

OPERATOR'S MANUAL

WESTERBEKE

BTG — 9 KW

Marine Gasoline

Generator Set

Publication # 36710

Edition One

June 1987



SAFETY PRECAUTIONS

The following symbols appear in this manual to call attention to and emphasize conditions potentially dangerous to the operator or to the equipment.

WARNING This symbol is used in the manual to warn of possible serious personal injury or loss of life.

CAUTION This symbol is used in the manual to caution personnel of possible damage to equipment.

Read the manual carefully and thoroughly before attempting to operate the equipment. Know when dangerous conditions can exist and take necessary precautions to protect personnel and equipment.

Fuels, exhaust gases, batteries, electrical equipment, and moving and hot parts are potential hazards that could result in serious personal injury or death. Follow recommended procedures carefully.

Always operate bilge blowers for at least five minutes before starting a gasoline-fueled engine; ensure no gasoline fumes are present before starting.

- Prevent Electric Shock

Shut off electric power before accessing electrical equipment.

Use insulated mats whenever working on electrical equipment.

Make sure clothing is dry, not damp (particularly shoes), and keep skin surfaces dry when handling electrical equipment.

Remove wristwatch and 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.

Be extremely careful when working on electrical components. High voltage can cause injury or death.

- Exhaust Gases Are Toxic.

Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check exhaust system regularly for leaks and make sure exhaust manifolds are securely attached and no warping exists.

Be sure the unit and its surroundings are well-ventilated.

- Use Extreme Care When Handling Engine Fuel. (A constant danger of explosion or fire exists.)

Do not fill fuel tank with engine running.

Do not smoke or use open flame near the engine or the fuel tank.

Keep combustible materials away from the unit.

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.

- Use Extreme Care When Servicing Batteries.

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 battery being serviced. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.

- Avoid Moving Parts.

Do not service unit while unit is running; if absolutely necessary to make operating adjustments, use extreme care to avoid moving parts and hot exhaust system components.

Do not wear loose clothing or jewelry when servicing equipment; avoid loose jackets, shirts or sleeves, rings, necklaces, or bracelets that might be caught in moving parts.

Make sure all attaching hardware is properly tightened and keep protective shields and guards in place at all times.

Do not check fluid levels or drive-belt tension while unit is operating.

Do not work on equipment when mentally or physically incapacitated by fatigue.

IMPORTANT

PRODUCT SOFTWARE DISCLAIMER

Product software of all kinds, such as brochures, drawings, technical data, operator's and workshop manuals, parts lists and parts price lists (and other related information), instructions and specifications provided from sources other than Westerbeke, is not within Westerbeke's control and, accordingly, is provided to Westerbeke customers only as a courtesy and service. WESTERBEKE CANNOT BE RESPONSIBLE FOR THE CONTENT OF SUCH SOFTWARE, MAKES NO WARRANTIES OR REPRESENTATIONS WITH RESPECT THERETO, INCLUDING THE ACCURACY, TIMELINESS OR COMPLETENESS THEREOF, AND WILL IN NO EVENT BE LIABLE FOR ANY TYPE OF DAMAGES OR INJURY INCURRED IN CONNECTION WITH, OR ARISING OUT OF, THE FURNISHING OR USE OF SUCH SOFTWARE.

For example, components and sub-assemblies incorporated into Westerbeke's products and supplied by others (such as engine blocks, fuel systems and components, transmissions, electrical components, pumps and other products) are generally supported by their manufacturers with their own software, and Westerbeke must depend on such software for the design of Westerbeke's own product software. Such software, however, may be outdated and no longer accurate. Routine changes made by Westerbeke's suppliers, of which Westerbeke rarely has notice in advance, are frequently not reflected in the supplier's software until after such changes take place.

Westerbeke customers should also keep in mind the time span between printings of Westerbeke product software, and the unavoidable existence of earlier, non-current Westerbeke software editions in the field. Additionally, most Westerbeke products include customer-requested special features that frequently do not include complete documentation.

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 currency of the product software being consulted by the customer.

FOREWORD

Thank you for selecting a Westerbeke marine product for your use. We at Westerbeke are pleased to have you as a customer.

Read this manual carefully and observe all safety precautions included throughout. Operating procedures, periodic preventive maintenance procedures, installation checks, system descriptions and minor adjustment procedures are included herein so that you can operate your equipment safely and properly, maintain the equipment at a high level of efficiency, and expect dependable performance and long service life in return.

Should your unit require special attention, contact your Westerbeke dealer for assistance. The Westerbeke Service Organization is trained to provide the support necessary to ensure long-term dependable performance.

If, within 60 days of submitting the Warranty Registration Form for your unit, you have not received a Customer Identification Card (see below) registering your warranty, please contact the factory in writing with Model information, including the unit serial number and commission date.


from:	J.H. Westerbeke Corp. Avon Industrial Park Avon, MA 02322
Mail To:	 <small>AVON INDUSTRIAL PARK AVON MA 02322 • TEL. (413) 588 7700 TELEX 924444 • FAX (413) 588 9323 • CABLE WESTCORP</small> CUSTOMER IDENTIFICATION Adam Smith 85 Maple Street Alden, IN 12234 Model BTG 9KW Ser.#1234C706 Expires 7/7/88

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GENERAL

Introduction

This manual contains the equipment operating procedures as well as information to assist the operator to maintain the equipment in proper working order. Study and follow the instructions carefully. A planned maintenance program is included in this manual; adhering to the program will result in better equipment performance and longer equipment life. Proper diagnosis of a problem is the most important step to satisfactory repair; consequently, a troubleshooting table is included.

Understanding the Gasoline Powered Generator

The gasoline engine driving the AC generator is in many ways similar to an automobile engine. The cylinders are vertical and in-line, with a belt-driven, overhead camshaft. The engine utilizes a breaker points and condenser type distributor which is horizontally-mounted and camshaft-driven, a pressure type lubrication system, and a thermostatically-controlled water-cooled engine block with an exchanger system.

To a great extent, the gasoline engine used to drive the AC generator requires the same preventive maintenance that any responsible operator would give the gasoline engine in his automobile. The most important factors contributing to the long life of the unit are proper ventilation and maintenance of the fuel system, ignition system, cooling system, and the generator end.

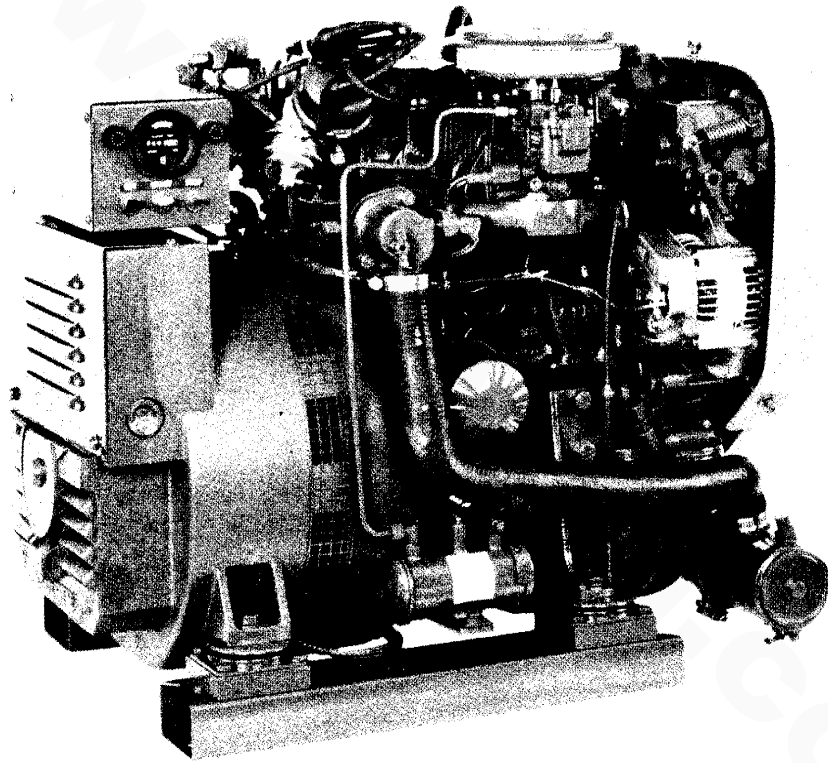
Ordering Parts

When contacting your Westerbeke dealer, parts distributor, or the factory about your Westerbeke unit, always provide the model number and serial number as they appear on the nameplate (located on the surface of the exhaust manifold/coolant tank). This information is necessary in order to identify your unit.

Note that component locations in the manual are referenced from the front of the engine which is the pulley/drive belt end. (The flywheel/generator or transmission end is the rear end.) Left and right sides are determined by the engine; imagine straddling the engine and facing in the same direction as the front of the engine: the left side is at your left, the right side at your right.

Westerbeke engines and generator sets are thoroughly checked and given a final run under various load conditions before leaving the factory. This is done to ensure dependable operation, long service, and a satisfied owner. A record of this test is maintained at the factory.

Care at the factory during assembly, and thorough testing, have resulted in a Westerbeke gasoline engine-driven generator capable of many thousands of hours of dependable service. However, the manufacturer cannot control the treatment the unit receives in the field. That part is up to the owner/operator.



BTG 9 KW Gasoline Generator Set

GENERAL SPECIFICATIONS

BTG 9 KW
MARINE GASOLINE GENERATOR SET

Engine Type	Gasoline, 4-cycle, 3-cylinder, vertical, in-line
Combustion Chamber	Multi-sphere type
Valve Mechanism	Overhead camshaft, belt-driven
Bore & Stroke	2.99 x 2.87 inches (76 X 73 mm)
Piston Displacement	60.6 cubic inches (0.993 liter)
Firing Order	1-2-3
Direction of Rotation	Clockwise, when viewed from the front
Compression Ratio	9.5:1
Compression Pressure	177.8 psi (12.5 kg/cm ²), at 350 rpm
Valve Timing	Intake Opens 19° BTDC Intake Closes 51° ABDC Exhaust Opens 51° BBDC Exhaust Closes 19° ATDC
Valve Seat Angle	Intake 45° Exhaust 45°
Valve Clearance (engine warm)	Intake 0.0079 inch (0.20 mm) Exhaust 0.0079 inch (0.20 mm)
Engine Speed	1800 rpm (belt-driven mechanical governor)
Dimensions	Height: 23.38 inches (593.85 mm) Width: 18.69 inches (474.73 mm) Length: 28.25 inches (717.55 mm)
Weight	386 lb (175.0 kg)
Sea Water Flow, at 1800 rpm (measured at discharge from heat exchanger)	4.5 - 5.0 gpm (17.03 - 18.92 lpm)
Fuel Consumption	1.5 gph (5.68 lph) at full rated output (approximate)

SYSTEMS SPECIFICATIONS

FUEL SYSTEM

Fuel	Unleaded or leaded gasoline (minimum octane 89)
Carburetor	Down-draft, single-barrel
Governor	Mechanical type, belt-driven
Lift Pump	12-Volt electric; lift capacity 6 ft (1.8 m)
Air Cleaner	Metal screen type - cleanable

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with sea water exchanger system
Operating temperature	130-150°F (55° - 66°C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Sea Water Pump	Positive displacement rubber impeller, belt-driven
Sea Water Flow, at 1800 rpm (measured at discharge from heat exchanger)	4.75 - 5.0 gpm (17.98 - 18.92 lpm)
System Capacity (fresh water)	5.7 qts (5.39 liters)

LUBRICATION SYSTEM

General	Pressure type with trochoid pump, chain-driven through balance shafts
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (filter not included)	3.0 qts (2.841 liters)
Oil Pressure, at 1800 rpm (engine hot)	50 - 70 psi (3.5 - 4.9 kg/cm ²)
Oil Grade	API spec SD or SE

ELECTRICAL SYSTEM

Starting Battery (recommended)	12-Volt, 30 A-H (45 A-H cold areas)
Starter	12-Volt, 1.2 kW, reduction type, solenoid-mounted
DC No-load current	90 Amp (max.) at 11.5 Volts and
DC Cranking Current (engine cold)	175 Amp
DC Charging Alternator	35-Amp belt-driven, with internal regulator and without isolation diodes

IGNITION SYSTEM

General	Battery ignition, 12 Volts, negative ground, distributor with points, ignition coil and spark plugs
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AC GENERATOR

General	Brushless, four-pole, revolving field, single-bearing design, reconnectable, single-phase trans- former regulation (optional solid- state voltage regulation)
Voltage	120 or 120/240 Volts-60 Hertz 110 or 110/220 Volts-50 Hertz voltage regulation: $\pm 5\%$ no load to full load frequency regulation: ± 3 Hertz (5%) no load to full load

Rating

60 Hertz (1800 rpm)	120 Volts	75 Amps
	120/240 Volts	75/37.5 Amps
50 Hertz (1500 rpm)	110 Volts	58 Amps
	110/220 Volts	58/29 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

32 cfm (0.906 cmm)

TUNE-UP SPECIFICATIONS

Spark Plug Gap

0.028 - .036 inch (0.7 - 0.9 mm)

Contact Point Clearance

0.016 - .020 inch (0.4 - 0.5 mm)

Dwell Angle

58° - 66°

Condenser Capacity

0.27 microfarad

Valve Clearance
(warm engine)

Intake 0.0079 inch (0.20 mm)

Exhaust 0.0079 inch (0.20 mm)

Timing, at 1800 rpm

14° ± 1° BTDC

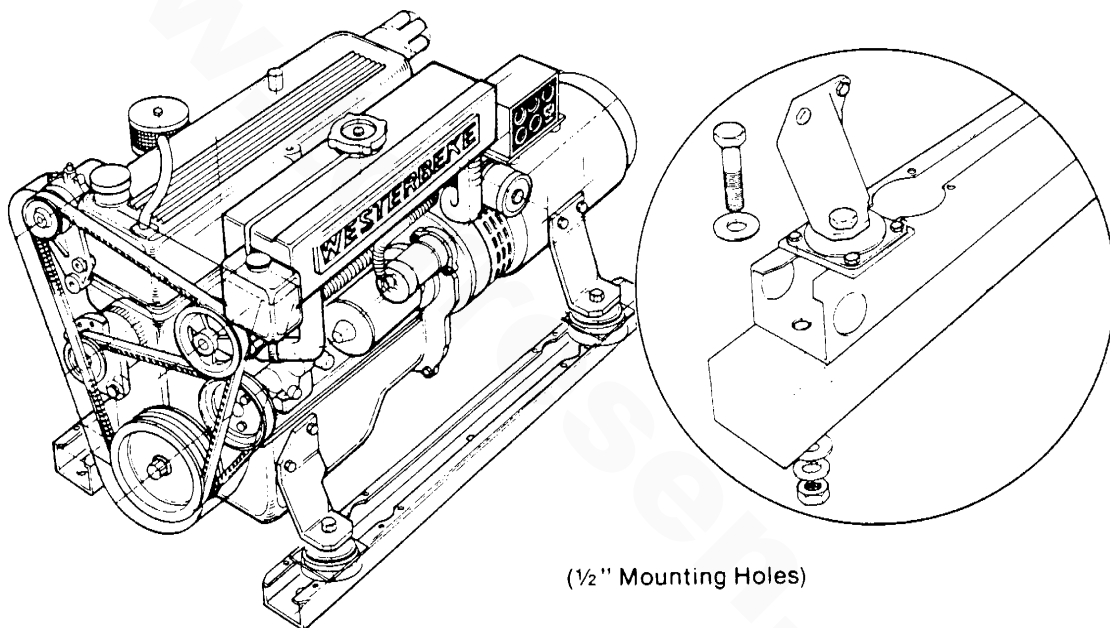
INSTALLATION

General

Proper location and installation of the generator set in the vessel are of prime importance.

Factors in the installation that must be considered are ventilation for the generator for proper cooling and engine combustion air; exhaust system to properly discharge raw cooling water, quiet the exhaust and expel exhaust gas; cooling water supply; fuel supply; and electrical connections.

Factors in the location that must be considered are proper support and access for servicing and repairs. These factors will be discussed in this manual.



(1/2" Mounting Holes)

There are four 1/2-inch bolt holes in each generator mounting rail to properly secure the generator to its mounting platform.

Location

The location should be such that it is dry, above low-lying vapor areas, and away from being splashed by bilge water or water from above. It should be properly ventilated and accessible for minor servicing and repairs. Access for major repairs should be given consideration as well. The location must be properly ventilated to provide the fresh cooling air for the generator end and for engine combustion. Hot generator discharge air must be removed from the generator area. The platform on which the generator is mounted should be strong enough to support the generator and securely hold the mounting rails fastened to it at all angles of vessel operation.

Ventilation

The generator set needs fresh cool air for combustion within the engine cylinders, for generator cooling and to remove harmful or flammable gasoline fumes from around the generator set. The 9 KW BTG engine requires air flow of 32 cubic feet per minute (0.906 cubic meters per minute) and the generator end requires from 225 to 250 cubic feet per minute (6.37 to 7.08 cubic meters per minute) air flow.

NOTE: Heated generator discharge air should not be allowed to accumulate in the generator compartment. It should be removed to prevent recirculation through the generator.

Exhaust System

WARNING

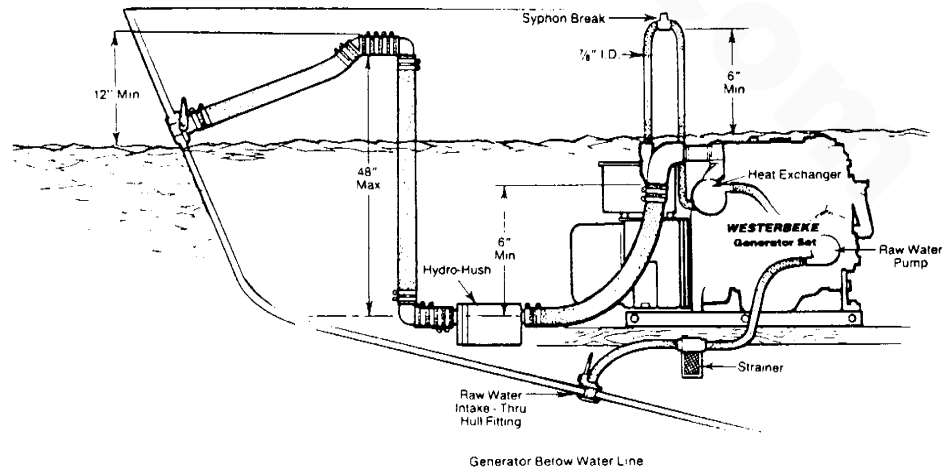
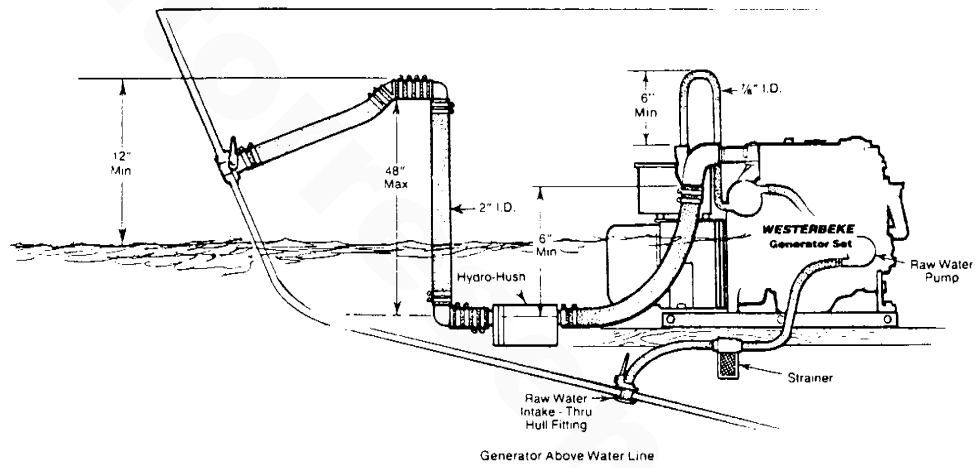
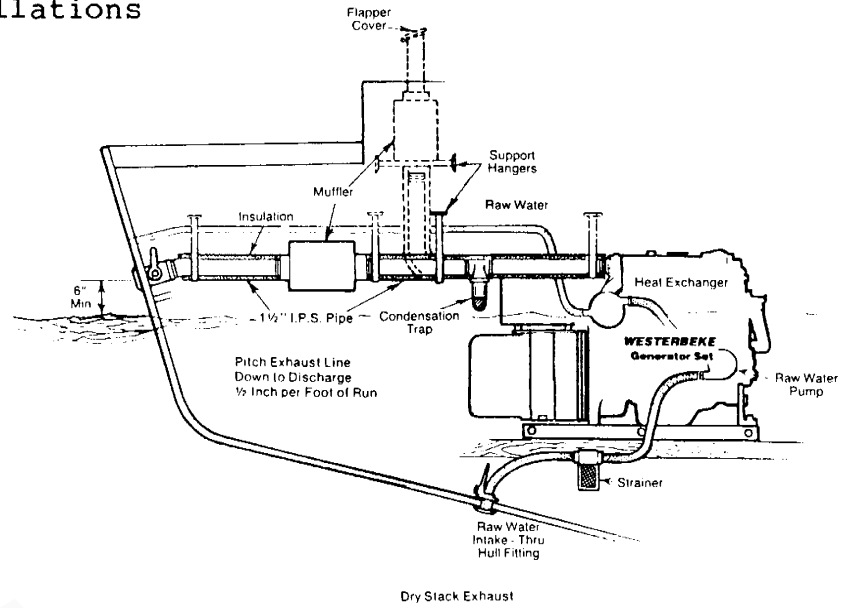
Exhaust gas is deadly; the exhaust system must be tight and free of leaks.

All exhaust systems must be configured to prevent the entry of water into the engine exhaust manifold and cylinders while the vessel is under power or sail, heeling, from following seas, when backing down or any other conditions.

General tips on exhaust system:

- Dry portions of exhaust system, between the engine and cooling water injection point, must be properly insulated.
- The exhaust hose must be of adequate size and minimal run to help prevent excessive back pressure. The use of fittings and elbows should be limited as these create back pressure.
- The generator exhaust system must be separate from any other engine exhaust system.
- Dry stack type exhaust systems must be flexibly attached to the engine manifold, be properly supported, have a spark arrestor and be protected against water entry.
- Hydro hush mufflers should be mounted as close to the generator as possible and the exhaust/cooling water mixture from the exhaust/water injected elbow should drop down into the muffler.
- Units installed with exhaust manifolds close to or below the vessel water line must have anti-siphon protection in the sea water plumbing to the exhaust/water injected elbow.

Exhaust System Installations



CAUTION

Overcranking with no engine start results in excessive amounts of cooling water pumped into the exhaust system. Exhaust gas pressure may not always be sufficient to discharge accumulated water during periods of excessive cranking. Shut off thru-hull water supply until unit starts and then open once started. Investigate reason(s) for hard starting and correct.

Fuel System

WARNING

Gasoline leakage in or around the generator compartment is a potential cause of fire and/or explosion. Repair leaks promptly and ensure the compartment is properly ventilated.

The fuel supply to the generator should be from its own pickup in the tank and not teed off the supply to another engine.

Anti-Siphon Protection is the term applied to the means of preventing siphoning action that permits fuel to continue to flow out of the fuel tank when there is a break or rupture in the fuel supply line, or when a fitting loosens to create a leak in the line between the fuel tank connection and the connection to the engine. Fuel systems must be designed and installed to protect against fuel siphoning.

The illustrations shown on the following page (taken from Coast Guard publication Fuel System Compliance Guideline), show basic fuel system layouts with anti-siphon protection.

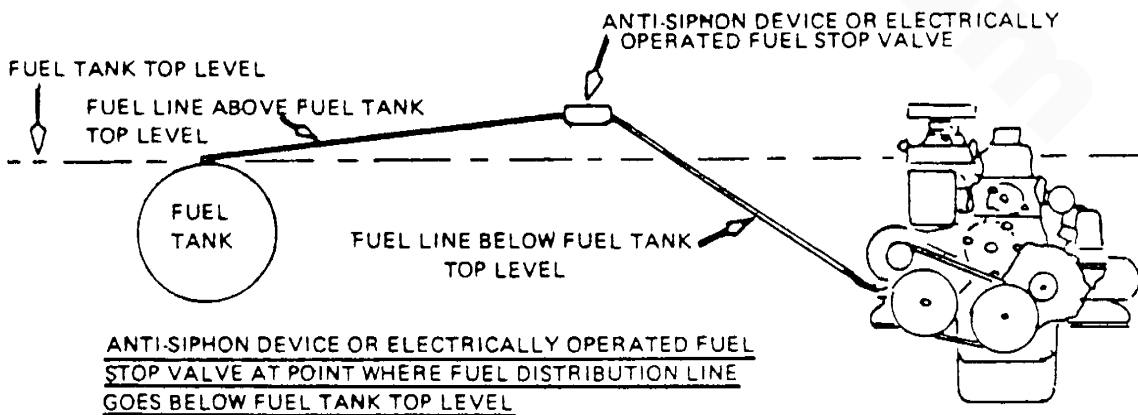
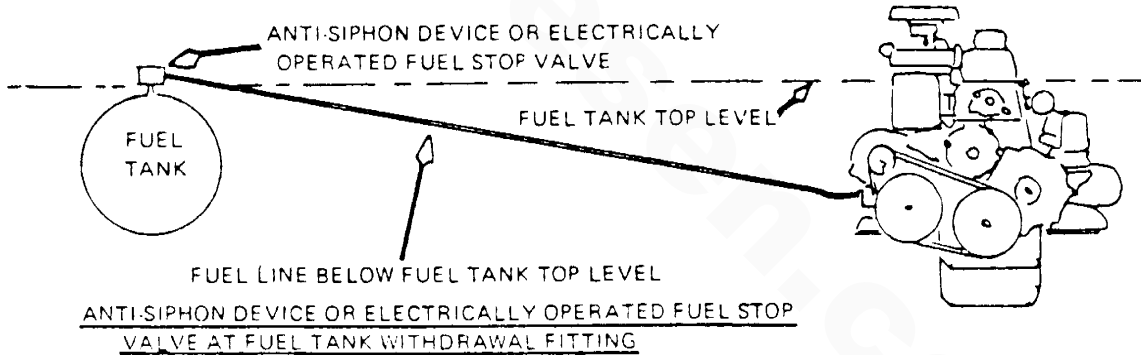
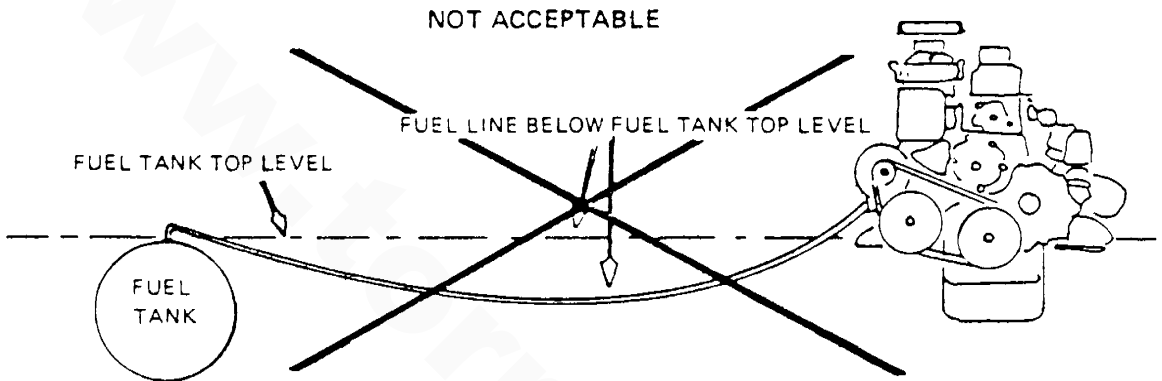
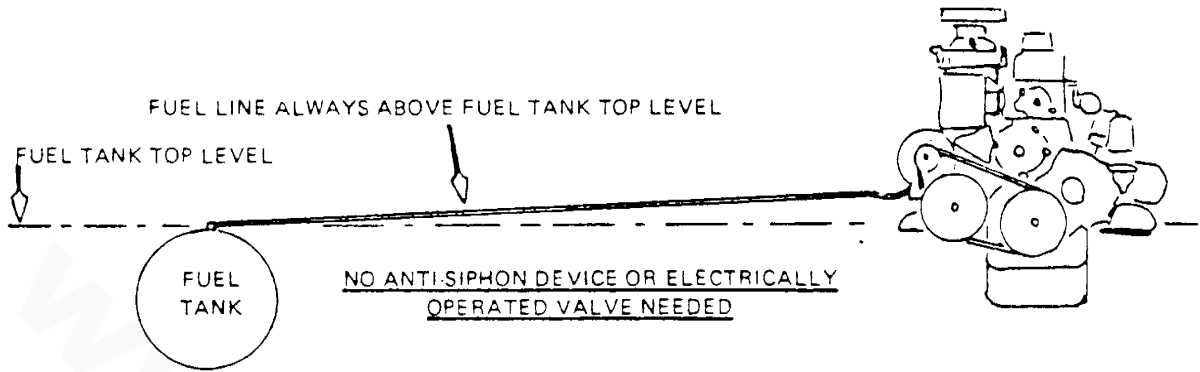
NOTE: Anti-siphon devices or electrically-operated fuel shut-off valves must be installed when the fuel distribution line is routed below the top level of the fuel tank.

The fuel line should be routed and supported to prevent leaks from vibration and chafing. The line should be supported every 12 - 14 inches. Use as few connections in the supply line as possible.

A filter/water separator is recommended for use in the fuel system, between the fuel tank and engine, to remove harmful debris and water from the fuel, both of which are prime causes of fuel system and/or engine failure.

The fuel tank vent should be routed, and the discharge located, so that that water cannot enter the fuel tank(s) through the vent. Moisture must not be allowed to accumulate in the vent line.

Basic Fuel System Layouts with Anti-Siphon Protection



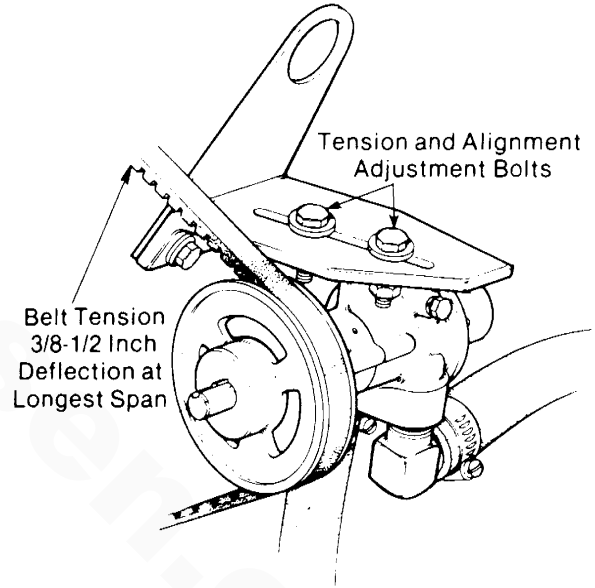
Fuel system components must be compatible with oxygenate (butanes, alcohols) blended fuels. Failure to ensure compatibility will result in the component failure and possible injury to the user.

The use of check valves in place of the solenoid-type shut-off valves is discouraged. Check valves may tax the ability of the fuel lift pump on the engine to draw fuel through them. Also, they can trap debris under their seats, defeating their purpose. Too high a cranking pressure for check valves will contribute to vapor lock shutdowns.

Cooling System

The generator engine is fresh water-cooled by an engine-mounted heat exchanger. Sea water is used as the exchange cooling medium and is pumped into the exchanger by a sea water pump and then injected into the exhaust discharge, carrying with it the heat removed from the engine fresh water system.

The sea water pump is belt-driven and sea water should be supplied to it through a flush-type hull fitting. This sea water should be brought through a visual-type sea water strainer and then delivered to the pump. Hoses routed from the thru-hull fitting to the strainer and to the sea water pump, should be wire-reinforced to prevent collapse from the suction of the sea water pump during generator operation. Sea water strainers should be mounted at or below the water line so as to be always self-primed.



CAUTION

Do not use a scoop-type thru-hull fitting for the sea water supply to the generator. Water pressure against this type fitting, while the vessel is underway, can push water past the sea water pump impeller and into the generator exhaust system, filling it and the engine as well. Flush-type, clear, thru-hull fittings are recommended and should be located on the hull so as to be below the waterline during all angles of boat operation.

The use of common-type street elbows is not recommended for plumbing the sea water circuit. These generally have a very restrictive inside diameter. Machined fittings are preferred.

Automatic Shutdown

High Exhaust Temperature Shutdown Switch (normally closed)

An exhaust temperature switch is located on the exhaust elbow and will open the ignition circuit should the switch sense excessive temperature, indicating a lack of proper sea water coolant flow. This switch opens at 260 - 270°F (127 - 132°C) and resets at approximately 225°F (107°C).

High Water Temperature Shutdown Switch (normally closed)

A high water temperature switch is located in the area of the thermostat housing to sense fresh water coolant temperature and shut down the generator should the engine fresh water coolant operating temperature reach approximately 205° F(96°C) \pm 5°. This switch resets at 195°F (approximate).

Low Oil Pressure Shutdown Switch (normally open)

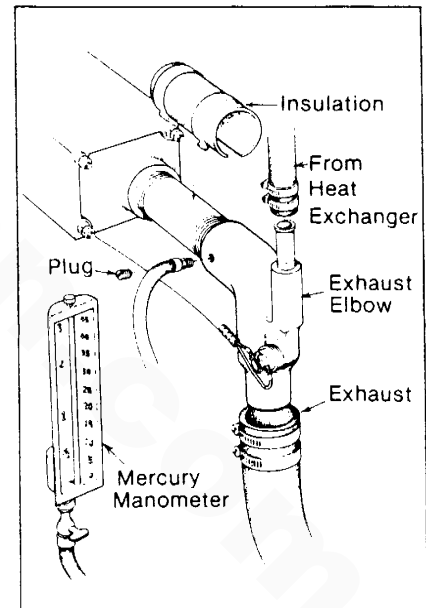
A low oil pressure shutdown switch is located in the engine oil gallery and is closed when engine oil pressure reaches 10 - 15 psi, maintaining the electrical run circuit. This switch will open and shut the generator down when engine oil pressure drops to 10 - 15 psi.

Exhaust Back-Pressure

Exhaust back-pressure should be checked prior to putting a generator into service. (Refer to the illustration.) Excessive back-pressure will affect engine performance and generator power output.

Measure back-pressure at the exhaust elbow with generator under full load. Back-pressure (manometer) should not be over 3 inches of mercury (0.104 kg/cm²), 39 inches of water column (0.099 kg/cm² at 4° C), 22 ounces per square inch or 1-1/2 psi (967 kg/m²).

Excessive back-pressure can be caused by small diameter exhaust hose, small muffler, sharp bends, fittings, water pockets or high volume of water in the exhaust system.



Oil Drain

An oil sump drain hose is installed on the engine with the discharge end secured by a bracket at the front of the engine. Oil may be drained from this hose by removing the cap and the discharge end of the hose from the support bracket and lowering the hose into a container. The hose cap fitting is 1/4-NPT and can be extended, or a pump added, for easier removal of oil, if desired.

DC Electrical Connections

A common ground for negative (-) DC is found at the bellhousing of the generator, next to the starter, in the form of a threaded grounding stud. It is recommended that the battery ground be connected here.

Connect battery positive (+) to the starter solenoid terminal tagged for this connection.

CAUTION

To avoid an overcharging condition, and possible equipment failure, do not disconnect the DC battery source while the engine is running.

Grounding

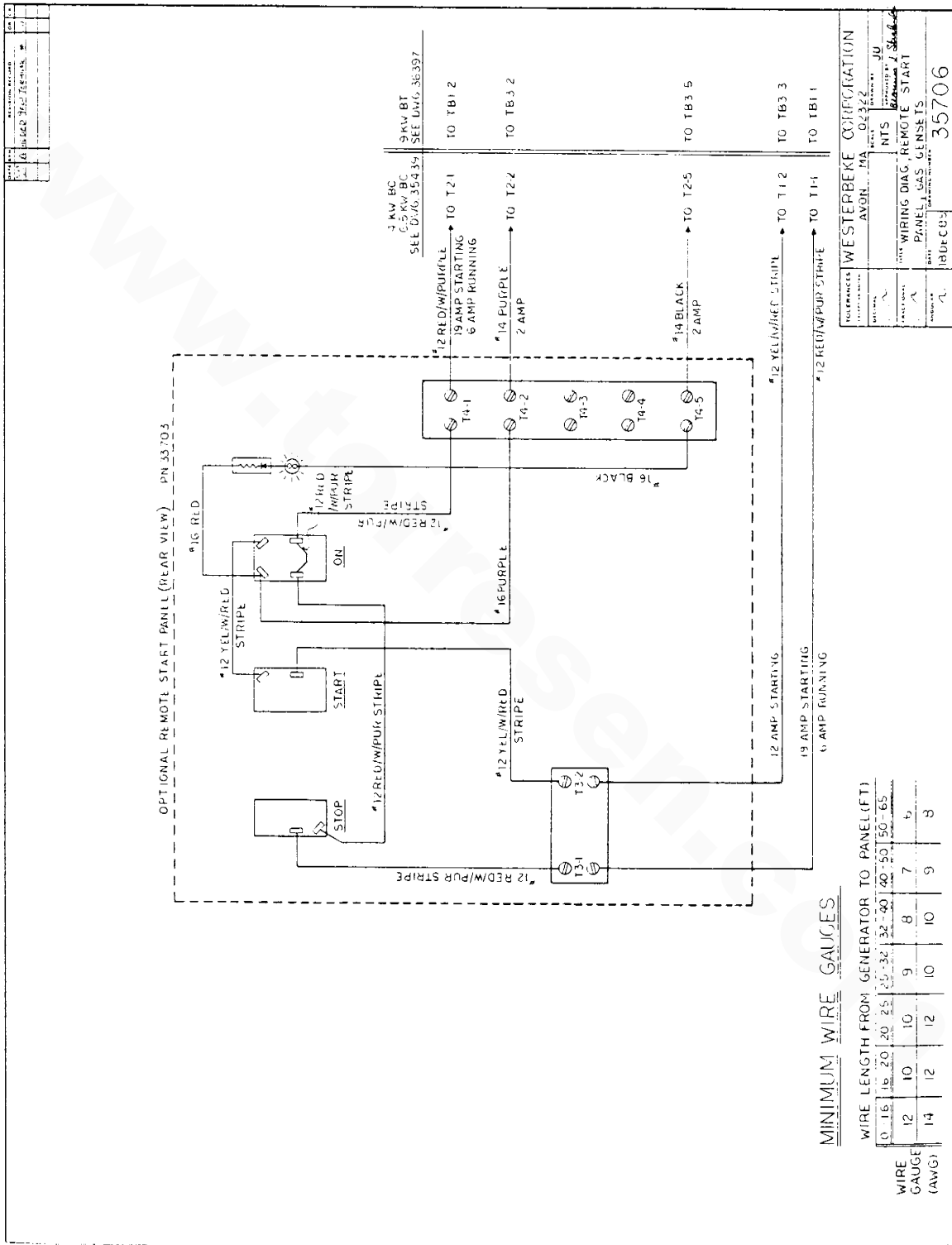
The generator set must be grounded to comply with United States Coast Guard regulation 33CFR-183 which specifies that a common conductor be connected between the generator set and the vessel's main propulsion engine grounded starter motor circuit. This conductor (common ground) prevents accidental passage of cranking current through fuel systems and smaller electrical conductors common to the engines. This conductor must be the same size as the largest battery cable.

Optional Remote Start/Stop Panel and Instrument Panel

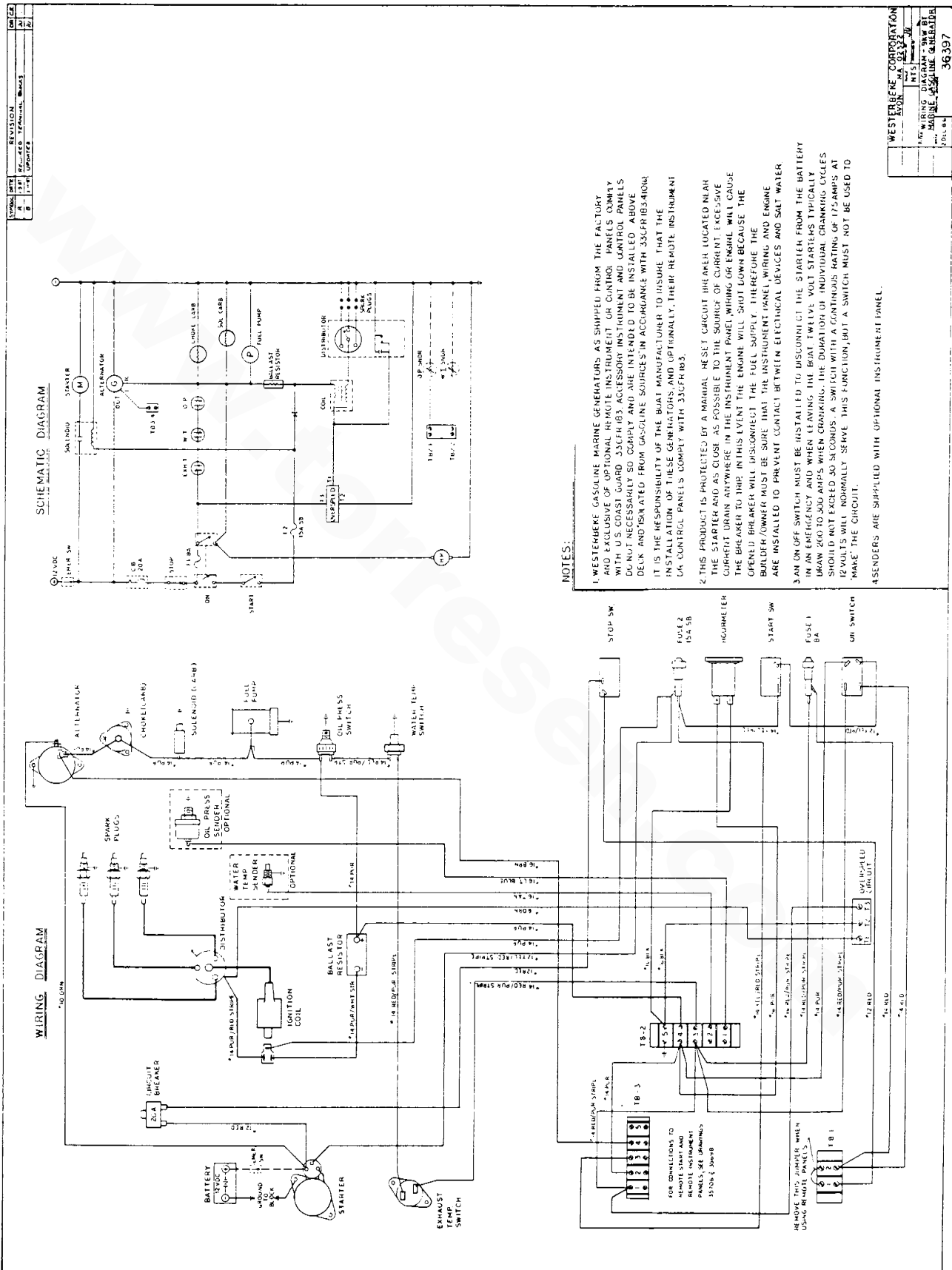
An optional remote start/stop panel is available, on which are mounted switches and a green RUN indicator light. This RUN indicator light will glow when the ON switch is depressed, dim when the START switch is depressed to engage the starter, and then glow bright when the engine starts (a signal to release the START switch). This panel is connected to the terminal blocks in the generator-mounted control panel. (Refer to wiring diagrams #35706 and #36397.) This remote start/stop panel can be mounted in areas such as the wheel house or galley.

An optional instrument panel is available which is supplied with an engine oil pressure gauge, water temperature gauge, DC voltmeter, engine operating hourmeter and start/stop control switches. This panel can be wired to the terminal blocks in the generator-mounted control panel and mounted at the location where the instruments can be monitored and the switches operated. (Refer to the DC wiring schematics #35698 and #36397 for proper connection points and recommended wire sizes for specific wire lengths.)

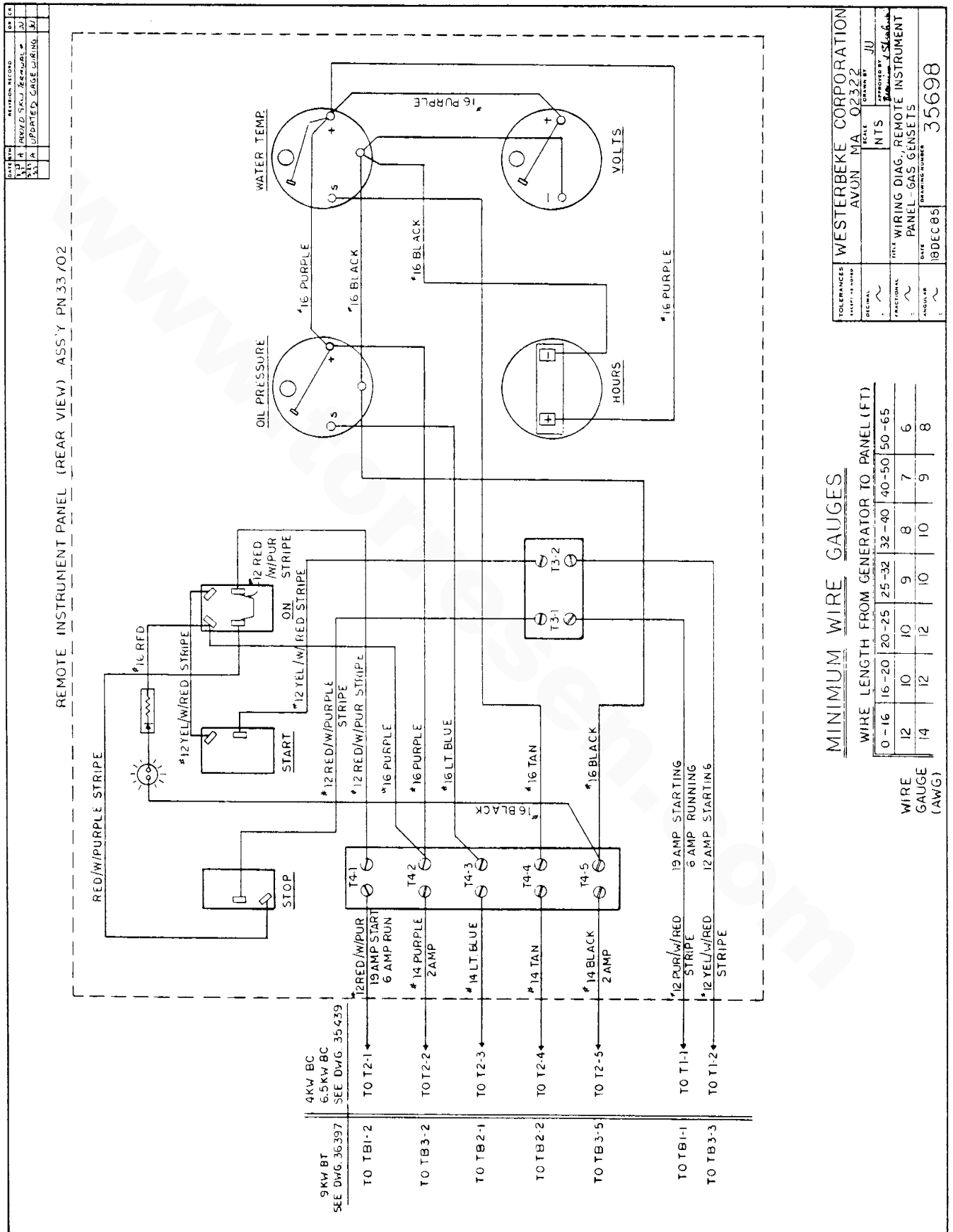
Remote Start Panel Wiring Diagram # 35706



DC Wiring Diagram #36397



Remote Instrument Panel Wiring Diagram #35698



BT GENERATOR

This generator is a brushless self-excited generator, which requires only the driving force of the engine to produce AC output. Two permanent magnets in the exciter stator are responsible for the self-exciting feature of this generator. The magnetic field they produce causes an AC voltage to be induced into the related exciter rotor windings during rotation. Diodes located in the exciter rotor rectify this voltage to DC and supply it to the windings of the rotating field. This creates an electromagnetic field which rotates through the windings of the main stator, inducing an AC voltage which is supplied to a load. A 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 main stator and is, in turn, supplied to a full-wave bridge rectifier. The rectifier produces a DC voltage to further excite the exciter stator windings, enabling the generator to produce a rated AC output.

An optional solid-state voltage regulator is available to work in tandem with the transformer regulator to produce a more stable AC output.

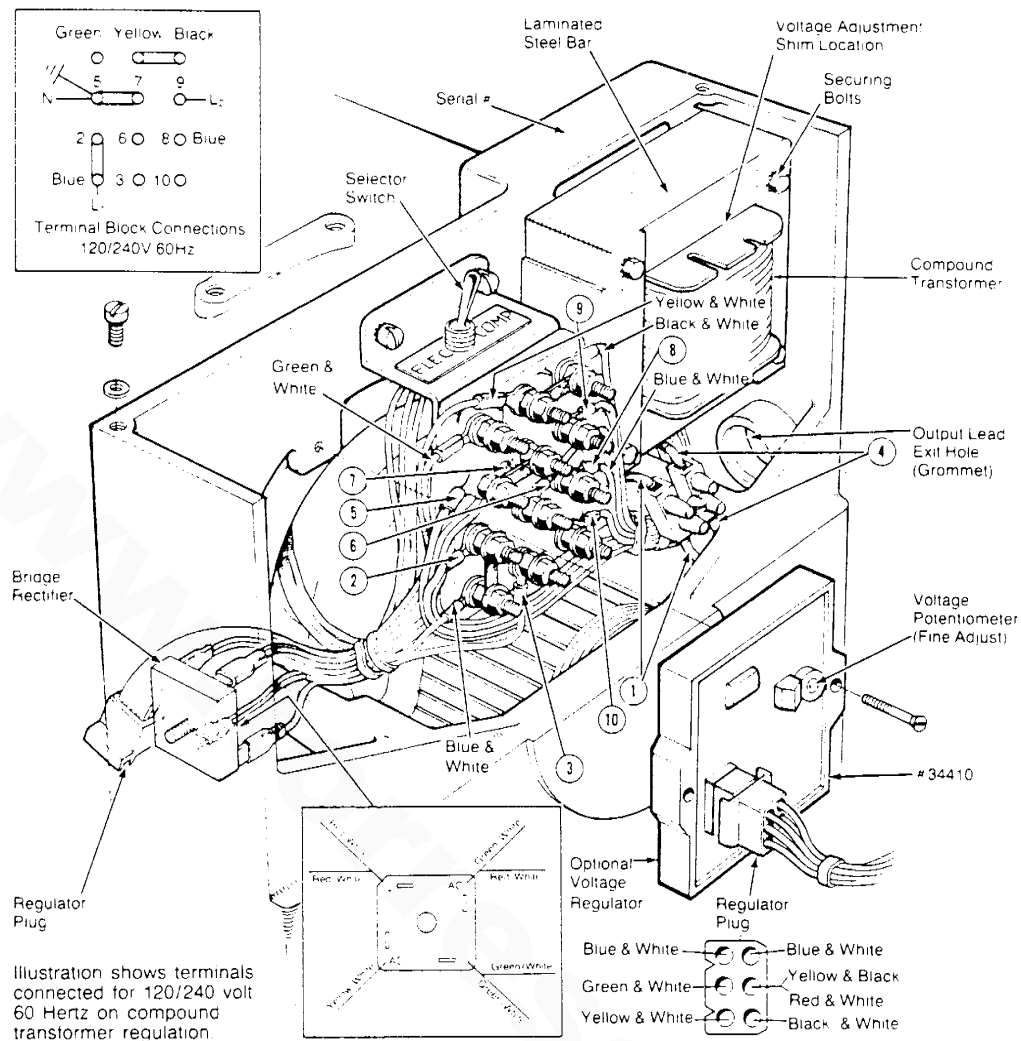
No-Load Voltage Adjustment

Voltage adjustment is made with the compound transformer governing generator regulation.

1. The selector switch must be in the COMP position.
2. Operate the generator and apply a moderate load momentarily; then remove the load. Note the voltage output from the generator's 120-Volt leg(s) (110 Volts at 50 Hertz). The no-load voltage should be between 121 - 123 Volts at 61.5 - 62 Hertz (111 - 113 Volts at 51.5 - 52 Hertz).

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

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



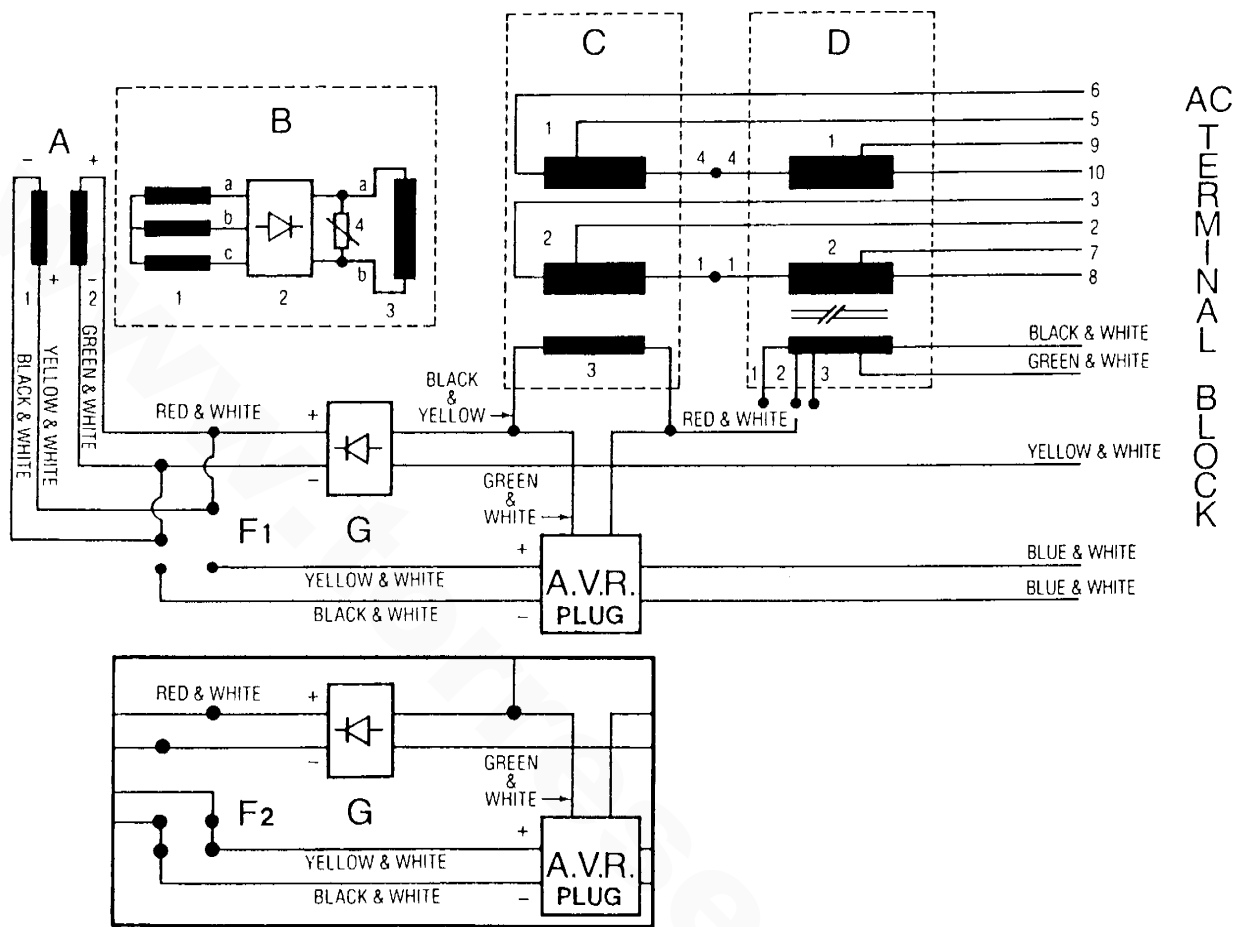
CAUTION

Under no circumstances attempt to increase the no-load voltage by increasing the gap between the laminated steel bar and the transformer core without the use of shims. Magnetic forces created within the transformer during generator operation may close the air gap and reduce no-load voltage output.

4. To remove the laminated steel bar, remove the two upper securing bolts from the compound transformer and lift the bar from the transformer. The addition of shim thickness will raise the no-load voltage and, conversely, the removal of shim thickness will lower the no-load voltage.

Varying shim thickness by .001 inch (0.025 mm) will change the no-load voltage by 4 to 6 Volts.

BT Generator Internal Wiring Diagram



- A. EXCITER STATOR WINDINGS
 1. Exciter Stator Windings
 2. Exciter Stator Windings

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

- B. EXCITER ROTOR
 1. Auxiliary Windings
 2. Diodes
 3. Rotating Field Windings

- F. SELECTOR SWITCH
 1. Compound
 2. Electronic and Compound

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

- G. BRIDGE RECTIFIER

A.V.R - Automatic Voltage Regulator

Optional Voltage Regulator

An optional solid-state voltage regulator (board #34410) is available for use with the 9 KW BTG generator. When installed, and the regulation switch is moved to the ELEC position, the regulator works together with the standard compound transformer regulator to regulate generator voltage output.

Installation

1. The regulator is mounted using existing tapped holes in generator case. Use (2) M4 x 0.7-mm screws, 15 mm 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 correctly.

3. Before moving the selector switch to ELEC, ensure the no-load voltage produced by the generator is properly adjusted, with the selector in COMP position, by following the procedures for No-Load Voltage Adjustment.
4. With generator no-load voltage properly adjusted, move the selector switch into the ELEC position. Adjust the regulator board potentiometer to set no-load voltage at 120 Volts, 61.5 - 62 Hertz (110 Volts, 51.5 - 52 Hertz). Generator voltage output should be within +5 percent from no-load to full-load.

Generator Frequency

Frequency is a direct result of engine/generator speed:

1800 RPM - 60 Hertz
1500 RPM - 50 Hertz

To change generator frequency:

1. Connect the AC output leads to the AC terminal block, following the illustrations on the preceding page.
2. Adjust the engine speed to obtain the frequency corresponding to the voltage selected.

Engine speed is increased or decreased by adjusting the belt-driven governor. (See Governor and Governor Adjustment paragraph under ENGINE ADJUSTMENT, later in this manual.)

3. Adjust no-load voltage output to corresponding frequency, as explained in earlier paragraph, No-Load Voltage Adjustment.

Load Connections

The generator data plate gives voltage, current and frequency rating of the generator. An AC wiring decal is affixed to the inside of the louvered cover on the generator end. A diagram of the various AC voltage connections is provided on the decal and is similar to the figure on the following page.

The generator is single-phase, reconnectable 120 VAC two-wire or 120/240 VAC three-wire, at 60 Hertz; or 110 VAC two-wire, 110/220 VAC three-wire, or 220 VAC two-wire, at 50 Hertz. Refer to specifications section for ratings.

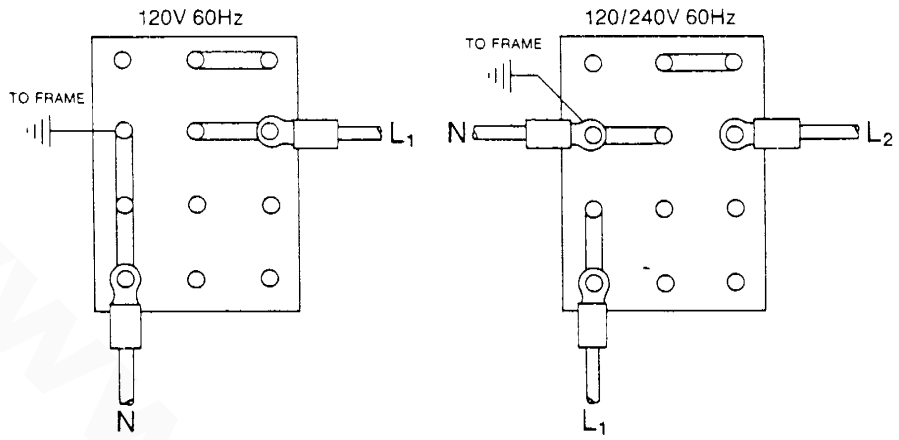
NOTE: When changing the frequency produced by the generator, an engine speed adjustment must be made and the connections on the AC output terminal block, located under the louvered cover on the back end of the generator, also must be changed according to the AC wiring diagram.

When the generator is wired for 120/240 Volts (110/220 Volts) and loads are applied to the 120-Volt(110-Volt) legs, these loads must be as balanced as possible. A load applied to one of the two 120-Volt (110-Volt) output legs while none is applied to the other, will produce a voltage difference between the two 120-Volt(110-Volt) output legs. The voltage on the loaded leg will go down and that on the unloaded leg will go up. The severity of this voltage difference will depend on the amount of load applied to the one 120-Volt(110-Volt) leg. Heavy loads applied to one leg will cause the generator to perform as above and also produce a rattling/growling noise from the generator end. The noise results from the unbalanced effect produced on the rotating field as its magnetic field passes through the loaded and unloaded stator 120-Volt (110-Volt) output windings.

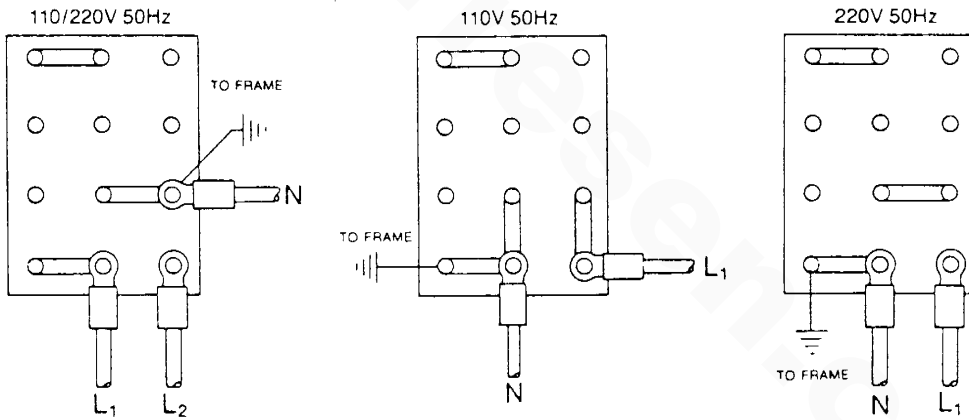
NOTE: It is recommended that the installer provide AC ammeters (optional) so that the operator can observe the load being taken off each leg of the generator.

A circuit breaker should be installed between the generator and the AC load. This circuit breaker should be rated for the generator's AC output and react to overloads quickly, subject to motor starting considerations.

AC Voltage Connections



60 Hertz, 1800 rpm



50 Hertz 1500 rpm

NOTE: The frame ground wire must be moved when changing from 110 Volts, 50 Hertz to 110/220 Volts, 50 Hertz.

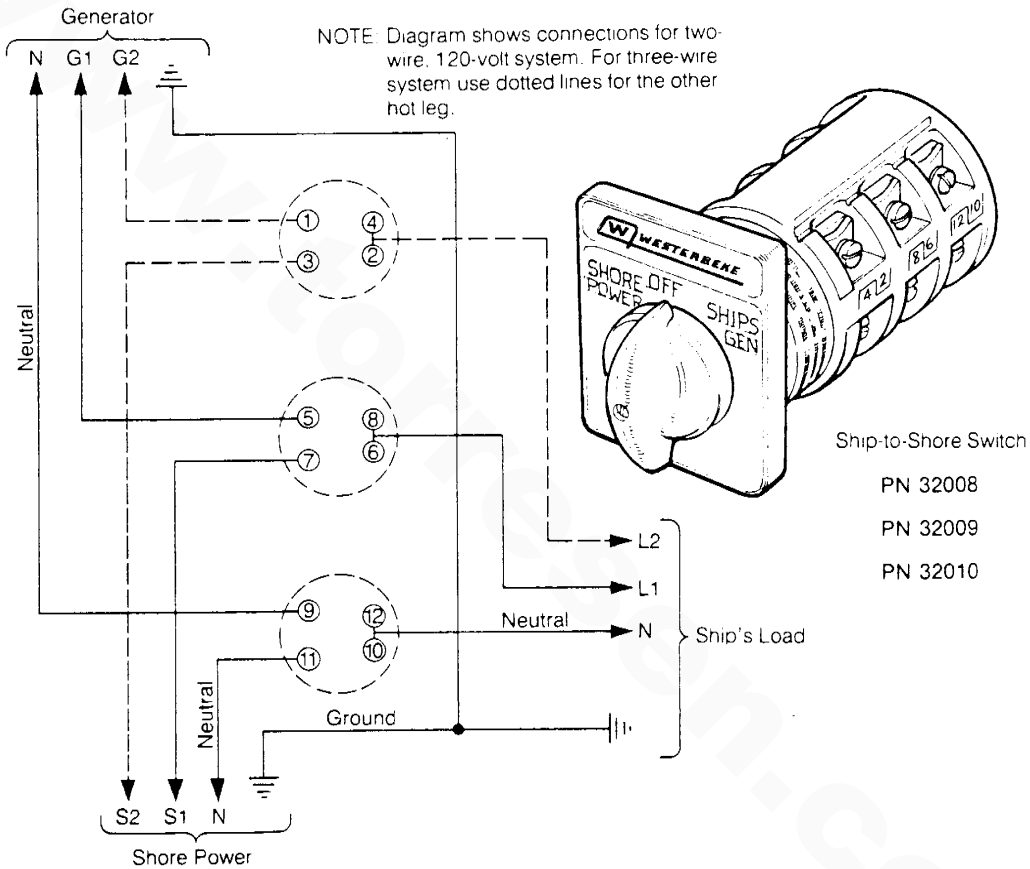
For making connections to the AC terminal block, use #10 terminal ends that will accept #6 or #8 multi-strand wire.

Shore Power Connections

If the installer connects shore power to the vessel's AC circuit, this must be done by means of the SHORE POWER/OFF/SHIPS GEN, center position-off transfer switch shown below. Use of 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.



OPERATION

Prior to starting the generator, check the following:

- Lubricating oil level
- Coolant (fresh water)
- Fuel to engine
- Sea water connections
- Battery connections
- Generator AC electrical connections
- Exhaust connections
- Belt tensions (governor/fresh water pump)

Engine Oil

Use a good grade of oil API Spec. SD or SE, preferably SE.

Refer to the specification section of this manual for oil sump capacity. Use the proper SAE number for the ambient temperature at which the unit will be operating.

CAUTION

Do not use oils designated API Spec DS.

Fresh Water Coolant

WARNING

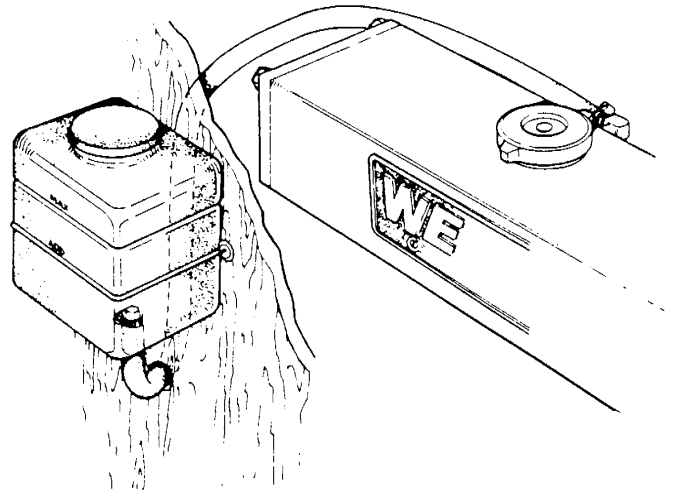
To avoid serious injury from escaping steam or scalding coolant, never remove engine manifold filler cap when the engine is hot. Coolant should always be added to the system via the remote coolant recovery tank.

Fill the fresh water cooling system with a 50-50% mixture of fresh water and antifreeze. Use an antifreeze that is compatible with aluminum cooling system components (Alumi Guard). Thoroughly mix the antifreeze and water before placing in the engine's cooling system. This is to ensure that any gelatin-like globules in the antifreeze are broken up and will not clog the cooling system exchanger. This mixture will provide freeze protection, reduce corrosion and aid in cooling.

NOTE: Ensure the passage between the manifold fitting and filler neck area is clear before attaching connecting hose to recovery tank.

A coolant recovery tank (#24977) is supplied with each engine and must be installed to allow coolant expansion and contraction without creating or introducing air into the cooling system. It should be used for monitoring and adding coolant.

NOTE: If coolant is lost through a leak in the system, it will be necessary to refill via the filler cap on the manifold and then refill the recovery tank.



Fuel

Use clean, filtered unleaded gasoline line when available. Regular gasoline may be used when unleaded is not available.

WARNING

Do not fill the fuel tank while the generator is running. Vapors and spilled fuel may ignite causing a fire and/or explosion.

WARNING

Gasoline engine exhaust gasses contain deadly carbon monoxide, a poisonous gas that can cause unconsciousness and eventual death.

The symptoms of carbon monoxide poisoning are:

- Headache
- Dizziness
- Relaxed, sleepy feeling
- Vomiting
- Muscle spasms
- Throbbing at the temples

If any of these symptoms are experienced while operating the generator, immediately get out into the fresh air. When recovered, shut down the generator, ventilate the compartment, and inspect the exhaust system for leaks.

Regular inspection of the generator exhaust system is required to prevent and/or correct potentially deadly exhaust leaks.

Starting

Ventilate the generator compartment for a minimum of 5 minutes before attempting to start the engine. The ventilating blowers remove potentially explosive fumes from the generator compartment and bilge.

Starting sequence:

1. Depress the ON switch and hold. (No load on generator).
2. Depress the START switch. When the engine starts, release the START switch only. Allow a few seconds to establish sufficient oil pressure and then release the ON switch. Check exhaust discharge for sea water coolant flow.

NOTE: Allow the generator to warm up before applying a heavy load. Apply only light loads during warm-up.

Break-In

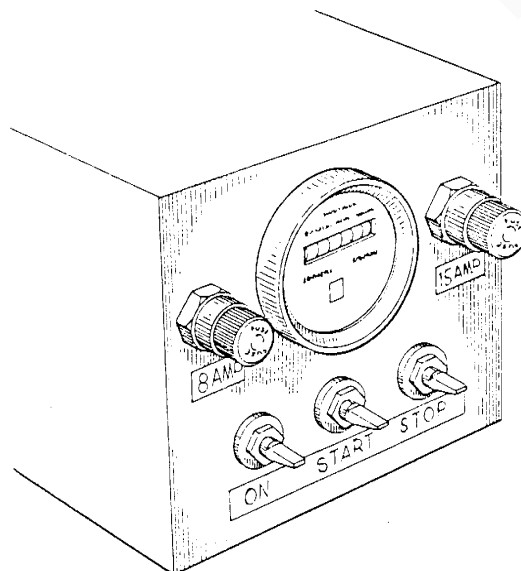
Run the generator at varying loads for the first 25 hours of operation to help seat the engine piston rings properly.

Avoid light loads for the first 100 hours of operation. Load the generator 50 percent or more during this time period.

Repeated light loads during break-in can cause improper seating of the piston rings, resulting in blow-by and high oil consumption.

Stopping Generator

1. Remove the load and allow generator to run unloaded for 5 minutes to dissipate heat and stabilize operating temperature.
2. Depress STOP switch and hold until generator has completely stopped rotating, then release.



SERVICE AND MAINTENANCE

Regular inspection and servicing of the engine and generator increases the service life of the unit and reduces repair costs and down time.

Table of Scheduled Maintenance

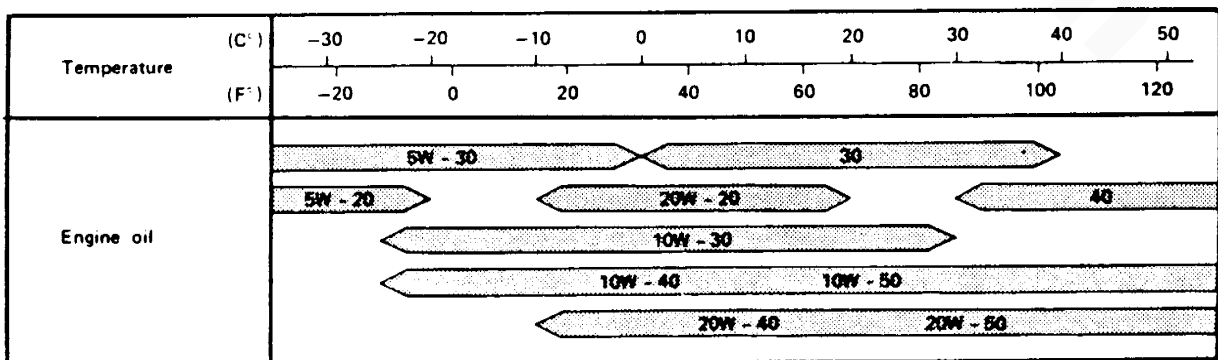
	Daily	50 Hrs.	100 Hrs.	300 Hrs.	500 Hrs.
Visually inspect unit	X				
Check lube oil level	X				
Check coolant level	X				
Check fuel supply	X				
Clean air screen (flame arrestor)		X-1	X		
Check spark plugs		X-1		X	
Change lube oil and filter		X-1	X		
Check valve clearance		X-1			X
Torque cylinder head bolts		X-1			X
Check AC connections		X-1		X	
Clean and lube governor linkage		X-1	X		
Check exhaust system	X				
Check starting battery		X-1	X		
Check fuel filters		X-1	X		
Check belts and belt tension		X-1	X		
Check zinc anode in heat exchanger		X-1	X		
Check sea water pump		X-1			X
Check governor adjustment		X-1	X		
Check timing belt					X

(X-1: Initial 50-hour break-in check)

NOTE: Replace timing belt after 1500 hours of operation.

Engine Lube Oil

Check lube oil level prior to each day's use. Maintain the sump oil level at the full mark on the dipstick. Change oil and filter regularly. Use a good brand of oil that meets API Spec. SC or SD. Select the proper SAE-numbered oil for the temperature condition of operation.



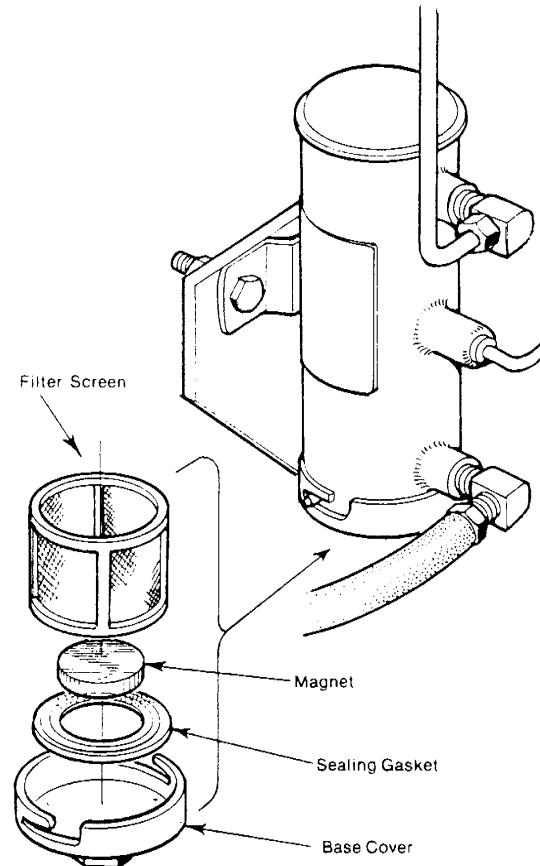
Electric Fuel Pump

The engine-mounted electric fuel pump supplies fuel to the engine carburetor during engine operation. A cleanable filter screen is contained in its base.

WARNING

Shut off fuel service valve at engine when servicing fuel system. Take care to catch fuel when opening filter elements. Do not allow any smoking, open flames, sparks or other sources of fire near the fuel system when servicing. Ensure proper ventilation when servicing the fuel system.

Remove the base cover by placing a wrench on the hex nut and twisting it loose from the bayonet fittings. Clean the screen as needed. Replace the base gasket (#34706) each time the base cover is removed and re-installed.



Spark Plugs

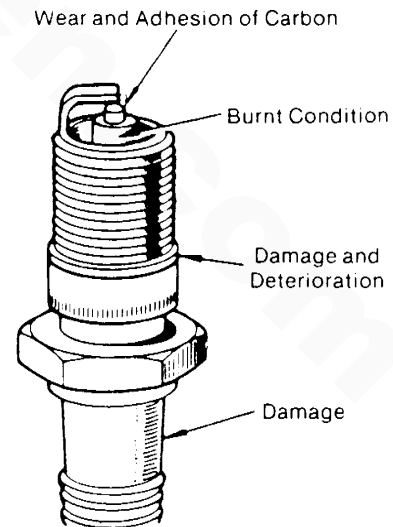
NOTE: Remove and install spark plugs with engine cold.

Check plugs for damage and/or wear.

To service spark plugs, clean and gap or replace, as needed.

Spark plug gap: 0.028 - 0.036 inch
(0.07 - 0.9 mm)

Spark plug torque: 10.8 - 15.9 lb-ft
(1.5 - 2.2 kg-m)



Cooling System

Monitor system coolant (50/50 antifreeze mixture) and, if rust or scale are evident, flush and clean system and replenish the antifreeze mixture. Use antifreeze that is compatible with aluminum engine components.

Maintain proper belt tension on the fresh water circulating pump and sea water pump, three-eighths to one-half inch deflection along the belt's longest span. Replace if cracked or frayed. Do not over-tighten as it is possible to bend the governor shaft by over-tightening.

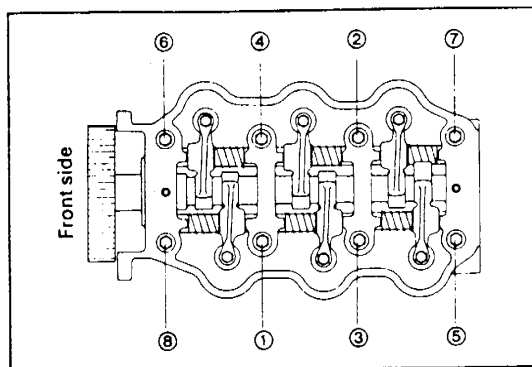
Check the impeller in the sea water pump. Ensure the vanes are flexible and not cracking.

Check the sea water pump for wear on the front cover, cam plate and inner wear plate.

An excessively-worn pump will not pump efficiently, resulting in improper cooling.

Cylinder Head and Valves

Tighten cylinder head bolts in the sequence shown. The engine should be cold. Loosen each bolt one-eighth to one-quarter turn before tightening in the sequence shown.



Tightening Sequence

Head bolt tightening torque:

32 - 43.4 lb-ft
(5.0 - 6.0 kg-m)

Valve clearance should be checked and adjusted, if necessary, each time bolts are torqued.

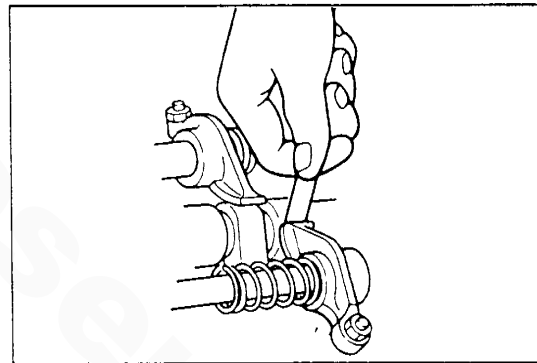
Valve Clearance Adjustment (Both intake and exhaust):

- (Hot) 0.0079 inch (0.20 mm)
- (Cold) 0.0071 inch (0.18 mm)

Valve Adjustment Procedure

1. Rotate the crankshaft in normal direction of rotation, placing No. 1 piston at the top of its compression stroke. Adjust the intake and exhaust valves for No. 1 cylinder, the exhaust valve for for No. 2 cylinder and the intake valve for No. 3 cylinder.
2. Rotate the crankshaft in its normal direction of rotation 360°. Locate the piston in No. 1 cylinder at the end of its exhaust stroke and beginning of intake. Adjust the intake valve for No. 2 cylinder and the exhaust valve for No. 3 cylinder.

Crank angle	Cylinder		
	1	2	3
When No.1 piston is set at end of compression stroke.	IN	○	○
	EX	○	○
When No.1 piston is set at tops of intake and end of exhaust strokes.	IN	○	
	EX		○



ENGINE ADJUSTMENT

Ignition Timing

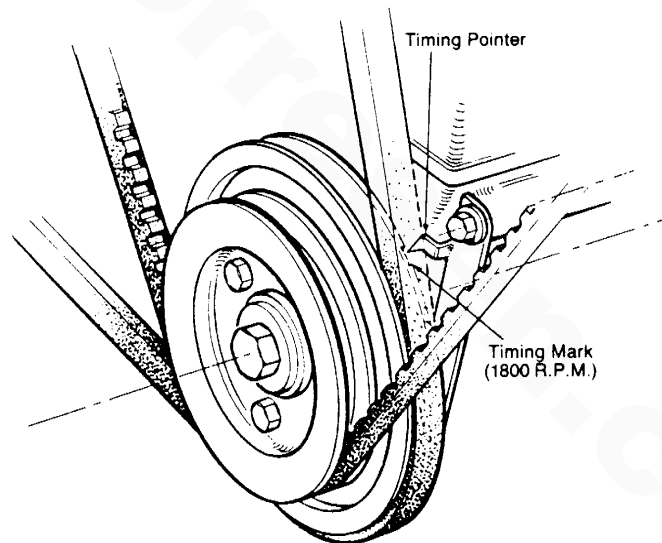
Attach a timing light to No. 1 spark plug and mark the front crankshaft pulley timing notch. Locate timing pointer on front gear case and mark same. Use of white or yellow marking crayon helps greatly in referencing these two points with the timing light.

Start the engine; allow it to warm up and stabilize engine speed.

Check timing with an ignition timing light. Ensure engine is operating with no load on the generator (61.5 - 62.0 Hertz).

Adjust timing as needed by loosening distributor hold-down bolt and turning distributor in the desired direction to place the timing mark on the crankshaft pulley in alignment with the timing pointer. Then tighten the distributor hold-down bolt.

NOTE: Check engine speed and adjust governor as needed, according to the procedure given later in this section. Check generator performance under load.



Electric Choke

The electric choke uses a 12-Volt heating element which opens the choke automatically once the engine starts and is running.

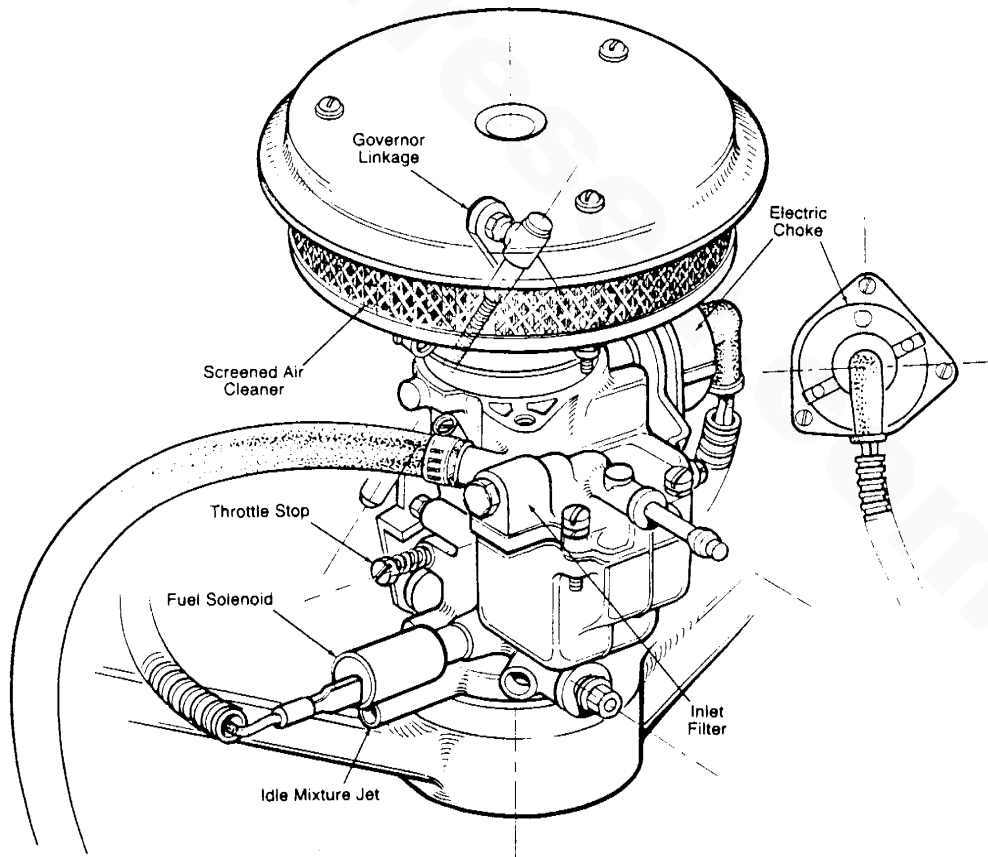
Some hunting will be present when the generator is started and on choke, with no-load on the generator.

WARNING

To avoid burns on fingers or hands, do not touch the choke housing while engine is operating. Allow engine to cool before making choke adjustments.

The choke is adjusted with the engine off and at room temperature. Adjust the choke by loosening the three cover-securing screws and rotating the cover clockwise to set the choke lean and counter-clockwise to set the choke rich. The choke is initially set at the factory for an average of 70°F (21°C) room temperature.

The choke may need readjustment at engine commissioning for the ambient temperature of the area in which the engine is to operate.



NOTE: Choke index mark is located on the choke cover: lower right, inboard side.

Carburetor Adjustment

1. Idle Mixture Jet

Disconnect the throttle linkage arm from the governor control arm and reduce engine speed with the idle stop screw. Adjust the idle mixture screw: turn screw clockwise (in) until engine skips; back screw out (counterclockwise) slowly until engine smooths then skips again; turn screw clockwise (in) one-quarter to one-half turn. Idle mixture should be satisfactory.

NOTE: Oil pressure switch will need to be jumped to prevent engine shut-down due to low oil pressure at idle.

2. Run Mixture Jet (1800 rpm)

This mixture jet is presized at the factory and is not adjustable. The idle mixture jet adjustment can be made in the 1800 rpm range to improve engine performance; the governor adjustment can improve engine performance as well.

Governor and Governor Adjustment

The governor maintains engine speed under varying conditions of generator load. The engine speed determines the frequency and effects voltage output of the generator.

The governor will maintain engine speed to within 3 Hertz of generator frequency output from no-load to full rated load of the generator (Generator Data Plate).

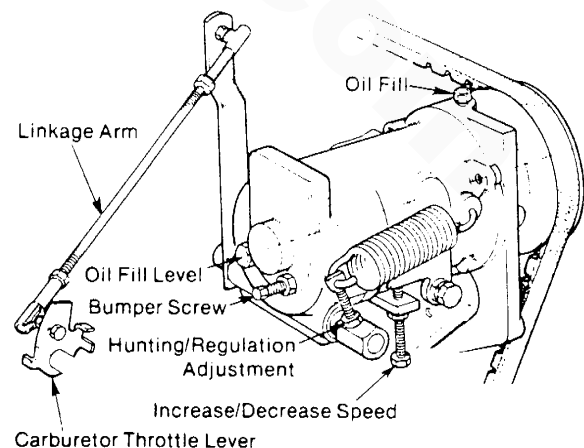
Operate the generator set to bring the engine up to operating temperature before attempting an adjustment.

NOTE: If the governor is severely out of adjustment, manually adjust the linkage at no load to obtain a safe output voltage before proceeding with the adjustment.

There are three adjusting points on the governor. (Refer to the illustration.)

1. Increase/Decrease Speed

This adjusting screw is used to set the no-load speed of the engine. (The linkage arm between the governor arm and throttle lever should be adjusted to hold the throttle full open when the engine is not running). En-



sure this linkage moves freely and that the ball joint connectors are properly lubricated. (Disconnect the ball joint and apply graphite lube to the inside of the joint.)

2. Hunting/Regulation

If variation in engine speed between no load and full load is too great, adjust this eyescrew to draw the spring closer to the lever hub.

The increase/decrease speed screw may need to be adjusted as well.

If the governor surges under load, adjust this eyescrew to move the spring away from the lever hub. (Check speed adjustment.)

3. Bumper Screw

This screw is used to remove a no-load surge only. Never adjust the bumper screw so that it will cause an increase in engine's no-load speed; this will increase the operating frequency.

Governor Maintenance

Periodically lubricate linkage arm attaching points at governor arm and throttle lever with a graphite lubricant or equivalent. Free movement of this linkage arm is important for proper governor/throttle operation.

Remove governor linkage from carburetor throttle arm and governor arm by popping the linkage end of the ball connector on these arms. Clean and lubricate linkage socket and arm ball with graphite lube and reassemble.

Governor oil capacity - 3 ounces (89 milliliters) of SAE 10W-30 engine oil. Do not overfill the governor.

Change governor oil every 500 hours of operation.

To change oil, remove governor from engine, remove oil fill plug and drain all oil. Reinstall on engine and fill with 3 ounces (89 milliliters) of SAE 10W-30 engine oil. Replace fill plug.

Governor drive belt should be maintained in good condition. Replace if it becomes worn or shows signs of cracking.

CAUTION

Do not overtighten the governor drive belt. Premature wear on governor or a bent governor shaft will result.

DC CIRCUIT DESCRIPTION: BTG 9 KW
GASOLINE MARINE GENERATOR SET

Safety Information

This circuit is designed and manufactured in compliance with United States Coast Guard Standards (33 CFR PART 183). No modifications may be made to it by the installer or user. It is the installer's responsibility to assure that the installation of the generator set and any remote start panels or remote instrument panels are installed in compliance with the above Coast Guard Standards. Failure to observe these requirements could be the cause of injury.

Electrical System Characteristics

The generator is started by a conventional, separate cranking motor which includes a self-contained positive-engaging starter solenoid. The starter is internally-grounded to the engine block.

Start battery charging is accomplished through a belt-driven, 12-Volt, 35-Amp DC alternator. Its voltage regulator is self-contained and the alternator does not have isolation diodes. DC voltage output is 13 - 14.5 Volts, 0 - 35 Amps.

Within 7 inches of the battery connection to the starter solenoid there is a circuit breaker which protects all subsequent wiring. This is a manually-resettable circuit breaker.

Three manually-operated momentary toggle switches are used to start and stop the generator set. No control relays are present in the design in the interests of simplicity and reliability in the marine environment.

Two panel-mounted fuses are installed to protect the starter circuit, the running B+ circuit through the protective switches, and the remote panel circuit.

The choke is automatic and electrically-operated. The ignition system is conventional, with contact points.

There is an overspeed shutdown which, when it senses engine speed at approximately 2175 rpm, shuts off the generator set by grounding out the ignition system. This shutdown consumes 25 milliamps (.025 or 1/40th of an Amp) at all times, once the generator is connected to its battery. As this only amounts to about 18 Amp-hours in a month, it is unnecessary to be concerned with this slight discharge during normal operation. If the generator set were to be unattended for many months, stop this slight drain by turning off the main battery switch which provides 12 Volts to the generator set.

An optional remote start panel is available for controlling the generator from a remote location. Remote start panels include a green LED which brightens at approximately 600 engine rpm. The purpose of the LED is to alert the operator to release the starter toggle switch; the LED then continues indicating that the generator set is running.

An optional remote instrument panel is available which includes starting controls. This panel also includes a water temperature gauge, oil pressure gauge, battery voltmeter, operating hourmeter, start-stop control switches, and senders to be installed on the engine for water temperature and oil pressure.

Circuit Description

The two-pole ON switch bypasses the protective shutdown switches during starting. The second pole provides a source of B+ to the START toggle switch.

While continuing to hold the ON switch to provide B+ to the START switch and to bypass the protective shutdown switches, the START switch is operated to cause the starter to crank the engine. If starting at the generator set, release the START switch when the generator is running. If starting at a remote location, release the START switch when the green LED brightens.

Continue depressing the ON switch. It is only necessary to continue holding the ON switch after releasing the START switch until oil pressure is sufficient to close the oil pressure safety switch, providing the normal B+ path to the ignition system. Note that it is impossible to energize the starter while the generator is running, unless ON switch is depressed. This protects the starter motor gears.

While operating, the overspeed shutdown module monitors engine speed and will ground the ignition system if it senses engine speed at approximately 2175 rpm.

Should the generator shut down from an overspeed condition, the overspeed circuit must be reset in order to restart the generator. This is done by simply depressing the STOP switch momentarily and then proceeding with the normal starting procedure. If the overspeed switch itself is faulty and resetting will not correct it, lift the T-1 coil connection and check for spark at plugs.

WARNING

It is very important that the overspeed shutdown always be installed and functioning. Any tampering with the overspeed shutdown module which would cause it to malfunction, could be a cause of injury should the generator belt-driven governor fail and cause the generator to run away.

To stop the generator, depress the STOP switch which opens the normally-closed B+ path to the ON and START switches. The STOP switch must be depressed (opened) until the generator comes to a stop. Remote start panels may be connected to the generator set as illustrated in the remote start/stop panel schematic. A jumper wire must be removed from the engine control panel when either of the optional panels is installed. Refer to the engine DC wiring schematic.

GENERAL INFORMATION AND CARE OF THE GENERATOR

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 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 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)	Running Current (Amperes)	Starting Current (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 that in the above table the maximum starting current is more for some small motors than for larger ones. This is because the hardest-starting types (split-phase) are not made in larger sizes.

Because the heavy surge of current required 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 of time. 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

Although individual units may vary slightly, the normal voltage and frequency of typical 60-(50-) Hertz engine-driven generators described in this manual are approximately as follows when run first with no load applied, then at half the generator capacity and finally when loaded to its full capacity as indicated on the generator data plate.

Load Applied	4-Pole Speed (rpm)	Frequency (Hertz)	Generator Voltage	
			120V (110) Plants	240V (220) Plants
None	1830 (1530)	62 (52)	122 (112)	244 (224)
Half	1800 (1500)	60 (50)	120 (110)	240 (220)
Full	1755 (1455)	59 (49)	110 (100)	220 (200)

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 ammeter is not installed to monitor voltage and load, check it with a portable meter and amprobe.

Preventive Maintenance

Maintenance on the generator is minimal.

- Keep the generator clean, dry and well-ventilated.
- Ensure all connections are clean and tight and that cables carrying AC voltage are properly supported and protected against chaffing.
- The rear armature bearing is lubricated and sealed; therefore, no maintenance is required. If the bearing becomes rough or noisy, replace it.

General Troubleshooting

A complete and illustrated text on troubleshooting the 9 KW BTG Generator is furnished in the Technical Manual that is available through your local dealer.

ENGINE TROUBLESHOOTING

<u>Trouble</u>	<u>Possible Cause</u>
Engine cranks but fails to start	<ol style="list-style-type: none"> 1. Out of fuel 2. Engine flooded 3. Filters clogged by contaminated fuel 4. Voltage drop at (+) on overspeed switch 5. Worn or faulty spark plugs 6. Bad ignition coil 7. High-tension leads grounding (system wet) 8. Automatic shutdown switch faulty 9. Fuel pump inoperative, filter clogged 10. Filter in carburetor clogged 11. Faulty overspeed switch (reset and start) (Lift T1 coil connection) 12. Engine circuit breaker tripped
Engine does not crank	<ol style="list-style-type: none"> 1. Battery low or dead 2. Sea water in cylinders 3. Loose battery connection 4. Voltage drop at starter solenoid terminal 5. Bad starter solenoid 6. Faulty START switch 7. Engine DC circuit breaker tripped
Engine starts, runs and shuts down	<ol style="list-style-type: none"> 1. Faulty automatic shutdown switch 2. Faulty overspeed switch (reset and start, lift T1 coil if switch will not reset.) 3. Faulty fuel pump 4. Faulty STOP switch 5. Engine circuit breaker tripping 6. Dirty fuel filters 7. Low oil level in sump
Backfire through carburetor	<ol style="list-style-type: none"> 1. Ignition timing wrong 2. Engine flooding 3. Choke stuck closed 4. Plug wires wrong - check firing order 5. Distributor cap cracked 6. Dirty air cleaner

ENGINE TROUBLESHOOTING
(continued)

<u>Trouble</u>	<u>Possible Cause</u>
Engine overheating	<ol style="list-style-type: none"> 1. Coolant loss (Pressure test system) 2. Belts loose or broken 3. Sea water pump impeller faulty 4. Sea water pump worn 5. Faulty hose 6. Thermostat stuck closed 7. Exchanger clogged 8. Faulty gauge (check with thermometer)
Engine hunting	<ol style="list-style-type: none"> 1. Throttle linkage binding 2. Dirty fuel filter 3. Defective fuel pump 4. Governor out of adjustment 5. Valves out of adjustment 6. Generator overloaded 7. Cracked distributor 8. Faulty high-tension leads
Engine misfires	<ol style="list-style-type: none"> 1. Ignition timing wrong 2. Spark plug worn 3. Valve clearance incorrect 4. Dirty carburetor 5. Dirty air cleaner 6. Poor quality fuel
High oil pressure	<ol style="list-style-type: none"> 1. Faulty gauge 2. Relief valve stuck 3. Dirty or wrong SAE oil
Low oil pressure	<ol style="list-style-type: none"> 1. Low oil level 2. Faulty gauge 3. Wrong SAE oil 4. Stuck relief valve 5. Faulty oil pump
No DC charge to start battery	<ol style="list-style-type: none"> 1. Connections to alternator loose or faulty 2. Faulty alternator 3. No excitation to alternator IG terminal
Black exhaust smoke	<ol style="list-style-type: none"> 1. Dirty air intake 2. Choke stuck closed 3. Carburetor flooding
Blue exhaust smoke	<ol style="list-style-type: none"> 1. Worn or misadjusted valves 2. Worn or unseated piston rings 3. Lube oil diluted 4. Crankcase breather hose clogged

TABLE OF TIGHTENING TORQUES

	<u>lb-ft</u>	<u>kg-m</u>
Cylinder head hold-down bolts	36.2 - 43.4	5.0 - 6.0
Main bearing caps	39.0 - 47.7	5.4 - 6.6
Connecting rod bearing cap	15.2 - 21.0	2.1 - 2.9
Front crankshaft pulley	65.2 - 72.4	9.0 - 10.0
Flywheel retaining bolts	28.9 - 36.2	4.0 - 5.0
Rocker cover cap nuts	5.8 - 8.7	0.8 - 1.2
Spark plugs	10.8 - 15.9	1.5 - 2.2
Exhaust and intake manifold to cylinder head	7.2 - 11.6	1.0 - 1.6
Camshaft timing belt pulley	21.7 - 32.5	3.0 - 4.5
Oil pan bolts	2.9 - 5.1	0.4 - 0.7
Banjo bolt-oil drain hose	18.1 - 25.3	2.5 - 3.5
Oil pump to engine block	10.8 - 15.9	1.5 - 2.2
Rear oil seal retainer	7.2 - 11.6	1.0 - 1.6
Balance shaft thrust plate	7.2 - 10.8	1.0 - 1.5
Timing belt tensioner	21.7 - 30.5	3.0 - 4.5
Oil pump drive shaft gear	7.2 - 11.6	1.0 - 1.6
Balance shaft gear cover	7.2 - 11.6	1.0 - 1.6
Distributor housing to block	2.9 - 5.1	0.4 - 0.7
Distributor to distributor housing	10.8 - 15.9	1.5 - 2.2
Backplate to block	7.2 - 11.6	1.0 - 1.6
Generator drive disc to flywheel	14.5 - 21.7	2.0 - 3.0
Drive disc to rotor shaft	28.9 - 39.8	4.0 - 5.5

TABLE OF STANDARD HARDWARE TIGHTENING TORQUES

unless stated otherwise for a specific assembly, use the following torque values when tightening standard hardware.

	<u>Pitch</u>	<u>lb-ft</u>	<u>kg-m</u>
Grade 4T			
6mm bolt/nut	1	2.9 - 5.1	0.4 - 0.7
8mm bolt/nut	1.25	7.2 - 11.6	1.0 - 1.6
10mm bolt/nut	1.25	13.7 - 22.4	1.9 - 3.1
10mm bolt/nut	1.5	13.0 - 21.7	1.8 - 3.0
12mm bolt/nut	1.25 (ISO)	25.3 - 39.8	3.5 - 5.5
12mm bolt/nut	1.5	25.3 - 39.8	3.5 - 5.5
12mm bolt/nut	1.75	21.7 - 36.2	3.0 - 5.0
13mm bolt/nut	1.5	32.5 - 50.6	4.5 - 7.0
14mm bolt/nut	1.5	36.2 - 57.9	5.0 - 8.0
14mm bolt/nut	2	34.0 - 55.7	4.7 - 7.7
16mm bolt/nut	1.5	54.2 - 79.6	7.5 - 11.0
16mm bolt/nut	2	51.4 - 76.7	7.1 - 10.6
Grade 6T			
6mm bolt/nut	1	4.3 - 6.5	0.6 - 0.9
8mm bolt/nut	1.25	10.8 - 15.9	1.5 - 2.2
10mm bolt/nut	1.25	21.7 - 32.5	3.0 - 4.5
10mm bolt/nut	1.5	19.5 - 30.4	2.7 - 4.2
12mm bolt/nut	1.25 (ISO)	36.2 - 57.9	5.0 - 8.0
12mm bolt/nut	1.5	36.2 - 50.6	5.0 - 7.0
12mm bolt/nut	1.75	34.7 - 49.2	4.8 - 6.8
Grade 7T, 8T and 8.8			
6mm bolt/nut	1	5.8 - 8.7	0.8 - 1.2
8mm bolt/nut	1.25	14.5 - 21.7	2.0 - 3.0
10mm bolt/nut	1.25	28.9 - 39.8	4.0 - 5.5
10mm bolt/nut	1.5	26.8 - 37.6	3.7 - 5.2
12mm bolt/nut	1.25 (ISO)	54.2 - 75.9	7.5 - 10.5
12mm bolt/nut	1.5	50.6 - 65.1	7.0 - 9.0
12mm bolt/nut	1.75	43.4 - 61.5	6.0 - 8.5
13mm bolt/nut	1.5	57.9 - 86.8	8.0 - 12.0
14mm bolt/nut	1.5	72.3 - 108.5	10.0 - 15.0
14mm bolt/nut	2	68.7 - 101.3	9.5 - 14.0
16mm bolt/nut	1.5	108.5 - 166.4	15.0 - 23.0
16mm bolt/nut	2	101.3 - 159.1	14.0 - 22.0
Grade 5 capscrew			
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