fuel with a cetane rating of 45 or higher. Do not use kerosene or home heating fuel.

FUEL WATER SEPARATOR

A primary fuel filter of the water separating type must be installed between the fuel tank and the engine to remove water and other contaminants from the fuel before they can be carried to the fuel system on the engine.

Most installers include a filter/water separator with the installation package as they are aware of the problems that contaminants in the fuel can cause.

A typical fuel filter/water separator is illustrated in this diagram. This is the Raycor Model 500 MA. Keep in mind that if a water separator type filter is not installed between the fuel supply tank and engine-mounted fuel system, any water in the fuel will affect the fuel pump, engine filter, and injection equipment. The owner/operator is responsible for making certain the fuel reaching the engine's injection equipment is free of impurities. This process is accomplished by installing and maintaining a proper filtration/separation system.



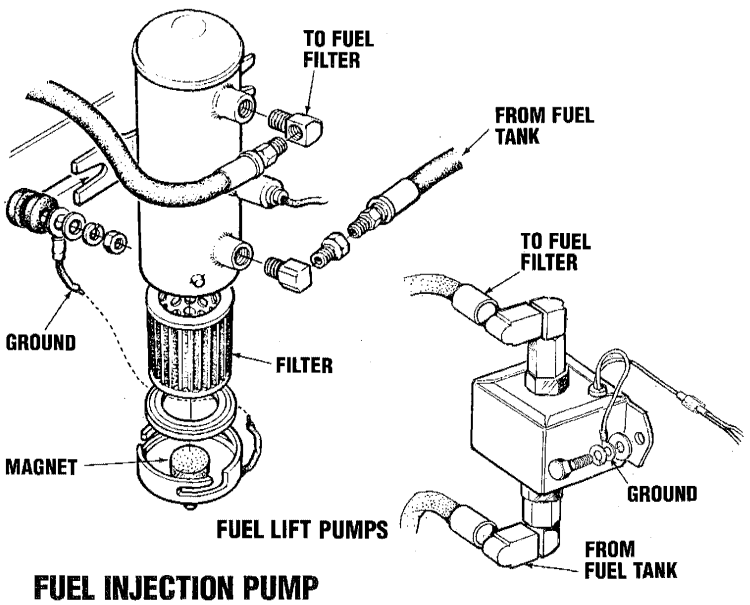
FUEL WATER SEPARATOR

FUEL LIFT PUMP

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

> ⚠ **WARNING:** ***Fuel leakage at the fuel pump or its connections is a fire hazard and should be corrected. Make sure proper ventilation exists whenever servicing fuel system components.***

NOTE: *Some 15.0 BTDA Generators have a cylindrical type fuel pump. This pump uses a replaceable filter element. This element should be changed during regular scheduled maintenance.*

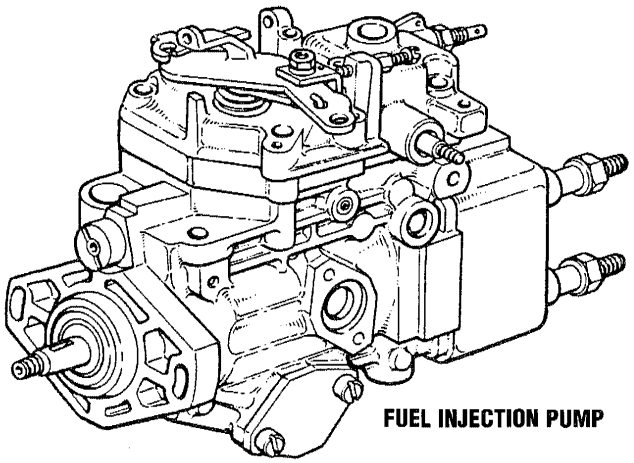


FUEL INJECTION PUMP

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

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

NOTE: *When servicing the injection pump, the service shop must be advised that the pump is being used in a generator application. The service shop will have to remove a timing shim located behind the oval cover attached to the lower side of the injection pump and replace the governor spring with a propulsion spring. Once the injector pump is set up to propulsion specifications, the generator governor spring and the timing shim are reinstalled in the injection pump and the pump remounted on the engine. Then set the throttle for proper engine no-load speed (Hertz).*



FUEL INJECTION PUMP

FUEL FILTERS

The fuel injection pump and the fuel injectors are precisely manufactured and they must receive clean diesel fuel, free from water and dirt. To ensure this flow of clean fuel, the fuel must pass through at least two fuel filters, a fuel water separator and the engine's spin-on fuel filter. Visually inspect, clean, and change these filters according to the maintenance schedule in this manual.

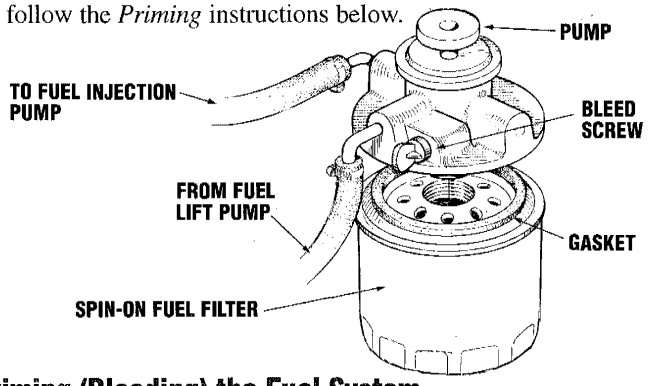
Changing the Fuel Filter

> ⚠ **WARNING:** ***Shut off the fuel valve at the tank when servicing the fuel system. Take care in catching any fuel that may spill. DO NOT allow any smoking, open flames or other sources of fire near the fuel system when servicing. Ensure proper ventilation exists when servicing the fuel system.***

1. Shut fuel supply off.
2. Loosen the fuel filter turning counterclockwise with a filter wrench.

NOTE: *The cartridge contains fuel. Take care not to spill it during disassembly. Perform the* PRIMING THE FUEL SYSTEM *after replacing the spin-on filter.*

3. Wipe clean the sealing face on the housing bracket with a rag, so the new filter can be seated properly.
4. Lightly oil the sealing o-ring on the new filter. To reinstall, turn the filter assembly clockwise carefully until the o-ring contacts the sealing surface of the housing bracket. Turn 2/3 further with the filter wrench.
5. Turn on the fuel and start the engine. The normal preheat function should quickly prime the system and the engine should start. If the engine should fail to start immediately, follow the *Priming* instructions below.



Priming (Bleeding) the Fuel System

The on-engine fuel system is nearly self-bleeding. Under ordinary circumstances the engine's electric fuel lift pump, which is energized by the preheat button, will supply a continuous flow of fuel from the tank. This fuel is drawn through the fuel/water separator to the engine lift pump, the primary spin-on fuel filter, and the injection pump.

There is, however, one bleed point in the on-engine fuel system to open for the removal of air. This bleed screw is located on the housing for the spin on fuel filter mounted on the engine. This screw should be opened one or two turns to remove air from the upper housing area of the fuel filter. Energizing the preheat switch for 10-20 seconds or by using the palm of one's hand to slowly depress and release the primer pump on the top of the filter housing will force air in this area out through this bleed point. Once all air is expelled, tighten the bleed screw.

NOTE: *When using the preheat function to bleed air from the filter assembly, keep in mind that the preheat elements (glow plugs) are being energized. Take care not to overheat them.*

Once the fuel filter is bled of air and the bleed screw tightened again, depress the preheat switch 10-20 seconds or slowly pump the primer on the fuel filter housing to force any air in the system between the filter housing and the injection pump out of the system and back to the fuel tank through the return.

> ⚠ **WARNING:** ***Do not allow smoking or open flames near the fuel system when servicing. Also provide proper ventilation.***

Fuel Pressure Gauge

Some 15.0 KW Generator models are equipped with a fuel line pressure gauge attached to the engine's primary fuel filter. The pressure gauge indicates the fuel inlet pressure. An ideal positive fuel supply flow should read 2.5 to 3.5 psi. Pressure below 1.5 psi will result in poor engine performance.

NOTE: *Low pressure is usually caused by unclean fuel, or in some cases, improper installation of fuel tanks and fuel lines.*

Fuel Additives

If fungus or bacteria is causing fuel problems you should have an authorized dealer correct these problems. Then use a diesel fuel biocide to sterilize the fuel (follow the manufacturers instructions).

Spares

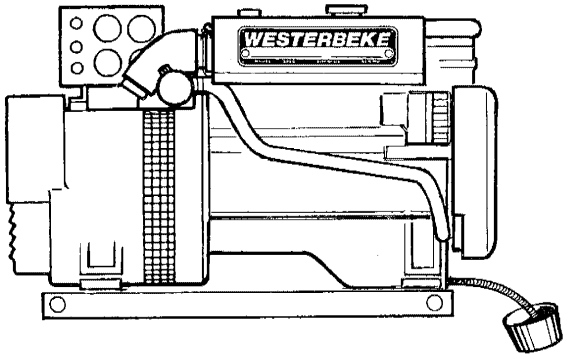
While the likelihood of having to service the system at sea is slim, the possibility does exist. Therefore, we recommend that banjo washers, injector seat washers, and a fuel filter be carried on board at all times. Purchase needed spares from your local WESTERBEKE dealer or distributor. If a leak should develop at a banjo washer that cannot be corrected by a simple tightening of the fitting, replace the sealing washer with a replacement found in the hardware kit for your model.

Engine Oil Change

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

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

Always observe the used oil as it is removed. A yellow/gray emulsion indicates the presence of water in the oil. Although this condition is rare, it does require prompt attention to prevent serious damage. Call a competent mechanic should water be present in the oil. Raw water present in the oil can be the result of a fault in the exhaust system attached to the engine and/or a siphoning of raw water through the raw water cooling circuit into the exhaust, filling the engine. This problem is often caused by the poor location or the lack of an anti-siphon valve.

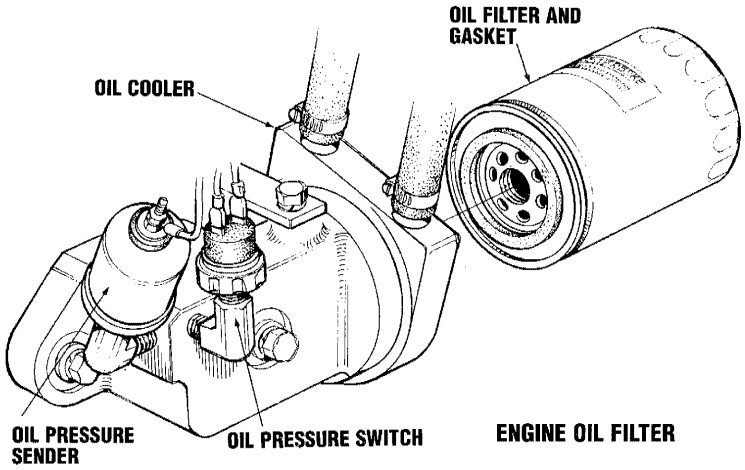


2. **Replacement of the Oil Filter.** When removing the used oil filter, you may find it helpful and cleaner to punch a hole in the upper and lower portion of the old filter to drain the oil from it into a container before removing it. This helps to lessen spillage. A small style automotive filter wrench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

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

Place some paper towels and a plastic bag around the filter when unscrewing it to catch any oil left in the filter. (Oil or any other fluid on the engine reduces the engine's cooling ability. Please keep your engine clean.) Inspect the old oil filter as it is removed to make sure that the rubber sealing gasket came off with the old oil filter. If this rubber sealing gasket remains sealed against the engine block, gently remove it.

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



NOTE: *Generic filters are not recommended, as the material standards or diameters of important items on generic parts might be entirely different from genuine parts. Immediately after an oil filter change and oil fill, run the engine to make sure the oil pressure is normal and that there are no oil leaks around the new oil filter.*

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

> ⚠ **WARNING:** ***Used engine oil contains harmful contaminants. Avoid prolonged skin contact. Clean skin and nails thoroughly using soap and water. Launder or discard clothing or rags containing used oil. Discard used oil properly.***

Oil Pressure

The engine's oil pressure, during operation, is indicated by the oil pressure guage on the instrument panel. During normal operation, the oil pressure will range between 50 and 65 psi.

NOTE: *A newly started, cold engine can have an oil pressure reading upwards of 65 psi. A warmed engine can have an oil pressure reading as low as 35 psi. These readings will vary depending upon the temperature of the engine and the load placed on the generator.*

REMOTE OIL FILTER (OPTIONAL)

INSTALLATION

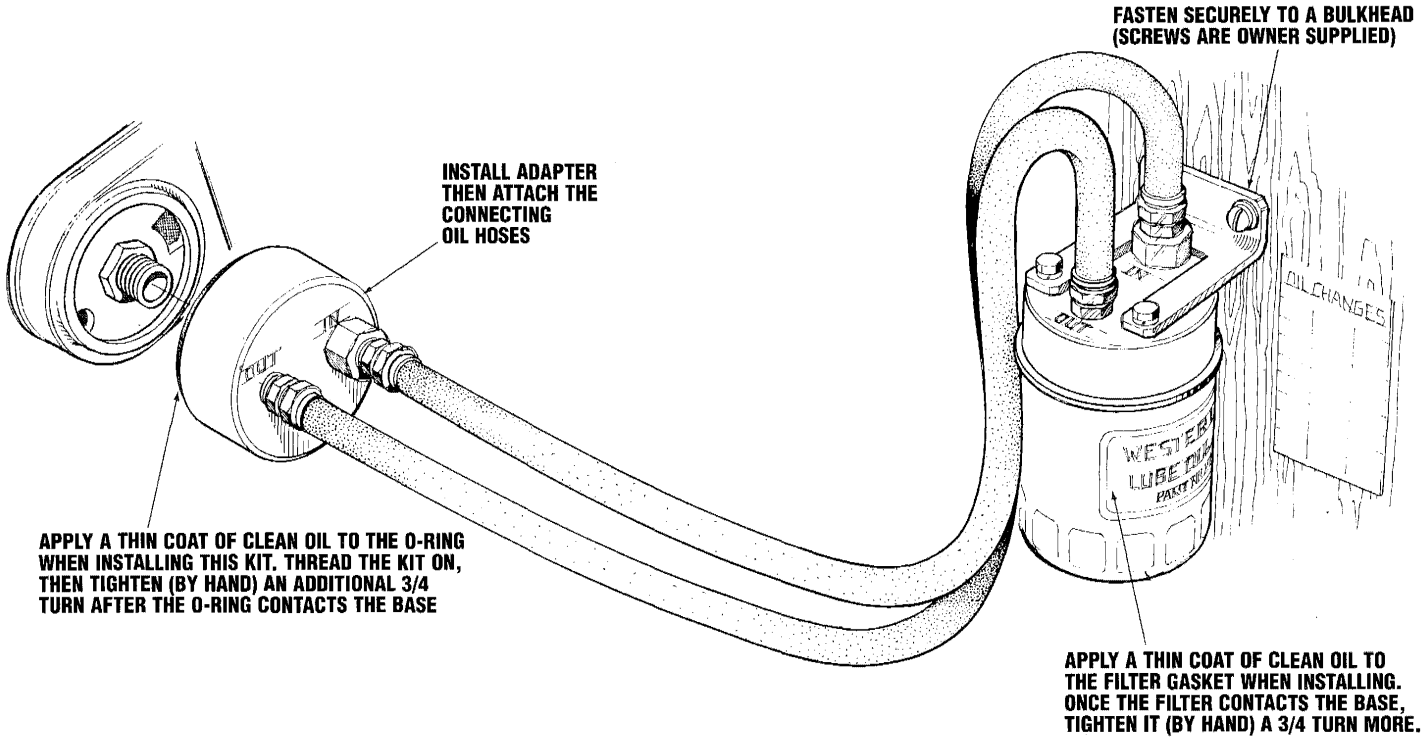
This popular accessory is used to relocate the engine's oil filter from the engine to a more convenient location such as an engine room bulkhead.

NOTE: *Refer to the* ENGINE OIL CHANGE *page 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.*



DC ELECTRICAL SYSTEM

DESCRIPTION

The DC Circuit on the 15.0 KW BTDA and BTDB functions to start, operate and stop the generator engine. The circuit is best understood by reviewing the DC WIRING SCHEMATICS for the model generator you have (#039422 with electronic governing or #036411 without electronic governing). The engine's DC wiring is designed with three simple basic circuits: preheat, start, and run or stop.

Engine 12-Volt DC Control Circuit

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

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

Battery Specification

The minimum recommended capacity of the battery used in the engine's 12-volt DC control circuit is 90-125 ampere hours.

Battery Care

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

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

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

GLOW PLUGS

The glow plug is a small heater installed in each pre-combustion chamber. They run off the engine starting battery and become red hot when activated.

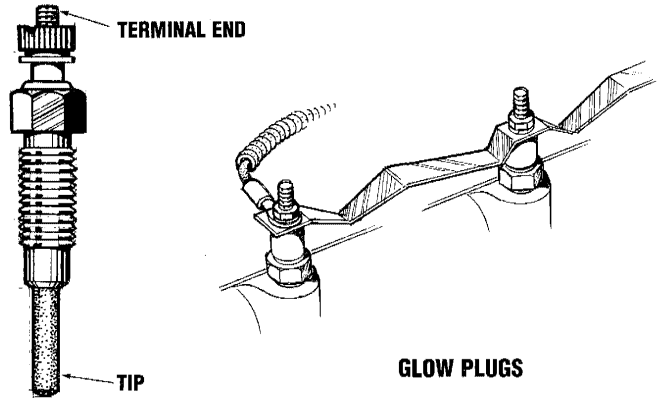
The glow plugs are wired through the preheat solenoid. When PREHEAT is pressed at the control panel this solenoid should "click" on and the glow plug should begin to get hot.

Glow plugs can be checked by unscrewing and holding them against a good ground (engine block) and turning them on. The tip should glow red hot. You can also use an ammeter to test the power drain (8 to 9 amps per plug), or an ohmmeter to test resistance (1.1 to 1.2 ohms).

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

Re-install the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) with 20 to 25 seconds. If the plugs don't heat up quickly, check for a short circuit.

> ⚠ **CAUTION:** ***Do not keep glow plug on for more than 30 seconds.***



DRIVE BELT ADJUSTMENT

> ⚠ **CAUTION:** ***Drive belts must be properly tensioned. Loose drive belts will not provide proper alternator charging and will eventually damage the alternator. Drive belts that are too tight will pull the alternator out of alignment and/or cause the alternator to wear out prematurely.***

For proper drive belt adjustment, see the *ENGINE ADJUSTMENTS* section of this manual.

CHARGING SYSTEM

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

Alternator Troubleshooting

If you suspect that the alternator is not producing enough voltage to charge the engine's battery, check the following:

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

☐ Make certain your alternator is securely mounted.

☐ Check the drive belts for proper tension.

☐ Inspect for loose or disconnected wires at the alternator.

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

> ⚠ **WARNING:** ***Shut off the engine battery switch or disconnect from the battery when working on the engine electrical system.***

Checking for Proper Voltage

If you suspect the alternator has failed, perform the following tests with the engine off:

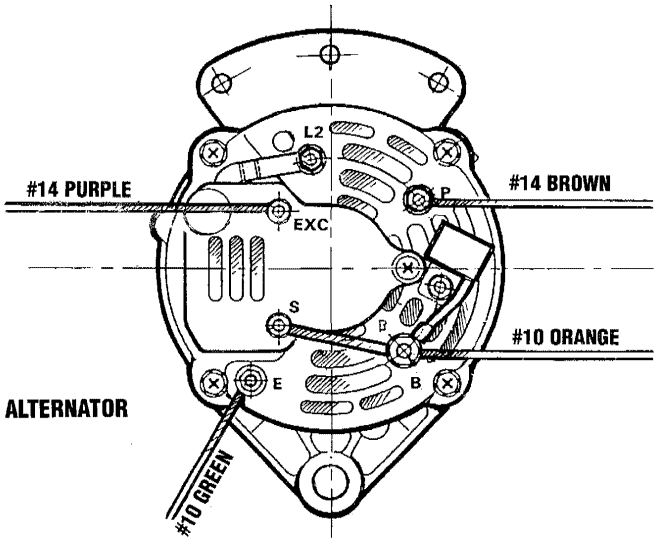
1. Using a voltmeter, connect the voltmeter red wire clip to the output terminal B.
2. Connect the voltmeter negative wire to any ground on the engine.
3. Check the battery voltage. If the battery is in good condition it should read 12 to 12.5 volts.
4. Check the voltage between the alternator (+) positive terminal B and any engine ground. If the circuit is good, the voltage at the alternator should be the same as the battery (unless there's an isolator in the circuit, then the reading would be zero).

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

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

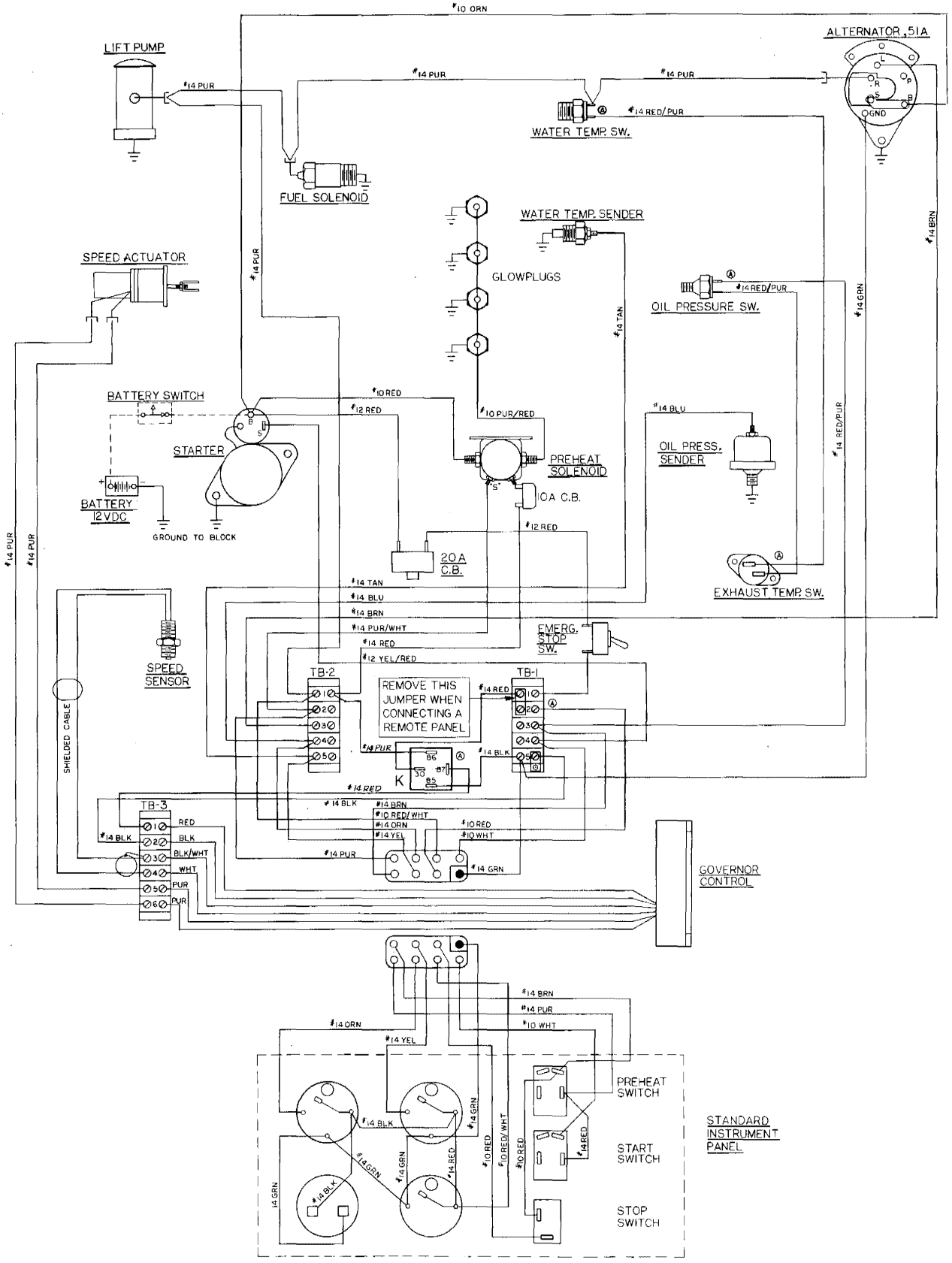
5. Start the engine.
6. The voltage reading for a properly operating alternator should indicate between 13.5 and 14.5 volts. If your alternator is over or undercharging, have it repaired at a reliable service shop.

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

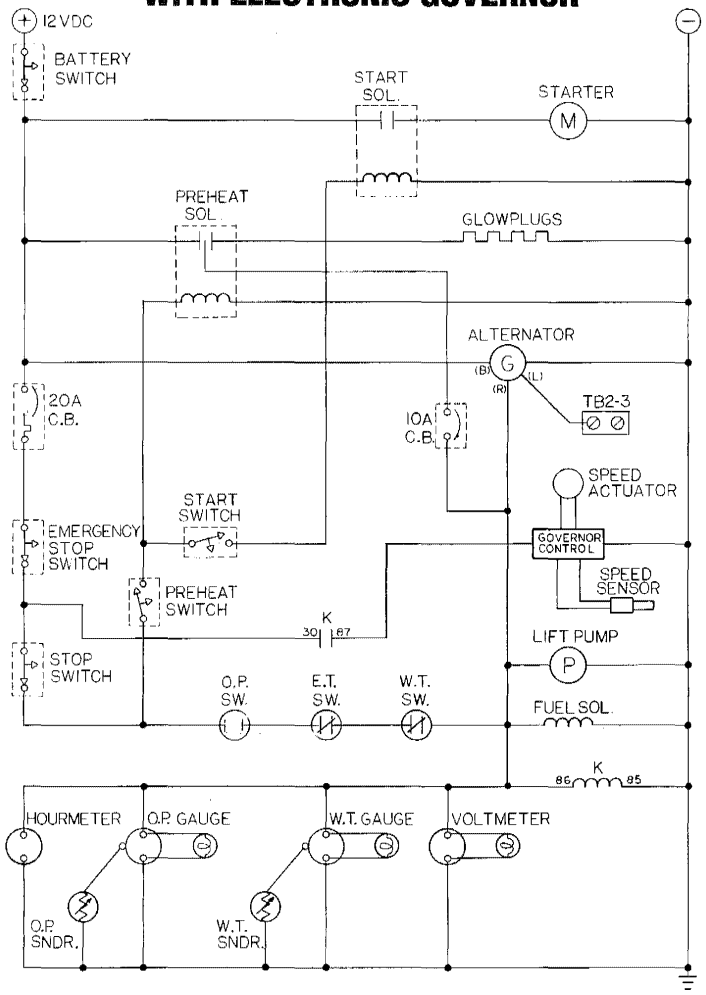


51 AMP ALTERNATOR

DC ELECTRICAL SYSTEM
WIRING DIAGRAM #39422
WITH ELECTRONIC GOVERNOR

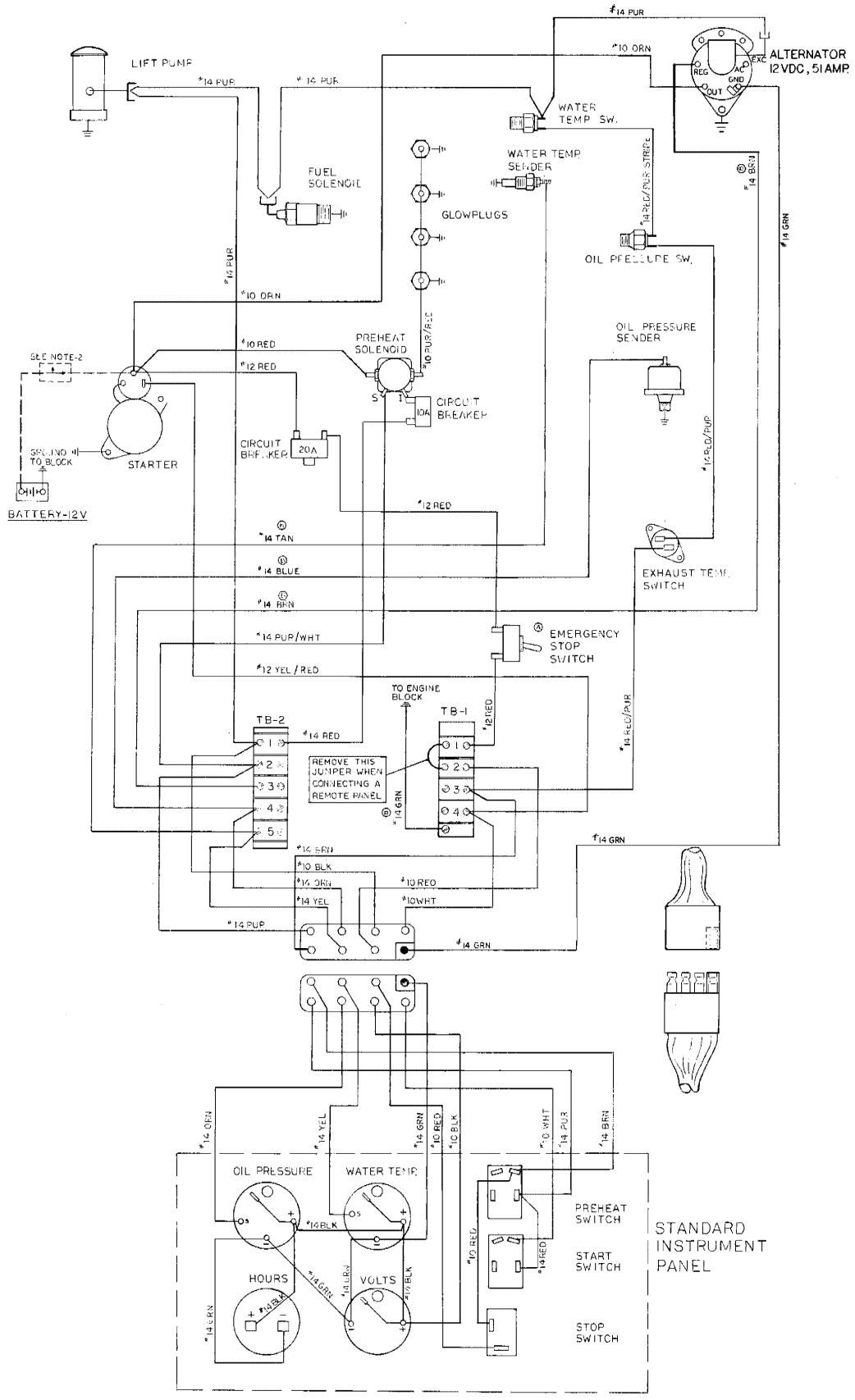


DC ELECTRICAL SYSTEM
WIRING SCHEMATIC #39422
WITH ELECTRONIC GOVERNOR

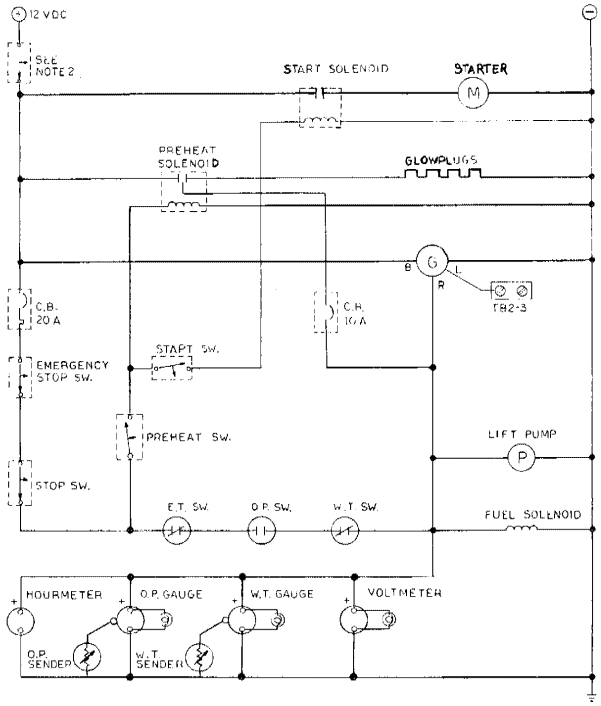


NOTE: *An on-off switch should be installed in this circuit to disconnect the starter from the battery in an emergency and when leaving the boat. Twelve volt diesel engine starters typically draw 200 to 300 amps when cranking. A switch with a continuous rating of 175 amps at 12 VDC will normally serve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

DC ELECTRICAL SYSTEM
WIRING DIAGRAM #36411

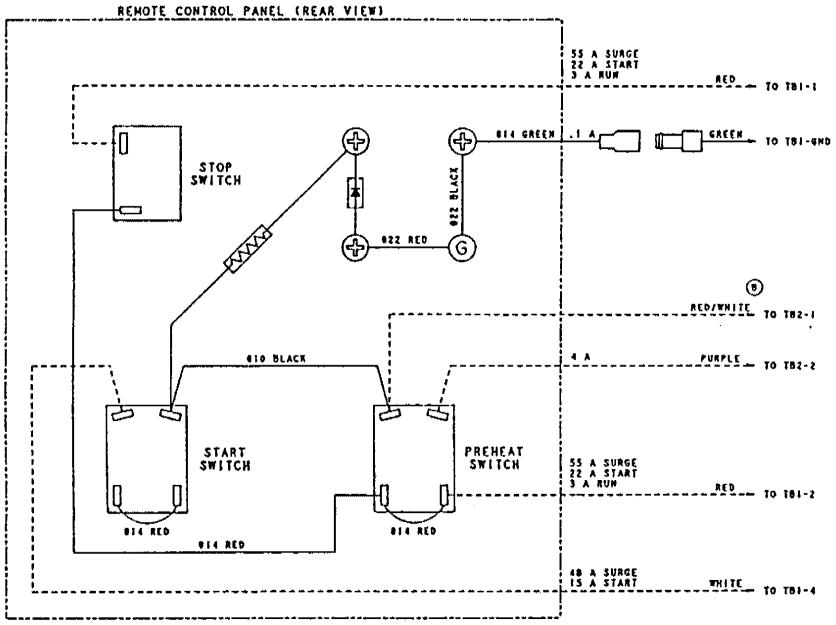


DC ELECTRICAL SYSTEM
WIRING SCHEMATIC #36411



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

REMOTE CONTROL PANEL



ENGINE ADJUSTMENTS

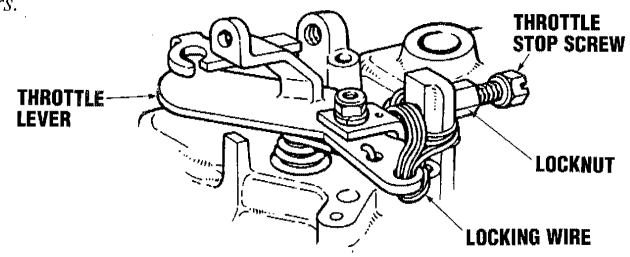
NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

ENGINE SPEED (HERTZ) ADJUSTMENT

Constant engine/generator speed is maintained by the governor mechanism inside the fuel injection pump. No-load speed is adjusted by positioning the throttle lever against the adjustable throttle stop screw, lock wiring it in that position and tensioning the throttle stop screw against the throttle lever and securing it with its lock nut. Moving the throttle lever to the right increases engine speed (Hertz) and moving the throttle lever left lowers engine speed (Hertz).

These adjustments may be required during the engine's break-in period (first 50 hours) and occasionally after this period. A no-load voltage adjustment may also be required in conjunction with this speed adjustment. These are not considered warrantable adjustments as they relate to normal maintenance.

NOTE: *See the ELECTRONIC GOVERNOR section in this manual for adjustments of generators with electronic governors.*



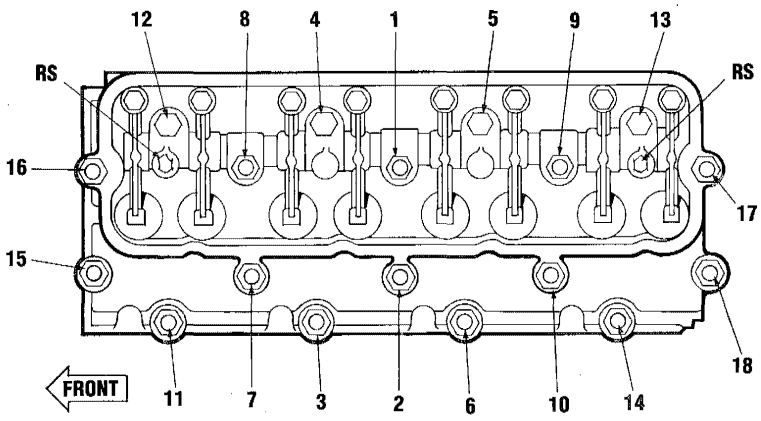
Adjust for: 61.5 - 62.0 Hertz at no-load

58.5 - 59.0 Hertz at full rated generator load.

TORQUING THE CYLINDER HEAD BOLTS

After the intial break-in period (approximately 50 hours), the cylinder head bolts should be re-torqued.

Tighten the cylinder head bolts according to the sequence shown. Make sure the engine is cold when this is done, and loosen one head bolt one-half turn and then tighten it between 80 - 85 lb-ft (11.0 - 11.7 kg/m). Then proceed to the next head bolt in the sequence. Tighten the RS (rocker cover stud) securely.

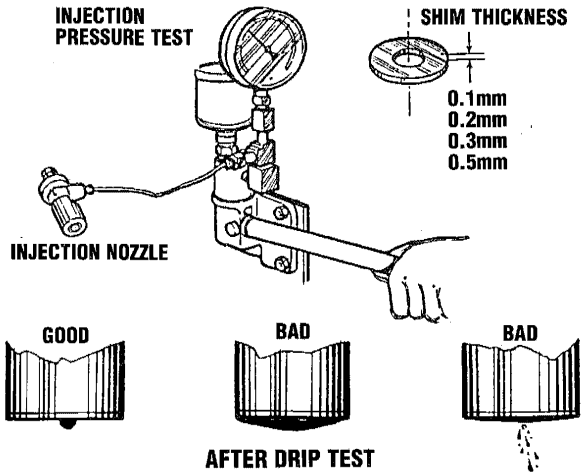


CYLINDER HEAD BOLT PATTERN

TESTING FUEL INJECTORS

Remove and check fuel injectors.

The injector spray pressure should be 1920 psi ± 71 psi (135 kg/cm² ± 5.0 kg/cm²). Undesirable injector conditions, to include after dripping, should be eliminated.



CHATTERING TEST

For the chattering test, operate the tester lever slowly. If the nozzle sprays sharply and intermittently, the nozzle is considered good. The nozzle should spray fuel straight in its axial direction. A nozzle is defective if it sprays fuel in a wrong direction, in several separate strips, or in the form of particles. These defects may sometimes be caused by clogging with dust, therefore all parts should be cleaned carefully before reassembly.

ENGINE COMPRESSION

Check the engine's compression pressure at 500 and 1250 operating hours or whenever engine performance is reduced. Remove each glow plug and check each cylinder's compression pressure. The engine's cranking speed is at 280 rpm.

Compression values:

Standard	Minimum
427 psi (30 kg/cm²)	384 psi (27 kg/cm²)

The maximum acceptable difference between cylinders is 43 psi (3.0 kg/cm²).

ENGINE ADJUSTMENTS

NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

VALVE CLEARANCE ADJUSTMENT

NOTE: *Retorque the cylinder head bolts before adjusting the engine's valves. See* TORQUING THE CYLINDER HEAD BOLTS.

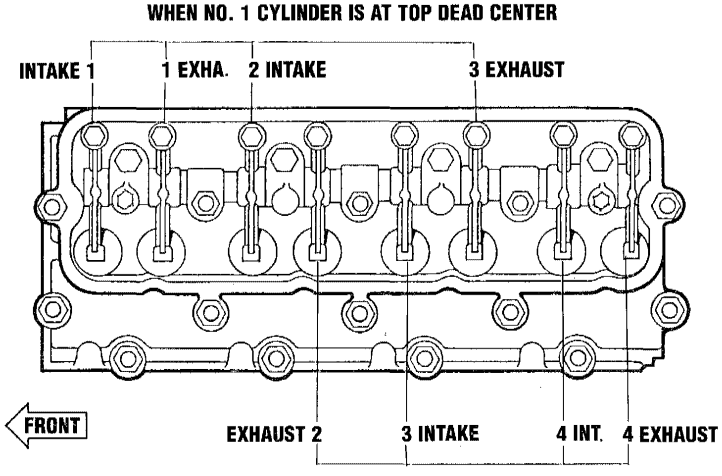
> ⚠ **CAUTION:** ***Adjust the valve clearance when the engine is cold. Valves are adjusted by cylinder in the firing order of the engine. Tighten the cylinder head bolts to the specified torque before adjusting the valves.***

Pull off the air breather pipe from the rocker cover, and take off the rocker cover bolts and the rocker cover to expose the rocker shaft and valve assembly.

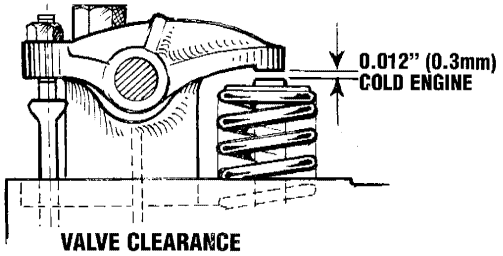
Position the No. 1 piston at Top Dead Center (TDC) on its compression stroke and adjust the # 1, 2, 3 and 6 valves as illustrated.

Position the No. 4 piston at TDC of its compression stroke and adjust the # 4, 5, 7 and 8 valves. The valves are numbered 1 to 8 from the front of the engine to the back.

Adjust each valve's clearance by inserting a 0.012 inch (0.3 mm) feeler gauge between the rocker arm and the valve stem. Make sure to adjust all valves to 0.012 inches (0.3 mm) while the engine is cold.



VALVE ADJUSTMENT SEQUENCE



DRIVE BELT ADJUSTMENT

For your safety, Westerbeke generator models come equipped with belt guards that cover over the belt(s) on the front of the engine. ("Out of sight - out of mind." The belt guard is NOT installed for that purpose.) Operators are advised that proper inspection, service, and maintenance is required.

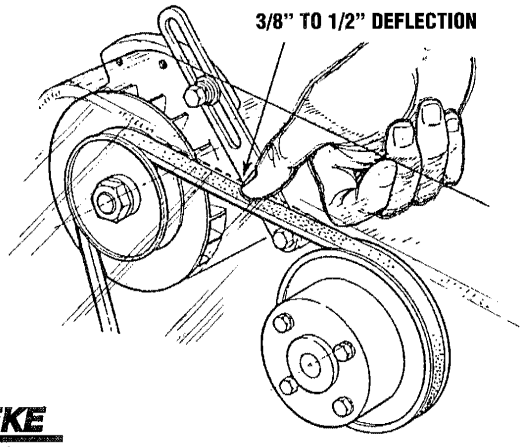
Drive belts must be properly tensioned. Loose drive belts will not provide proper alternator charging and will eventually damage the alternator. Drive belts that are too tight will pull the alternator out of alignment and/or cause the alternator to wear out prematurely. Excessive drive belt tension can also cause rapid wear of the belt and reduce the service life of the 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.

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

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

Adjusting Belt Tension

1. Remove the belt guard.
2. Loosen the alternator adjusting strap bolt and the base mounting bolt.
3. With the belt loose, inspect for wear, cracks, and frayed edges.
4. Pivot the alternator on the base mounting bolt to the left or right as required, to loosen or tighten.
5. Tighten the base mounting bolt and the adjusting strap bolt.
6. Operate the generator for about 5 minutes then shut down and recheck the belt tension.
7. Replace the guard.



ELECTRONIC GOVERNING SYSTEM

The system is composed of three basic components:

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

Controller Adjustments

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

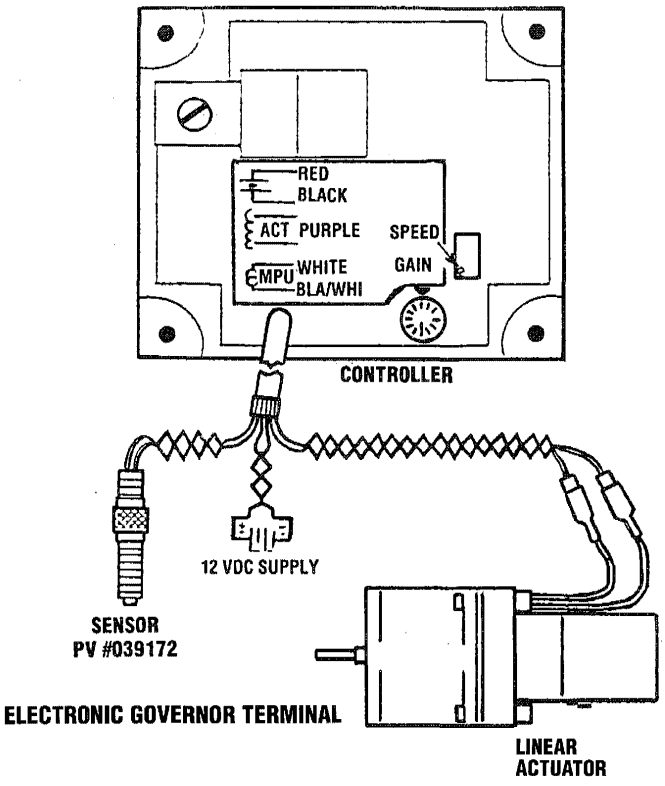
NOTE: *A high gain adjustment can induce an oscillating of the actuator producing a hunting mode. In such cases, lessen the gain adjustment.*

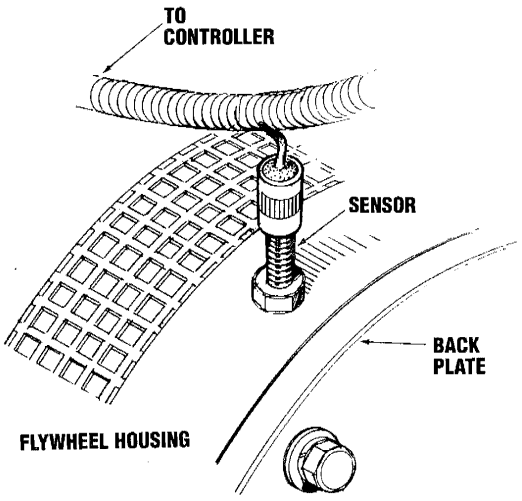
Calibration

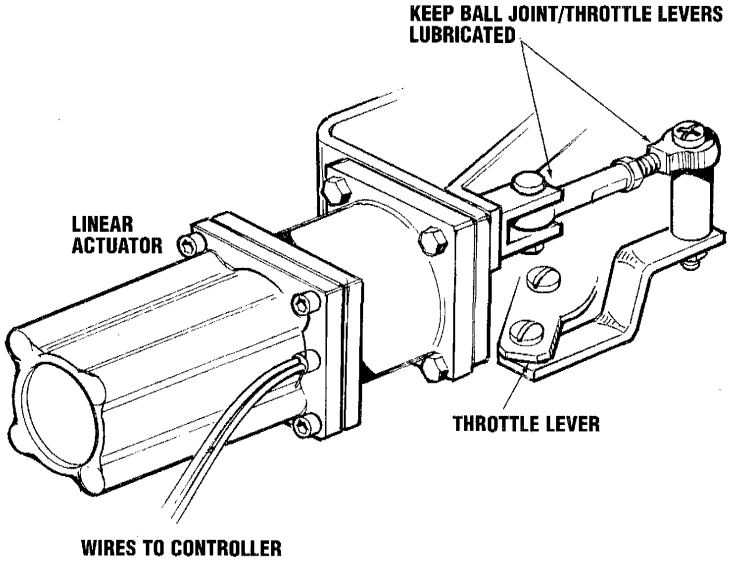
1. With no power to the governor (engine not running) adjust the GAIN potentiometer to 9:00 o'clock.
2. Start the engine and adjust the speed by turning the SPEED potentiometer clockwise to desired speed.

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

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







TROUBLESHOOTING THE ELECTRONIC GOVERNOR

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

CONTROL PANEL TROUBLESHOOTING

MANUAL STARTER DISCONNECT (TOGGLE SWITCHES)

NOTE: *The engine control system is protected by a 20 amp manual reset circuit breaker mounted on a bracket at the top rear of the engine near the* PREHEAT *circuit.*

Problem	Probable Cause	Verification/Remedy
PREHEAT depressed, no panel indications electric fuel pump and preheat solenoid not energized.	1. Oil Pressure switch. 2. 20 amp circuit breaker tripped.	1. Check switches and/or battery connections. 2. Reset breaker. If it opens again, check preheat solenoid circuit and run circuit for shorts to ground.
START SWITCH DEPRESSED, no starter engagement.	1. Connection to solenoid faulty. 2. Faulty switch. 3. Faulty solenoid. 4. Loose battery connections. 5. Low battery.	1. Check connection. 2. Check switch with ohmmeter. 3. Check that 12 volts are present at the solenoid connection. 4. Check battery connections. 5. Check battery charge state.
ENGINE CRANKS, does not start.	1. Faulty fueling system. 2. Check for air in the fuel system. 3. Faulty fuel lift pump.	1. Check for fuel. 2. Allow system to bleed. 3. Replace fuel lift pump.
NOT CHARGING BATTERY	1. Faulty alternator drive.	1. Check the drive belt and its tension. Be sure the alternator turns freely. Check for loose connections. Check the output with a voltmeter. Ensure 12V are present at the regulator terminal.
BATTERY RUNS DOWN	1. Oil pressure switch. 2. High resistance leak to ground. 3. Low resistance leak to ground. 4. Faulty alternator.	1. Observe if the gauges and panel lights are activated when the engine is not running. Test the oil pressure switch. 2. Check the wiring. Insert sensitive (0-.25 amp) meter in battery lines (Do NOT start engine). Remove connections and replace after short is located. 3. Check all wires for temperature rise to locate the fault. 4. After a good battery charging, disconnect alternator at output. If leakage stops. Remove alternator and bench test. Repair or replace.

TROUBLESHOOTING WATER TEMPERATURE AND OIL PRESSURE GAUGES

If the gauge reading is other than what is normally indicated by the gauge when the instrument panel is energized, the first step is to check for 12 volts DC between the ignition (B+) and the Negative (B-) terminals of the gauge.

Assuming that there is 12 volts as required, leave the instrument panel energized and perform the following steps:

1. Disconnect the sender wire at the gauge and see if the gauge reads zero, which is the normal reading for this situation.
2. Remove the wire attached to the sender terminal at the gauge and connect it to ground. See if the gauge reads full scale, which is the normal reading for this situation.

If both of the above gauge tests are positive, the gauge is undoubtedly OK and the problem lies either with the conductor from the sender to the gauge or with the sender.

If either of the above gauge tests are negative, the gauge is probably defective and should be replaced.

Assuming the gauge is OK, check the conductor from the sender to the sender terminal at the gauge for continuity.

Check that the engine block is connected to the ground. Some starters have isolated ground terminals and if the battery is connected to the starter (both plus and minus terminals), the ground side will not necessarily be connected to the block.

ENGINE TROUBLESHOOTING

The tables which follow indicate troubleshooting procedures based upon certain problem indicators, the probable causes of the problems, and the recommendations to overcome these problems.

Note: *The engine's electrical system is protected by a 20 amp manual reset circuit breaker located on a bracket at the rear of the engine. The preheat solenoid is close by, as is the emergency* STOP *switch, which may be mounted on the same bracket or on the back of the instrument panel, depending upon the generator model.*

Problem	Probable Cause	Verification/Remedy
Key switch on, PREHEAT switch depressed: no panel indications; fuel solenoid or electrical fuel pump	1. Battery Switch not on.	1. Check switch and/or battery connections.
	2. Emergency stop switch off.	2. Check emergency stop switch position.
	2. 20-Amp circuit breaker tripped.	2. Reset breaker; if breaker trips again, check preheat solenoid circuit and check circuit for shorts to ground.
	3. 10-Amp breaker tripped on preheat solenoid.	3. Check voltage at and after breaker on preheat solenoid.
	4. Loose battery connections.	4. Check (+) connection to starter solenoid and (-) connection to engine ground stud. Check battery cable connections.
	5. Preheat solenoid not operating.	5. Check solenoid "S" terminal for voltage.
START SWITCH DEPRESSED, no starter engagement.	1. Connection to solenoid faulty.	1. Check connection.
	2. Faulty switch.	2. Check switch with ohmmeter.
	3. Faulty solenoid.	3. Check that 12 volts are present at the solenoid connection.
	4. Loose battery connections.	4. Check battery connections.
	5. Low battery.	5. Check battery charge state.
START switch is depressed; panel indications OK; starter solenoid OK fuel solenoid not functioning.	1. Poor connections to fuel solenoid.	1. Check connections.
	2. Defective fuel solenoid.	2. Check that 12 volts are present at the (+) connection on the fuel run solenoid.
Generator engine cranks, but does not start, fuel solenoid energized.	1. Faulty fueling system.	1. Check that fuel valves are open.
		1a. Switch to combine house and start batteries.
		1b. Replace batteries.
		2c. Check fuel lift pump.
	2. Preheat solenoid faulty.	2. Check solenoid.
Engine can't be stopped.	1. Faulty DC alternator.	1. Remove Exc. connection at alternator, repair alternator.
Battery runs down.	1. Oil Pressure switch.	1. Observe if gauges and panel lights are activated when engine is not running. Test the oil pressure switch.
	2. High resistance leak to ground.	2. Check wiring. Insert sensitive (0 - .25 amp) meter in battery lines. (Do not start engine.) Remove connections and replace after short is located.
	3. Low resistance leak.	3. Check all wires for temperature rise to locate the fault.
	4. Poor battery connections.	4. Check cable connections at battery for loose connections, corrosion.
	5. DC alternator not charging..	5. Check connections, check belt tension, test alternator. See *DC ELECTRICAL SYSTEM/ALTERNATOR.*
Battery not charging	1. DC charge circuit faulty.	1. Perform D.C. voltage check of generator charging circuit. See *Testing the Battery Charging Circuit* in this manual.
	2. Alternator drive.	2. Check drive belt tension. Alternator should turn freely. Check for loose connections. Check output with voltmeter. Ensure 12 volts are present at the Exc. terminal.
Generator engine stops.	1. Fuel lift pump failure.	1. Fuel lift pump should make a distinct ticking sound. Replace pump with spare.
	2. Switches and/or wiring loose or disconnected.	2. Inspect wiring for short circuits and loose connections. Inspect switches for proper operation.
	3. Fuel starvation.	3. Check fuel supply, fuel valves, fuel lift pump.
	4. 20 Amp circuit breaker tripping.	4. Check for high DC amperage draw during operation. Ensure breaker is not overly sensitive to heat which would cause tripping.
	5. Exhaust system is restricted.	5. Check for blockage, collapsed hose, carbon buildup at exhaust elbow.
	6. Water in fuel.	6. Pump water from fuel tank(s); change filters and bleed fuel system.

ENGINE TROUBLESHOOTING

Problem	Probable Cause	Verification/Remedy
Generator engine overheats/shuts down.	1. Raw water not circulating. 2. Coolant not circulating.	1. Raw water pump failure. Check impeller — replace. 2. Obstruction at raw water intake or raw water filter. **2a.** Thermostat — remove and test in hot water. Replace thermostat. **2b.** Loss of coolant — check hoses, hose clamps, drain plug, etc. for leaks. **2c.** Broken or loose belts — tighten/replace. **2d.** Air leak in system; run engine and open the pressure cap to bleed air. Add coolant as needed.
Generator engine shuts down, Low oil pressure.	1. Loss of oil. 2. Oil pressure switch.	1. Check dipstick, look for oil leaks at oil filter and at oil drain hose connection. 2. Replace oil pressure switch.
Generator engine shuts down, High exhaust temperature.	1. Exhaust too hot. 2. High temperature switch opens at too low a temperature.	1. Check raw water injection flow, look for exhaust obstruction. 2. Check for satisfactory operation with switch bypassed, check with ohmmeter, replace if faulty.
Exhaust smoking problems	1. Blue smoke. 2. White smoke. 3. Black smoke.	1. Incorrect grade of engine oil. **1a.** Crankcase is overfilled with engine oil (oil is blowing out through the exhaust). 2. Engine is running cold. **2a.** Faulty injector or incorrect injector timing. 3. Improper grade of fuel. **3a.** Fuel burn incomplete due to high back pressure in exhaust or insufficient air for proper combustion (Check for restrictions in exhaust system; check air intake.). **3b.** Improperly timed injectors or valves or poor compression. **3c.** Lack of air — check air intake and air filter. Check for proper ventilation. **3d.** Overload.

TROUBLESHOOTING WATER TEMPERATURE AND OIL PRESSURE GAUGES

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Assuming that there is 12 volts as required, leave the instrument panel energized and perform the following steps:

1. Disconnect the sender wire at the gauge and see if the gauge reads zero, which is the normal reading for this situation.
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If either of the above gauge tests are negative, the gauge is probably defective and should be replaced.

Assuming the gauge is OK, check the conductor from the sender to the sender terminal at the gauge for continuity.

Check that the engine block is connected to the ground. Some starters have isolated ground terminals and if the battery is connected to the starter (both plus and minus terminals), the ground side will not necessarily be connected to the block.

GENERATOR INFORMATION

USE OF ELECTRIC MOTORS

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

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

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

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

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

Required Operating Speed

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

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

Generator Frequency Adjustment

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

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

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

Therefore, to change the generator's frequency, the generator's drive engine's speed must be changed. Along with a reconfiguring of the AC output connections at the generator, a regulator board voltage output adjustment must also be made. See *ELECTRONIC GOVERNOR SYSTEM* and *VOLTAGE REGULATOR ADJUSTMENTS* sections located within this manual.

Generator Maintenance

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

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

☐ In addition to periodic cleaning, the generator should be inspected for (a) tightness of all connections, (b) evidence of overheated terminals and (c) loose or damaged wires.

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

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

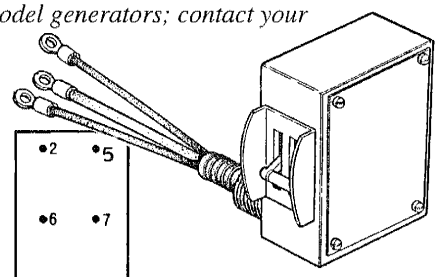
☐ Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. if side motion is detectable, bearings are wearing or wear on shaft of bearing socket outside bearing has occurred. Repair must be made quickly or major components will rub and cause major damage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

BT GENERATOR SINGLE PHASE

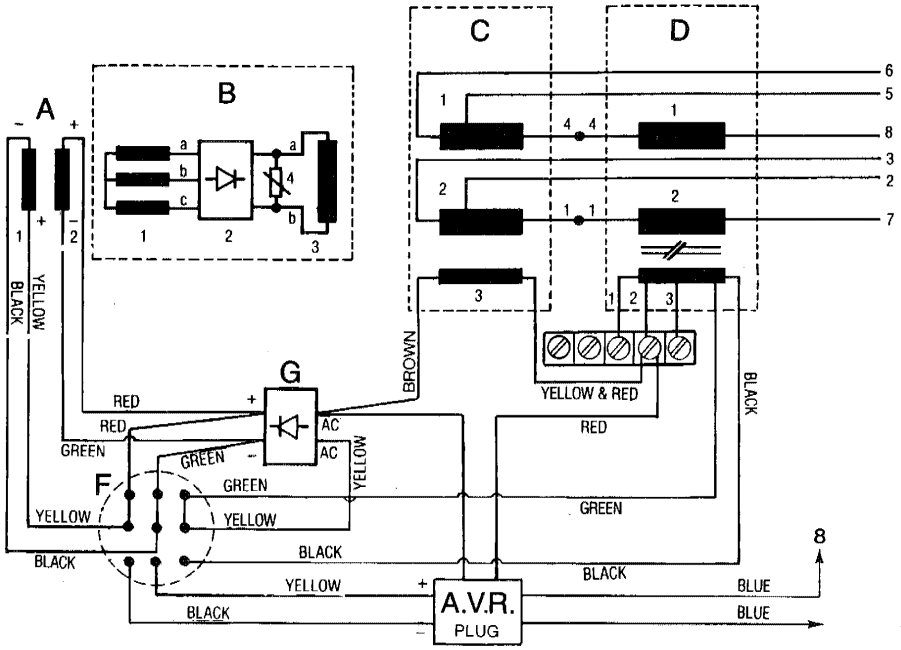
This generator is a four-pole, brushless, self-excited generator which requires only the driving force of the engine to produce AC output. The copper and laminated iron in the exciter stator are responsible for the self-exciting feature of this generator. The magnetic field produced causes an AC voltage to be induced into the related excitor rotor windings during rotation. Diodes located in the exciter rotor rectify this voltage to DC and supply it to the windings of the rotating field. This creates an electromagnetic field which rotates through the windings of the main stator, inducing an AC voltage which is supplied to a load. A step down transformer is connected in parallel to the AC output of the main stator. An AC voltage is produced in the auxiliary windings of the transformer and the main stator and is, in turn, supplied to a full-wave bridge rectifier. The rectifier produces a DC voltage to further excite the exciter stator windings, enabling the generator to produce a rated AC output. An optional solid-state voltage regulator is available to work in tandem with the transformer regulator to produce a more stabile AC output.

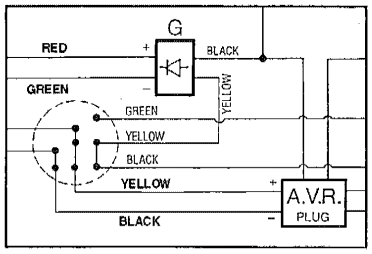
A circuit breaker is installed on all WESTERBEKE generators. This circuit breaker will automatically disconnect generator power in case of an electrical overload. The circuit breaker can be manually shut off when servicing the generator to ensure that no power is coming into the boat.

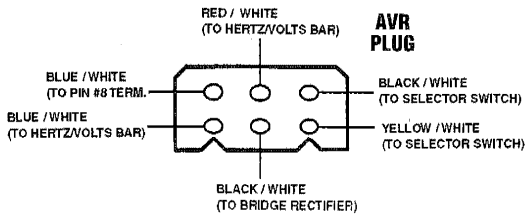
NOTE: *This circuit breaker is available as a* WESTERBEKE *add-on kit for earlier model generators; contact your* WESTERBEKE *dealer.*



CIRCUIT BREAKER
#42710 15.0 KW
#42709 12.0 KW







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

B. EXCITER ROTOR
   1. Auxiliary Windings (A - B - C)
   2. Diodes (6)
   3. Rotating Field Windings
   4. Pozi Resistor

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

D. COMPOUND TRANSFORMER
   1. Compound Transformer Windings
   2. Compound Transformer Windings
   3. Compound Transformer Auxiliary Windings with Voltage/Hertz Connection Bar

F. SELECTOR SWITCH
   F-1 Switch in Compound Position
   F-2 Switch in Electronic and Compound Position

G. BRIDGE RECTIFIER

BT GENERATOR SINGLE PHASE

NOTE: *WESTERBEKE recommends that the following generator tests and adjustments be performed by a qualified technician.*

No-Load Voltage Adjustment

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

1. The selector switch must be in the COMP position.
2. Operate the generator, apply a moderate load momentarily and remove it. Note the voltage output from the generator's 120 volt leg (S) (230 volt, 50 Hertz). The no-load voltage should be between 121 - 124 volts at 61.5 - 62 Hertz (222 - 238 volts at 51.5 - 52 Hertz).

NOTE: *The no-load voltage should be adjusted to the voltage produced by the generator once started and a momentary load should be applied to excite the transformer and then removed. The voltage produced by the generator after this momentary load is removed is no-load voltage.*

3. To raise or lower the voltage, shims of varying thickness (non-conductive material) are placed or removed from under the steel laminated bar on top of the compound transformer. The material used for shimming should not soften at temperatures in the 176° F (80° C) range. A small reduction in no-load voltage (1 to 3 volts) can sometimes be accomplished by gently tapping the top of the laminated steel bar to reduce the gap between the existing shims and the transformer core.

Changing the Frequency of Operation

1. Locate the Voltage/Hertz Connection bar shown in the illustration.

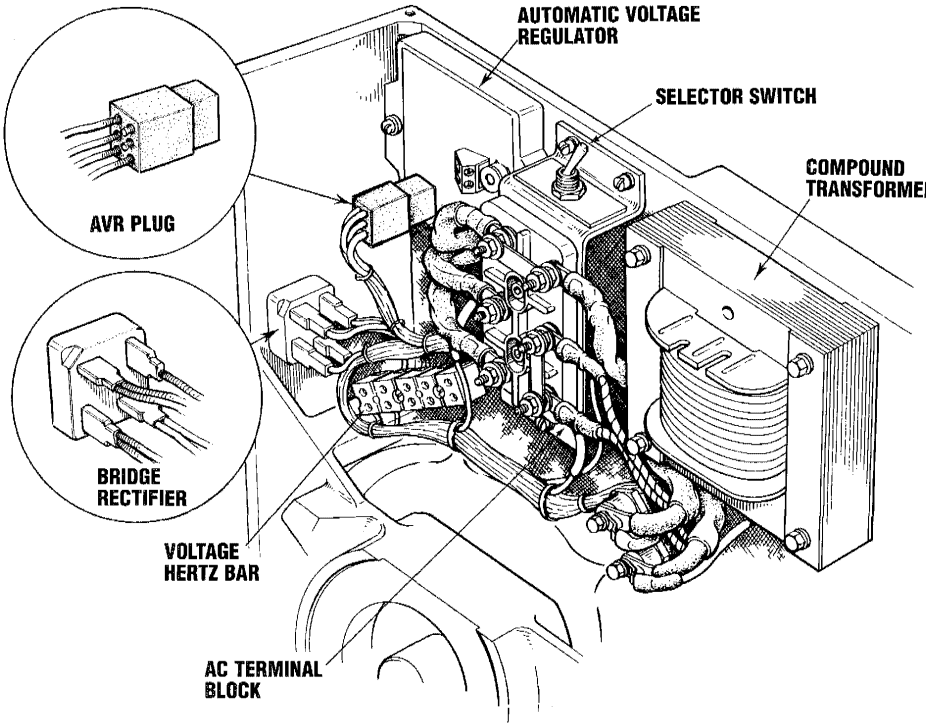
NOTE: *The placement of wires #5 and #6 are only applicable when the optional voltage regulator is installed.*

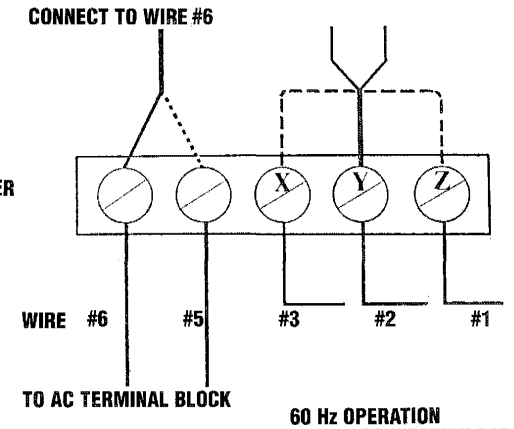
2. For 60 Hertz Operation - wire as in Diagram A.
   For 50 Hertz Operation - wire as in Diagram B.

NOTE: *On some units (A) and (B) may be reversed. To ensure a proper connection, be sure the blue and white striped leads coming off of A or B go to the numbered terminal stud on the AC terminal block. Terminal #6 for 60 Hertz and Terminal #5 for 50 Hertz operation.*

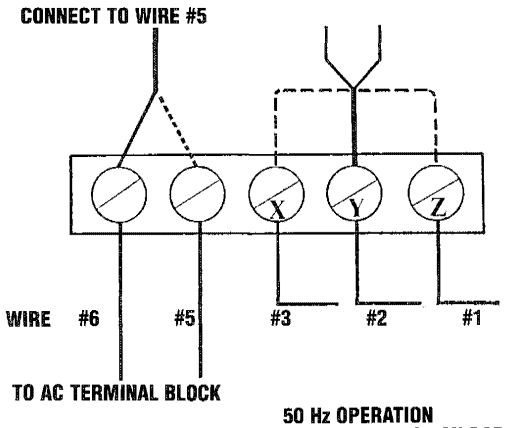
4. Generator output voltage in a full load condition falling below 108 volts at 60 Hertz or 215 volts at 50 Hertz can be raised by repositioning the two leads red/white and red/yellow from attachment at (Z) to (Y) and to (X). This will provide greater voltage to the excitor circuit and increase full load output voltage. No-load voltage may need to be readjusted as well when this repositioning is made.

NOTE: *Do not use this as a means of adjusting no load voltage or as a means of compensating if an overload condition exists.*



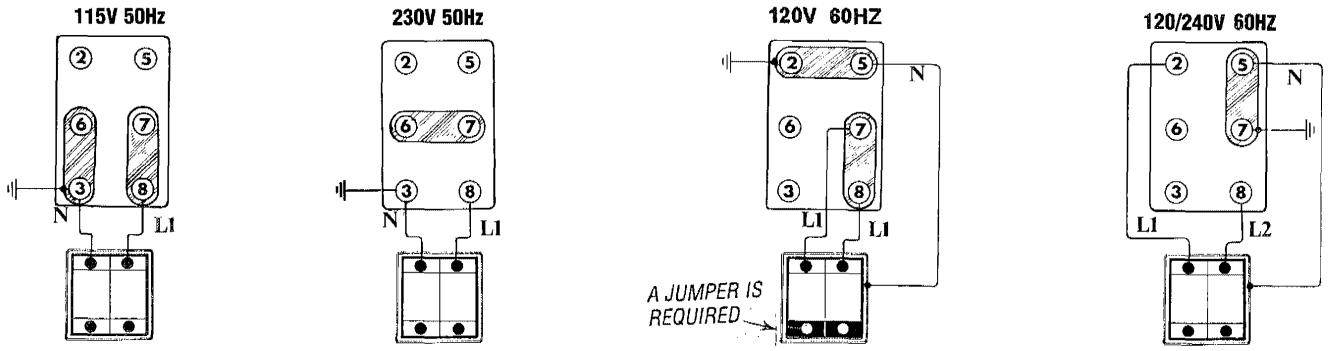


60 Hz OPERATION
VOLTAGE/HERTZ CONNECTION BAR
DIAGRAM A



50 Hz OPERATION
VOLTAGE/HERTZ CONNECTION BAR
DIAGRAM B

BT GENERATOR SINGLE PHASE



AC VOLTAGE CONNECTIONS

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

Generator Frequency

1. Frequency is a direct result of engine/generator speed: 1800 rpm = 60 hertz; 1500 rpm = 50 hertz.
2. To change generator frequency, follow the steps below:
   A. Configure the AC terminal block for the desired voltage frequency as shown above. Ensure that the case ground wire is connected to the correct terminal block neutral ground stud.

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

   B. Reposition the wire on the voltage/hertz connection bar to correspond to the hertz selected (only applicable when the optional regulator is installed).

   C. Start the engine (models without electronic governing), monitor voltage and adjust engine no-load speed
   Adjust the throttle arm or the throttle stop screw to produce engine speed desired

60 hertz	no-load speed	60.0 - 60.5 hertz
50 hertz	no-load speed	50.0 - 50.5 hertz

   Models with Electronic Governor only: Adjust the speed pod on the control board that is mounted in the panel to change engine speed to the desired speed.

   D. After the no-load hertz adjustment is made, the no-load voltage may need to be readjusted. In most cases, if the generator was producing the correct no-load voltage at the previous hertz setting, it would be correct at the changed hertz setting.
   In the event it needs adjustment, adjust the shim thickness under the laminated steel of the transformer.
   Frequency range:

60 hertz	no-load voltage	121 - 124 volts
50 hertz	no-load voltage	114 - 118 volts, 228-232 volts

   E. Load the generator to the rated amperage output corresponding to the hertz speed of the generator.
   Rated Loaded Speed:

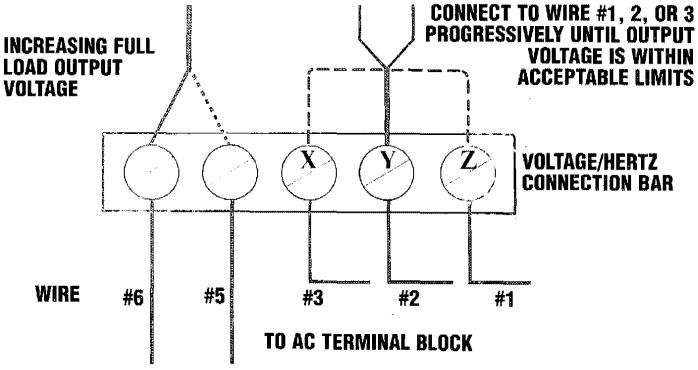
60 hertz	loaded speed	59.7 - 60.0 hertz
50 hertz	loaded speed	49.7 - 50.0 hertz

Electronic Governed

.3 Hertz variation from no-load to rated output.

Maximum voltage drop acceptable at full rated output (amps)

60 hertz	108 - 110 volts
50 hertz	210 - 215 volts



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

NOTE: *No-load voltage may be effected needing readjustment with the compound transformer. Do not use these adjustments to compensate for overload conditions being placed on the generator/engine (inductive-motor type loads). Loss of generator hertz/speed, the result of overload, will cause a drop in voltage output.*
For engine speed/generator hertz adjustment, non-electronic governing, see the ENGINE ADJUSTMENTS *section in this manual. For engine speed/generator hertz adjustment, electronic governor system, see* ELECTRONIC GOVERNOR *in this manual.*

OPTIONAL AUTOMATIC VOLTAGE REGULATOR (AVR)

An optional solid-state voltage regulator (board #34410) is available for use with the BT series generators. When installed, and the regulation switch is moved to the ELEC position, the regulator works together with the standard compound transformer regulator to regulate the generator's voltage output. In the ELEC mode, the regulator provides excitation to the group1 exciter windings, and the transformer provides excitation to the group 2 exciter windings.

Installation

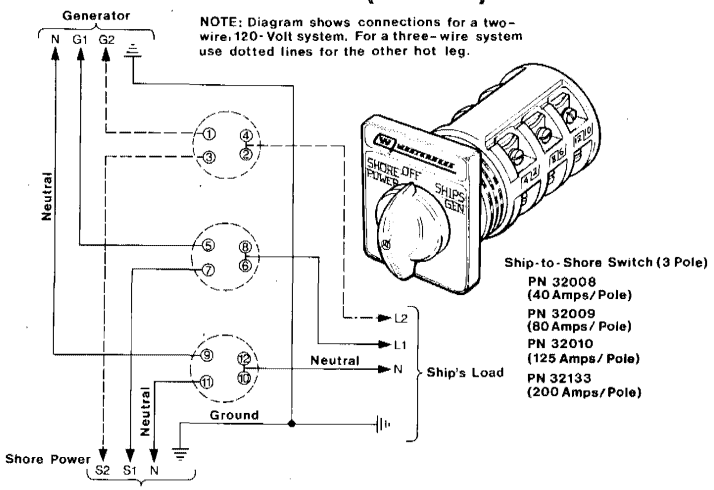
1. The regulator is mounted using existing tapped holes in the generator's case. Use two (2) M4 x 0.7mm screws, each 15mm long, with lock washers to mount the regulator board.
2. Connect the 6-prong generator plug to the receptacle on the regulator board.

NOTE: *The plug is keyed to engage the regulator receptacle in one direction. Check this and insert it correctly.*

3. Before moving the selector switch to the ELEC position the NO-Load voltage produced by the generator when in the COMP position will have to be adjusted. The NO-Load voltage should be adjusted down between 114 - 118 volts following the procedures as explained earlier in this manual.
4. With the generators no load voltage properly adjusted, move the selection switch into the ELEC position. Adjust the regulator board potentiometer to set NO-Load voltage at 120 - 122 volts at 61.5 - 62.0 Hertz (230 - 234 volts at 51.5 - 52.0 Hertz). The regulator board is operating in parallel with the compound transformer and should maintain voltage output within ±5 per cent from NO-Load to FULL-Load.

NOTE: *Do not use the regulator to force NO-Load voltage down. Use the compound transformer for this function. Using the regulator to perform this causes the regulator to use more exciter circuit power. This leaves less exciter circuit power for loaded conditions.*

Shore Power Connections (60 Hertz)



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

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

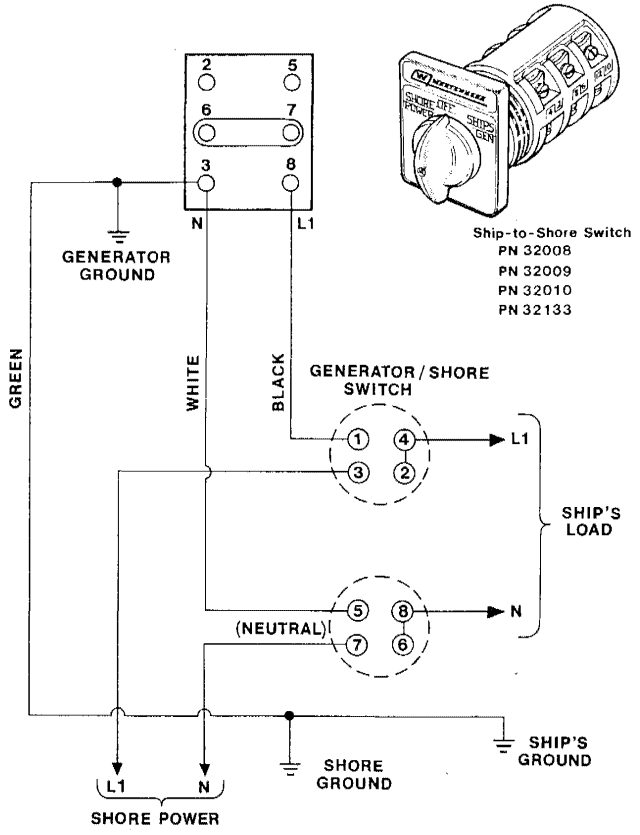
SHORE POWER TRANSFER SWITCH CONNECTIONS

Switching Shore Power to Generator Power

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

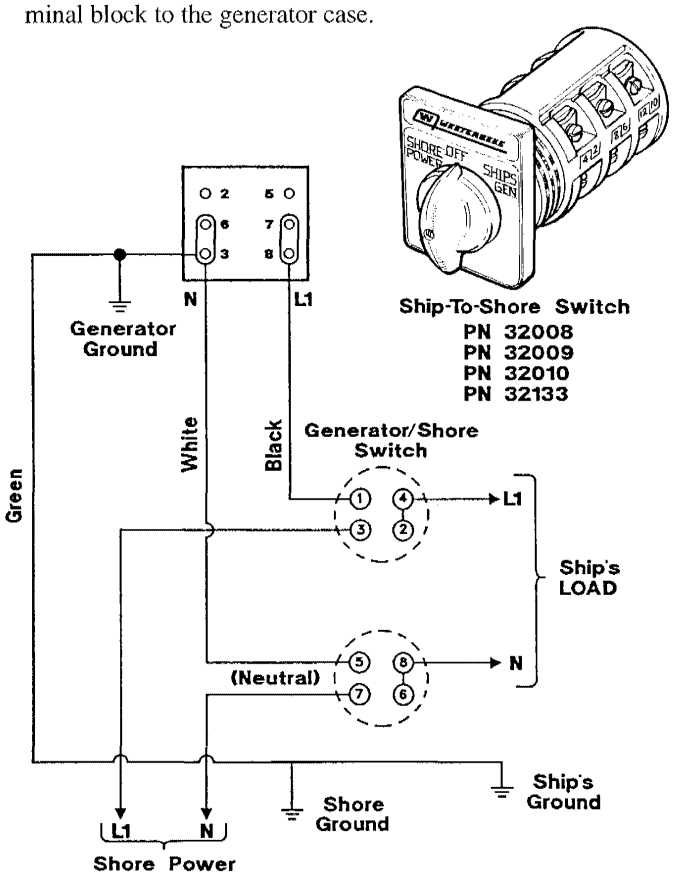
230 Volt/50 Hertz Two Wire Configuration

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



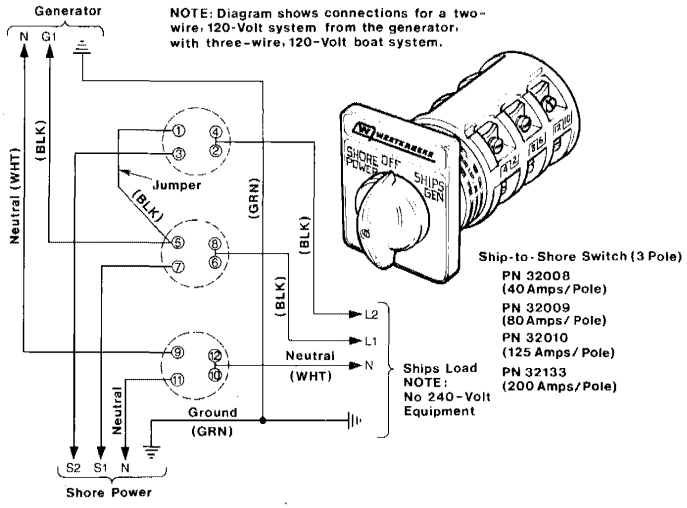
115 Volt/50 Hertz Two Wire Configuration

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

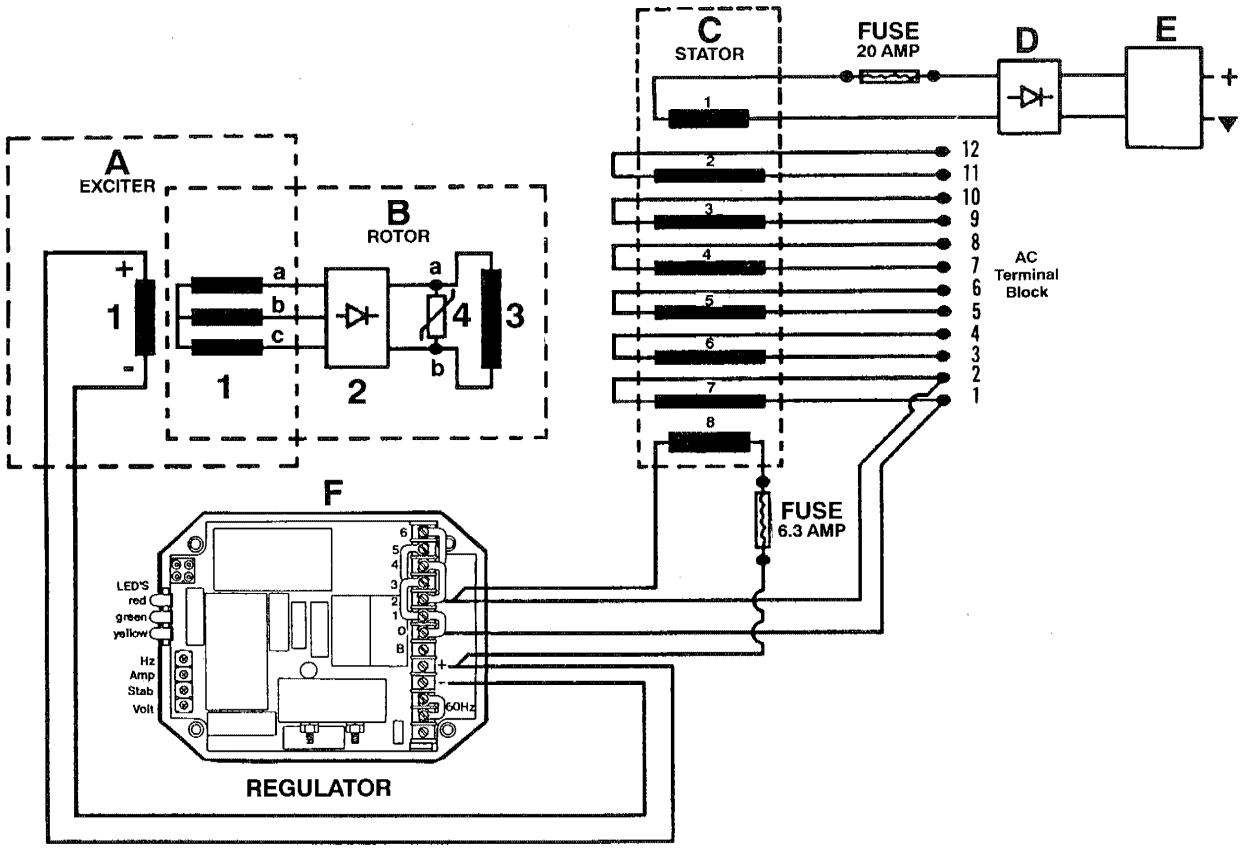


120 Volt/60 Hertz Three Wire Configuration

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



3 PHASE BT GENERATOR WIRING



A. EXCITER
   1. Exciter Stator Windings

B. ROTOR
   1. Auxiliary Exciter Windings (A - B - C)
   2. Diodes (6)
   3. Main Rotor Windings
   4. Pozi Resistor

C. MAIN STATOR
   1. Auxiliary Windings (DC Charging Circuit)
   2-7. Main Stator Windings
   3. Auxiliary Windings (AC to Regulator)

D. BRIDGE RECTIFIER

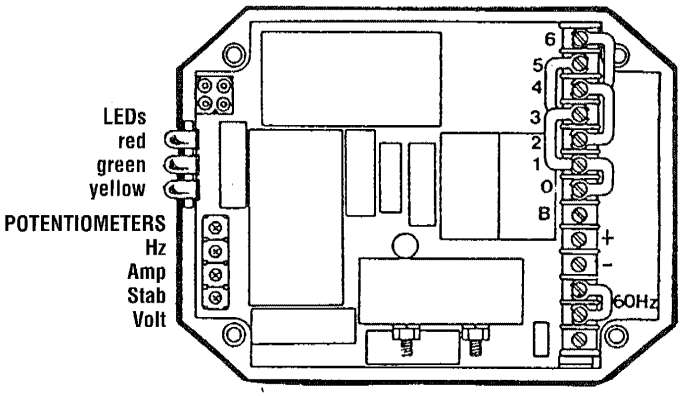
E. DC CONTROLLER

F. VOLTAGE REGULATOR BOARD

3 PHASE VOLTAGE REGULATOR ADJUSTMENTS

Description

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



AUTOMATIC VOLTAGE REGULATOR

Volts

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

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

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

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

Stability

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

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

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

Amp-Hertz

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

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

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

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

Setting the Overload Protection

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

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

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

Setting the Underspeed Protection

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

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

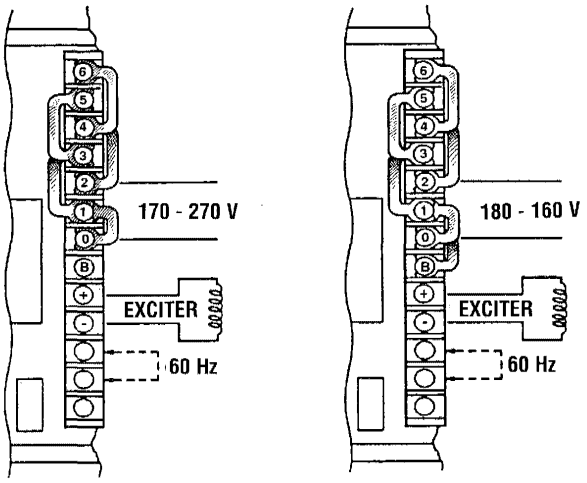
With the above adjustments made, the regulator should function normally.

REGULATOR SENSING 3 PHASE WYE-DELTA CONFIGURATIONS

Description

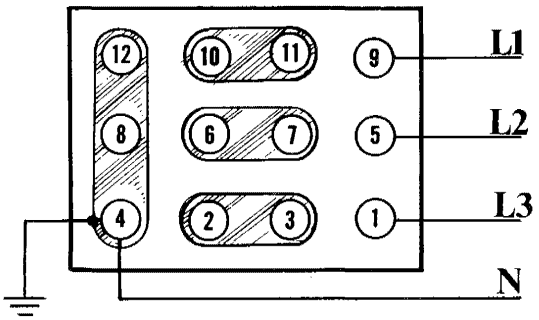
The regulator is equipped with seven numbered terminals (0 to 6) and their related brass jumpers. The illustrations shown connection points and jumpers for the 3 phase configuration of the generator. The sensing leads connect between pin #1 and pin #2 on the AC terminal block and connection #2 and #0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

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



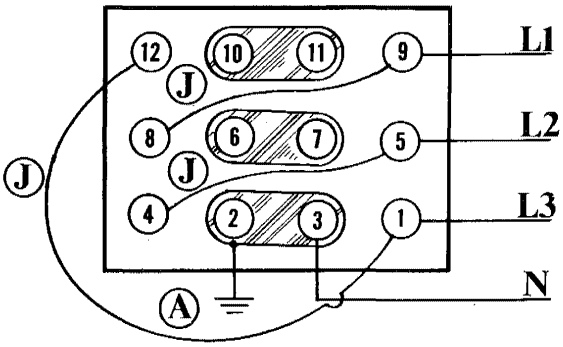
3 PHASE VOLTAGE REGULATOR

SERIES WYE (STAR)



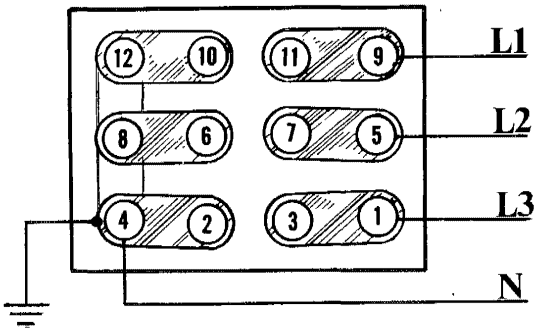
L - L	460 VAC	3Ø 60 Hertz
L - N	265 VAC	1Ø 60 Hertz
L - L	380 VAC	3Ø 50 Hertz
L - N	230 VAC	1Ø 50 Hertz

SERIES DELTA



L - L	240 VAC	3Ø 60 Hertz
L2, L3, - N	120 VAC	1Ø 60 Hertz
L - L	230 VAC	3Ø 50 Hertz
L2, L3, - N	115 VAC	1Ø 50 Hertz

PARALLEL WYE (STAR)



L - L	208 VAC	3Ø 60 Hertz
L - N	120 VAC	1Ø 60 Hertz
L - L	190 VAC	3Ø 50 Hertz
L - N	115 VAC	1Ø 50 Hertz

BT GENERATOR TROUBLESHOOTING

NOTE: *The following is a list of faults with the generator operating on (compound) transformer regulation (No Automatic Voltage Regulator installed).*

Problem	Probable Cause	Verification/Remedy
Low Voltage (70 volts) at N/L and loss of voltage as load is applied (no loss of engine speed and hertz).	1. Selector switch in wrong position.	1. Place selector switch in COMP position.
High voltage (125 - 135 volts) at N/L with correct voltage when loaded (115 - 120 volts).	1. Generator's engine speed (rpm) high at N/L.	1. Check N/L speed and adjust N/L voltage.
High voltage at N/L and F/L.	1. Generator's engine speed (rpm) high. 2. Short in compound transformer auxiliary windings D-3.	1. Check N/L rpm and adjust N/L voltage. 2. Check continuity and connections of D-3 windings.
Low voltage (0 - 5 volts) at N/L with growling noise from generator and loss of engine speed when load is applied.	1. Main stator windings shorted C-1, C-2. 2. Compound transformer windings shorted D-1, D-2.	1. Check continuity and resistance values of C-1, C-2 windings and connections. 2. Check continuity and resistance values of D-1, D-2 windings.
Generator does not excite; voltage is is 0 volts at N/L.	1. Generator's engine speed is slow. 2. Short in the main stator windings or transformer.	1. Adjust the engine's speed and adjust N/L voltage. 2. Check the diodes as shown in this manual.
Low voltage (10 - 20 volts) at N/L, when load is applied, voltage drops.	1. Diodes(s) in rotating exciter (B-2) shorted. 2. Bridge rectifier defective. 3. Auxiliary windings B-1 shorted. 4. Auxiliary windings D-3 and/or C-3 open.	1. Check B-1 and B-2 in the rotating exciter as explained in this manual. 2. Follow test procedure for the bridge rectifier. 3. Check the continuity and resistance values. 4. Check the continuity and resistance values of windings and connections.
Voltage correct at N/L, but not at F/L with loss of engine rpm (hertz).	1. Generator overload. 2. Rotating diode failing. 3. Generator's engine speed is low. 4. Low power load factor.	1. Monitor the load. 2. Check the diode. 3. Check the electronic governor operation. 4. Check the type of load applied. Consider use of optional regulator board.
Unstable voltage.	1. Engine's rpm fluctuating. 2. Electronic governor	1. Check the engine operation and the fuel system. 2. Check the gain adjustment.
Low voltage at N/L and voltage drops	1. Diode's in the exciter rotor shorted (B-2).. 2. Auxiliary windings in exciter rotor shorted (B-2).	1. Check the diodes in the exciter rotor. 2. Check the resistance values and continuity to ground.
Voltage OK at N/L and low at F/L.	1. Auxiliary windings in the exciter rotor. 2. Exciter stator compound windings A-2 is open. 3. Auxiliary windings D-3 or C-3 open.	1. Check resistance values and continuity to ground. 2. Check continuity and connection of windings. 3. Check continuity and connection of windings.
Voltage unstable.	1. Defective regulator board. 2. Engine is hunting. 3. Electrical connections.	1. Check stability of DC voltage from regulator to exciter stator windings. Operate unit on COMP. Replace regulator board. 2. Check engine operation and the fuel system. 3. Check for clean and secure connections.

LAY-UP AND RECOMMISSIONING

General

Many owners rely on their boatyards to prepare their craft, including engines and generators, for lay-up during the off-season or for long periods of inactivity. Others prefer to accomplish lay-up preparation themselves.

The procedures which follow will allow you to perform your own lay-up and recommissioning, or to use as a check list if others do the procedures.

These procedures should afford your engine protection during a lay-up and also help familiarize you with the maintenance needs of your engine.

If you have any questions regarding lay-up procedures, call your local servicing dealer; he will be more than willing to provide assistance.

Fresh Water Cooling System

A 50-50 solution of antifreeze and fresh water is recommended for use in the fresh water cooling system at all times. This solution may require a higher concentration of antifreeze, depending on the area's winter climate. Check the solution to make sure the antifreeze protection is adequate.

Should more antifreeze be needed, drain an appropriate amount from the engine block and add a more concentrated mixture. Operate the engine to ensure a complete circulation and mixture of the antifreeze concentration throughout the cooling system. Now recheck the antifreeze solution's strength.

Lubrication System

With the engine warm, drain all the lubricating oil from the oil sump. Remove and replace the oil filter. (Place some paper towels and a plastic bag around the filter to catch the oil during its removal.)

When installing the new oil filter, be sure to apply a small amount of oil on the rubber sealing gasket at the base of the filter. Fill the sump with the correct amount of oil for your engine. (Refer to the *SYSTEM SPECIFICATIONS* section of this manual.) Use an oil with an API specification of CF or CG-4. Run the generator and check for proper oil pressure and make sure there are no leaks.

> ⚠ **CAUTION:** ***Do not leave the engine's old lubricating oil in the sump over the lay-up period. Lubricating oil and combustion deposits combine to produce harmful chemicals which can reduce the life of your engine's internal parts.***

Fuel System

Top off your fuel tanks with No. 2 diesel fuel. Fuel additives such as BioBor and Sta-Bil should be added at this time to control algae and condition the fuel. Care should be taken that the additives used are compatible with the primary filter/water separator used in the system. Change the element in your primary fuel filter/water separator, if the fuel system contains one, and clean the separator sediment bowl.

Change the fuel filter elements on the engine and bleed the fuel system, as needed. Start the engine and allow it to run for 5 - 10 minutes to make sure no air is left in the fuel system. Check for any leaks that may have been created in the fuel system during this servicing, correcting them as needed. Operating the engine for 5-10 minutes will help allow movement of the treated fuel through the injection equipment on the engine

Raw Water Circuit

Close the through-hull sea cock. Remove the raw water intake hose from the sea cock. Place the end of this hose into a 5-gallon bucket of clean fresh water. Before starting the engine, check the zinc anode found in the primary heat exchanger on the engine and clean or replace it as required, and also clean any zinc debris from inside the heat exchanger where the zinc anode is located. Clean the raw water strainer, if one is installed, in the inside of the hull.

Start the engine and allow the raw water pump to draw fresh water through the system. When the bucket is empty, stop the engine and refill the bucket with an antifreeze solution slightly stronger than needed for winter freeze protection in your area.

Start the engine and allow all of this mixture to be drawn through the raw water system. Once the bucket is empty, stop the engine. This antifreeze mixture should protect the raw water circuit from freezing during the winter lay-up, as well as providing corrosion protection.

Remove the impeller from your raw water pump (some antifreeze mixture will accompany it, so catch it in a bucket). Examine the impeller. Acquire a replacement, if needed, and a cover gasket. Do not replace the impeller (into the pump) until recommissioning, but replace the cover and gasket.

Intake Manifold and Through-Hull Exhaust

Place a clean cloth, lightly soaked in lubricating oil, in the opening of the intake manifold to block the opening. Do not shove the cloth out of sight. (If it is not visible at recommissioning, and an attempt is made to start the engine, you may need the assistance of a servicing dealer.) Make a note to remove the cloth prior to start-up. The through-hull exhaust port can be blocked in the same manner.

LAY-UP AND RECOMMISSIONING

Generator End

Remove the louvered cover on the generator end. Check all wire connections on the AC terminal block and those running to the bridge rectifier making sure they are secure. Should these connections appear corroded, they should be removed, cleaned, and reconnected. Make sure all AC leads are properly cleaned and reconnected. Make sure all AC leads are properly supported and not chafing as they exit the generator housing.

Starter Motor

Lubrication and cleaning of the starter drive pinion is advisable, if access to the starter permits its easy removal. Make sure the battery connections are shut off before attempting to remove the starter. Take care in properly replacing any electrical connections removed from the starter.

Cylinder Lubrication

It is not necessary to remove the fuel injectors from the cylinder head to squirt light lubricating oil into the cylinders for the few months of normal lay-up. However, if you anticipate a longer lay-up period (12 months or more), we recommended that this procedure be performed. The light oil in the cylinders will prevent the piston rings from sticking to the cylinder walls. Make sure you have replacements for the injector and return line sealing washers.

Spares

Lay-up time provides a good opportunity to inspect your Westerbeke engine to see if external items such as drive belts or coolant hoses need replacement. Check your basic spares kit and order items not on hand, or replace those items used during the lay-up, such as filters and zinc anodes. Refer to the SPARE PARTS section of this manual.

Batteries

If batteries are to be left on board during the lay-up period, make sure they are fully charged, and will remain that way, to prevent them from freezing. If there exists any doubt that the batteries will not remain fully charged, or that they will be subjected to severe environmental conditions, remove the batteries and store them in a warmer, more compatible environment.

Recommissioning

The recommissioning of your Westerbeke engine after a seasonal lay-up generally follows the same procedures as those presented in the *PREPARATIONS FOR STARTING* section regarding preparation for starting and normal starts. However, some of the lay-up procedures will need to be counteracted before starting the engine.

1. Remove the oil-soaked cloths from the intake manifold.
2. Remove the raw water pump cover and gasket and discard the old gasket. Install the raw water pump impeller removed during lay-up (or replacement, if required). Install the raw water pump cover with a new cover gasket.

> ⚠ **CAUTION:** ***Wear rubber gloves, a rubber apron, and eye protection when servicing batteries. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or a lighted cigarette, cigar, or pipe. Do not smoke or allow an open flame near the battery being serviced. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.***

3. Reinstall the batteries that were removed during the lay-up, and reconnect the battery cables, making sure the terminals are clean and that the connections are tight. Check to make sure that the batteries are fully-charged.
4. Check the condition of the zinc anode in the raw water circuit and clean or replace the anode as needed. Note that it is not necessary to flush the antifreeze/fresh water solution from the raw water coolant system. When the engine is put into operation, the system will self-flush in a short period of time with no adverse affects. It is adviseable to, as either an end of season or recommissioning service to inspect the area that the zinc is located at in the heat exchanger and clear any and all zinc debris from that area.
5. Start the engine in accordance with procedures in the *PREPARATIONS FOR STARTING* section of this manual.

SPECIFICATIONS
WESTERBEKE 15 KW BTDA AND 15 KW BTDB GENERATORS

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism(30 hp at 1800 rpm maximum).
Combustion Chamber	Swirl type
Bore & Stroke	3.50 x 3.50 inches (88.9 x 88.9 mm)
Piston Displacement	134.8 cubic inches (2.209 liters)
Firing Order	1 - 3 - 4 - 2
Direction of Rotation	Clockwise, when viewed from the front
Maximum Torque (at 1800 rpm)	148 lb-ft (20.46 kg-m)
Compression Ratio	21:1
Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm limit 384 pi (27.0 kg/cm²)
Valve Timing	Intake Opens 17° Intake Closes 47° ABDC Exhaust Opens 51° BBDC Exhaust Closes 13° ATDC
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance (engine cold)	Intake 0.012 inches (0.3 mm) Exhaust 0.012 inches (0.3 mm)
Engine Speed	1800 rpm 60 Hertz 1500 rpm 50 Hertz
Dimensions	Height: 25.74 inches (653.8 mm) Width: 21.19 inches (538.2 mm) Length: 39.63 inches (1006.6 mm)
Weight	765 lbs (347 kgs)
Fuel Consumption (approximate)	1.8 gph (6.81 lph) at full rated output
Inclination	Continuous 15° Temporary 20° (not to exceed 20 min.)
Power Take-Off	30 hp maximum (Generator end)

TUNE-UP SPECIFICATIONS

Injector Pressure	1920 ±71 psi (135 ±5 kg/cm²)
Engine Timing inches	Static timed - drop valve method 0.180 ± 005 BTDC or 0° T.D.C. #1 cylinder. 1mm of cam lift using measuring device for injection pump.

FUEL SYSTEM

General	Open flow, self priming - one bleed point
Fuel	No. 2 diesel oil (cetane rating of 45 or higher)
Fuel Injection Pump	Distributor Type (VE) Diesel KiKi - Zexel
Fuel Injection Timing	0° TDC (Top Dead Center)
Nozzle	Throttle type
Fuel Filter	Spin-on (Replaceable) PN#024363
Air cleaner	Metal screen type - cleanable
Air Flow (engine combustion)	70.0 ocfm (1.9 cmm)

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
Raw Water Flow, at 1800 rpm	6.0 gpm (22.7 lpm) (measured before discharging into exhaust elbow)
System Capacity (fresh water)	10.0 qts (9.46 liters)

LUBRICATION SYSTEM

General	Pressure fed system
Oil Filter	Full flow, paper element, spin-on type PN# 035828
Sump Capacity (not including filter)	5.3 U.S. qts (5.0 liters) plus filter/cooler assembly
Operating Oil Pressure (engine hot)	50 - 65 psi (3.5 - 4.57 kg/cm2)
Oil Grade	API Specification CF or CG-4, SAE 30, 10W-30, 15W-40

ELECTRICAL SYSTEM

Starting Battery	12-Volt, (-) negative ground
Battery Capacity	400-600 CCA
DC Charging Alternator	51 Amp rated, belt-driven
Starter	12-Volt, reduction
Starting Aid	Glow plugs, sheathed type
DC No-Load Current	±2% of rated Amps
DC Cranking Current	280 Amps (engine cold)

SPECIFICATIONS
WESTERBEKE 15 KW BTDA AND 15 KW BTDB GENERATORS

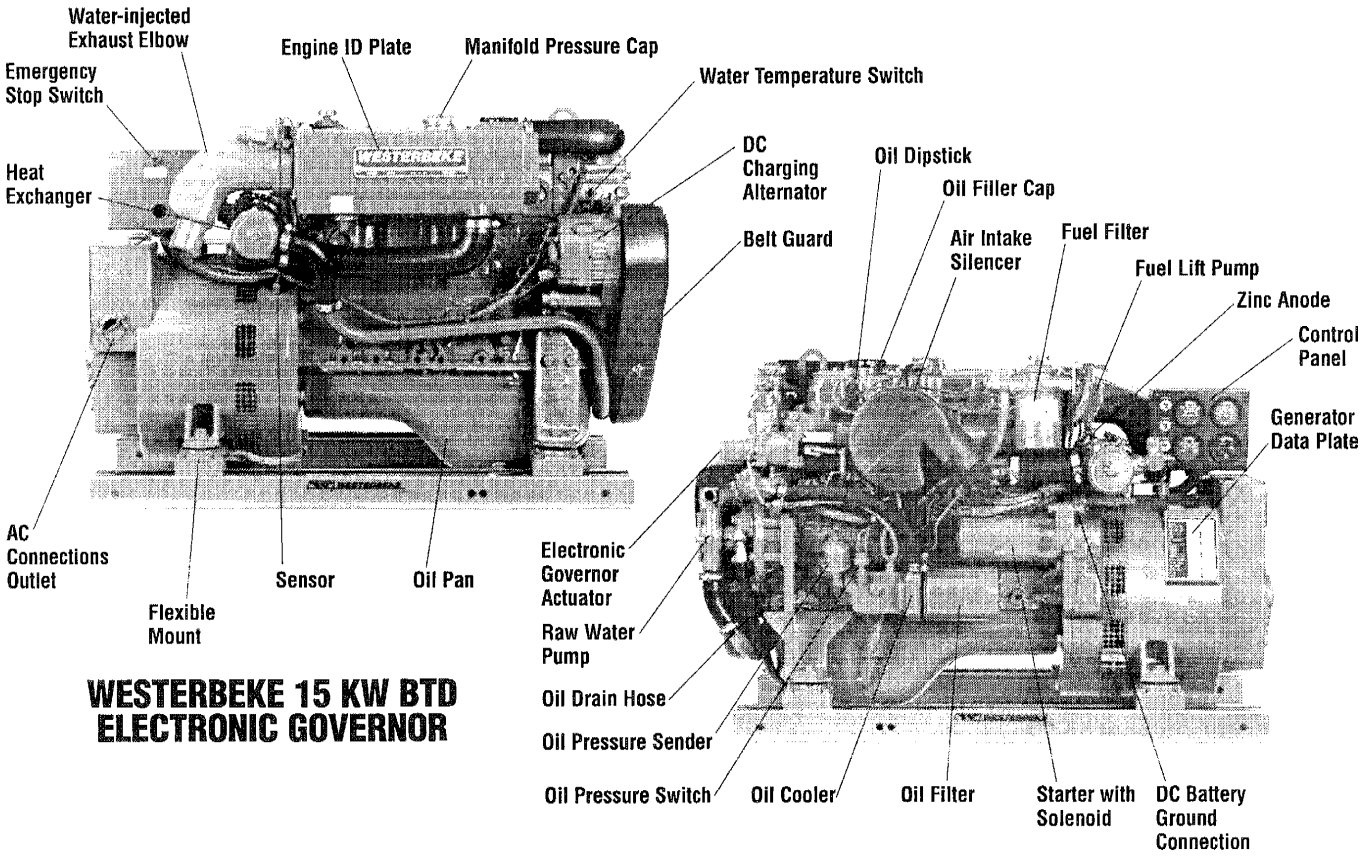
AC GENERATOR (Single Phase)

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

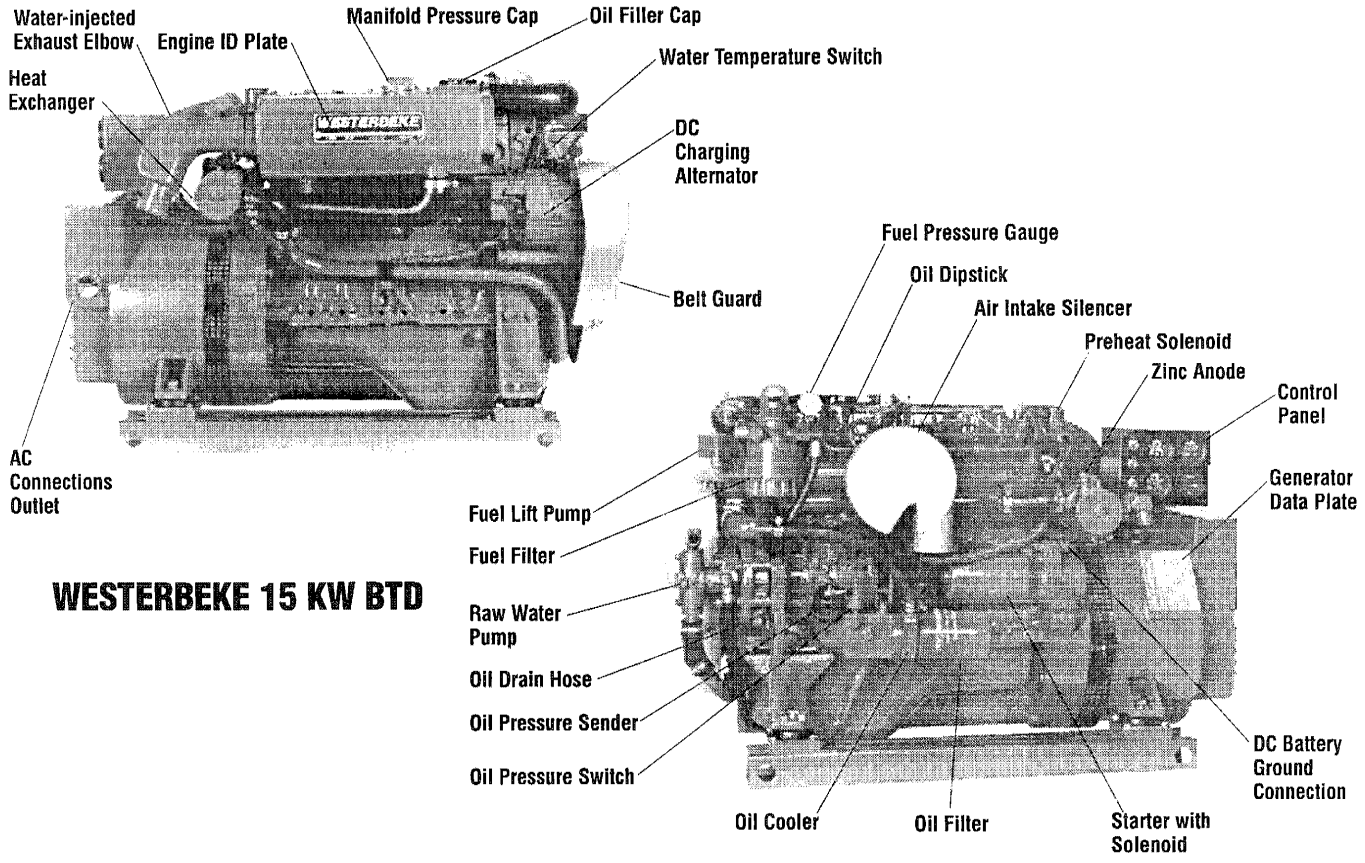
AC GENERATOR (3 Phase)

Three Phase 15.0 Kw - 60 Hertz 12.0 Kw - 50 Hertz	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase 50 Hertz	Low Voltage WYE High Voltage WYE DELTA	208 Volts 480 Volts 240 Volts
Voltage - 3 Phase 50 Hertz	High Voltage WYE DELTA	380 Volts 230 Volts
Amperage - 3 phase 60 Hertz	Low Voltage WYE High Voltage WYE DELTA	52 Amps 22 Amps 45 Amps
Amperage - 3 phase 50 Hertz	High Voltage WYE DELTA	22 Amps 39 Amps
Generator Compartment Ambient Temperature Recommendations	104°F (40°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 104°F (40°C).*	

WESTERBEKE 15.0 KW BTD PARTS IDENTIFICATION



WESTERBEKE 15 KW BTD ELECTRONIC GOVERNOR



WESTERBEKE 15 KW BTD

STANDARD HARDWARE TORQUES

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

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

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

15 KW BTD GENERATOR TIGHTENING TORQUE TABLE

	Ft-lb	Kg-m
Cylinder head	80 - 85	11.0 - 11.7
Cylinder head cover	2 - 3	0.3 - 0.45
Connecting road cap	50 - 54	6.9 - 7.5
Main bearing cap	80 - 85	11.0 - 11.7
Camshaft thrust plate	12 -17	1.6 - 2.4
Camshaft gear	45 - 51	6.2 - 7.0
Idle gear	17 - 23	2.3 - 3.2
Injection pump drive gear	29 - 51	4.0 - 7.0
Rocker arm assembly	80 - 85	11.0 - 11.7
Timing gear case	12 -17	1.6 - 2.4
Timing gear cover	12 -17	1.6 - 2.4
Rear oil seal cap	11 - 15	1.5 - 2.0
Oil Pan	5 - 9	0.7 - 1.2
Oil pipe (oil pump)	6 - 9	0.8 - 1.2

	Ft-lb	Kg-m
Water pump	12 -17	1.6 - 2.4
Crankshaft pulley	145 - 181	20.0 - 25.0
Temperature gauge unit	9 - 13	1.2 - 1.8
Oil pressure switch	9 - 13	1.2 - 1.8
Glow plug	7 - 11	1.0 - 1.5
Injection nozzle	12 -17	1.6 - 2.4
Injection pipe flare unit	18 - 22	2.5 - 3.0
Intake manifold	12 -17	1.6 - 2.4
Exhaust manifold	12 -17	1.6 - 2.4
Exhaust elbow (to exhaust manifold)		
Back plate	24 - 35	24 - 35.0
Injector spray pressure	1920 ± 71.0 psi	135 ± 5 kg/cm²
Cylinder compression pressure	427 psi (200 rpm)	30 kg/cm² (200 rpm)

METRIC CONVERSIONS

INCHES TO MILLIMETERS / MILLIMETERS TO INCHES

Inches	mm	Inches	mm	mm	Inches	mm	Inches
1	25.40	15	381.00	1	0.0394	15	0.5906
2	50.80	20	508.00	2	0.0787	20	0.7874
3	76.20	25	635.00	3	0.1181	25	0.9843
4	101.60	30	762.00	4	0.1575	30	1.1811
5	127.00	35	889.00	5	0.1969	35	1.3780
10	254.00	40	1016.00	10	03937	40	1.5748

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

INCHES TO METERS / METERS TO INCHES

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

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

YARDS TO METERS / METERS TO YARDS

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

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

POUNDS TO KILOGRAMS / KILOGRAMS TO POUNDS

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

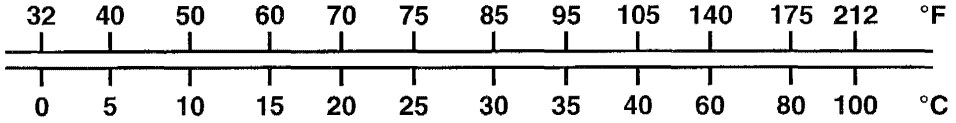
GALLONS TO LITERS / LITERS TO GALLONS

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

PINTS TO LITERS / LITERS TO PINTS

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

TEMPERATURE




WESTERBEKE
Engines & Generators