will be covered in the succeeding sections of this chapter, so for the present you can concentrate on the importance of the third duty of the station operator—keeping a daily operating log.

The number of operating hours is recorded in the generating station log. The log serves as a basis for determining when a particular piece of electrical equipment is ready for inspection and maintenance. The station log can be used in conjunction with previous logs to spot gradual changes in equipment condition that ordinarily are difficult to detect in day-to-day operation. It is particularly important that you impress upon your watch standers the necessity for taking accurate readings at periods specified by local operating conditions.

Ensure that watch standers keep their spaces clean and orderly. Impress on them the importance of keeping tools and auxiliary equipment in their proper places when not in use. Store clean waste and oily waste in separate containers. Oily waste containers are required to be kept covered. Care given to the station floor will be governed by its composition. Generally, it should be swept down each watch. Any oil or grease that is tracked around the floor should be removed at once.

14.1.0 Generator Watch

Personnel you assign to stand the generator watch must be alert and respond quickly when they recognize a problem. The watch standers might not have control of every situation, but at least they need to be capable of securing the generator and preventing serious problems.

The primary purpose of the generator watch is to produce power in a safe and responsible manner. The watch stander may notice maintenance or repair actions that need to be rectified but do not require their immediate attention. The generator watch needs to make note of these problems so that they will be taken care of by the repair crew.

A generator watch involves performing operator maintenance, maintaining the operator’s log, operating a single generator, or operating paralleled generators.

14.2.0 Operator’s Log

The operator’s log (also called the station log) is a complete daily record of the operating hours and conditions of the generator set. The log must be kept clean and neat. The person who signs the log for a watch must make any corrections or changes to entries for that watch.

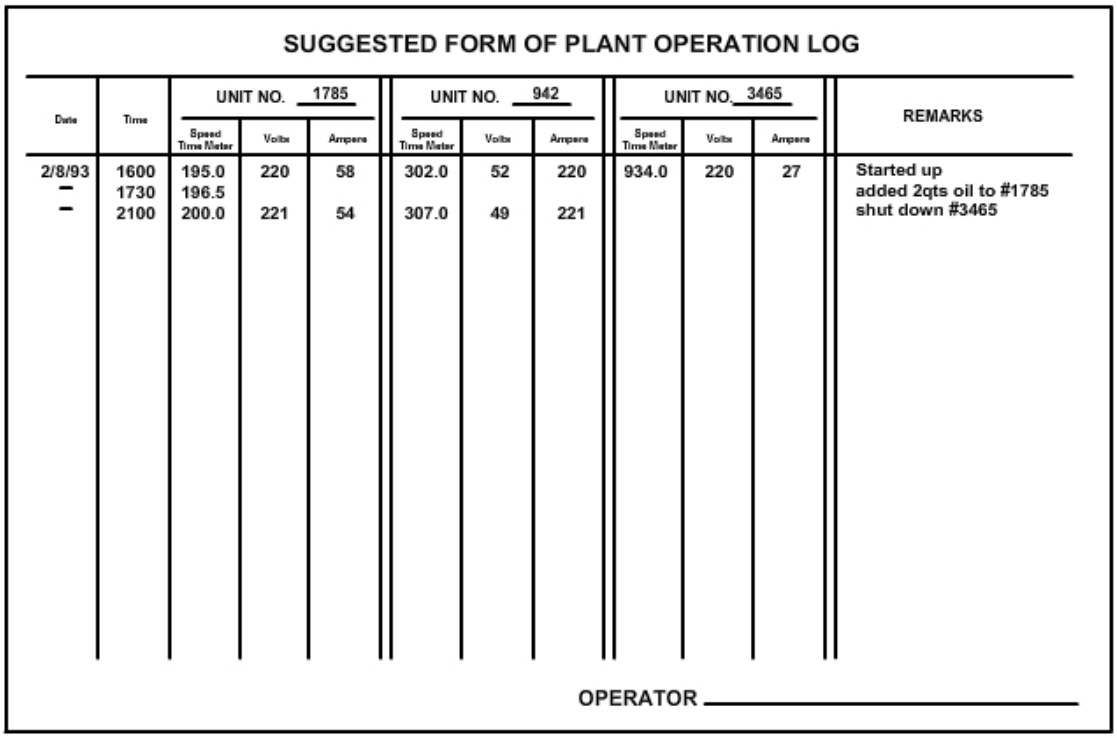
The log serves as a basis for determining when a particular piece of electrical equipment is ready for inspection and maintenance. Current and previous logs can be compared to spot gradual changes in equipment condition. These changes might not otherwise be detected in day-to-day operation.

Note defects discovered during operation of the unit for future correction; such correction should be made as soon as operation of the generator set has ceased.

Making accurate periodic recordings is particularly important. The intervals of these recordings will be based on local operating conditions.

The form used for log entries varies with the views of the supervisory personnel in different plants, and there is no standard form to be followed by all stations. Regardless of form, any log must describe the hourly performance not only of the generators but also of the numerous indicating and controlling devices.

Figure 2-34 shows one type of log that may be kept on the generator units of a power plant. This is only a suggested form, of course, and there may be many other forms at your generating station to keep records on.



SUGGESTED FORM OF PLANT OPERATION LOG

Date	Time	UNIT NO. 1785			UNIT NO. 942			UNIT NO. 3465			REMARKS
		Speed Time Meter	Volts	Amperes	Speed Time Meter	Volts	Amperes	Speed Time Meter	Volts	Amperes	
2/8/93	1600	195.0	220	58	302.0	52	220	934.0	220	27	Started up
—	1730	196.5									added 2qts oil to #1785
—	2100	200.0	221	54	307.0	49	221				shut down #3465

OPERATOR _____

Figure 2-34 – Typical generating station operator's log.

14.3.0 Plant Equipment

Setting up a power generator is only one phase of your job. After the plant is set up and ready to go, you will be expected to supervise the activities of the operating personnel of the generating station. In this respect, you should direct your supervision toward one ultimate goal--to maintain a continuous and adequate flow of electrical power to meet the demand. That can be accomplished if you have a thorough knowledge of how to operate and maintain the equipment and a complete understanding of the station's electrical systems as a whole. Obviously, a thorough knowledge of how to operate and maintain the specific equipment found in the generating station to which you are assigned cannot be covered here; however general information will be given. It will be up to you to supplement this information with the specific instructions given in the manufacturer's instruction manuals furnished with each piece of equipment.

Similarly, you can gain familiarity with the station's electrical system as a whole only by studying information relating specifically to that installation. This information can be found to some extent in the manufacturer's instruction manuals. You can obtain the greater part of it from the station's electrical plans and wiring diagrams. Remember, however, to supplement your study of the electrical plans and diagrams with an actual study of the generating station's system. That way, the generators, switchgear, cables, and other electrical equipment are not merely symbols on a plan but are physical

objects whose locations you definitely know and whose functions and relation to the rest of the system you thoroughly understand.

15.0.0 SINGLE UNIT OPERATION

Connecting an electric plant to a de-energized bus involves two general phases: (1) starting the diesel engine and bringing it up to rated speed under control of the governor and (2) operating the switchboard controls to bring the power of the generator onto the bus.

Different manufacturers of generating plants require the operator to perform a multitude of steps before starting the prime mover; for example, if a diesel engine is started by compressed air, the operator would have to align the compressed air system. This alignment would not be necessary if the engine is of the electric-start type. It is important that you, as the plant supervisor, establish a prestart checklist for each generating plant. The prestart checklist provides a methodical procedure for confirming the operational configuration of the generating plant; following this procedure assures that all systems and controls are properly aligned for operation. This section will first give general information and have a separate section for the Tactical Quiet Generator (TQG-B).

The checklist mentioned above should include, but is not limited to, the following:

1. Align ventilation louvers.
2. Check lube oil, fuel oil, and cooling water levels.
3. Ensure battery bank is fully charged.
4. Align electrical breakers and switches for proper operation of auxiliary equipment.
5. Check control panel and engine controls.
6. Select the proper operating position for the following controls for single plant operation.
   - Voltage regulator switch to UNIT or SINGLE position.
   - Governor switch to ISOCHRONOUS or SINGLE position.

   NOTE: Adjust hydraulic governor droop position to 0.

   - Voltage regulator control switch to AUTO position.

Complete the prestart checklist in sequence before you attempt to start the generating plant.

Start the generating plant and adjust the engine revolutions per minute (rpm) to synchronous speed. Adjust the voltage regulator to obtain the correct operating voltage. Set the synchronizing switch to the ON position and close the main circuit breaker. Adjust the frequency to 60 hertz with the governor control switch. Perform hourly operational checks to detect abnormal conditions and to ensure the generating set is operating at the correct voltage and frequency.

15.1.0 Operating Procedures for Single Generator Sets (General)

The following operating procedures are general procedures for operating a single generator unit. Some procedures will vary with different types of generators. Study carefully the recommendations in the manufacturer’s manual for the generator you are

to operate. Learn about the capabilities and limitations of your machine(s). In the event of a problem, you will know what action is required to lessen the effects of the problem. You or your senior should make a checklist of operating procedures from the manual and post it near the generator.

The steps below will cover starting and operating a typical diesel-driven generator set. (This set uses a dc powered motor for starting the diesel engine.) These steps will also cover applying an electrical load.

15.1.1 Starting the Generator Set (General)

Proceed as follows to start the typical generator set:

WARNING

Do not operate the generator set unless it has been properly grounded. Electrical faults (such as leakage paths) in the generator set, feeder lines, or load equipment can cause injury or death by electrocution.

Before operating the set for the first time, ensure that service procedures were performed upon its receipt according to the manufacturer's literature. See also that all preventive maintenance checks have been performed. The voltage change board must be adjusted for the required voltage (*Figure 2-35*).

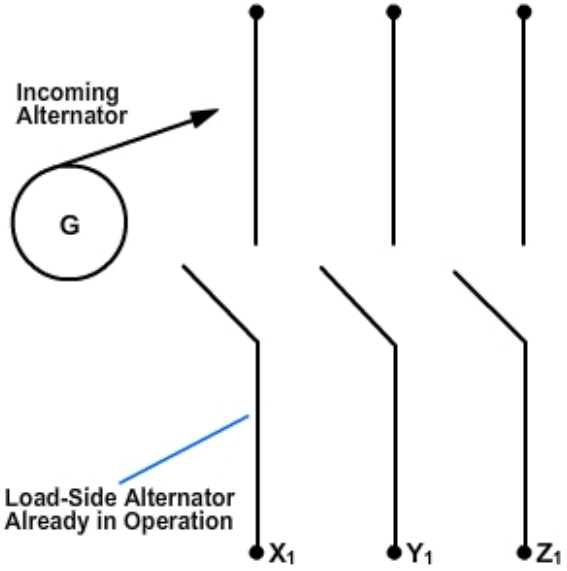


Figure 2-35 – Typical changeover board assembly.

1. Open the CONTROL CUBICLE and AIR INTAKE DOORS (*Figure 2-36*). Close the HOUSING PANEL (ACCESS) DOORS.
2. Set the FUEL TRANSFER VALVE (*Figure 2-36*) to the desired source of fuel, preferably the auxiliary tank, if it is connected.

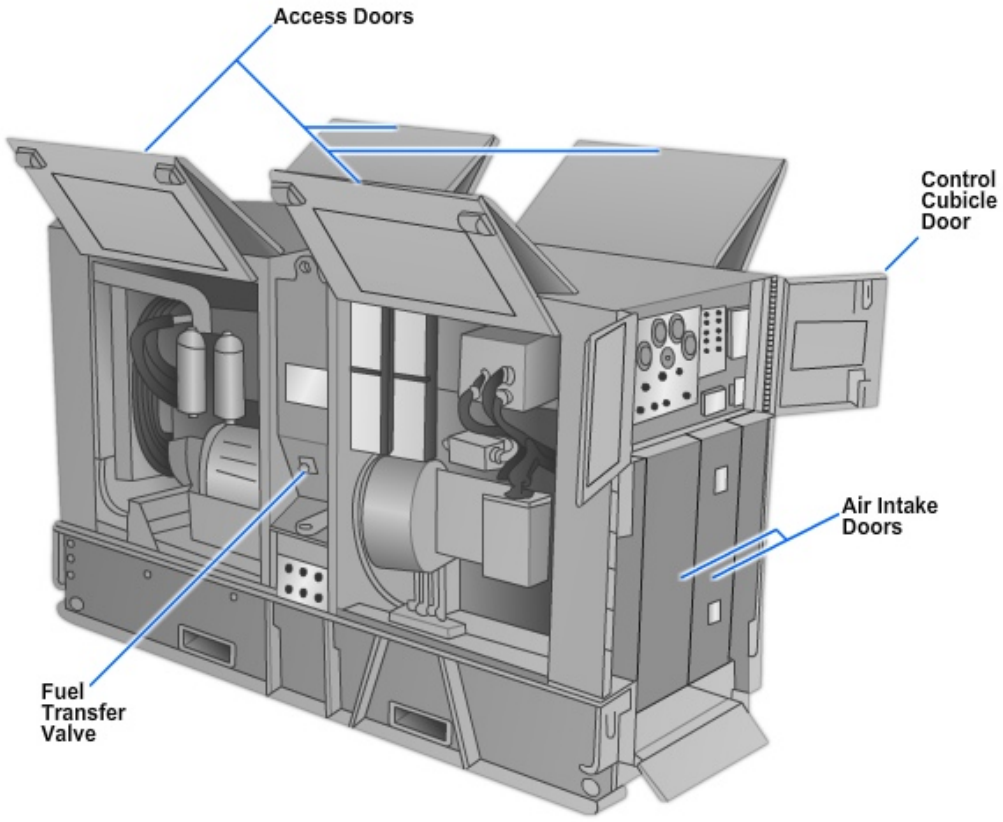


Figure 2-36 – Generator set, left rear, three quarters view.

NOTE

Refer to *Figure 2-37* for the for the CONTROL CUBICLE, FAULT INDICATOR PANEL, DC CONTROL CIRCUIT BREAKER, and ENGINE MANUAL SPEED CONTROL. Notice that the control cubicle is divided into an engine section and a generator section.

3. Set the PARALLEL OPERATION - SINGLE UNIT OPERATION select switch (located in the GENERATOR section of the CONTROL CUBICLE) to SINGLE UNIT OPERATION.
4. Set the VOLTAGE ADJUST - INCREASE control to the lower half of the adjustment range.
5. Depress the DC CONTROL CIRCUIT BREAKER (located to the lower right of the CONTROL CUBICLE) to ON.
6. Set the START - STOP - RUN switch (located in the ENGINE section of the CONTROL CUBICLE) to RUN.
7. Set and hold the TEST or RESET switch (on the FAULT INDICATOR PANEL) in the UP position. Check each fault indicator light that is on and replace defective lamps or fuses.
8. Allow the TEST or RESET switch to return to the mid position. Each fault indicator light, with the exception of the LOW OIL Pressure light, should go out. When the engine has started, the LOW OIL PRESSURE light should also go out.

If the NO FUEL light stays lit, refill the set or auxiliary tank. Position the BATTLE SHORT switch (CONTROL CUBICLE) to ON (the fuel pump will run to fill the day tank).

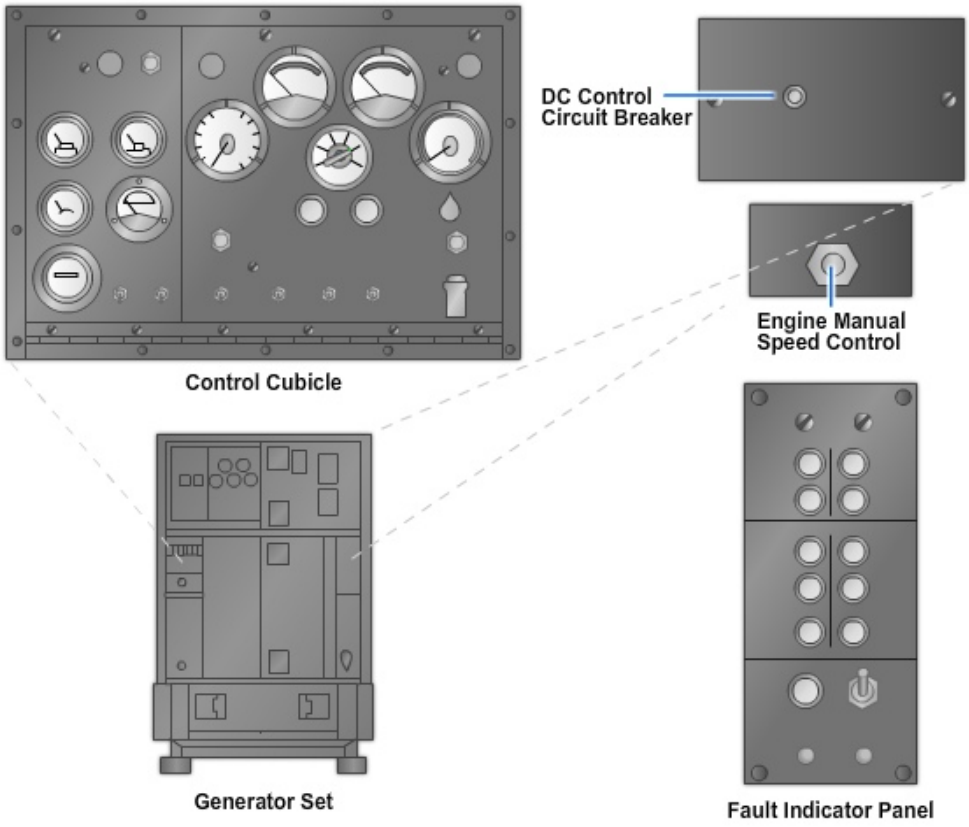


Figure 2-37 – Control cubicle, controls, and indicators.

Set the TEST or RESET switch to the UP position and then release it; the NO FUEL light should go out when the switch handle is released.

9. Set the CKT BRK CLOSE - OPEN switch (CONTROL CUBICLE) to OPEN.
10. Push and release the AIR CLEANER CONDITION indicator, BATTLE SHORT indicator, and CKT BKR indicator. EACH indicator light should go on as the indicator is pushed and go out when the indicator is released.
    a. If the AIR CLEANER CONDITION indicator remains lit, the air cleaner must be serviced.
    b. If the CKT BKR indicator remains on after you set the CKT BRK switch to OPEN, you cannot continue the procedure. The circuit breaker must function properly. The generator cannot be used until the problem is corrected.
11. Depress the lock button on the ENGINE MANUAL SPEED CONTROL (located below the DC CONTROL CIRCUIT BREAKER), and set the control.

⚠ CAUTION ⚠

Do NOT crank the engine in excess of 15 seconds at a time. Allow the starter to cool a minimum of 3 minutes between cranking.

WARNING

Operation of this equipment presents a noise hazard to personnel in the area. The noise level exceeds the allowable limits for unprotected personnel. Wear earmuffs or earplugs.

12. Set and hold the START - STOP - RUN switch to the START position until the engine starts. As the engine starts, observe the following:
    a. The OIL PRESSURE gauge indicates at least 25 pounds per square inch gauge (psig).
    b. The VOLTS AC meter indicates the presence of voltage.
    c. The LOW OIL PRESSURE indicator light on the FAULT INDICATOR PANEL goes out.
13. Release the START - STOP - RUN switch. Position the switch to RUN.

15.1.2 Operating the Generator Set (General)

The procedures for operating a single generator set (single unit) are as follows:

1. Ensure that the PARALLEL OPERATION - SINGLE UNIT OPERATION switch is set to SINGLE UNIT OPERATION.
2. Position the AMPS – VOLTS selector switch to the required position. Rotate the VOLTAGE ADJUST control to obtain the required voltage. Read the voltage from the VOLTS AC meter.
3. Depress the locking button and slide the ENGINE MANUAL SPEED CONTROL in or out to obtain the approximate rated frequency; rotate the vernier knob (the knob on the control) clockwise or counterclockwise to obtain the rated frequency.

NOTE

If necessary, the load may be applied immediately.

4. Operate the engine for at least 5 minutes to warm it up.
5. Apply the load by holding the CKT BRK switch (on the CONTROL CUBICLE) to CLOSE until the CKT BRK indicator lights go out. Then release the switch.
6. Observe the readings from the VOLTS AC meter and the HERTZ (FREQUENCY) meter. The voltage readings should be 120/208 to 240/416 volts ac (depending on the positions of the AMPS-VOLTS select switch and the voltage change board). Let us say, for example, that you positioned the voltage change board for 120/208 volts before you started the generator set. When you position the AMPS-VOLTS selector switch to L2-L0 VOLTS/L2 AMPS while the generator is operating, the VOLTS AC meter should indicate 120 volts. The PERCENT RATED CURRENT meter will indicate the percent rated current (not more than 100 percent) between generator line 2 and neutral. The HERTZ (FREQUENCY) meter should indicate 50 or 60 hertz. The KILOWATTS meter should indicate no more than 100 percent with the HERTZ (FREQUENCY) meter showing 60 hertz. Readjust the voltage and frequency, if necessary.
7. Observe the KILOWATTS meter. If the meter indicates that more than the rated kilowatts are being consumed, reduce the load.

8. Rotate the AMPS-VOLTS selector switch to each phase position and monitor the PERCENT RATED CURRENT meter. If it indicates more than the rated load for any phase position, reduce or reapportion the load.
9. Periodically (not less than once per hour), monitor the engine and generator indicators to ensure their continued operation.
10. Perform any preventive checks.

When in operation, monitor the generator set periodically (at least once an hour) for signs indicating possible future malfunctions.

After the warm-up, the lubricating oil pressure should remain virtually constant. Check and record the level of lubricating oil while the engine is running normally. If any significant changes occur in the oil pressure, notify maintenance personnel. Check and record the coolant temperature of the normally running engine. Notify maintenance personnel if the coolant temperature changes significantly.

Learn the sounds of a normally running generator set so that you may detect any unusual sounds indicating the possible start of a malfunction may be detected early enough to avoid major damage.

Stop the operation immediately if a deficiency that would damage the equipment is noted during operation.

15.2.0 Operating Procedures for Single Generator TQG-B

This section is about the single operating procedures for the TQG-B generator. Before the operating procedures are discussed, it is important that you understand the components that make up the TQG-B (*Figure 2-38*). Failure to understand these components could lead to personnel injury or death and damage to the generator.

Figure 2-38 – TQG-B Generator.

Before learning about the components and operating procedures of the TQG-B, take a moment to read the next two important safety warnings (*Figure 2-39*). It is imperative for you to take each warning seriously. (1) Remember to make sure the unit is completely shut down and free of any power source before attempting any repair or maintenance on the unit. High voltage is produced when the generator set is in operation and failure to comply with this safety procedure can result in injury or death to personnel. (2) Remember to remove metal jewelry when working on electrical systems or components. Metal jewelery can conduct electricity, and failure to comply with this safety procedure can cause injury or death to personnel by electrocution.

The TQG-Bravo recently took the place of the Alpha model. There are similarities between the Alpha and Bravo models. Both models deliver the same precise power with the same voltage and frequency. Both generators also have the same engines: John Deere Diesel/JP-8 engines. The following is a listing of similarities between both models:

- Both models deliver the same precise power, voltage, and frequency levels.
- Both have the same engines.
- Output: 30,000 Kw.
- Voltage: 120/208 low wye.

  240/416 high wye.
- Frequency: 50 – 60 Hz.
- Engine: John Deere JP-8 Diesel

Figure 2-39 – Warning notices.

While the Alpha and Bravo models do have some similarities, they also have some important differences that you need to be aware of. The bravo model has a Digital Control System or DCS, while the Alpha model uses physical gauges, lights, and meters. It is important to know that you cannot parallel a TQG-Alpha with a TQG-Bravo. Attempting to do so will result in damage to the generator sets.

15.2.1 Components and Instrumentation of the TQG-B

The TQG-Bravo models have several components and instruments with which you need to be familiar. You will learn about the components and instruments in a 360° rotation starting at the rear and completing on the right side of the generator.

Refer to *Figure 2-40* for the rear portion of TQG-B.

Figure 2-40 – TQG-B rear components.

15.2.1.1 Rear: Components and Instruments

15.2.1.1.1 DCS

Figure 2-40 is the DCS that you will use to start, operate, and shut down the TQG-B. It is extremely important that you know the function of each component and instrument on the DCS.

15.2.1.1.2 Air Cleaner Assembly

The air cleaner assembly is located on the front, behind the air cleaner access door. The air cleaner assembly has a dry-type, disposable paper filter and canister. There is also a restriction indicator which will pop up during operation when the air cleaner requires servicing.

15.2.1.1.3 Paralleling Receptacle

The paralleling receptacle is used to connect the paralleling cable between two generator sets of the same size and model to operate in parallel.

15.2.1.1.4 Convenience Receptacle

The convenience receptacle is a 120 VAC receptacle used to operate small plug-in type equipment. This can be used to operate a laptop or other normal appliances.

15.2.1.1.5 Ground Fault Circuit Interrupter Test Switch

The ground fault circuit interrupter consists of the test switch and reset switches. The test switch tests to see if the ground fault circuit interrupter is working. The reset switch resets the ground fault circuit interrupter.

15.2.1.2 Left Side Components and Instrumentation

Refer to *Figure 2-41* for the left side portion of TQG-B.

15.2.1.2.1 Radiator

The radiator is in the front of the engine compartment. It acts as a heat exchanger for the engine coolant and helps keep the engine cool.

15.2.1.2.2 Dead Crank Switch

The dead crank switch is located on the left side of the engine compartment. The switch allows for engine turn-over without starting for maintenance purposes.

15.2.1.2.3 Dipstick

The dipstick is on the left side of the engine compartment. The dipstick measures the oil level in the engine drain pan. It has two sides, an engine stopped or cold side and an engine running or hot side.

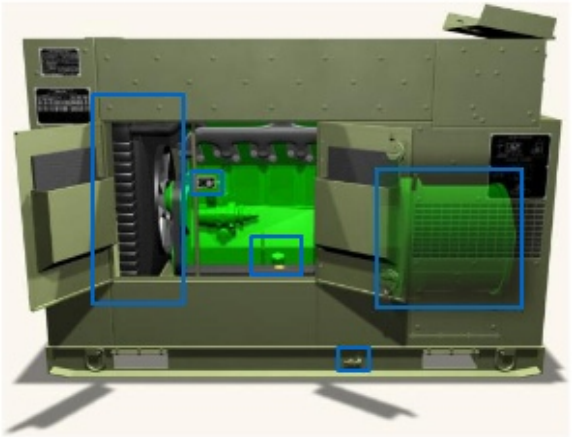


Figure 2-41 – Left side components of the TQG-B generator.

15.2.1.2.4 Fuel Drain Valve

The fuel drain valve is on the left side of the generator set's skid base. The fuel drain allows fuel to be drained for maintenance.

15.2.1.2.5 AC Generator

The ac generator is coupled directly to the rear of the diesel engine and is the component that produces electricity using the energy from the diesel engine.

15.2.1.2.6 Actuator

The actuator is on the engine's left side. The actuator regulates fuel amounts that enter the engine to maintain the desired engine speed.

15.2.1.2.7 Turbocharger

The engine's turbocharger takes air from the intake filter. Exhaust gases are pushed into the turbine of the turbocharger through the exhaust manifold. The turbine drives the turbocharger, which compresses the intake air and forces it into the engine, creating more powerful explosions in the combustion chambers.

15.2.1.2.8 Fuel Pump

The fuel pump is on the engine's left side. It delivers fuel to the Fuel Injection Pump.

15.2.1.2.9 Magnetic Pickup

The magnetic pickup is on the rear bell housing of the engine's flywheel. It uses magnetic impulses to monitor engine speed for the governor control unit.

15.2.1.3 Front End Components and Instrumentation

Refer to *Figure 2-42* for the front end portion of TQG-B.

15.2.1.3.1 Batteries

Two maintenance-free 12-volt dc batteries are located at the front of the TQG-B. The generator is capable of operating without the batteries connected after it is started. There is a diode behind the control panel that protects the generator set if the batteries are connected incorrectly.

15.2.1.3.2 Oil Drain-Off Valve

The oil drain valve is located at the front of the generator. This is where oil is drained for maintenance purposes.

Figure 2-42 – Front end components of the TQG-B generator.

15.2.1.4 Right Side Components and Instrumentation

Refer to *Figure 2-43* for the right side portion of TQG-B.

15.2.1.4.1 NATO Slave Receptacle

The NATO slave receptacle is located on the right side of the generator set. The NATO receptacle is used for remote battery operation and jump starting the unit from any other piece of equipment that has a 24 VDC starting system.

15.2.1.4.2 Load Output Terminal

The load output terminal board is at the rear of the generator on the right side. It consists of four ac output terminals mounted on a board. The four terminals are labeled L1, L2, L3, and L0. There is also a fifth terminal labeled GND that serves as the ground

for equipment. A copper bar is connected between the L0 and GND terminals (*Figure 2-43*).

15.2.1.4.3 Reconnection Board

The reconnection board is located on the right side of the generator at the rear above the Load Output Box. The reconnection board allows reconfiguration from 120 to 208 for low wye and 240 to 416 for high wye VAC output.

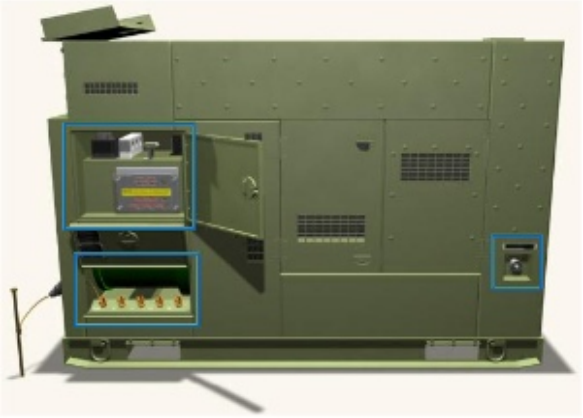


Figure 2-43 – Right side components of TQG-B generator.

15.2.1.4.4 Muffler

The muffler and exhaust tubing are connected to the engine's turbo charger. The exhaust exits through the top of the generator set. Gases are exhausted upward.

15.2.1.4.5 Radiator Fill Bottle

The radiator fill bottle is located on the right side of the engine. The bottle has hot and cold markings that indicate where the coolant levels should be during operation when hot and when cold. Only authorized personnel can add coolant to the engine and only through the fill bottle.

15.2.1.4.6 Serpentine Fan Belt

The serpentine fan belt is located in the engine compartment on the front of the engine. The fan belt drives several components including the fan, water pump, and battery-charging alternator.

15.2.1.4.7 Water Pump

The water pump is located at the front of the engine. The pump circulates coolant through the engine block and the radiator.

15.2.1.4.8 Battery Charging Alternator

The battery-charging alternator is located on the right side of the engine. It is capable of constantly charging the batteries to keep them in a charged state in addition to providing the required 24 volts to the control circuits. The alternator is protected by an inline fuse rated at 30 amps located above the fuel tank and below the alternator.

15.2.1.4.9 Oil Filter

The oil filter is in the engine compartment on the left side. The oil filter removes impurities from the oil.

15.2.1.4.10 Starter

The starter is on the right side of the engine. The starter motor engages the engine's flywheel to start the diesel engine.

15.2.1.4.11 Crankcase Breather Filter Assembly

The crankcase breather filter assembly is at the right side of the engine compartment. The filter element removes particles from oil and air contaminants when they pass from the crankcase to the engine air intake.

15.2.1.4.12 Fuel Filter/Water Separator

The fuel filter/water separator is on the right side of the engine compartment. The element removes water impurities from the diesel fuel.

15.2.2 Operation of TQG-B

15.2.2.1 Checklists for the TQG-B

Checklists exist to give you a thorough reference for inspecting the generator set at various points. The checklists contain a list of components for each of the sides of the generator set that need to be checked. There are four checklists for the before operations check, during operations check, after operations check, and parallel operations check (*Figure 2-44*).

Figure 2-44 – Checklists utilized for TQG-B operation.

15.2.2.1.1 Before Operations Check

It is very important to check the components and instruments of the TQG-B before starting it. Performing the before operations check will ensure that the generator is in good condition to start. The generator set could be damaged or fail to start if the before operations check is not done or is done incorrectly.

Figure 2-45 gives guidance for a thorough before operation exam of the generator. The Before Operations Checklist covers all the major components and

Figure 2-45 – Before Operations Checklist.

instruments of the generator and is important because it does the following:

- Reduces the likelihood of damage to the generator.
- Allows you to identify maintenance issues before they become a problem.
- Increases the chances of supplying power to those crews that need it when they need it.

Remember, never attempt to start the generator set unless it is properly grounded. The generator set produces high voltage when it is in operation, and failure to comply can result in injury or death to personnel.

15.2.2.1.2 Before Operations Check: Rear

We will now use the pre-operations checklist to perform the before operations check. The before operations check is performed in a 360° rotation that starts at the rear of the generator (*Figure 2-46*).

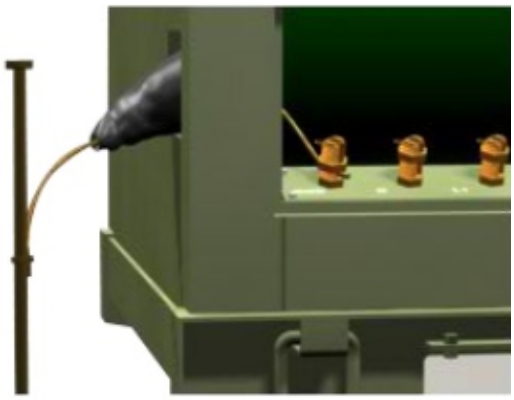


Figure 2-46 – Before operations check – rear.

15.2.2.1.2.1 Ground Rod Inspection

First, inspect the ground rod and generator ground stud to ensure proper grounding. Remember that failure to ensure proper grounding may result in death or serious bodily injury by electrocution.

15.2.2.1.2.2 Housing Inspection

Check the housing, door fasterners, and hinges. Note that the generator will be deadlined if the doors are not secure.

15.2.2.1.2.3 Identification Plate Inspection

Check that the identification plates are secured in place.

15.2.2.1.2.4 Indicator and Controls Inspections

Check all indicators and controls for damaged or missing parts. Note that if a discrepancy exists, the unit is deadlined.

15.2.2.1.2.5 Control Box Harness Inspection

Check the control box harness for loose or damaged wiring. Note that if a discrepancy exists, the unit is deadlined.

15.2.2.1.2.6 Power Fuse Inspection

Confirm that the dc power control fuse is intact and has a ten amp power rating.

15.2.2.1.2.7 Frequency Selection

Verify that the frequency selection switch is at the correct position for the power you are providing. For NORMAL the switch should be set to NORMAL sixty hertz. For NATO the switch should be set to NATO 50 hertz.

15.2.2.1.2.8 Cable Inspections

Check the parallel receptacle and parallel cable for damage.

15.2.2.1.2.9 Air Cleaner Element Inspection

Inspect the air cleaner element and assembly for restrictions or damage. The restriction indicator will tell you whether the air cleaner filter needs changing.

15.2.2.1.3 Before Operations Check: Left Side

Refer to *Figure 2-47* for inspection points associated with before operations check – left side.

15.2.2.1.3.1 Skid Base Inspection

Inspect the skid base for corrosion and cracks.

15.2.2.1.3.2 Housing Inspection

Inspect the engine compartment housing, along with the air ducts and exhaust grills. You also need to check the door fasteners and hinges just like you did for the rear of the generator.

Figure 2-47 – Before operations check – left side.

15.2.2.1.3.3 Identification Plate Inspection

Check that the identification plates are secured and in place.

15.2.2.1.3.4 Engine Compartment Inspection

Inspect the engine compartment for damage.

15.2.2.1.3.5 Engine Compartment Wiring Inspection

Inspect the engine compartment and look for loose or missing components.

15.2.2.1.3.6 Acoustic Material Inspection

Inspect the acoustic material pockets to make sure that all acoustic materials are intact.

15.2.2.1.3.7 Lubrication System Inspection

Check the dipstick to make sure the oil is at the full level. Then inspect the rest of the lubrication system to make sure there are no leaks. Note that if any class three leaks exist, the generator will be deadlined.

15.2.2.1.3.8 Fuel System Inspection

Inspect the fuel system for leaks and damaged or missing parts. Note that if any leaks or other discrepancies exist, the generator will be deadlined.

15.2.2.1.3.9 Cooling Fan Inspection

Make certain the cooling fan is not damaged or loose and is in good working condition.

15.2.2.1.3.10 Radiator Cap and Hose Inspection

Inspect the Radiator Cap without removing it. Make sure there are no cracks in the Radiator Cap or the hoses.

15.2.2.1.4 Before Operations Check: Front

Refer to *Figure 2-48* for inspection points associated with before operations check – front side.

Figure 2-48 – Before operations check – front side.

15.2.2.1.4.1 Housing Inspection

Inspect the housing, door fasteners, and hinges just like you did for the rear and left sides of the generator. Note that the generator set will be deadlined if the doors cannot be secured.

15.2.2.1.4.2 Identification Plate Inspection

Check that the identification plates are secured and in place.

15.2.2.1.4.3 Types of Batteries

Check the battery type to see if they are maintenance free.

15.2.2.1.4.4 Electrolyte Levels

Check the electrolyte level of the batteries if they are not maintenance-free batteries.

15.2.2.1.4.5 Battery Inspection

Check the batteries for any damage or corrosion to the battery terminals and connections. Make sure the connections are secure. Note that the generator is deadlined if cables are loose, damaged, or missing.

15.2.2.1.5 Before Operations Check: Right Side

Refer to *Figure 2-49* for inspection points associated with before operations check – right side.

Figure 2-49 – Before operations check – right side.

15.2.2.1.5.1 Skid Plate Inspection

Inspect the skid plate for corrosion and cracks.

15.2.2.1.5.2 Housing Inspection

Inspect the engine compartment housing, along with the air ducts and exhaust grills. You also need to check the door fasteners and hinges just like you did for the rear of the generator.

15.2.2.1.5.3 Identification Plate Inspection

Check that the identification plates are secured and in place.

15.2.2.1.5.4 Engine Compartment Inspection

Inspect the engine compartment for damage.

15.2.2.1.5.5 Engine Compartment Component Inspection

Inspect the engine compartment and look for loose or missing components.

15.2.2.1.5.6 Acoustic Material Inspection

Inspect the acoustic material pockets to make sure that all acoustic materials are intact.

15.2.2.1.5.7 Serpentine Belt Inspection

Check serpentine belt for cracks, fraying, or looseness.

15.2.2.1.5.8 Fuel Filter/Water Separator Inspection

Check the fuel filter and the water separator, and drain off water and other contaminants.

15.2.2.1.5.9 Radiator Bottle Inspection

Check the radiator bottle for the proper coolant level and for leaks. Note that the generator will be deadlined if any class three leaks are present. Make sure to add coolant to the overflow bottle only. Never remove the radiator cap to fill the coolant. Removing the radiator cap could cause serious burns.

15.2.2.1.5.10 Exhaust System Inspection

Inspect the muffler and exhaust system for corrosion, damage, or missing parts. Note that the generator is deadlined if a discrepancy exists.

15.2.2.1.5.11 Ether Start System Inspection

Inspect the ether start system and confirm that there are no missing or loose components.

15.2.2.1.5.12 Output Box Assembly Inspection

Inspect the output box assembly for loose or damaged wiring or cables. Note that if hardware,cables, or wires are damaged, the unit is deadlined until repairs are made.

15.2.2.1.5.13 Voltage Reconnection Board/Selector Switch Inspection

Ensure that the voltage reconnection board and the voltage selection switch are positioned correctly.

15.2.2.1.6 Precautions Prior to Starting the TQG-B

Now that you have completed the before operations checks using the Pre-Operations Checklist, you can continue with the controls, sequences, and safety precautions required to start the TQG-B generator. Other Seabees are relying on the power that you supply for their safety and their ability to operate necessary equipment. Failing to start the TQG-B could leave you and your fellow Seabees in the dark and vulnerable to the enemy.

15.2.2.1.6.1 Ground Rod Warning

Before learning how to start the TQG-B, take a moment to read this important safety warning. It is imperative for you to take this warning seriously. Remember, never attempt to start the generator set unless it is properly grounded. The generator set produces high voltage when it is in operation, and failure to comply can result in injury or death to personnel (*Figure 2-50*).

Figure 2-50 – Ground rod warning.

15.2.2.1.6.2 Deadly Gases Warning

It is imperative for you to take this warning seriously. Never attempt to operate the generator set in an enclosed area unless exhaust discharge is properly vented outside. Exhaust discharge contains deadly gases, including carbon monoxide. Failure to comply can cause injury or death to personnel (*Figure 2-51*).

Figure 2-51 – Deadly gases warning.

15.2.2.1.7 Starting the TQG-B

Starting the TQG-B is a ten-step process that you must be able to execute without the use of a checklist or other aid. Pay close attention to each step, and you will be able to start the TQG-B quickly and correctly. Start-up is conducted as follows:

- Turn the Dead Crank Switch to the NORMAL position.
- Place the Master Control Switch to the ON position.
- Ensure the Emergency Stop Switch is pulled out.
- Ensure the Battle Short Switch is in the OFF position.
- Scroll to Display Mode on the CIM and press SELECT using the keypad to continue to the FULL screen.

- Hold the Fault Reset Switch in the ON position and place the Engine Control Switch in the START position and hold no longer than fifteen seconds or until engine oil pressure reaches twenty-five PSI. Then release the Fault Reset Switch and the Engine Control Switch. NOTE: Never hold the Engine Control Switch in the START position for longer than 15 seconds. If utilizing an auxiliary fuel source, place the Engine Control Switch to PRIME & RUN AUX FUEL.
- Scroll to the FULL icon on the Display Mode of the CIM using the keypad and press SELECT to display all generator set indicators.
- Adjust the voltage and frequency to the proper values using the Frequency Adjustment Switch and the Voltage Adjustment Switch.
- Allow the generator set to run with no load for five minutes for warmup. NOTE: Damage to the engine can occur if a load is applied before the engine warms up.
- Place the AC Circuit Interrupter Switch into the CLOSED position. This will apply energy to the load.

15.2.2.1.8 During Operations Check

It is very important to check some components of the TQG-B during operation. Performing the during operations check will ensure that the generator is running correctly. The generator set could be damaged if the during operations check is not done or is done incorrectly (*Figure 2-52*).

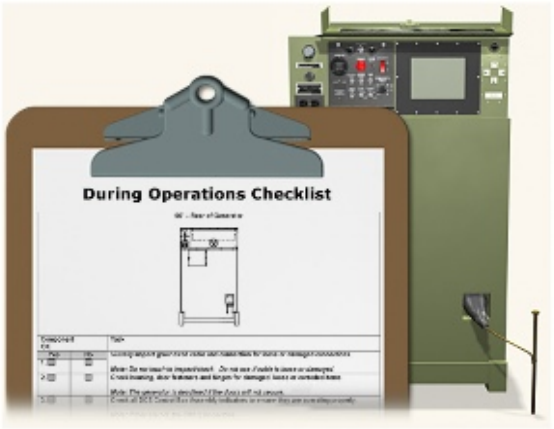


Figure 2-52 – During Operations Checklist.

The checklist gives guidance for a during operations exam of the generator. The During Operations Checklist covers all the components and instruments of the TQG-B that need to be checked while running. The During Operations Checklist does the following:

- Reduces the likelihood of damage to the generator.
- Allows you to identify maintenance issues before they become a problem.
- Increases the chances of supplying power to those Seabees that need it when they need it.

Before learning how to perform a during operations check, take a moment to read the following two safety warnings. It is imperative for you to take each warning seriously. (1) Remember, never attempt to connect or disconnect load cables while the generator set is running. High voltage is produced when the generator set is in operation, and failure to comply can result in injury or death to personnel.

It is imperative for you to take this warning seriously. (2) Remember, personnel must wear hearing protection when operating or working near the generator set with any access door open. Failure to comply can cause hearing damage to personnel.

15.2.2.1.8.1 During Operations Check: Rear

Now that you have read the warnings you can use the During Operations Checklist to perform the during operations check. Like other checks, the during operations check is performed in a 360° rotation that starts at the rear of the generator. Here are the three steps required to inspect the rear side of the TQG-B when it is running:

- Visually inspect the ground rod cable and connection for loose or damaged connections. Do not touch to inspect/check. Do not use if cable is loose or damaged.
- Check housing, door fasteners and hinges for damaged, loose, or corroded items. The generator is deadlined if the doors will not secure.
- Check all DCS Control Box Assembly indicators to ensure they are operating properly. If indicators are not operating properly, the CIM is inoperative.

15.2.2.1.8.2 During Operations Check: Left

Now you will learn how to perform the second part of the 360° rotation by inspecting all necessary components on the left side of the TQG-B. There are six steps to inspect the left side of the TQG-B:

- Check the housing, door fasteners and hinges for damaged, loose, or corroded items. Check air ducts and exhaust grills for debris. The generator is deadlined if the doors will not secure or the debris cannot be cleared.
- Check that the engine compartment is not damaged.
- Check that the engine compartment has no loose or missing components.
- Check the lubrication system for leaks and damaged, loose, or missing parts. If any Class III leaks or other discrepancies are present, the generator is deadlined.
- Check the fuel system for leaks, damaged, loose, or missing parts. Any leaks or other discrepancies deadline the generator.
- Check for unusual noise being emitted from the cooling fan area. If the fan is damaged or loose, the generator is deadlined.

15.2.2.1.8.3 During Operations Check: Front

You have learned how to perform the steps of the during operations check on the rear and left side of the generator. Now you will learn to inspect the front of the TQG-B. There is only one step on the during operations check for the front of the generator:

- Check housing, door fasteners, and hinges for damaged, loose, or corroded items. The generator is deadlined if the doors will not secure.

15.2.2.1.8.4 During Operations Check: Right Side

You will now learn the final part of the 360° rotation by inspecting all necessary components on the right side of the TQG-B. There are four steps to inspect the right side of the TQG-B:

- Check the housing, door fasteners, and hinges for damaged, loose, or corroded items. Check air ducts and exhaust grills for debris. The generator is deadlined if the doors will not secure or the debris cannot be cleared.
- Check that the engine compartment is not damaged.

- Check that the engine compartment has no loose or missing components.
- Check the radiator overflow bottle for leaks and missing parts. Generator is deadlined if a Class III leak is present. The cooling system operates at high temperature and pressure.

15.2.2.1.9 Shutting Down the TQG-B

Following the seven-step process for shutting down the generator will prevent damage to vital equipment.

Shutting down the TQG-B is a seven-step process that you must be able to execute without the use of a checklist or other aid. Pay close attention to each step and you will be able to shut down the TQG-B quickly and correctly. Refer to *Figure 2-53* for shutdown sequence.

Figure 2-53 – TQG-B generator shutdown sequence.

Step 1: Place the AC Circuit Interrupter Switch into the OPEN position until contactor on the CIM display screen reads Open.

Step 2: Allow the engine to operate for approximately 5 minutes with no load applied to allow cooling off of the engine and AC generator.

Step 3: Scroll to EXIT on the CIM and select. After approximately 5 seconds the engine will stop.

Step 4: Place the Master Control Switch into the OFF position when the CIM screen displays a message that it is safe to turn off the computer.

Step 5: Place the Engine Control Switch into the OFF position.

Step 6: Turn the Panel Light Switch to the OFF position. Note: This step is not necessary if panel lights are already off.

Step 7: Place the Dead Crank Switch into the OFF position.

15.2.2.1.10 After Operations Checks

It is very important to check the components and instruments of the TQG-B after you operate it. Performing the after operations check will ensure that the generator is in good condition for its next use. The generator set could be damaged or fail to start if the after operations check is not done or is done incorrectly. Refer to *Figure 2-54*.

The After Operations Checklist gives you guidance for a thorough after operations inspection of the generator and covers the components and instruments that need checking after operation. The After Operations Checklist is essential before operation of the TQG-B because it does the following:

- Reduces the likelihood of damage to the generator.
- Allows you to identify maintenance issues.

Before learning how to conduct the after operations checks take a moment to read the following safety warning. It is imperative for you to take the warning seriously.
Remember: Avoid shorting any positive with ground/negative. DC voltages are present at generator set electrical components even with the generator set shut down. Failure to comply can cause injury to personnel and damage to equipment.

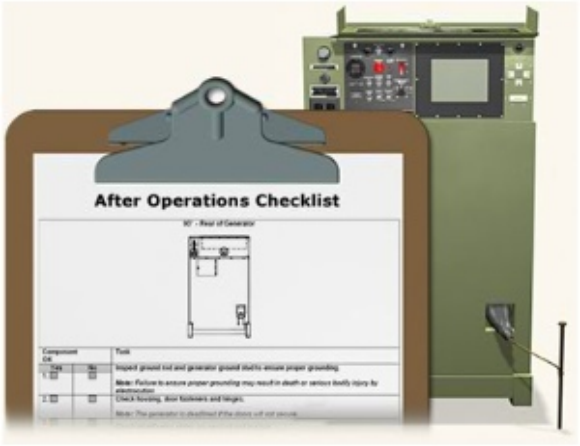


Figure 2-54 – After Operations Checklist.

15.2.2.1.10.1 After Operations Check: Rear

The after operations check is performed in a 360° rotation around the generator. Begin by inspecting all components at the rear of the TQG-B. There are nine steps to the inspection of the rear side of the TQG-B:

- Inspect the ground rod and generator ground stud to ensure proper grounding. Failure to ensure proper grounding may result in death or serious bodily injury by electrocution.
- Check the housing, door fasteners, and hinges. The generator is deadlined if the doors will not secure.
- Check that the identification plates are secured and in place.
- Check all indicators and controls for damaged or missing parts. If a discrepancy exists, the unit is deadlined.
- Check the control box harness for loose or damaged wiring. If a discrepancy exists, the unit is deadlined.
- Verify that the dc power control fuse is serviceable with a power rating of 10 AMPS.
- Verify that the frequency selection switch is positioned correctly. NORMAL - 60 Hz NATO = 50 Hz.
- Inspect the parallel cable and the cable connections for damage. This cable is used for parallel operation.
- Check the air cleaner element or assembly for damage or restrictions. Generator is deadlined if the exhaust elements are clogged or the piping connections are loose.

15.2.2.1.10.2 After Operations Check: Left Side

There are ten steps to inspect the left side of the TQG-B:

- Check that the skid bases are not corroded or cracked.
- Check the housing, air ducts, exhaust grills, door fasteners, and hinges. The generator is deadlined if the doors will not secure.
- Check that the identification plates are secured and in place.

- Check that the engine compartment is not damaged.
- Check that the engine compartment has no loose or missing components.
- Check that the acoustical materials are not missing or damaged.
- Check the lubrication system for leaks, oil level, or oil contamination. If any Class III leaks are present, the generator is deadlined.
- Check the fuel system for leaks, and damaged, loose or missing parts. Any leaks or other discrepancies deadline the generator.
- Check the cooling fan for damage or looseness. If the fan is damaged or loose, the generator is deadlined.
- Check the radiator cap and hoses for cracks and leaks.

15.2.2.1.10.3 After Operations Check: Front

The following five steps are required in performing the after operations check on the front of the generator:

- Check the housing, door fasteners, and hinges. The generator is deadlined if the doors will not secure.
- Check that the identification plates are secured and in place.
- Check to see if the unit has maintenance-free batteries. Both batteries need to be of the same type (maintenance-free or electrolyte--do not mix the two). Maintenance-free batteries are often recognizable by their lack of fill caps.
- Check the electrolytes if the unit does not have maintenance-free batteries.
- Check the batteries for damage or corrosion on connections and cables. Generator is deadlined if cables are loose, damaged, or missing.

15.2.2.1.10.3 After Operations Check: Right Side

There are 13 steps to inspect the right side of the TQG-B:

- Check that the skid bases are not corroded or cracked.
- Check the housing, air ducts, exhaust grills, door fasteners, and hinges. The generator is deadlined if the doors will not secure.
- Check that the identification plates are secured and in place.
- Check that the engine compartment is not damaged.
- Check that the engine compartment has no loose or missing components.
- Check that the acoustical materials are not missing or damaged.
- Check serpentine belt for cracks, fraying, or looseness. Generator is deadlined if the belt is broken or missing.
- Check fuel filter/water separator, and drain off water and other contaminants.
- Check the radiator bottle for leaks and coolant level. Generator is deadlined if a Class III leak is present. Add coolant to the overflow bottle ONLY. DO NOT remove the radiator cap.
- Check muffler and exhaust system for corrosion, damage, or missing parts. Generator is deadlined if a discrepancy exists.

- Check ether start system for missing or loose hardware.
- Check the output box assembly for loose or damaged wiring or cables. If hardware, cables, or wires are damaged, the unit is deadlined until repairs are made.
- Verify the voltage reconnection board and the voltage selection switch are positioned correctly.

16.0.0 PARALLEL OPERATION

If the load of a single generator becomes so large that it exceeds the generator's rating, add another generator in parallel to increase the power available for the generating station. Before two ac generators can be paralleled, the following conditions have to be fulfilled:

- Their terminal voltages have to be equal.
- Their frequencies have to be equal.
- Their voltages have to be in phase.

When two generators are operating so that the requirements are satisfied, they are said to be in synchronism. The operation of getting the machines into synchronism is called synchronizing.

Generating plants may be operated in parallel on an isolated bus (two or more generators supplying camp or base load) or on an infinite bus (one or more generators paralleled to a utility grid).

One of the primary considerations in paralleling generator sets is achieving the proper division of load. That can be accomplished by providing the governor of the generator with speed droop. That would result in a regulation of the system. The relationship of REGULATION to LOAD DIVISION is best explained by referring to a speed versus load curve of the governor. For simplicity, we will refer to the normal speed as 100 percent speed and full load as 100 percent load. In the controlled system, we will be concerned with two types of governor operations: isochronous and speed droop.

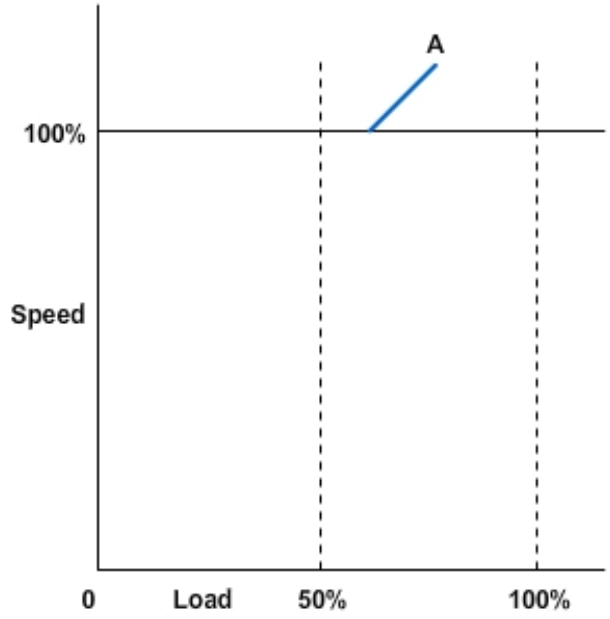


Figure 2-55 – Isochronous governor curve.

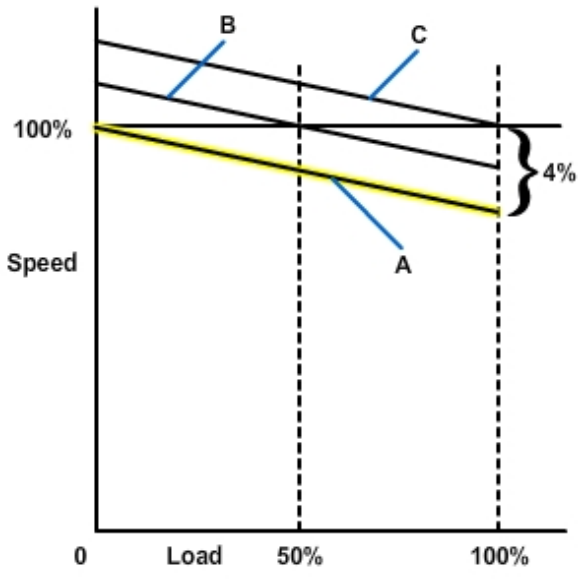


Figure 2-56 – Speed droop governor curve.

The operation of the isochronous governor (0 percent speed droop) can be explained by comparing speed versus load (*Figure 2-55*). If the governor were set to maintain the speed represented by Line A and connected to an increasing isolated load, the speed would remain constant. The isochronous governor will maintain the desired output frequency regardless of load changes if the capacity of the engine is not exceeded.

The speed-droop governor (100 percent speed droop) has a similar set of curves, but they are slanted (*Figure 2-56*). If a speed-droop governor were connected to an increasing isolated load, the speed would drop until the maximum engine capacity was reached (*Figure 2-56,* Line *A*).

Now imagine that you connect the speed droop governor (slave machine) to a utility bus so large that our engine cannot change the bus frequency (an infinite bus). Remember that the speed of the engine is no longer determined by the speed setting but by the frequency of the infinite bus. In this case, if we should change the speed setting, we would cause a change in load, not in speed. To parallel the generator set you must have a speed setting on Line *A* at which the no-load speed is equal to the bus frequency (*Figure 2-56*). Once the set is paralleled, if you increase the speed setting to Line *B*, you do not change the speed, but you pick up approximately a half-load. Another increase in speed setting to Line *C* will fully load the engine. If the generator set is fully loaded and the main breaker is opened, the no-load speed would be 4 percent above synchronous speed. This governor would be defined as having 4 percent speed droop.

Paralleling an isochronous governor to an infinite bus would be impractical because any difference in speed setting would cause the generator load to change constantly. A speed setting slightly higher than the bus frequency would cause the engine to go to full-load position. Similarly, if the speed setting were slightly below synchronous speed, the engine would go to no load position.

Set speed droop on hydraulic governors by adjusting the speed-droop knob located on the governor body. Setting the knob to position No. 5 does not mean 5 percent droop. Each of the settings on the knob represents a percentage of the total governor droop. If the governor has a maximum of 4 percent droop, the No. 5 position would be 50 percent of 4 percent droop. Set speed droops on solid-state electronic governors by placing the UNIT-PARALLEL switch in the PARALLEL position. The governor speed droop is factory set, and no further adjustments are necessary.

16.1.0 Isolated Bus Operation

In the following discussion, assume that one generator, called the master machine, is operating and that a second generator, called the slave machine, is being synchronized to the master machine. Governor controls on the master generator should be set to the ISOCHRONOUS or UNIT position. The governor setting on the slave generator must be set to the PARALLEL position.

NOTE

The hydraulic governor droop setting is an approximate value. Setting the knob to position No. 5 will allow you to parallel and load the generator set. Minor adjustments may be necessary to prevent load swings after the unit is operational.

When you are paralleling in the droop mode with other generator sets, the governor of only one set may be in the isochronous position; all others are in the droop position. The isochronous set (usually the largest capacity set) controls system frequency and

immediately responds to system load changes. The droop generator sets carry only the load placed on them by the setting of their individual speed controls. Both voltage regulators should be set for parallel and automatic operation.

Bring the slave machine up to the desired frequency by operating the governor controls. It is preferable to have the frequency of the slave machine slightly higher than that of the master machine to assure that the slave machine will assume a small amount of load when the main circuit breaker is closed. Adjust the voltage controls on the slave machine until the voltage is identical to that of the master machine. Thus two of the requirements for synchronizing have been met: “frequencies are equal and terminal voltages are equal.”

There are several methods to check generator phase sequence. Some generator sets are equipped with phase sequence indicator lights and a selector switch labeled “GEN” and “BUS.” Set the PHASE SEQUENCE SELECTOR SWITCH in the BUS position, and the “1-2-3” phase sequence indicating light should light. (The same light must light in either GEN or BUS position.) If “3-2-1” phase sequence is indicated, shut down the slave machine, isolate the load cables, and interchange two of the load cables at their connection to the load terminals.

Another method to verify correct phase sequence is by using the synchronizing lights. When the synchronizing switch is turned on, the synchronizing lights will start blinking. If the synchronizing lights blink on and off simultaneously, the voltage sequences of the two machines are in phase. The frequency at which the synchronizing lights blink on and off together indicates the different frequency output between the two machines. Raise or lower the speed of the slave machine until the lights blink on together and off together at the slowest possible rate. If the synchronizing lights are alternately blinking (one on while the other is off), the voltage sequence of the two machines is not in phase. Correct this condition by interchanging any two of the three load cables connected to the slave machine.

Some of the portable generators being placed in the Table of Allowances (TOA) are equipped with a permissive paralleling relay. This relay, wired into the main breaker control circuit, prevents the operator from paralleling the generator until all three conditions have been met.

Now that all three paralleling requirements have been met, the slave machine can be paralleled and loaded.

If you use a synchroscope, adjust the frequency of the slave machine until the synchroscope pointer rotates clockwise slowly through the ZERO position (twelve o’clock). Close the main circuit breaker just before the pointer passes through the ZERO position. To parallel using synchronizing lights, wait until the lamps are dark; then, while the lamps are still dark, close the main circuit breaker and turn off the synchronizing switch.

After closing the main breaker, check and adjust the load distribution by adjusting the governor speed control. Maintain approximately one-half load on the master machine by manually adding or removing the load from the slave machine(s). The master machine will absorb all load changes and maintain correct frequency unless it becomes overloaded or until its load is reduced to zero.

The operator also must ensure that all generating sets operate at approximately the same power factor (PF). PF is a ratio, or percentage, relationship between watts (true power) of a load and the product of volts and amperes (apparent power) necessary to supply the load. PF is usually expressed as a percentage of 100. Inductive reactance in

a circuit lowers the PF by causing the current to lag behind the voltage. Low PFs can be corrected by adding capacitor banks to the circuit.

Since the inductive reactance cannot be changed at this point, the voltage control rheostat has to be adjusted on each generator to share the reactive load. This adjustment has a direct impact on the generator current, thus reducing the possibility of overheating the generator windings.

PF adjustment was not discussed in the “Single Plant Operation” section because a single generator has to supply any true power and/or reactive load that may be in the circuit. The single generator must supply the correct voltage and frequency regardless of the PF.

16.2.0 Infinite Bus Operation

Paralleling generator sets to an infinite bus is similar to the isolated bus procedure with the exception that all sets will be slave machines. The infinite bus establishes the grid frequency; therefore, the governor of each slave machine has to have speed droop to prevent constant load changes.

16.3.0 Operating Procedures for Paralleling Generators (General)

This section will include procedures for paralleling generators, removing a set from parallel operations, and stopping generator set operation. Operating procedures for paralleling the TQG-B generator will be discussed in a separate section.

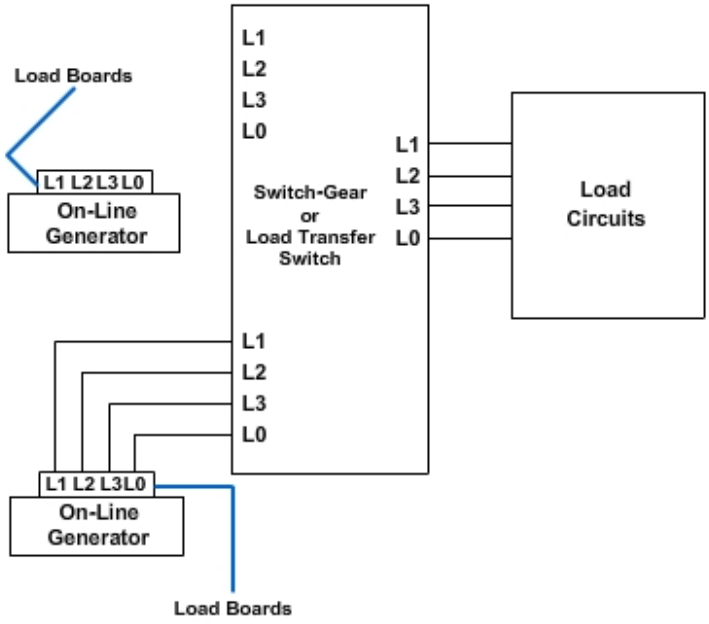


Figure 2-57 – Parallel operation connection diagram.

NOTE

These procedures assume that one generator set is on line (operating and connected to the distribution feeder lines through the switchgear). The set that is to be paralleled is designated the incoming set (*Figure 2-57*).

CAUTION

When you are operating generator sets in parallel, they must have the same output voltage, frequency, phase relation, and phase sequence before they can be connected to a common distribution bus. Severe damage may occur to the generator sets if these requirements are not met.

Adjusting the engine speed of the incoming set while observing the output frequency and the SYNCHRONIZING LIGHTS will bring the phase and frequency into exact agreement (*Figure 2-37)*. As the phase and frequency approach the same value, the

SYNCHRONIZING LIGHTS will gradually turn on and off. When the blinking slows to a rate of once per second or slower, close the main circuit breaker of the incoming set while the SYNCHRONIZING LIGHTS are dark. The phase sequence relates to the order in which the generator windings are connected. If the phase sequence is not correct, the SYNCHRONIZING LIGHTS will not blink on and off together. When the incoming set is first connected to the load through the appropriate switchgear (*Figure 2-57*), you should observe one of four occurrences. When the phase sequence, voltage, frequency, phase, and engine performance are the same, the changeover will be smooth with only the slightest hesitation in engine speed; if each output is slightly out of phase, one of the engines will shudder at the point of changeover; if the phase sequence or voltage levels are incorrect, the reverse power relay will trip on one of the generator sets and open its main circuit breaker contactors; if the incoming generator set loses speed significantly or almost stalls, the incoming engine may be defective.

CAUTION

Should either generator set lose speed, buck, or shudder when the incoming set is connected to the distribution feeder lines, immediately flip the CKT BRK switch of the incoming set to open, and then recheck the paralleling setup procedures.

WARNING

When performing Step 1, make certain that the incoming set is shut down and that there are no voltages at the switchgear terminals being connected to the incoming set. Do not take anybody's word for it! Check it out for yourself! Dangerous and possibly deadly voltages could be present. Take extreme care not to cross the L0 (neutral) with any of the other phases (L1, L2, or L3).

16.3.1 Paralleling Procedures (General)

1. Connect the incoming set as shown in *Figure 2-57*
2. Make certain that the voltage change board (reconnection board) of the incoming generator is set up for the same output voltage as the online generator.
3. Set CKT BRK switch on the incoming set to OPEN. When the incoming set circuit breaker is open (CKT BRK indicator light will be out), operate the load switchgear so that the on line output voltage is present at the voltage change board of the incoming set.
4. Set the PARALLEL OPERATION-SINGLE UNIT operation switch on both sets to PARALLEL OPERATION.
5. Start the incoming set. The on line set should be in operation already.
6. After a 5-minute warmup, try the VOLTAGE ADJUST control on the incoming set until the output voltages of both sets are equal.

CAUTION

If the synchronizing lights do not blink on and off in unison, the phase sequence is incorrect. Shut down the incoming set and recheck the cabling to and from the incoming set.

7. On the incoming set, position the ENGINE MANUAL SPEED CONTROL until the SYNCHRONIZING LIGHTS blink on and off as slowly as possible.

8. With one hand on the CKT BRK switch, adjust the ENGINE MANUAL SPEED CONTROL vernier knob until the SYNCHRONIZING LIGHTS dim gradually from full on to full off as slowly as possible. Just as the SYNCHRONIZING LIGHTS dim to out, set and hold the CKT BRK switch to close. When the CKT BRK indicator light comes on, release the switch.
9. On both sets, check that the readings of the PERCENT RATED CURRENT meters and KILOWATTS meters are well within 20 percent of each other. If not, increase the engine power of the set with the lower readings (by adjusting the ENGINE MANUAL SPEED CONTROL to increase the speed) until the readings are about equal.

NOTE

The division of the kilowatt load is also dependent on the frequency droop of the two sets and must be adjusted at the next higher level of maintenance. If the current does not divide as described above, adjust the reactive current sharing control located at the right side of the special relay box for equal reading on both percent rated current meters.

10. On the incoming set, readjust the voltage and frequency of the output until it is equal to the output of the on line set.

16.3.2 Removing a Generator Set from Parallel Operation (General)

CAUTION

Before removing the generator set(s) from parallel operation, make sure the load does not exceed the full-load rating of the generator set(s) remaining on the line.

1. On the outgoing set, position and hold the CKT BRK switch to OPEN until the CKT BRK indicator light goes out. Release the switch.
2. On the outgoing set, allow the engine to operate with no load for about 5 minutes.
3. On the outgoing set, pull the DC CONTROL CIRCUIT BREAKER to OFF.
4. On the outgoing set, set the START-STOP-RUN switch to STOP.

WARNING

Make certain the outgoing set is shut down and there are no voltages at the switchgear terminals connected to the outgoing set. Do not take anybody’s word for it! Check it out for yourself!

5. Disconnect the cables going from the outgoing set to the load switchgear.

16.3.3 Stopping Generator Set Operation (General)

1. Set the CKT BRK switch to OPEN until the CKT BRK indicator light goes out, and then release the CKT BRK switch.
2. Allow the engine to cool down by operating at no load for 5 minutes.
3. Set the START-STOP-RUN switch to STOP.
4. Close all generator doors.

16.3.4 Emergency Shutdown

In the event of engine over speed, high jacket water temperature, or low lubricating oil pressure, the engine may shut down automatically and disconnect from the main load by tripping the main circuit breaker. In addition, an indicator may light or an alarm may sound to indicate the cause of shutdown. After an emergency shutdown and before the engine is returned to operation, investigate and correct the cause of the shutdown.

NOTE

It is important to check the safety controls at regular intervals to determine that they are in good working order.

16.4.0 Operating the TQG-B in Parallel

It is very important to check components and indicators of the TQG-Bravo before operating in parallel. Performing the parallel operations check will ensure that both generators are paralleled without damaging equipment or injuring personnel.

16.4.1 Importance of the Parallel Operations Checklist

The Parallel Operations Checklist covers all the components and instruments of the TQG-B that need to be checked before paralleling. It also guides you through the process of paralleling two generator sets (*Figure 2-58*). The Parallel Operations Checklist is important because it does the following:

- Reduces the likelihood of damage to the generator.
- Guides you through the process of paralleling two generator sets.

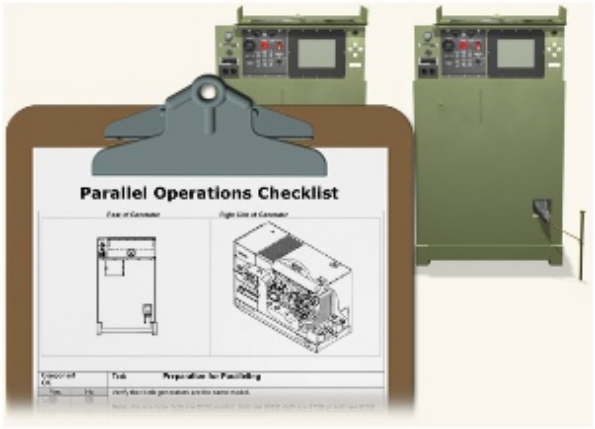


Figure 2-58 – Parallel Operations Checklist.

Before learning how to perform a parallel operations check, take a few moments to read this important safety warning. It is imperative for you to take this warning seriously. Remember to make sure there is no input to the load output terminal board and the generator sets are shut down before making any connections for parallel operation or moving a generator set which has been operating in parallel. Failure to comply can cause injury or death to personnel by electrocution.

16.4.2 Parallel Operations Check

Now that you have read the safety warning you are ready to use the Parallel Operations Checklist to perform the parallel operations check. The parallel operations check will prepare and start the generators, then apply power from both generators to the load. There are eighteen steps total on the Parallel Operations Checklist, which have broken up into two groups. Begin with the first four steps which prepare the generator for parallel operations. These four steps are to be performed in sequence. Refer to *Figure 2-58* for sequence.

Step 1: Make sure that both generators are the same model. Examples would be two 805 bravos, 806 bravos, 815 bravos, or 816 bravos. Never try to parallel two different models of generators.

Step 2: Conduct a before operations check using the Pre Operations Checklist on each generator set.

Step 3: Verify the frequency selection switch is set to NORMAL, 60 hertz if you are operating at normal frequency and NATO 50 hertz if operating at NATO frequency.

Step 4: Verify that the voltage selection switch of each generator was positioned correctly during setup.

Figure 2-59 – Parallel operations checks.

The last part of the Parallel Operations Checklist provided steps for preparing the generators for parallel. The next part guides you through the procedures for achieving parallel operations for the two generator sets. Refer to *Figure 2-60* for sequence.

Step 5: Designate Set #1.

Step 6: Designate Set #2.

Step 7: Verify that the load cable is rated at an amperage high enough to handle maximum load. The TQG-Bravo model's highest amperage is 208 Amps.

Step 8: Connect the parallel cable to each parallel receptacle and connect the load cables to each load stud on each generator load terminal board.

Figure 2-60 – Parallel operations sequence.

Step 9: Verify that both generators are connected to the power distribution system.

Step 10: Conduct the 10-step starting procedures for both generators.

Step 11: Verify that the CIM on each generator is displaying the FULL mode screen.

Step 12: Adjust Set #1 to the proper voltage, and then adjust Set #2 to the same voltage as Set #1.

Step 13: Adjust Set #1 to the proper frequency and then adjust Set #2 to the same frequency as Set #1. Carefully adjust the frequency; too much adjustment can cause the generator to go into reverse power.

Step 14: Close AC CIRCUIT INTERRUPT switch on Set #1 and on Set #2. The generators are now running in parallel with no load.

Step 15: Verify that the POWER gauge on both sets reads “zero.”

Step 16: Close the circuit breaker on the power distribution system. The generators are now supplying power to the load.

Step 17: Verify that the GEN CURRENT indicators on BOTH generators are approximately the same. If not, adjust the VOLTAGE ADJUST switch up or down to achieve the proper balance. One generator may have to be adjusted upward, while the other may have to be adjusted downward.

Step 18: Verify that POWER readings from both CIM displays are within 10% of each other. If readings are not within 10% of each other, remove generators from load, shut down, and notify the next level of maintenance.

17.0.0 BALANCING the LOAD

Once you have installed the branch circuit conductors and breakers, you must balance the load. Conductors cannot be connected to a panelboard by attaching each one as you come to it. The arrangement or sequence of attaching conductors to the panelboard is determined by the arrangemet of the bus bars in the panelboard, whether the circuits are 240 volts or 120 volts, and the need to balance the load on the phase conductors. Bus bars are installed into panelboards in one of several ways. Most of the time, the bus bars are run in a vertical configuration. In one arrangement, a split-bus panelboard is used that has all the 240-volt circuits in the upper section and the 120-volt circuits in a lower section. Another type of split-bus panelboard uses one main circuit breaker to feed one set of branch circuits and a second main circuit breaker to feed a second set. In many cases, panelboards are designed so that any two adjacent terminals can be used to provide 240-volt service. This arrangement also means that two 120-volt circuits attached to adjacent terminals are connected to different phase conductors. Since there are so many panelboard layouts, you must look at the panelboard to see how it is set up for 240-volt service, and you must be sure you get the conductors for 240- volt circuits connected to the proper terminals.

Loads that are connected to a panelboard should be divided as evenly as possible between the supply conductors. This process of equalizing the load is commonly referred to as load balancing. The purpose of load balancing is to reduce voltage drop that results from overloading one side of the incoming service. It also prevents the possibility of overloading the neutral. A perfectly balanced load between the supply conductors reduces current flow in the neutral to zero.

Load balancing is no problem for 240-volt circuits on a three wire, single-phase system since the load has to be equal on each phase conductor. However, the 120-volt circuits are a different matter. These must be connected in such a way that the loads tend to equalize. Generally speaking, the simplest way to balance the load on a panelboard is to connect an equal number of branch circuits to each phase conductor. But this method does not necessarily give you a balanced load as will be evident if you look at the top of *Figure 2-61*. As you can see, the indiscriminate connection of branch circuits without consideration of their loads can cause you to end up with an unbalanced condition. On the other hand, you can connect the circuits so that one with a heavy load is offset by one with a light load, which does result in the balanced condition shown at the bottom of *Figure 2-61*. Most of the time, you should be able to connect half of the lighting circuits and half of the appliance circuits to each phase conductor to give you a reasonably well balanced load. Spare circuits should also be equalized. There is one more thing to consider and that is when there are appliance circuits where the loads are known to be heavy, these circuits must be divided between the phase conductors.

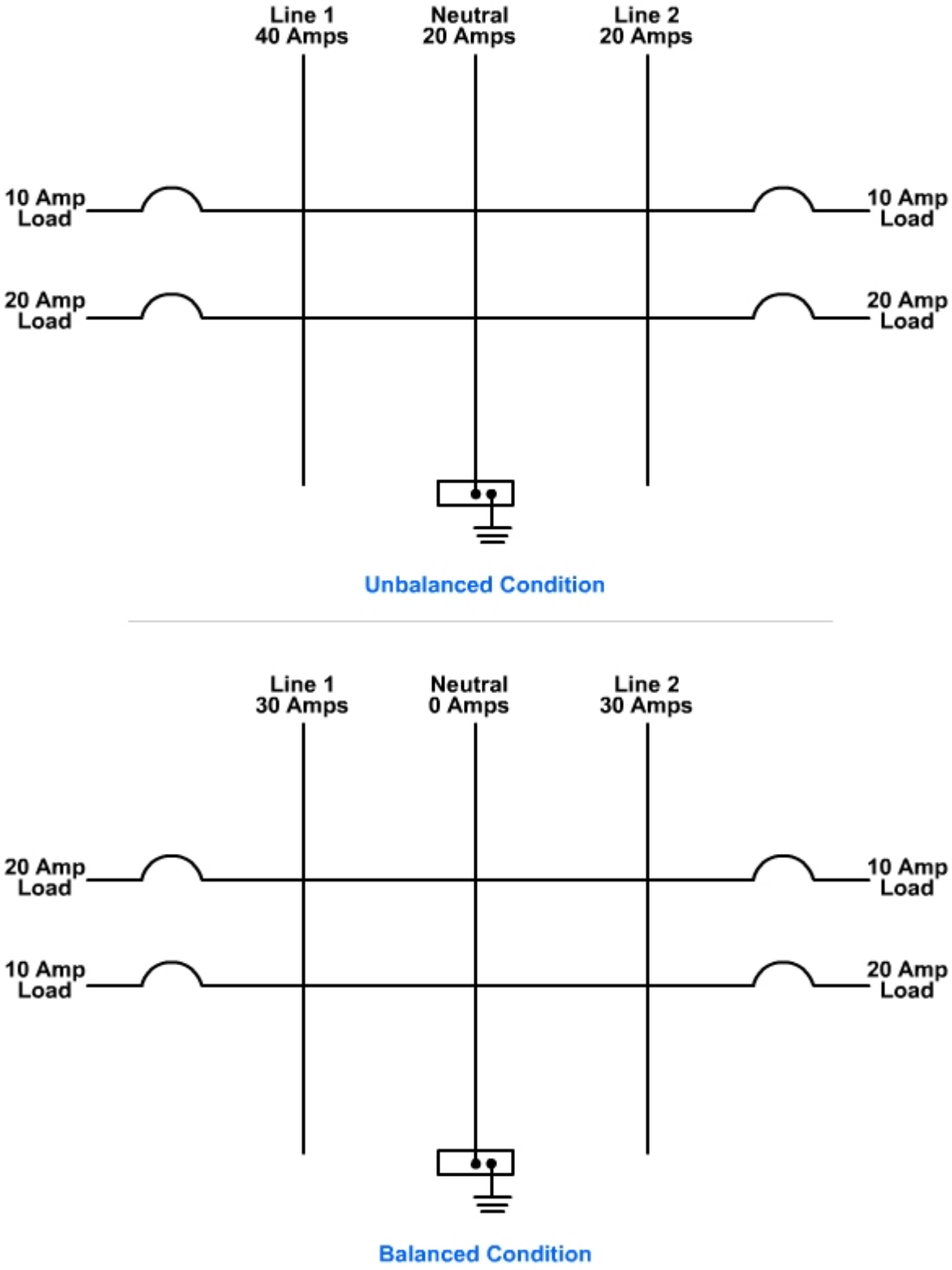


Figure 2-61 – Load balancing.

18.0.0 MAINTAINING FREQUENCY

The output frequency of alternator voltage depends upon the speed of rotation of the rotor and the number of poles. The faster the speed, the higher the frequency. The lower the speed, the lower the frequency. The more poles there are on the rotor, the higher the frequency is for a given speed. When a rotor is rotated through an angle such that two adjacent rotor poles (a north and a south pole) have passed one winding, the voltage induced in that winding will have varied through one complete cycle. For a given frequency, the more pairs of poles there are, the lower the speed of rotation. This principle is illustrated in *Figure 2-62*; a two-pole generator must rotate at four times the speed of an eight-pole generator to produce the same frequency of generated voltage.

The frequency of an ac generator in hertz (Hz), which is the number of cycles per second, is related to the number of poles and the speed of rotation, as expressed by the equation:

$$F = \frac{NP}{120}$$

Where *P* is the number of poles, *N* is the speed of rotation in revolutions per minute (rpm), and 120 is a constant to allow for the conversion of minutes to seconds and from poles to pairs of poles. For example, a 2-pole, 3600-rpm alternator has a frequency of 60 Hz and is determined as follows:

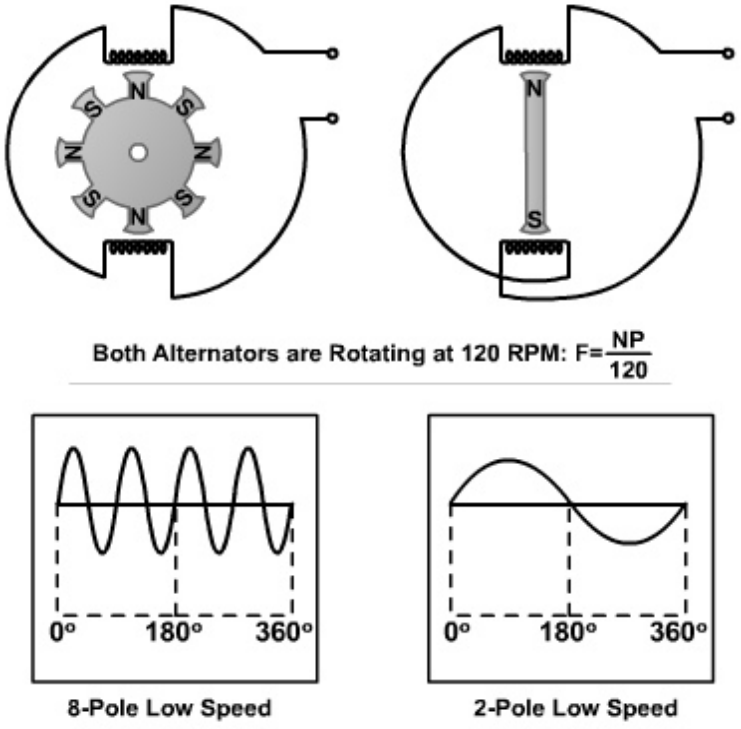


Figure 2-62 — Frequency regulation.

$$\frac{2 \times 3600}{120} = 60\ H_Z$$

A 4-pole, 1800-rpm generator also has a frequency of 60 Hz. A 6-pole, 500-rpm generator has a frequency of:

$$\frac{6 \times 500}{120} = 25\ H_Z$$

A 12-pole, 4000-rpm generator has a frequency of:

$$\frac{12 \times 4000}{120} = 400\ H_Z$$

The above statements about frequency regulation are general in nature. The TQG-B generator is designed with a frequency select switch (*Figure 2-40)*, and once frequency is set it is automatic and will need adjustment only if a fluctuation of voltage takes place. Remember that the TQG-B generator can be set between 50 and 60 Hz.

19.0.0 MAINTAINING VOLTAGE

It has been stated previously in this chapter that when the load on a generator is changed, the terminal voltage varies. The amount of variation depends on the design of the generator.

The voltage regulation of an alternator is the change of voltage from full load to no load, expressed as a percentage of full-load volts, when the speed and dc field current are held constant.

$$\frac{E_{\eta L} - E_{fL}}{E_{fL}} \times 100 = Percent\ of\ \ regulation$$

Assume the no-load voltage of an alternator is 250 volts and the full-load voltage is 220 volts. The percent of regulation is:

$$\frac{250 - 220}{220} \times 100 = 13.6\ Percent$$

Remember, the lower the percent of regulation, the better it is in most applications.

19.1.0 Principles of AC Voltage Control

In an alternator, an alternating voltage is induced in the armature windings when magnetic fields of alternating polarity are passed across these windings. The amount of voltage induced in the windings depends mainly on three things:

- Number of conductors in series per winding
- Speed (alternator rpm) at which the magnetic field cuts the winding
- Strength of the magnetic field

Any of these three factors could be used to control the amount of voltage induced in the alternator windings

The number of windings is fixed when the alternator is manufactured. Also, if the output frequency is required to be of a constant value, then the speed of the rotating field must be held constant. This prevents the use of the alternator rpm as a means of controlling the voltage output. The only practical method for obtaining voltage control is to control the strength of the rotating magnetic field. The strength of this electromagnetic field may be varied by changing the amount of current flowing through the field coil. This is accomplished by varying the amount of voltage applied across the field coil.

The above statements concerning voltage control are general in nature. The TQG-B generator has a voltage regulation system which consists of the automatic voltage regulator and power potential transformer. The automatic voltage regulator senses and controls generator output voltage, which is operator adjustable within the design limits by use of the voltage adjust switch (*Figure 2-40*). The power potential transformer provides operating power to the automatic voltage regulator module. Generator output voltage is indicated on the CIM display screen.

20.0.0 DEMAND FACTOR

As previously mentioned, you must take various factors into consideration in selecting the required generating equipment.