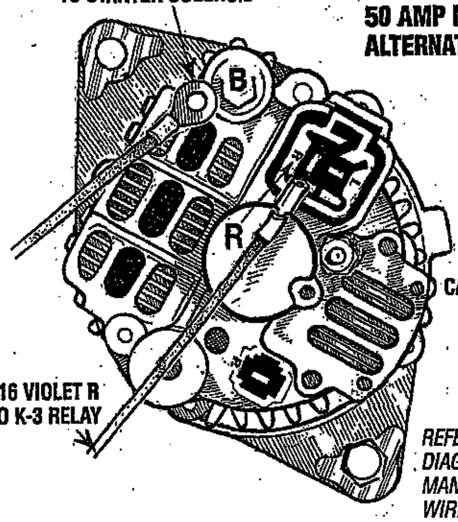
ALTERNATORS TESTING/TROUBLESHOOTING



DESCRIPTION

The following information applies to the standard alternators that are supplied with WESTERBEKE'S Engines and Generators.

ELECTRICAL CHARGING CIRCUIT

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

It is desirable to test the charging system (alternator and voltage regulator) using the wiring harness and electrical loads that are a permanent part of the system and will then provide the technician with an operational test of the charging system as well as the major components of the electrical system.

ALTERNATOR DESCRIPTION

The stator is connected to a three-phase, full-wave bridge rectifier package which contains six diodes. The bridge converts the AC generated in the stator to a DC output for battery charging and accessories,

Power to the regulator and the field of the integral regulator alternator is provided by the field diode (or diode trio) package contained in the alternator.

These alternators produce a rated output of 50 or 51 amps. rated output is achieved at approximately 6000 alternator rpm at an ambient temperature of 75°F (23.8°C). The alternators are designed to operate in an ambient temperature range of -40° to 212°F (-40° to 100°C).

VOLTAGE REGULATOR

The integral voltage regulator is an electronic switching device which senses the system voltage level and switches the voltage applied to the field in order to maintain a proper system voltage.

The regulator design utilizes all-silicon semi conductors and thick-film assembly techniques. After the voltage has been adjusted to the proper regulating valve, the entire circuit is encapsulated to protect the circuit and the components from possible damage due to handling or vibration.

ALTERNATOR TROUBLESHOOTING

Use this troubleshooting section to determine if a problem exists with the charging circuit or with the alternator. If it is determined that the alternator or voltage regulator is faulty, have a qualified technician check it.

> **WARNING:** ***A working alternator runs hot. A failed alternator can become very hot. Do not touch the alternator until it has cooled.***

LOW BATTERY/FAULTY CIRCUIT

If the starter only moans or makes a clicking sound instead of spinning the engine to life it is likely a low battery or a faulty connection in the starting circuit and not an alternator problem.

PRELIMINARY INSPECTION

Before starting the actual alternator and voltage regulator, testing the following checks are recommended.

1. Make certain your alternator is securely mounted.
2. Check the drive belts for proper tension. Replace the belt if it is worn or glazed.
3. Check that all terminals, connectors and plugs are clean and tight. Loose or corroded connections cause high resistance and this could cause overcharging, undercharging or damage to the charging system. Badly corroded battery cables could prevent the battery from reaching a fully charged condition.
4. Check the condition of the battery and charge if necessary. A low or discharged battery may cause false or misleading readings in the tests.

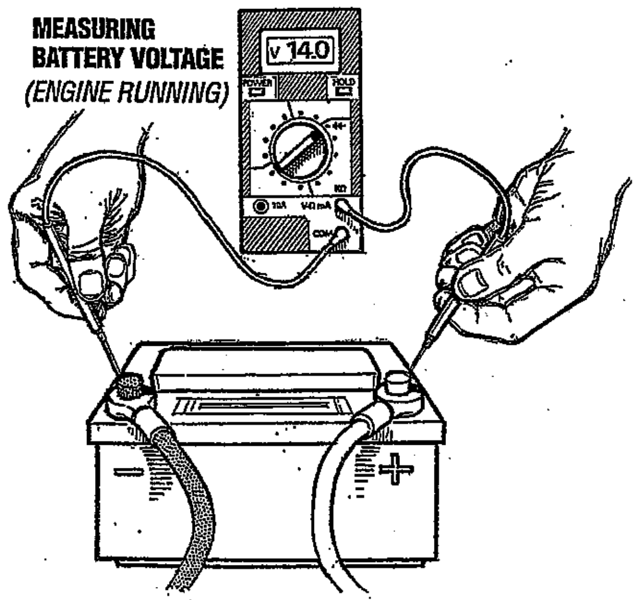
NOTE: *An isolator with a diode, a solenoid, or a battery selector switch is usually mounted in the circuit to isolate the batteries so the starting battery is not discharged along with the house batteries. If the isolator is charging the starting battery but not the house battery, the alternator is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

TESTING THE ALTERNATOR

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

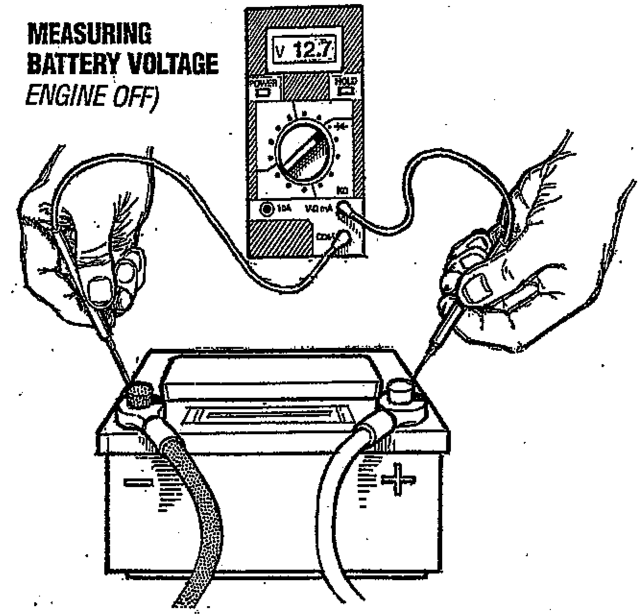
1. **Start the Engine.**
2. After the engine has run for a few minutes, measure the starting battery voltage at the battery terminals using a multimeter set on DC volts.
   a. If the voltage is increasing toward 14 volts, the alternator is working.
   b. If the voltage remains around 12 volts, a problem exists with either the alternator or the charging circuit; continue with Steps 3 through 6.

MEASURING BATTERY VOLTAGE
(ENGINE RUNNING)



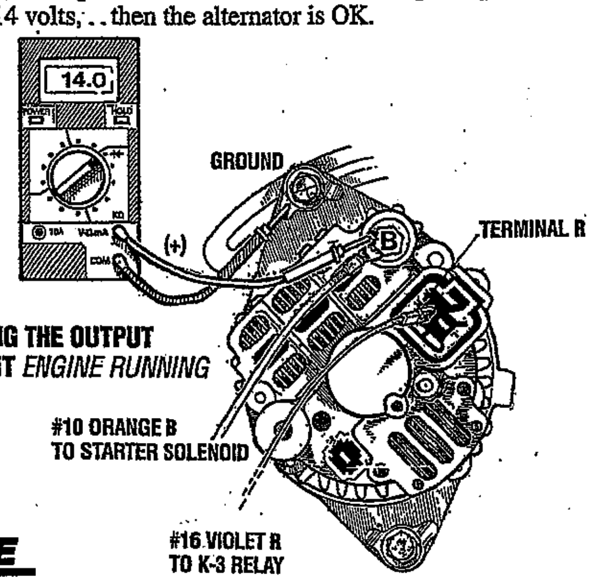
3. **Turn off the engine.** Inspect all wiring and connections. Ensure that the battery terminals and the engine ground connections are tight and clean
4. If a battery selector switch is in the charging circuit,ensure that it is on the correct setting.
5. Check the battery voltage. If your battery is in good condition the reading should be 12 to 13 volts.

MEASURING BATTERY VOLTAGE
ENGINE OFF)



TESTING THE OUTPUT CIRCUIT

1. Connect the positive probe to the output terminal **B** and connect the negative probe to ground.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is obtained, or if the reading varies, check the alternator output circuit for loose or dirty connections or damaged wiring.
3. **Start the engine.**
4. Repeat the same measurement, the negative probe to ground, the positive probe to **B** with the engine running. The voltage reading should be between 13.5 and 14.5 volts. If your alternator is over or under-charging, have it repaired at a reliable service shop.
5. If the previous test reads only battery voltage at terminal **B**, use the meter to measure the DC excitation terminal. If 12 volts is not present at exciter terminal **R**, inspect the wiring for breaks and poor connections. Jump 12 volts from a 12 volt source (such as the battery) and operate the alternator. If the voltage output is 13-14 volts,...then the alternator is OK.

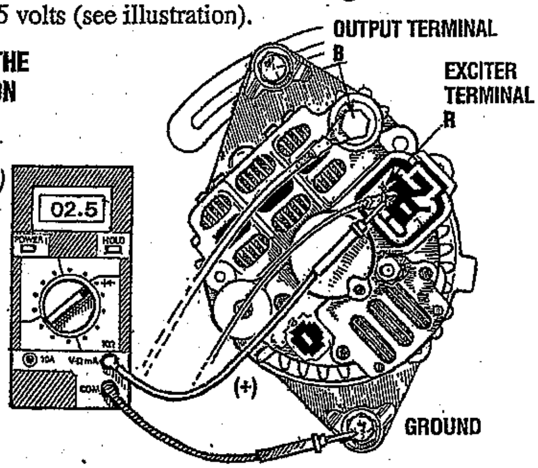


TESTING THE OUTPUT CIRCUIT *ENGINE RUNNING*

TESTING THE EXCITATION CIRCUIT

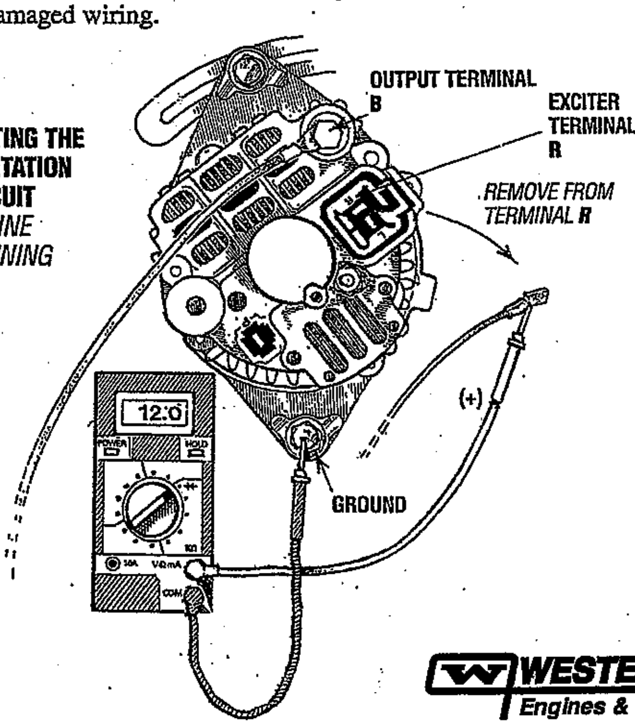
1. Connect the positive (+) multimeter probe to the excitation terminal **R** on the alternator and the negative (–) lead to ground.
2. **Turn the ignition switch to the on position** and note the multimeter reading. The reading should be 1.3 to 2.5 volts (see illustration).

TESTING THE EXCITATION CIRCUIT *(ENGINE RUNNING)*



3. **If the reading is between .75 and 1.1 volts,** the rotor field circuit probably is shorted or grounded.
4. **If the reading is between 6.0 and 7.0 volts,** the rotor field circuit probably is open.
5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal **R.** Connect the positive multimeter probe to the excitation lead and the negative multimeter probe to ground.
   If the multimeter now indicates an approximate battery voltage, the voltage regulator is defective and must be replaced. If no voltage is indicated, check the excitation circuit for loose or dirty connections or damaged wiring.

TESTING THE EXCITATION CIRCUIT *ENGINE RUNNING*



CHECKING THE SERVICE BATTERY

Check the voltage of the service battery. this battery should have a voltage between 13 and 14 volts when the engine is running. If not, there is a problem in the service battery charging circuit. Troubleshoot the service battery charging circuit by checking the wiring and connections, the solenoid, isolator, battery switch, and the battery itself.

When the problem has been solved and before the alternator is back in operation, take the time to tighten and clean the terminal studs. Also clean the connecting terminals from the wiring harness.

ALTERNATOR REPAIR

If tests indicate a failed alternator, it will need to be disassembled and repaired. Any good alternator service shop can do the job.

NOTE: *WESTERBEKE'S Service Manual has detailed instructions for the disassembly and repair of their standard alternators.*

BATTERY CARE

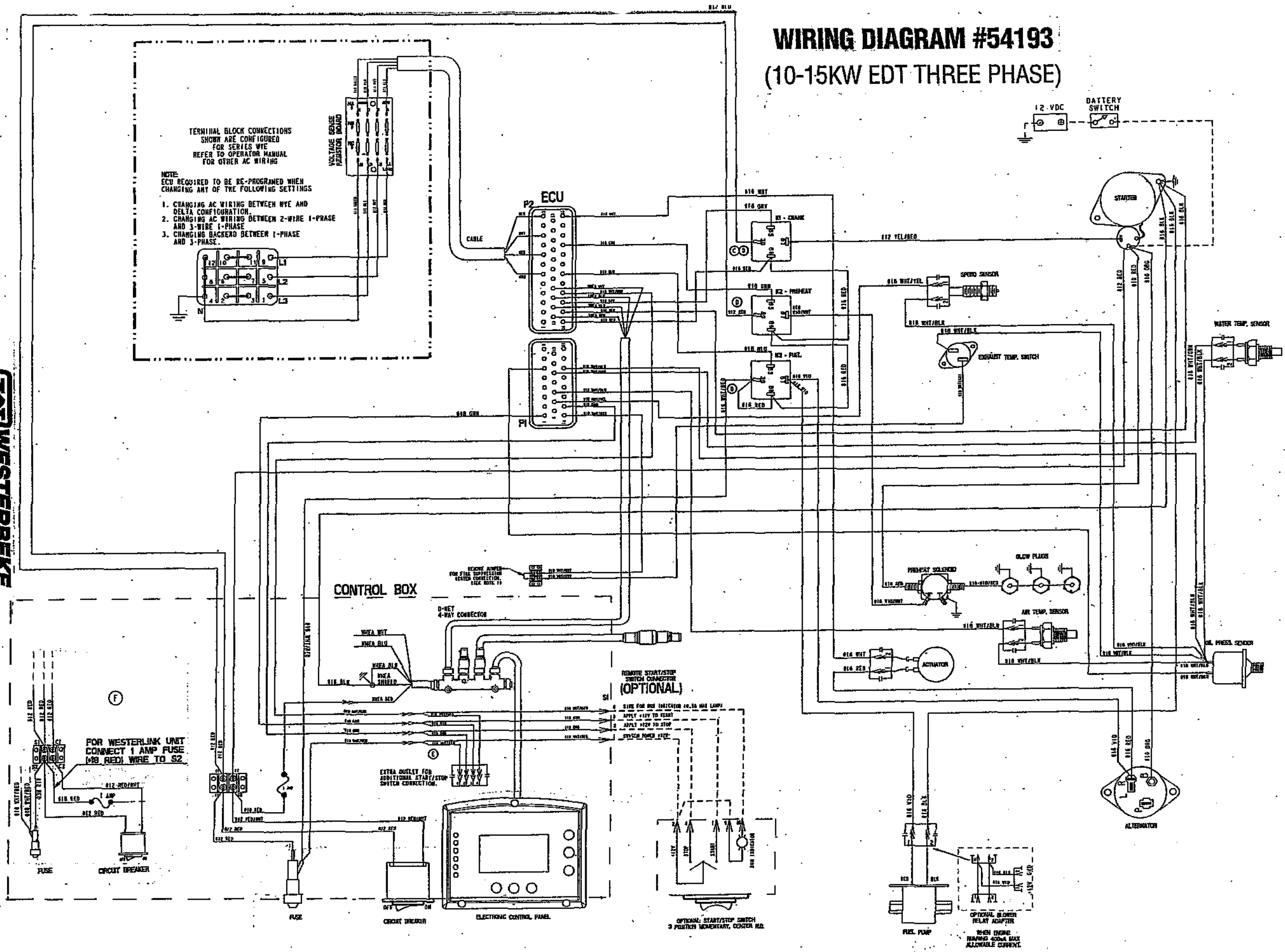
The minimum recommended capacity of the battery used in the engine's 12 volt DC control circuit is 600 – 900 Cold Cranking Amps (CCA).

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).

WIRING DIAGRAM #54193

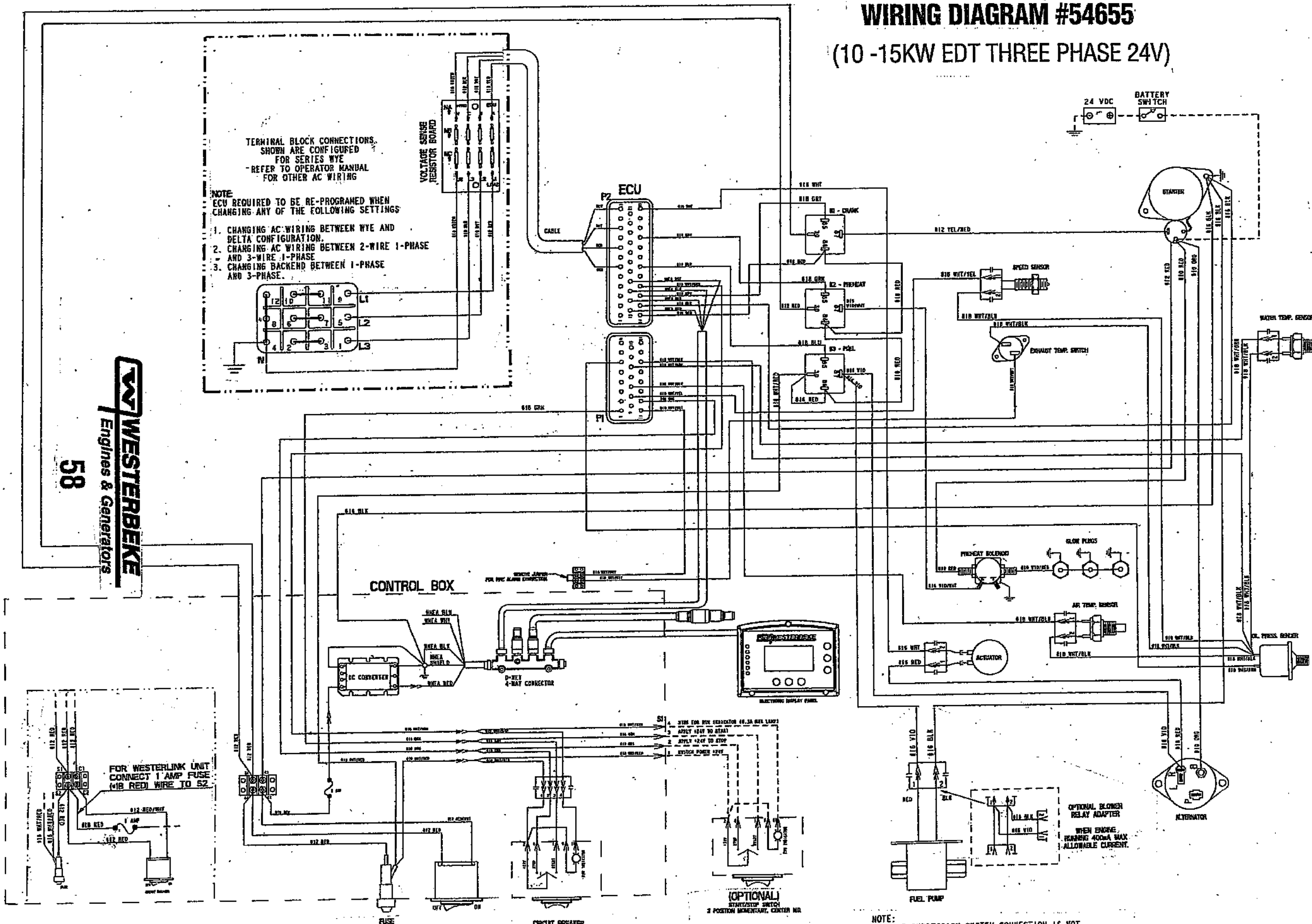
(10-15KW EDT THREE PHASE)



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

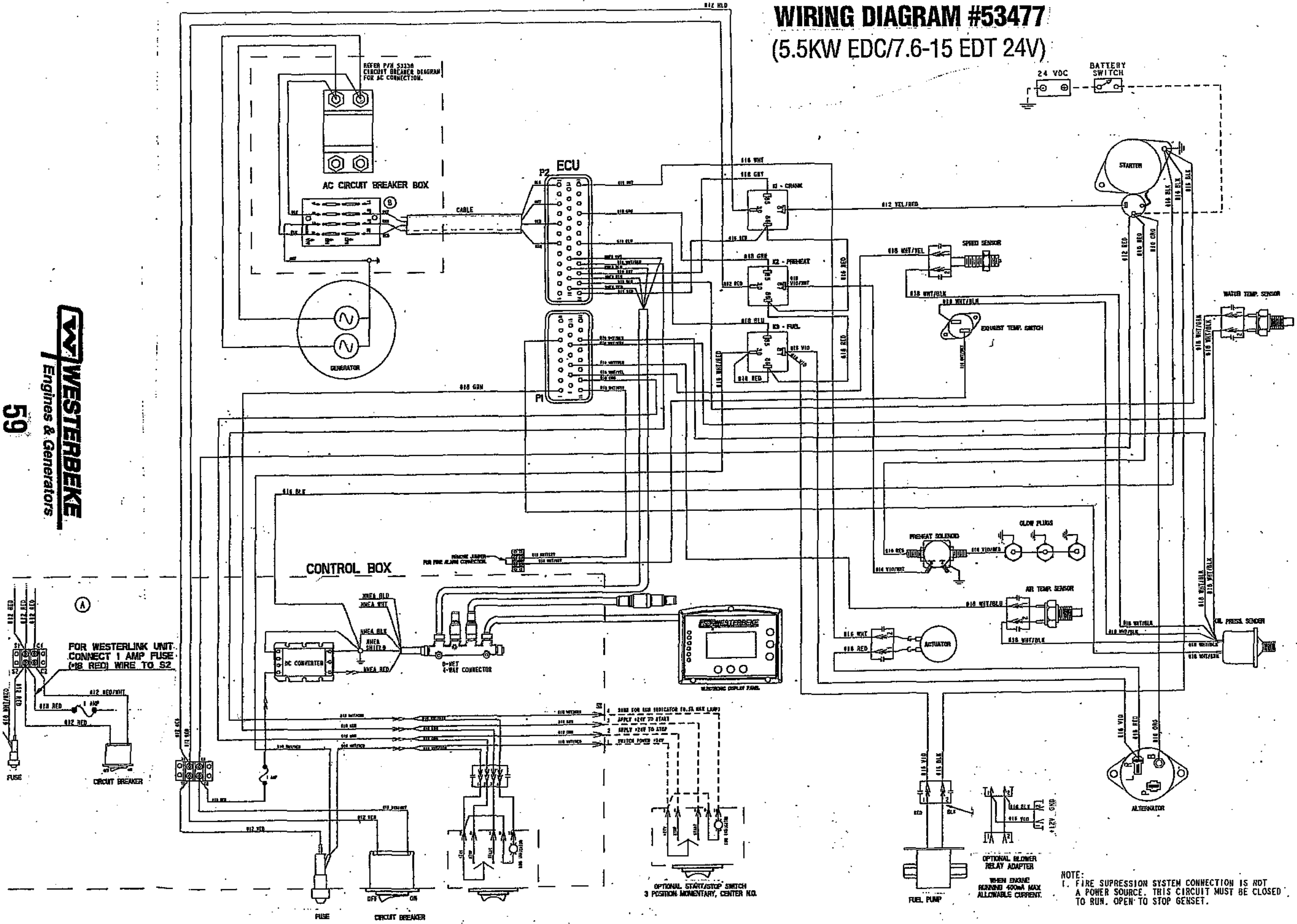
WIRING DIAGRAM #54655

(10 -15KW EDT THREE PHASE 24V)



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

WIRING DIAGRAM #53477
(5.5KW EDC/7.6-15 EDT 24V)

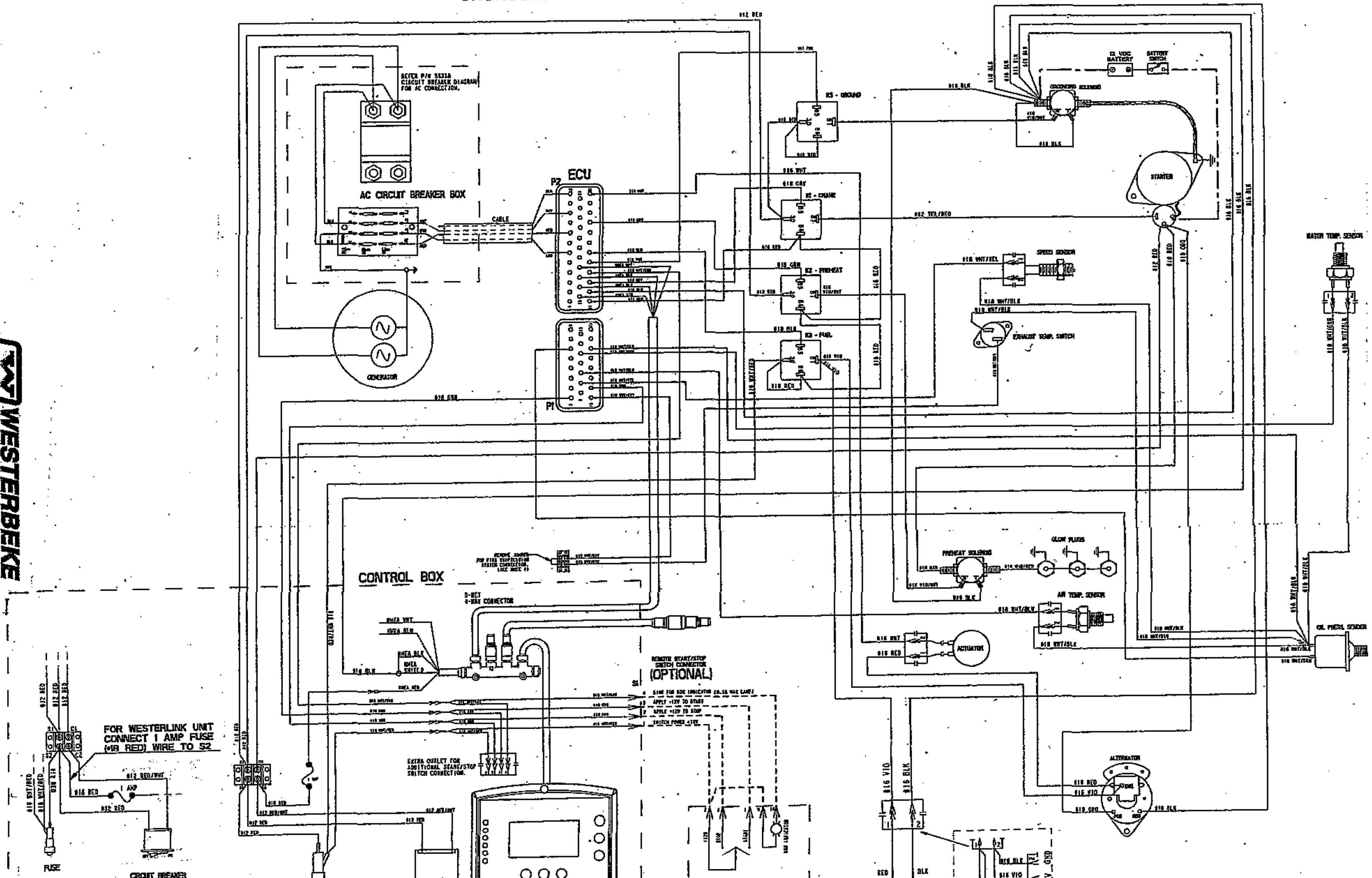


NOTE:
1. FIRE SUPRESSION SYSTEM CONNECTION IS NOT A POWER SOURCE. THIS CIRCUIT MUST BE CLOSED TO RUN. OPEN TO STOP GENSET.

WESTERBEKE Engines & Generators

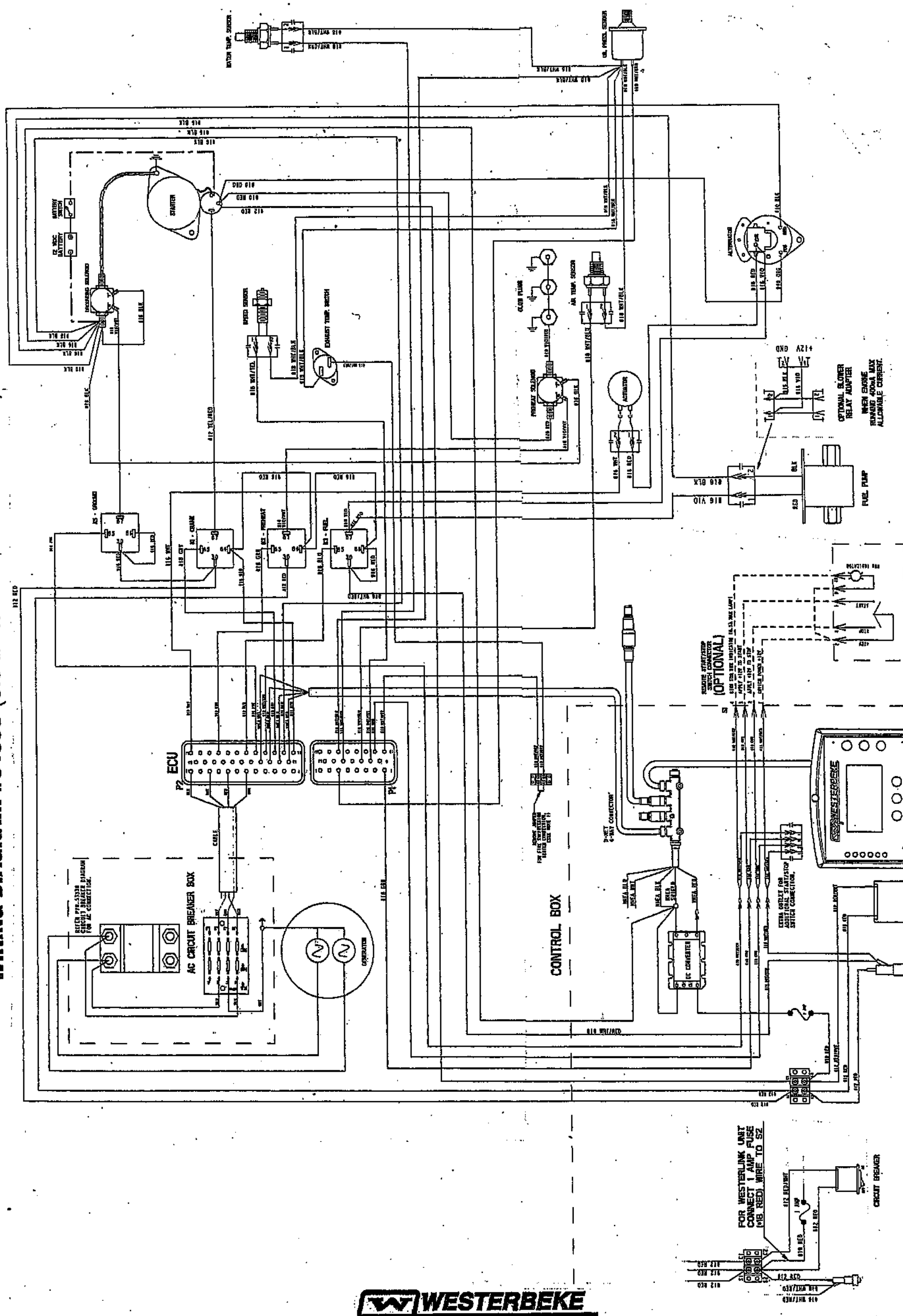
WIRING DIAGRAM #54628 (5.5 EDC/7.6 - 15KW EDT)

UNGROUNDED



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

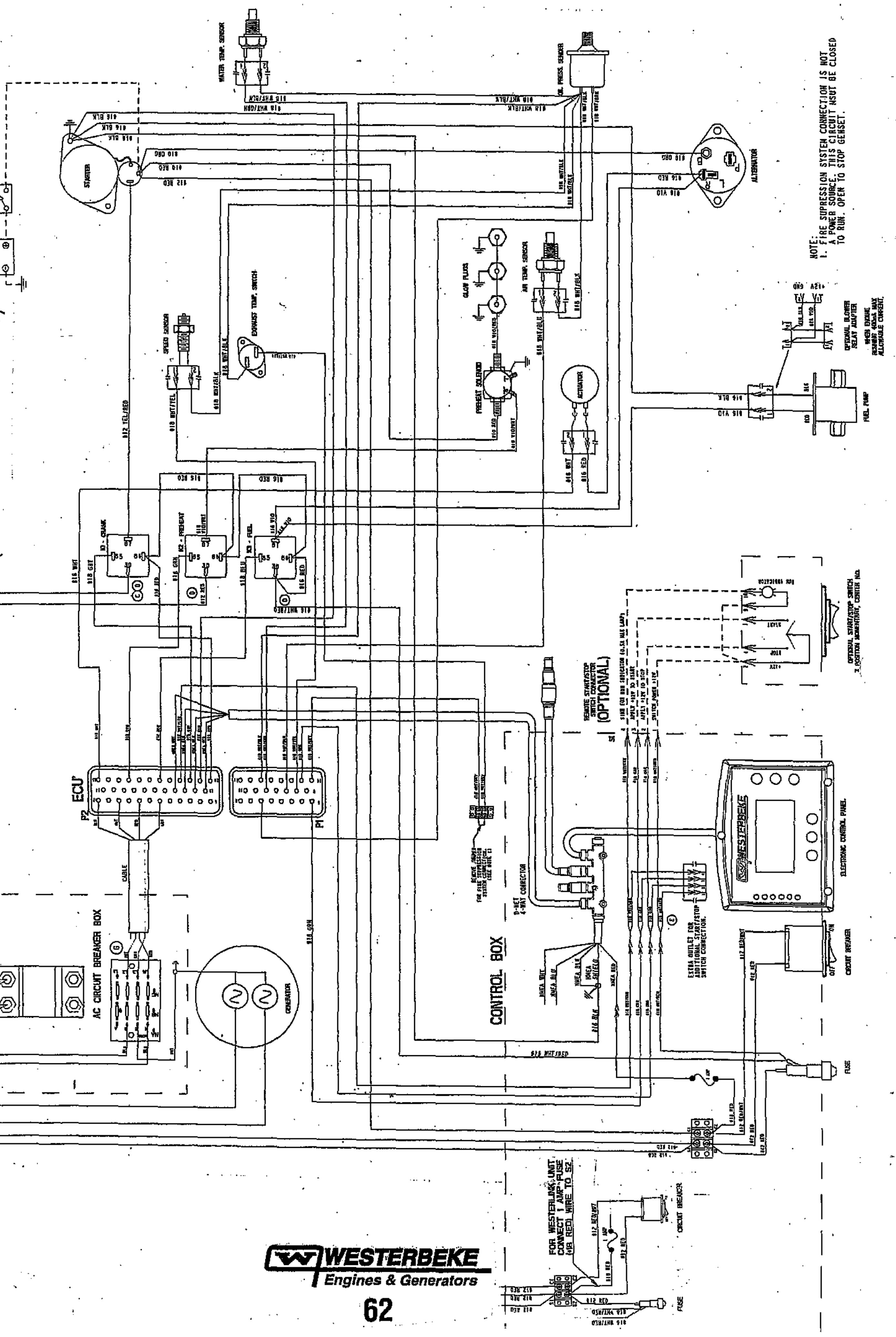
WIRING DIAGRAM #54680 (5.5 EDC/7.6 - 15KW EDT 24V)



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

WIRING DIAGRAM #52793

(5.5 EDC/7.6 - 15KW EDT)



WESTERBEKE
Engines & Generators

SPECIFICATIONS - ENGINE
12.5/9.4KW EDT & 15.0/12.0KW EDT

GENERAL

Engine Type	Diesel, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Displacement	107.3 cubic inches (1.758 liter)
Aspiration	Naturally aspirated.
Combustion Chamber	Swirl type.
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)
Firing Order	1 - 3 - 4 -2
Direction of Rotation	Clockwise, when viewed from the front.
Compression Ratio	22:1
Dimensions - Inches (mm) Engine Only	Height: 24.0 inches (609.6 mm) Width: 19.0 inches (482.6 mm) Length: 34.6 inches (878.8 mm)
Inclination	Continuous 15° (all directions) Temporary 25° (not to exceed 30 minutes)
Weight (dry)	
12.5/9.4KW	561 lbs (254.5 kgs)
15.0/12.0KW	569 lbs (258.1 kgs)
Fuel Consumption (full amperage load)	
12.5KW	1.19 gph (4.50 lph)
9.4KW	0.19 gph (3.44 lph)
15.0KW	1.42 gph (5.38 lph)
12.0KW	1.12 gph (4.24 lph)
HP @ 1800 RPM	25 HP
HP @ 1600 RPM	22 HP

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Spilled Timing (Static)	17° (spill) BTDC
Valve Seat Angle	Intake 45° Exhaust 30°
Engine Speed	1800 rpm (60Hz) 1500 rpm (50Hz)
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance	0.25 inches (0.0098 mm)
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Engine Timing	17° BTDC

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	800 – 1000 Cold Cranking Amps (CCA)
DC Charging Alternator	50 Amp rated, belt-driven
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 – 190° F (77 – 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump	Positive displacement, rubber impeller, belt driven
System Capacity (Fresh Water)	8.0 US qts (7.6 liters)
Raw Water Flow at 1800 rpm (Measures before discharging into exhaust elbow)	7-8 gpm (25.9 - 29.6 gpm)
Engine Combustion Air Requirements at at 1800 rpm	56 cfm (1.60 cmm)
Engine Combustion Air Requirements at at 1500 rpm	46 cfm (1.31 cmm)

LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	4.5 U.S. qts (4.3 liters)
Operating Oil Pressure (engine hot)	40 – 60 psi (3.5 – 4.2 kg/cm²)
Oil Grade	API Specification CF or CG-4, SAE 30, 10W-30, 15W-40

SPECIFICATIONS - GENERATOR 11.5/9.2KW EDT

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 regulator)	
Voltage	120 or 120/240 volts - 60 hertz 230 Volts - 50 Hertz	
Voltage Regulation	±5% no load to full load.	
Frequency Regulation	.5 Hertz (.60%) no load to full load.	
Rating (Volts AC) **60 Hz (1800 rpm)** **11.5 KW**	120 volts 120/240 volts	95.8 amps 95.8/47.9 amps
50 Hz (1500 rpm) **9.2 KW**	230 volts	40.0 amps
Generator Cooling	225 - 250 cfm (5.66 - 6.37 cmm) Air requirements (60 Hz) at 1800 rpm	

NOTE: *Increase air supply 15% for 50 Hertz operation (1500 rpm)*

Engine Combustion Air Requirements	42 cfm (1.19 cmm)
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum

AC GENERATOR (3 Phase)

General - 3 Phase **11.5 Kw - 60 Hertz** **9.2 Kw - 50 Hertz**	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 220 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	34 Amps 17 Amps 34 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	16 Amps 29 Amps
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	42 cfm (1.19 cmm)	
Engine Compartment Cooling Air	100 - 200 cfm (2.83 - 5.66 cmm)	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

SPECIFICATIONS - GENERATOR 12.6/10.4KW EDT

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:	.5 Hertz (.60%) no load to full load.	
Rating (Volts AC) **60 Hertz (1800 rpm)** **12.6 KW**	120 Volts 120/240 Volts	66 Amps 66/33 Amps
50 Hertz (1500 rpm) **10.4 KW**	230 Volts	27 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	175 - 200 cfm (4.95 - 5.66 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	42 cfm (1.19 cmm)	
Engine Compartment Cooling Air	100 - 200 cfm (2.83 - 5.66 cmm)	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

AC GENERATOR (3 Phase)

General - 3 Phase **12.6KW – 60 Hertz** **10.4KW – 50 Hertz**	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 220 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	38 Amps 19 Amps 38 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	18 Amps 32 Amps
Engine Combustion Air Requirements (60 Hertz), at 1800 rpm	42 cfm (1.19 cmm)	
Engine Compartment Cooling Air	100 - 200 cfm (2.83 - 5.66 cmm)	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

SPECIFICATIONS - GENERATOR 12.5/9.4KW EDT

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:	.5 Hertz (.60%) no load to full load.	
Rating (Volts AC) **60 Hertz (1800 rpm)** **12.5 KW**	120 Volts 120/240 Volts	104 Amps 104/52 Amps
50 Hertz (1500 rpm) **9.4 KW**	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).*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

AC GENERATOR (3 Phase)

Three Phase **12.5 KW - 60 HERTZ** **9.4 KW - 50 HERTZ**	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	38 Amps 18 Amps 37 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	17 Amps 30 Amps
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	
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).*	

15.0/12.0KW EDT

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole, revolving field. Pre-lubricated, single-bearing design. Reconnectable, single-phase transformer regulation (optional solid-state voltage regulation).	
Voltage	120 or 120/240 Volts - 60 Hertz 220 Volts - 50 Hertz.	
Voltage regulation:	±5% no load to full load.	
Frequency regulation:	.5 Hertz no load to full load.	
Rating (Volts AC) **60 Hertz (1800 rpm)** **15.0 KW**	120 Volts 120/240 Volts	105 Amps 105/52.5 Amps
50 Hertz (1500 rpm) **12.0 KW**	220 Volts	45.2 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	225 - 250 cfm (5.66 - 6.37 cmm) **NOTE:** *Increase air supply 15% for 50 Hertz operation (1500 rpm).*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

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 (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	38 Amps 18 Amps 37 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	17 Amps 30 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).*	
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum	

SPECIFICATIONS - ENGINE
8.0/6.0 KW EDT, 10.0/7.5 KW EDT, 11.5/9.2 KW EDT. 12.6/10.4KW EDT

GENERAL

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Displacement	80.4 cubic inches (1.318 liter)
Aspiration	Naturally aspirated.
Combustion Chamber	Swirl type.
Bore & Stroke	3.07 x 3.62 inches (78 x 92 mm)
Firing Order	1 - 3 - 2
Direction of Rotation	Clockwise, when viewed from the front.
Compression Ratio	22:1
Weight	8.0 EDT 477 lbs (216 kilos) 10.0 EDT 520 lbs (236 kilos) 11.5 EDT 520 lbs (236 kilos) 12.6 EDT 520 lbs (236 kilos)
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)

TUNE-UP SPECIFICATIONS

Compression Pressure Minimum	427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
Spilled Timing (Static)	17° (spill)
Valve Seat Angle	45°
Engine Timing	17° BTDC
Injector Pressure	1991 + 71 - 0 psi (140 + 5 - 0 kgf/cm²).
Valve Seat Angle	Intake 45° Exhaust 30°
Valve Clearance (engine cold)	0.25mm (0.0098 inches)
Engine Speed	1800 rpm (60 Hz) 1600 rpm (50 Hz)

LUBRICATION SYSTEM

General	Pressure fed system.
Oil Filter	Full flow, paper element, spin-on type.
Sump Capacity (not including filter)	3.9 U.S. qts (3.7 liters)
Operating Oil Pressure (engine hot)	50 – 60 psi (3.5 – 4.2 kg/cm²)
Oil Grade	API Specification CF, CG-4, CG-4 or CI-4 SAE 10W-30 or 15W-40

FUEL SYSTEM

General	Open flow, self priming.
Fuel	No. 2 diesel oil (cetane rating of 45 or higher).
Fuel Injection Pump	In-line plunger type (BOSCH).
Nozzle	Throttle type.
Fuel Filter	Cartridge type (PN#030200).
Air Cleaner	Replaceable paper filter cartridge.
Fuel Lift Pump	12 volt DC lift capacity of 5' (1.5 mm) solid state

ELECTRICAL SYSTEM

Starting Battery	12 Volt, (–) negative ground
Battery Capacity	800 – 1000 Cold Cranking Amps (CCA)
DC Charging Alternator	50 Amp rated, belt-driven
Starting Aid	Glow plugs, sheathed type
Starter	12 Volt, reduction gear
Cold Cranking Amp Draw	240 - 250 amps (approx.)
Engine Combustion Air Requirements at 60 Hz 1800rpm	41 cfm (1.16 cmm)

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 – 190° F (77 – 88° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump	Positive displacement, rubber impeller, belt driven
Raw Water Flow at 1800 rpm (Measures before discharging into exhaust elbow)	7-8 gpm (25.9 - 29.6 gpm)
System Capacity (Fresh Water)	5.0 US qts (4.7 liters)

SPECIFICATIONS - GENERATOR 10.0/7.5KW EDT

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:	.5 Hertz (.60%) no load to full load.	
Rating (Volts AC) **60 Hertz (1800 rpm)** **10.0 KW**	120 Volts 120/240 Volts	83.3 Amps 83.3/41.6 Amps
50 Hertz (1500 rpm) **7.5 KW**	230 Volts	22.6 Amps
Generator Cooling	225 - 250 cfm (5.66 - 6.37 cmm) Air Requirements(60 Hertz) at 1800 rpm	

NOTE: *Increase air supply 15% for 50 Hertz operation (1500 rpm).*

Engine Compartment	100 - 200 cfm (2.83 - 5.66 cmm).

AC GENERATOR (3 Phase)

Three Phase **10.0 KW - 60 Hz** **7.5 KW - 50 Hz**	Brushless, six-pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	35 Amps 15 Amps 30 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	14 Amps 24 Amps
Engine Compartment	100 - 200 cfm (2.83 - 5.66 cmm)	
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	225 - 250 cfm (5.66 - 6.37 cmm)	

NOTE: *Increase air supply 15% for 50 Hertz operation (1500 rpm).*

8.0/6.0 KW EDT

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:	.5 Hertz (.60%) no load to full load.	
Rating (Volts AC) **60 Hertz (1800 rpm)** **8.0 KW**	120 Volts 120/240 Volts	66 Amps 66/33 Amps
50 Hertz (1500 rpm) **6.0 KW**	230 Volts	22.6 Amps
Generator Cooling Air Requirements (60 Hertz) at 1800 rpm	175 - 200 cfm (4.95 - 5.66 cmm)	

NOTE: *Increase air supply 15% for 50 Hertz operation (1500 rpm).*

Engine Compartment	100 - 200 cfm (2.83 - 5.66 cmm)

NOTE: Generator compartment ambient temperature should not exceed 122°F (50°C). Forced ventilation must be provide to maintain temperatures below this stated temperature.

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 amprobe.

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

GENERATOR MAINTENANCE

- Maintaining reasonable cleanliness is important. Connections of terminal boards and rectifiers may become corroded, and insulation surfaces may start conducting if salts, dust, engine exhaust, carbon, etc. are allowed to build up. Clogged ventilation openings may cause excessive heating and reduced life of windings.
- For unusually severe conditions, thin rust-inhibiting petroleum-base coatings should be sprayed or brushed over all surfaces to reduce rusting and corrosion.
- In addition to periodic cleaning, the generator should be inspected for tightness of all connections, evidence of overheated terminals and loose or damaged wires.
- The drive discs on single bearing generators should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.
- The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.
- Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. If side motion is detectable, inspect the bearing and shaft for wear. Repair must be made quickly or major components will rub and cause major damage to generator.

Carbon Monoxide Detector

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

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

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

BT GENERATOR TROUBLESHOOTING CHART

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

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

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

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

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

COMPONENT CHECKS

REFER TO THE INTERNAL WIRING DIAGRAMS

1. LOW VOLTAGE 60-100 VOLTS AC

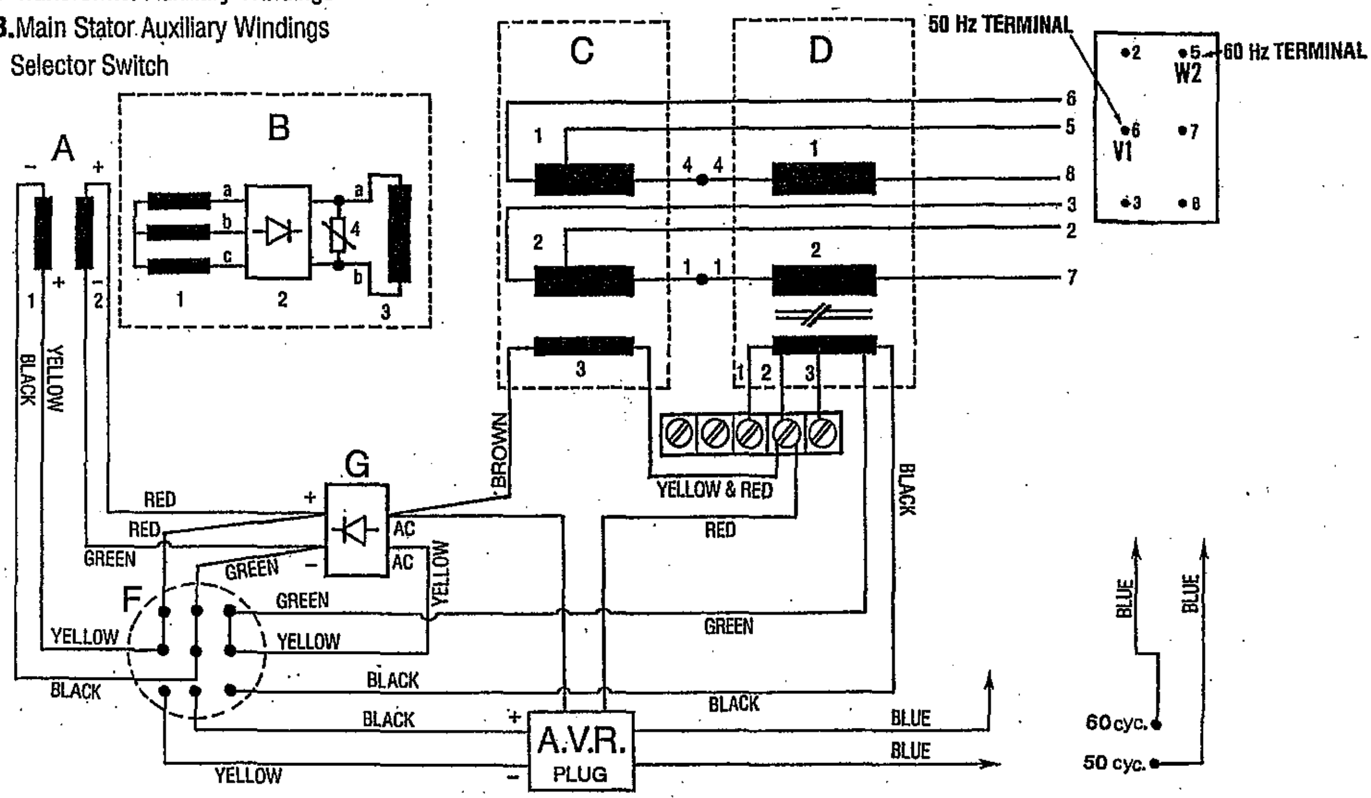
- **F.** Selector Switch
- **B.** Rotor Components
  - **B-2** Exciter Rotor Diodes
  - **B-3** Rotor Field Windings
  - **B-1** Exciteor Rotor Windings **a,b, c**
- **A.** (1-1+2) Exciter Stator Windings

2. RESIDUAL VOLTAGE - EXCITER CIRCUIT FAULTY

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

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

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



BT GENERATOR TROUBLESHOOTING/SINGLE PHASE

Main Stator Windings

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

   NOTE: *No continuity should be found between any of the lifted stator leads and the case ground or between the connections of the two groups.*

3. **Main Stator Auxiliary Windings.** The resistance values for these windings are measured between the black double lead connection lifted off the AC terminal of the bridge rectifier (G) and the red #3 lead lifted off the Voltage/Hertz connection bar.

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

Compound Transformer

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

   NOTE: *No continuity should be found between either of these lifted leads or to the generator case/ground.*

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

Selector Switch (6 Stud BT only)

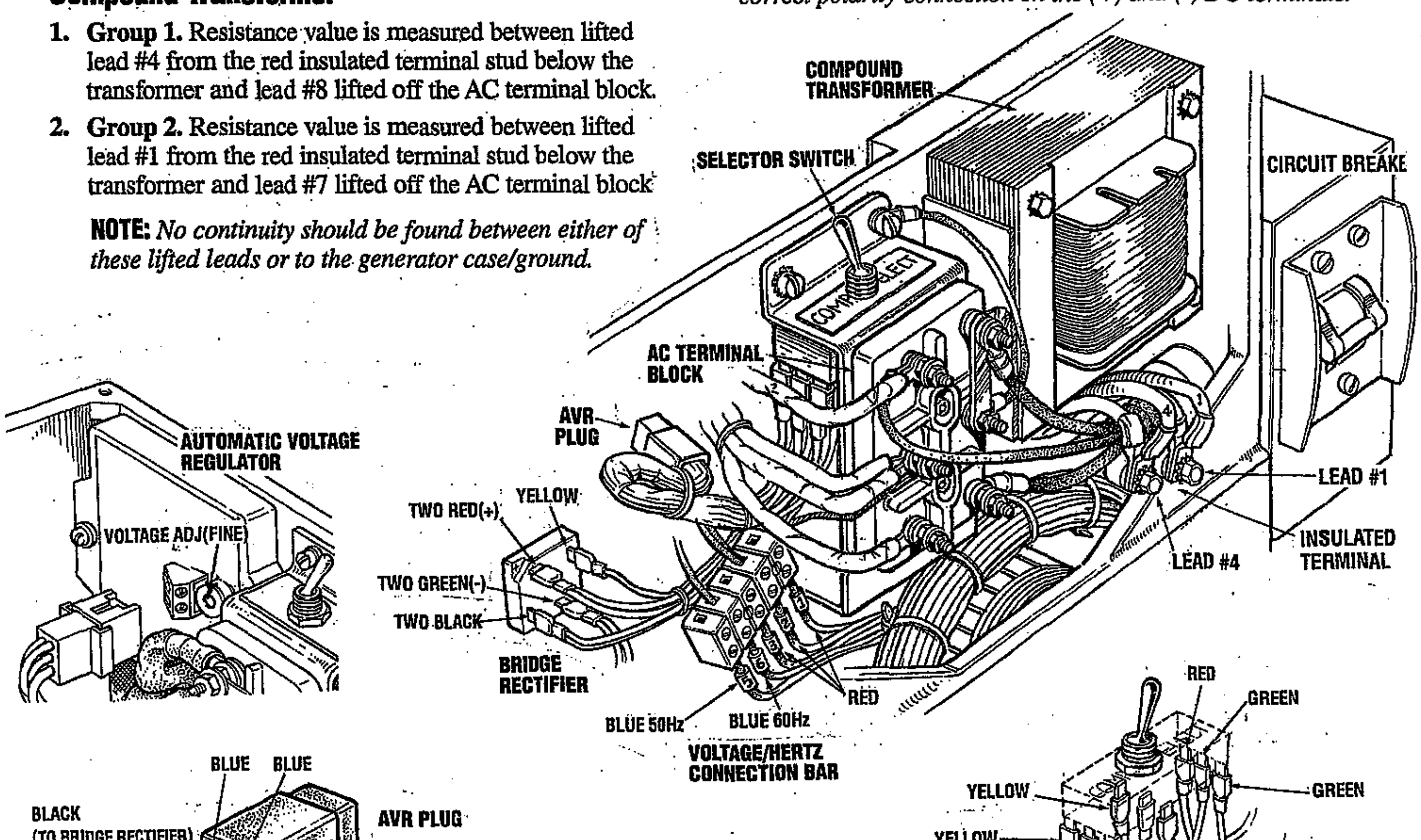
This switch is is normally set in the COMP position. If an optional AVR is installed, the switch is toggled to the ELEC position..

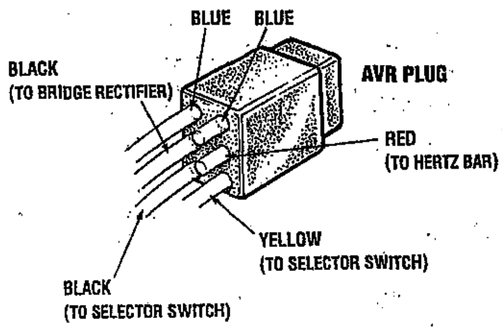
NOTE: *With the selector switch in ELEC position the exciter stator windings are divided, one group is excited through the bridge rectifier and the other group through the A.V.R.*

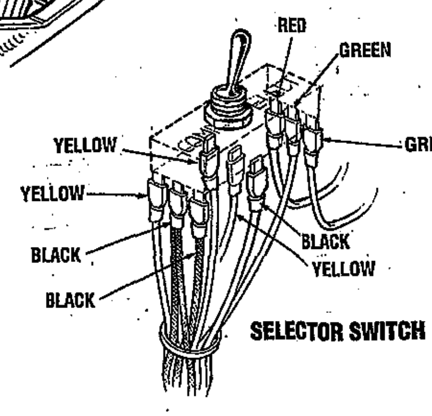
Bridge Rectifier Wiring

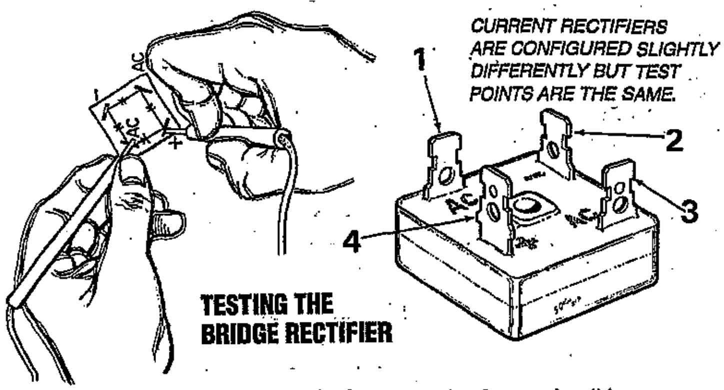
The illustration below shows the color coded wires at the two AC terminals and the color coded wires at the (+) and (-) DC terminals.

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









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

If the rectifier fails any of the previous tests (1 - 4) it is defective and should be replaced.

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

Component Resistance Values

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

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

C. Main Stator
- C-1 0.089 ohm
- C-2 0.089 ohm

Auxiliary Windings
- C-3 0.85 ohm

D. Compound Transformer
- D-1 0.007 ohm
- D-2 0.007 ohm

Auxiliary Windings
- D-3 5.02 ohm

E. A.C. Terminal Board
F. Selector Switch
G. Bridge Rectifier
H. Optional AVR

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

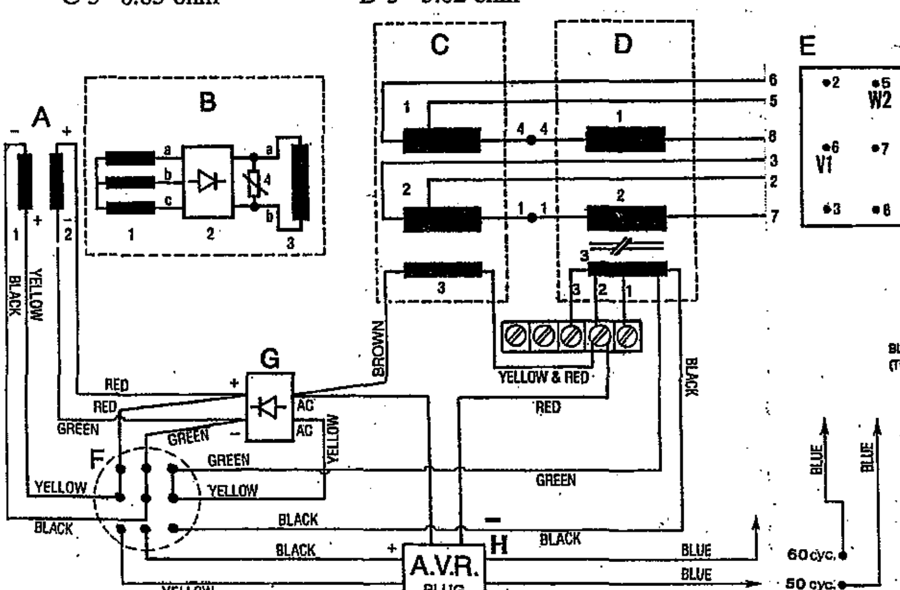
NOTE: *These two model BT generators are used on models rated lower than the capabilities of the generator. However, the generator is rated according to the capabilities of the drive engine since horsepower produces kilowatts.*

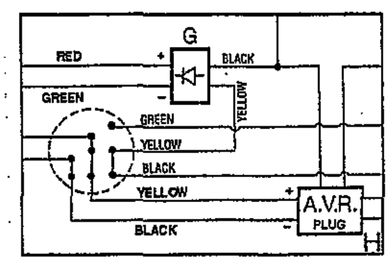
COMPONENT RESISTANCE CHECKS

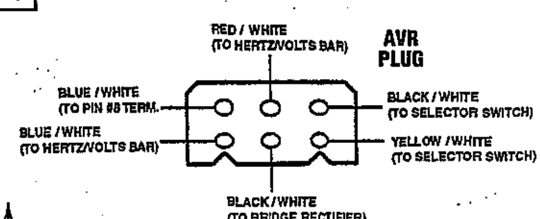
Exciter Stator Windings

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

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



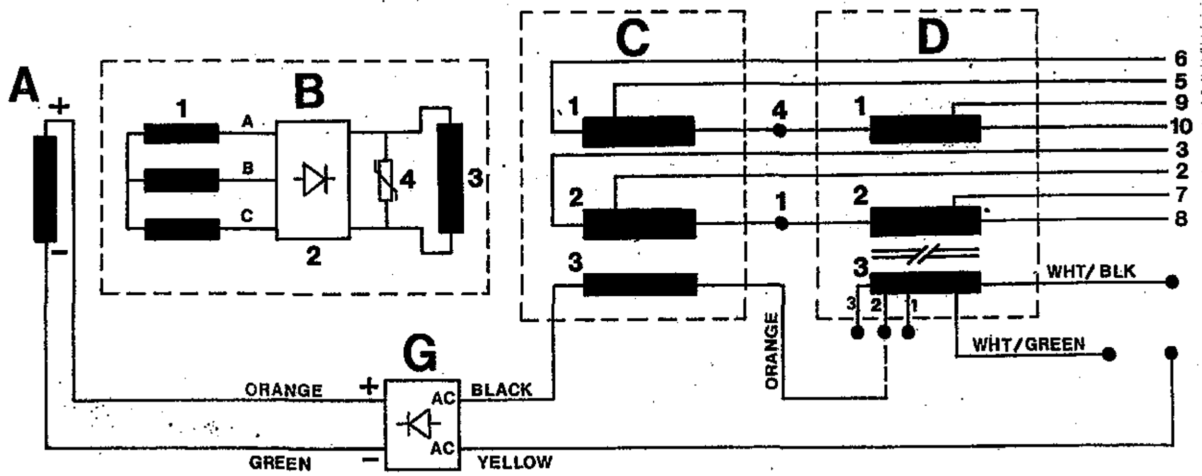




BT GENERATOR INTERNAL WIRING SCHEMATIC (W/OPTIONAL AVR)

BT GENERATOR 12 STUD INTERNAL WIRING SCHEMATIC

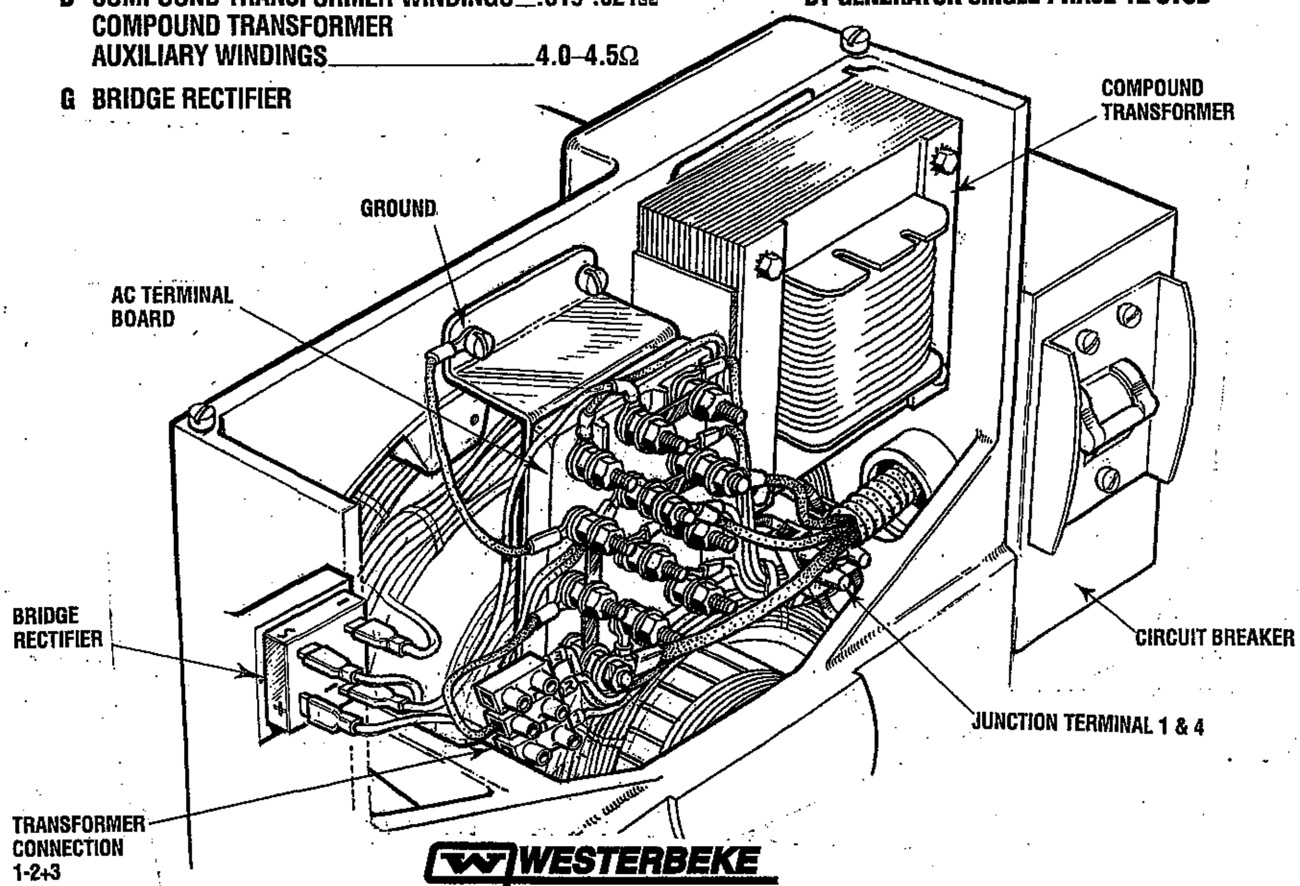
NOTE: *Refer to the text and diagrams for the proper method of testing for resistance and continuity.*



COMPONENT RESISTANCE VALUES [OHMS]

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

BT GENERATOR SINGLE PHASE 12 STUD



WESTERBEKE
Engines & Generators

Testing Residual Voltage

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

Residual Voltage 10-14 volts AC (6 stud) . 18-22 volts AC (12 stud)

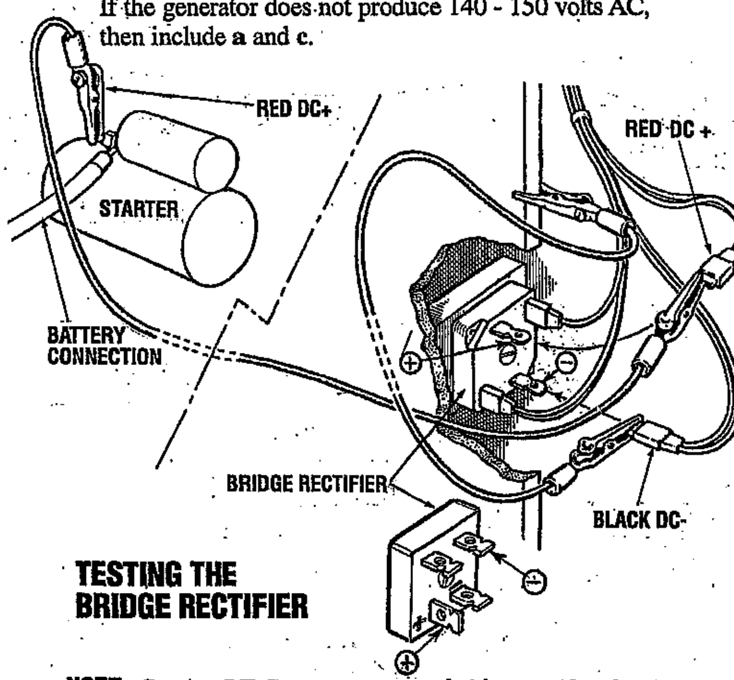
This voltage is the AC voltage produced by the generator from magnetism in the exciter stator field. This voltage is measured between the AC Neutral and Hot leg(s) with no-load on the generator running at 60 hertz.
The presence of residual voltage is an indication that the following generator components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

a. Exciter Rotor (B-1 a, b, & c) & (B-2);
b. Rotating Field (B-3);
c. Main Stator (C-1 & C-2); and
d. Compound Transformer (D-1 & D-2).

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

a. Exciter Stator (A-1 & A-2)
b. Bridge Rectifier (G)
c. Selector Switch (F)
d. Main Stator Auxiliary Windings (C-3)
e. Compound Transformer Auxiliary Winding (D-3)

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



TESTING THE BRIDGE RECTIFIER

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

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

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

BRIDGE RECTIFIER

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

120 Volts	120/240
N/L F/L	N/L F/L
17 - 55 volts AC	17 - 55 volts AC

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

120 Volts	120/240
N/L F/L	N/L F/L
8 - 17 volts DC	8 - 17 volts DC

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

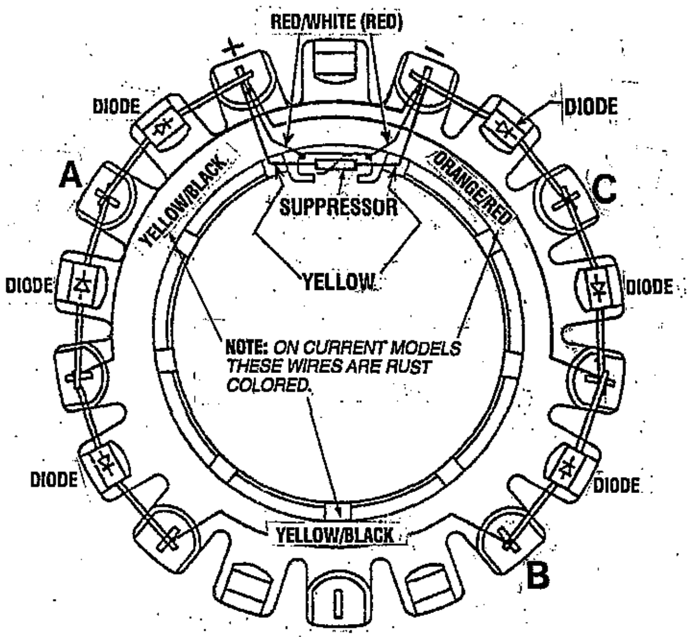
Testing the Bridge Rectifier for Faults with an Ohmmeter

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

1. Set the ohmmeter scale on RX1 (+ DC) and set the needle to zero.
2. Connect the positive (+) lead from the ohmmeter to point #4. Taking the ohmmeter's negative (-) lead, momentarily contact points #1, #2, #3, and #5. The ohmmeter should register no deflection for any of the points touched.
3. Remove the positive (+) lead from point #4 and connect the negative (-) lead to point #4 and, with the positive (+) lead, momentarily touch points #1, #2, and #3. The ohmmeter's needle should deflect when each point is touched, showing a passage of meter voltage through the diodes in the rectifier.

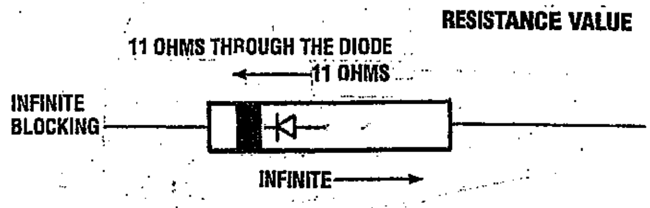
Exciter Rotor/Field

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



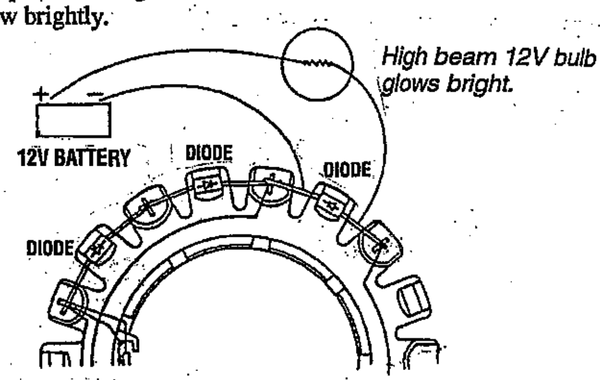
2. **Rotating Field Windings.** Refer to the illustration above of the exciter rotor. The field winding connections are noted as the (+) and (–) connections of the red & white striped wires. Measure the resistance value with your ohmmeter between these two connection points. These connections need not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

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



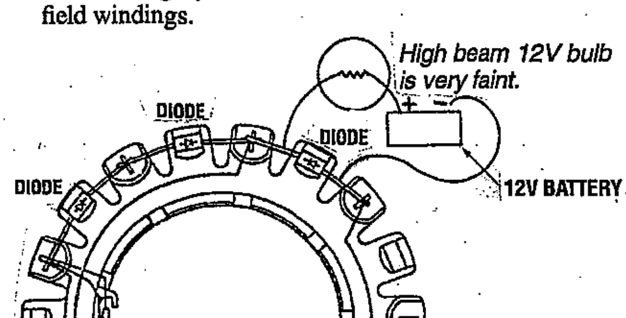
NOTE: *Attempting to check diodes in place with an ohmmeter will give erroneous readings on the diodes due to the auxiliary winding's connections.*

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



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

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



6. **Rotating Field Windings** (Reading taken between the two red & white wires connected to the (+) and (–) terminals of the exciter rotor as shown.
7. *Suppressor.* (Infinite readings between both yellow leads lifted from the (+) and (–) terminals on the exciter rotor.)
   A shorted suppressor will destroy the rotating field and cause the AC output voltage to drop to zero.

GENERATOR FREQUENCY/VOLTAGE CHANGES

NO-LOAD VOLTAGE ADJUSTMENT

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

1. The selector switch *must* be in the COMP position.
2. To confirm no-load voltage, start the generator and apply a momentary (moderate) load to excite the transformer. The voltage produces by the generator after the momentary load is removed is no-load voltage, Note the voltage output from the generators 120 volt leg(s) (230 volt 50 hertz). the no-load voltage should be between 121-124 volts at 60.0-60.5 hertz (232-236 volts at 50.0-50.5 hertz).
3. To raise or lower the voltage, shims of varying thickness (non-conductive material) are placed or removed from under the steel laminated bar on top of the compound transformer. The material used for shimming should not soften at temperatures in the 176° F (80° C) range. A small reduction in no-load voltage (1 to 3 volts) can some times be accomplished by gently tapping the top of the laminated steel bar to reduce the gap between the exist ing shims and the transformer core.

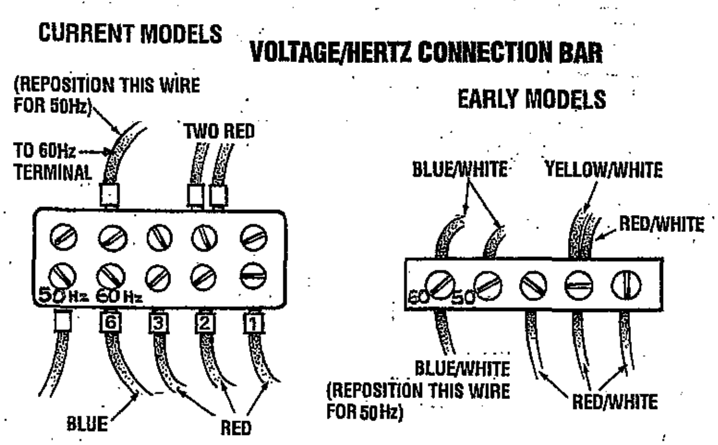
VOLTAGE/HERTZ CONNECTION BAR

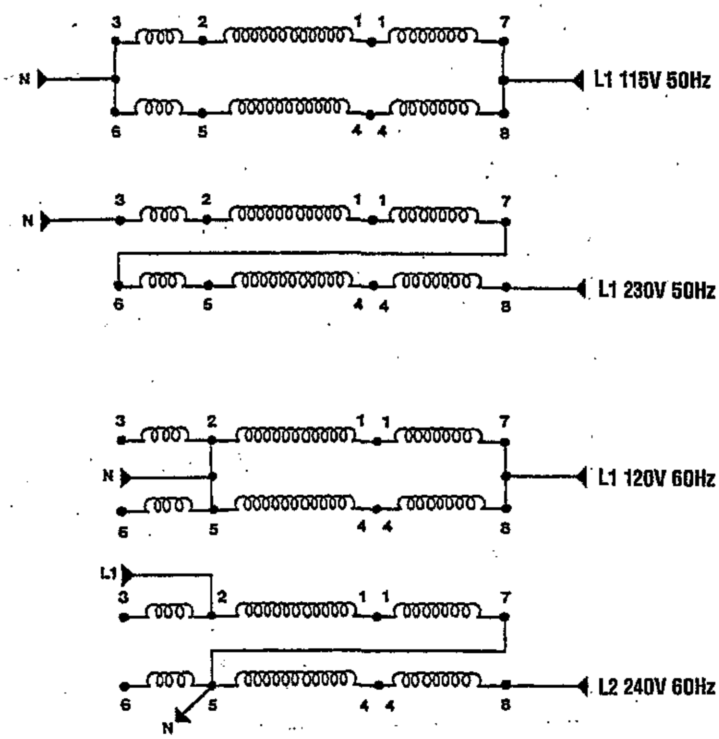
If there is no automatic voltage regulator (AVR) installed, do not change the wiring on the Voltage/Hertz Connection Bar. Simply reconfigure the AC voltage connections at the AC terminal for the hertz change.

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

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

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





Terminal Block Wiring Connections

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

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

GENERATOR FREQUENCY/VOLTAGE CHANGES

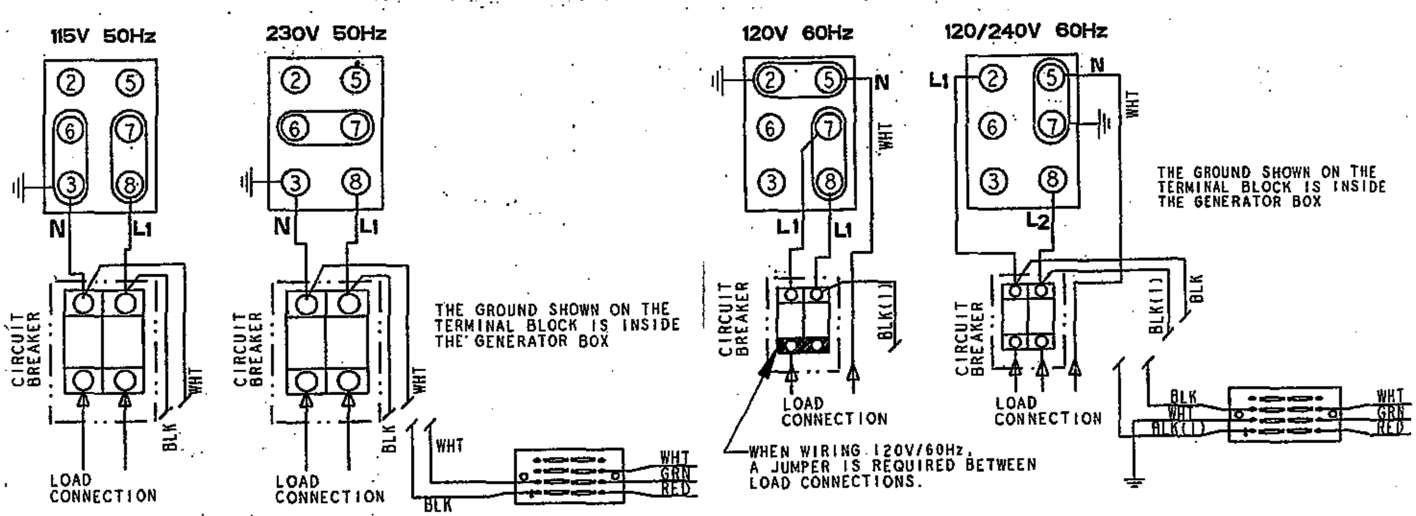
GENERATOR FREQUENCY CHANGES (HERTZ)

1. Frequency is a direct result of engine/generator speed.
   1800 rpm = 60 Hertz
   1500 rpm = 50 Hertz
2. To change generator frequency, follow these steps below.
   a. Reconfigure the AC output connections on the 6/12 stud terminal block following the illustrations below. Install the correctly rated AC breaker for the Hertz selected.
   b. Properly connect the leads from the voltage sensing board to the line connections on the AC breaker and the neutral/ground to the brass neutral/ground stud in the breaker box. When only one line is present, tie off the unused line sense connection.
   c. **Note:** On six stud AC models **only** when an optional AVR is installed, reposition the blue/white lead to correspond to the hertz selected on the voltage/hertz connection bar.
   d. Shut off the 20 amp DC panel breaker and move the #1 dipswitch on the ECU to the proper position for the hertz selected - ON for 50 hertz, OFF for 60 hertz. Then turn the DC breaker back on.
   e. Shut OFF the AC breaker and start the unit. Monitor the no-load AC voltage. If voltage adjustment is needed, add or remove shim material from under the laminated steel bar of the compound transformer.

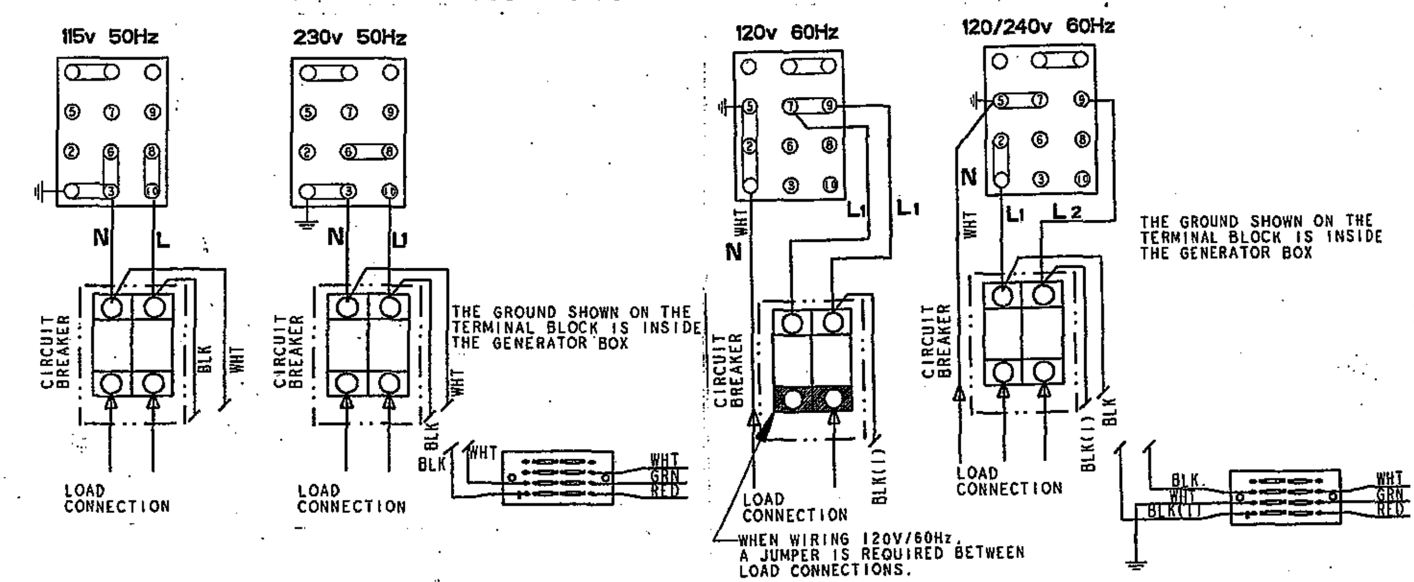
60 Hertz	No-Load voltage	121-124 volts
50 Hertz	No-Load voltage	232-236 volts

   f. Close the AC breaker and load the generator and monitor operation.

SIX STUD AC VOLTAGE CONFIGURATIONS



TWELVE STUD AC VOLTAGE CONFIGURATIONS



GENERATOR FREQUENCY CHANGES (HERTZ)

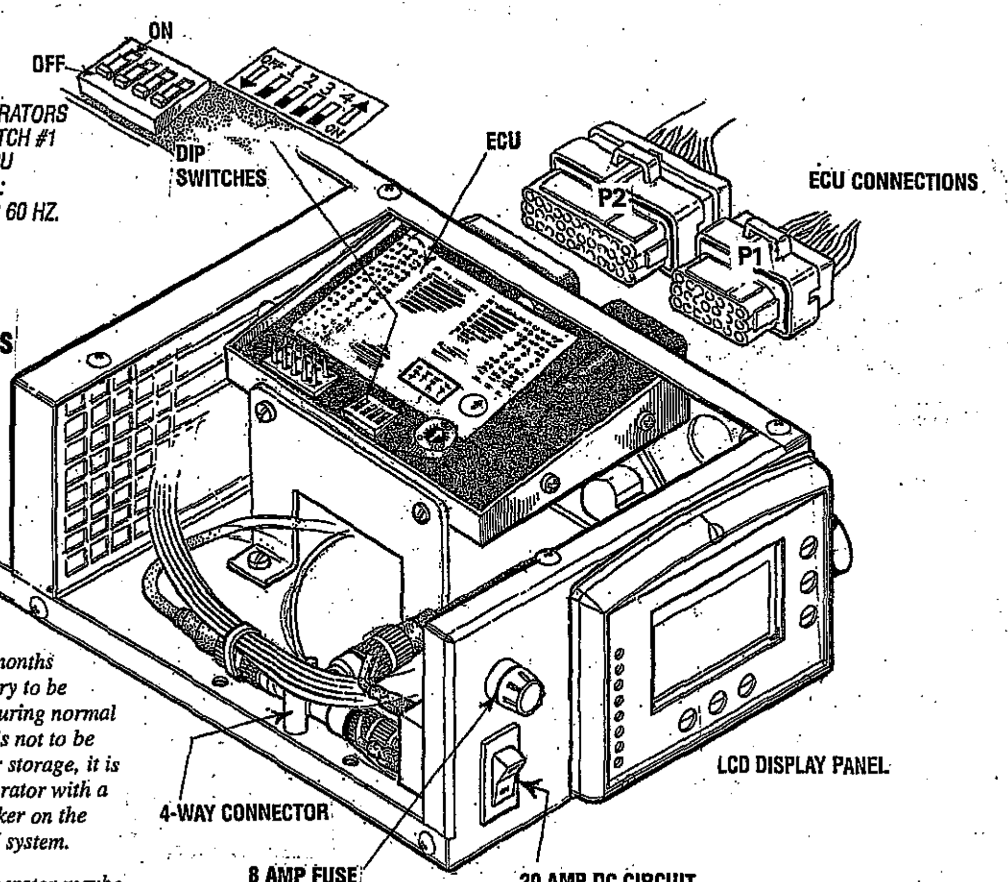
Generator Frequency is a direct result of engine/generator rotational speed, as indicated by the following:

When the generator is running at 1800 rpm. The AC voltage output frequency is 60 Hertz.

When the generator is running at 1500 rpm. The AC voltage output frequency is 50 Hertz.

Therefore to change the generator's frequency, the engine speed must be changed. To accomplish the frequency change on the D-Net diesel unit is a very simple task.

1. Turn the DC breaker on the control panel to the OFF position.
2. Open the cover of the control box and view the ECU (Electronic Control Unit).
3. Locate the #1 dipswitch on the ECU and move it to the position that corresponds to the Hertz operation desired). See the illustration below showing the ECU in the control box.
4. Replace the control box cover, turn the DC breaker ON and start the unit. Monitor the frequency that the engine/generator is operating is operating at the correct frequency.



CAUTION (WESTERLINK or NMEA-2000): *The electronic components in the Digital Diesels draw a very small amount of amperage (milli-amps) from the generator's starting battery when the unit is in a static state. This maybe as much as 50 milli-amps for the system ECU and 50 milli-amps for each display. This can be as much as 72 amp-hours in a months time with no generator use. It is not necessary to be concerned with this slight amperage draw during normal seasonal use. However, if the generator set is not to be used for a number of months, such as winter storage, it is best to disconnect the DC power to the generator with a NMEA-2000 system or shut off the DC breaker on the generator's control box for a WESTERLINK system.*

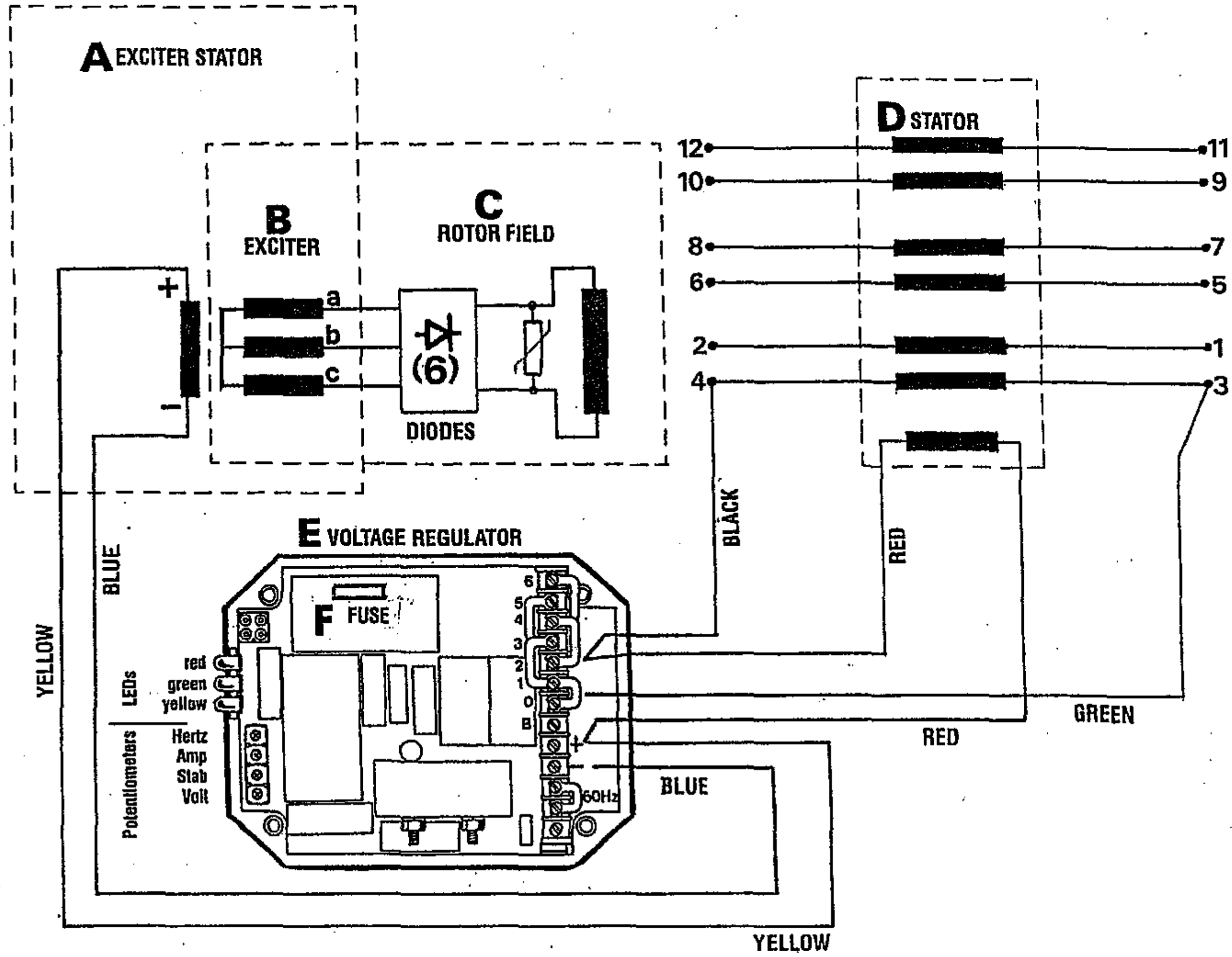
NOTE: *Keep in mind that the Westerbeke generator maybe the DC power supply for the vessel's NMEA-2000 network.*

LCD DISPLAY

Periodically clean the control panel and its LCD screen using a soft cloth.

NOTE: *Operating temperatures may cause the LCD display to vary in color. This is normal and a change in color will not affect the operation of the control panel.*

BT GENERATOR INTERNAL WIRING
3 PHASE TWELVE WIRE RECONNECTABLE



RESISTANCE VALUES

A. EXCITER STATOR (17.9 ohm)

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

C. ROTATING FIELD (2.49 ohm)
  DIODES (6)
  SUPPRESSOR

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

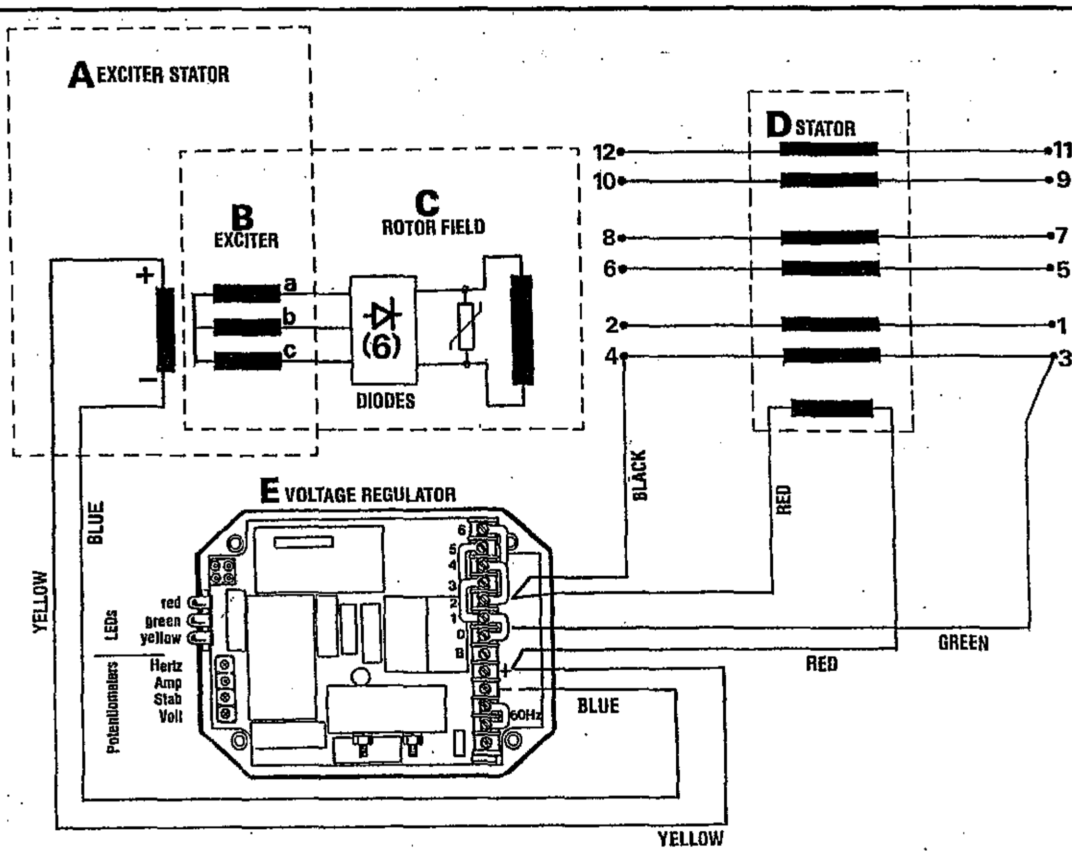
E. VOLTAGE REGULATOR

F. AUXILIARY CIRCUIT FUSE

BT GENERATOR TROUBLESHOOTING/3 PHASE

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

FAULT	PROBABLE CAUSE
NO AC VOLTAGE OUTPUT AT NO LOAD.	1. Short or open in the main stator winding. 2. Shorted suppressor on exciter rotor. 3. Four or more shorted or open diodes on exciter rotor. 4. Open in exciter stator winding. 5. Open in rotating field winding.
RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.	1. Blown 6 AMP fuse auxiliary circuit feed to AVR. 2. Faulty voltage regulator 3. Shorted or open main stator auxiliary winding.
LOW AC VOLTAGE OUTPUT AT NO LOAD 60 - 100 VAC.	1. Open or shorted diodes in exciter rotor 1 to 3 diodes. 2. Shorted exciter rotor winding. 3. Faulty voltage regulator.
HIGH AC OUTPUT VOLTAGE 150 VAC OR HIGHER.	1. Faulty voltage regulator.
UNSTABLE VOLTAGE OUTPUT.	1. STB pod on regulator needs adjustment. 2. Faulty voltage regulator.
AC VOLTAGE DROP UNDER LOAD 60 - 100 VOLTS AC.	1. Diode(s) on exciter rotor breaking down when load is applied (inductive) 1-3 diodes.

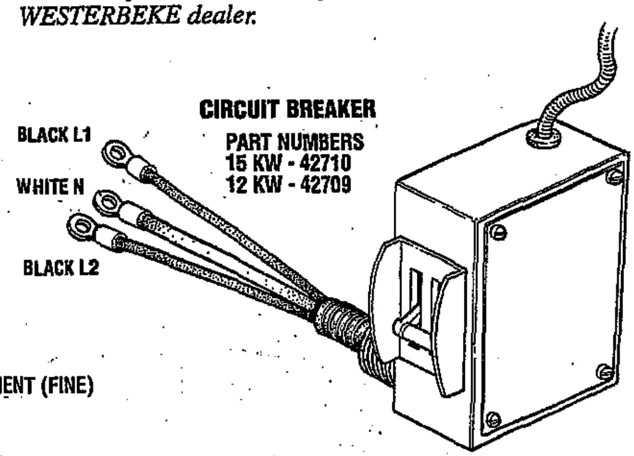


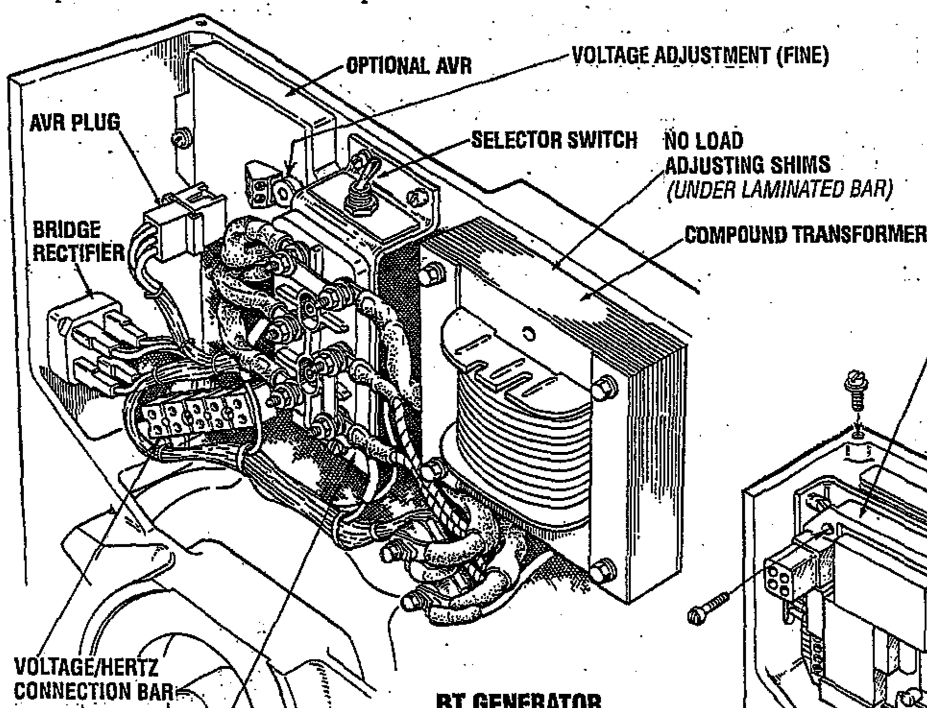
BT GENERATOR SINGLE/THREE PHASE

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

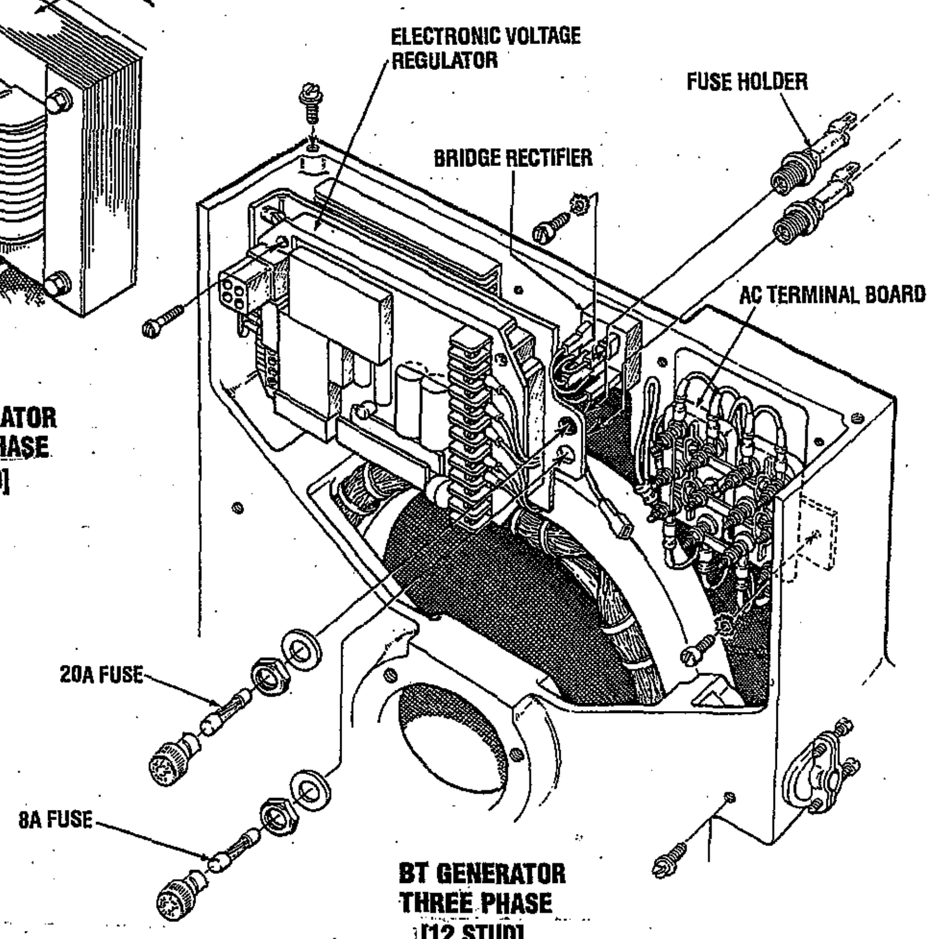
A circuit breaker is installed on all WESTERBEKE generators. This circuit breaker will automatically disconnect generator power in case of an electrical overload. The circuit breaker can be manually shut off when servicing the generator to ensure no power is coming into the boat.

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





BT GENERATOR SINGLE PHASE [6 STUD]

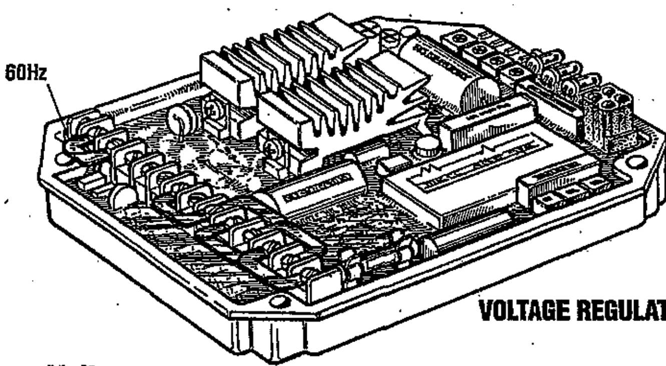


BT GENERATOR THREE PHASE [12 STUD]

BT GENERATOR VOLTAGE REGULATOR ADJUSTMENTS

Description

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



VOLTAGE REGULATOR

Volts

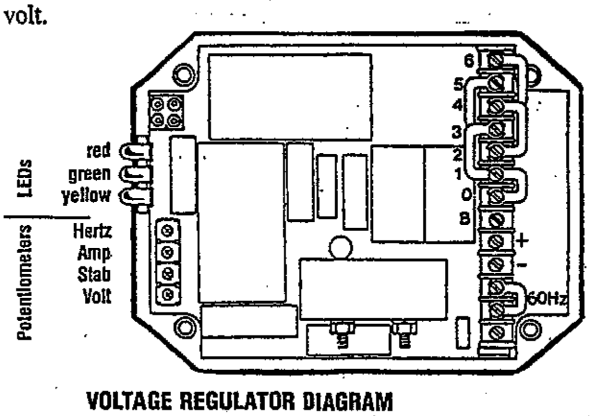
This potentiometer is used to adjust output voltage. At proper engine operating speed the output voltage should be held at ±1% from a no-load condition to a full rated generator output and from power factor 1.0 - 0.8 with engine drive speed variations up to -6%. Prior to starting the engine, turn the VOLT and STAB trimmers (using a mini phillips screwdriver) fully in a counter clockwise (Minimum) direction until you feel them hit their stops. Turn the AMP and HERTZ trimmers completely clockwise (Maximum) in the same manner. With the generator running at no-load, at normal speed, and with VOLT adjust at minimum, it is possible that output voltage will oscillate. Slowly rotate the VOLT adjust clockwise. The voltage output will increase and stabilize. Increase the voltage to the desired value. In this situation, only the green LED will stay lit.

Stability

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

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

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



VOLTAGE REGULATOR DIAGRAM

Amp-Hertz

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

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

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

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

Setting the Overload Protection

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

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

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

Setting the Underspeed Protection

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

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

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

METRIC CONVERSIONS

LENGTH-DISTANCE

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

DISTANCE EQUIVALENTS

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

VOLUME

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

MASS-WEIGHT

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

PRESSURE

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

TORQUE

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

VELOCITY

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

POWER

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

FUEL CONSUMPTION

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

TEMPERATURE

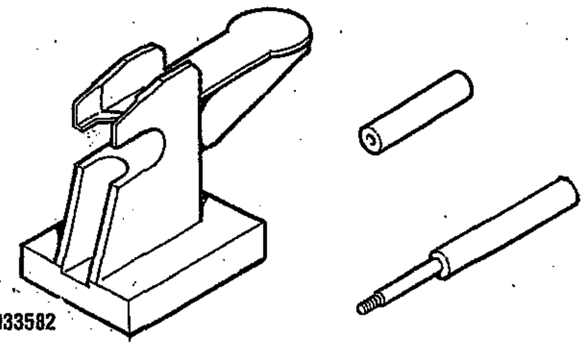
Degree Fahrenheit (°F) = (°C X 1.8) + 32
Degree Celsius (°C) = (°F - 32) x .56

LIQUID WEIGHTS

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

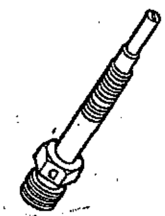
SPECIAL TOOLS - ENGINE

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



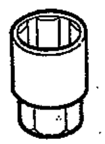
033582

COMPRESSION GAUGE ADAPTER [039254]
FOR COMPRESSION PRESSURE MEASUREMENT

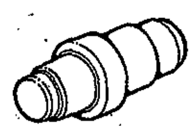


039254

OIL PRESSURE SWITCH SOCKET WRENCH
TO REMOVE THE OIL PRESSURE SWITCH



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



033583

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

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

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

ALSO REFER TO SPECIAL TOOLS - GENERATOR IN THIS MANUAL

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.

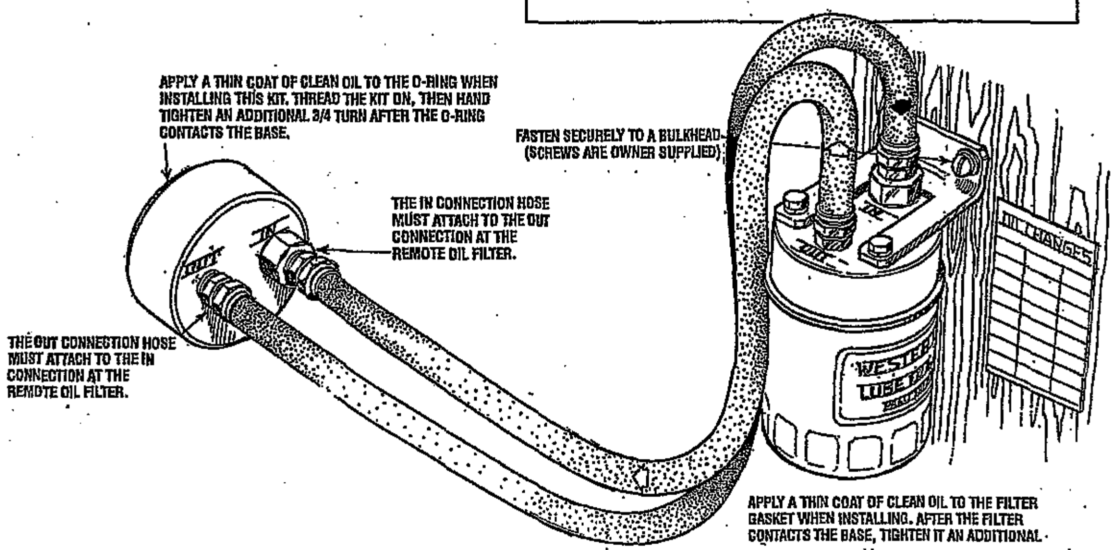
NOTE: *Refer to ENGINE OIL CHANGE in this manual for instructions on removing the oil filter.*

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

Contact your WESTERBEKE dealer for more information.

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

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

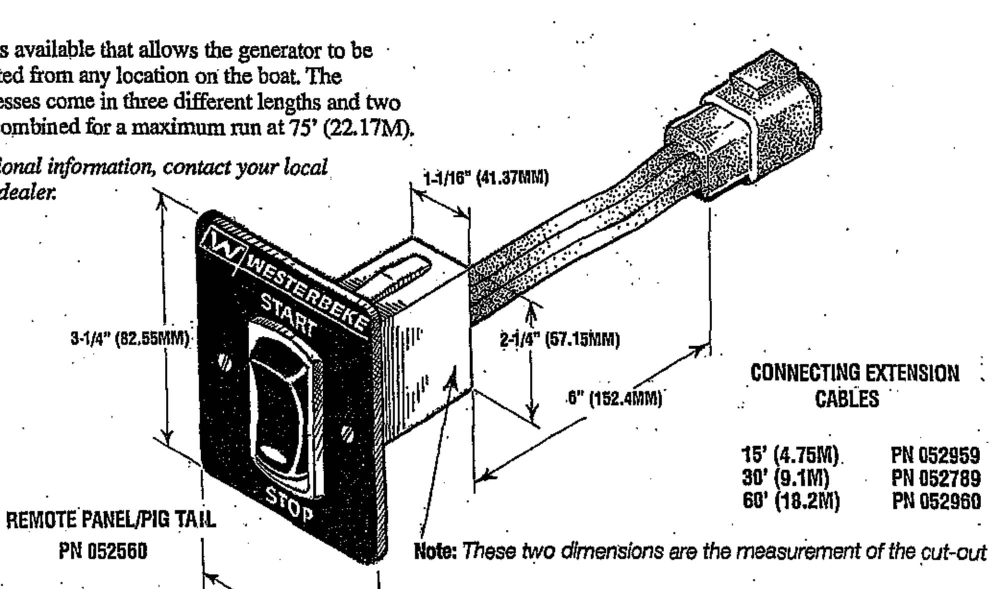


REMOTE STOP/START PANEL AND EXTENSION HARNESSES

DESCRIPTION

A remote panel is available that allows the generator to be stopped and started from any location on the boat. The connecting harnesses come in three different lengths and two of these can be combined for a maximum run at 75' (22.17M).

NOTE: *For additional information, contact your local WESTERBEKE dealer.*



Note: *These two dimensions are the measurement of the cut-out opening.*

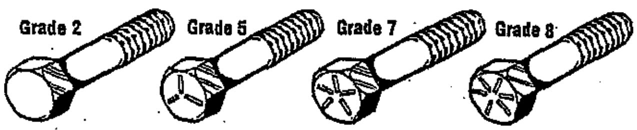
STANDARD HARDWARE

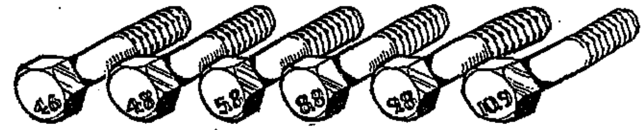
BOLT HEAD MARKINGS

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

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

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





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

STANDARD BOLT & NUT TORQUE SPECIFICATIONS

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

METRIC BOLT & NUT TORQUE SPECIFICATIONS

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

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

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

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

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

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

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

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

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

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

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

BOLTS & FASTENERS/ASSEMBLIES

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

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

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

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

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

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Imperial Quarts (IMP qt) x 1.201 = US Quarts (US qt) x .833 = IMP qt
Imperial Gallons (IMP gal) x 1.201 = US Gallons (US gal) x .833 = IMP gal
Fluid Ounces x 29.573 = Milliliters x .034 = Ounces
US Pints (US pt) x .473 = Liters(L) x 2.113 = Pints
US Quarts (US qt) x .946 = Liters (L) x 1.057 = Quarts
US Gallons (US gal) x 3.785 = Liters (L) x .264 = Gallons

MASS-WEIGHT

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

PRESSURE

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

TORQUE

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

VELOCITY

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

POWER

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

FUEL CONSUMPTION

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

TEMPERATURE

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

LIQUID WEIGHTS

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

DECIMAL TO METRIC EQUIVALENT CHART

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

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