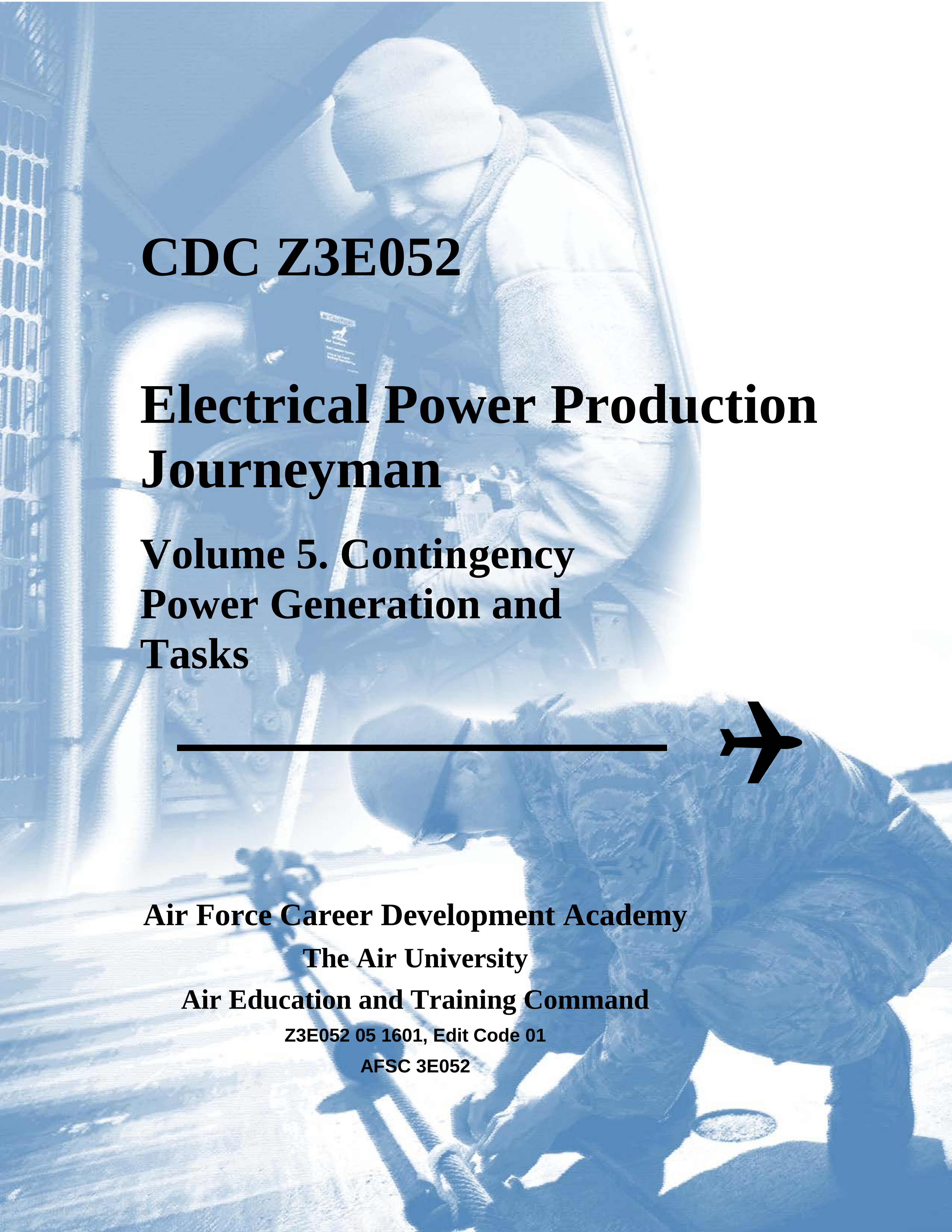

CDC Z3E052

Electrical Power Production Journeyman

Volume 5. Contingency Power Generation and Tasks

Air Force Career Development Academy

The Air University

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Author: MSgt Stewart Herringshaw
366th Training Squadron
Electrical Power Production
366TRS/TRR
727 Missile Road
Sheppard Air Force Base, Texas 76311–2254
DSN: 736–5854
E-mail address: stewart.herringshaw@us.af.mil

Instructional Systems Specialist: Hozell Odom

Editor: Elizabeth S. Melton

Air Force Career Development Academy (AFCDA)
The Air University (AETC)
Maxwell-Gunter Air Force Base, Alabama 36118–5643

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THIS FITH VOLUME of CDC Z3E052 explores contingency operations. This CDC contains two units that provide you with the information necessary to perform the duties of the 5-level electrical power production journeyman in a contingency environment.

Unit 1 begins by exploring the task of planning, installing, operating and maintaining contingency power plants.

Unit 2 covers electrical distribution in a bare base environment and operating telescopic floodlight sets.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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This volume is valued at 12 hours and 4 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings, numbers, and page location. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Acknowledgment

Preparation of this volume was aided through the cooperation and courtesy of Cummins Power Generattion.

Company	Figures
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Contents

Unit 1. Contingency Power Plants

OPERATING POWER PLANTS in a contingency location is one of the most important assignments you will have. These power plants provide all of the power necessary to complete the mission. This means the mission success rides on your shoulders. The operation and maintenance required to keep these power plant generators in top operating condition is very similar to the smaller generators you work on. Within this section we will look at the systems you will see in a contingency power plant, the mobile electric power (MEP)–12.

1–1. Mobile Electric Power–12 Generators

The MEP–12 is the most common generator used in contingency power plants today. Your understanding of its operation is essential to the successful completion of the mission. The power you provide may be the only power available to your assigned site.

801. Electrical hazards, safety practices

Almost all personnel must work on or around electrical circuits as they perform their jobs in the bare base environment. We cannot see electricity; therefore, we cannot determine if a conductor is energized by looking at it. In addition, we cannot determine the amount of voltage applied to the conductor. In order to work safely around electrical equipment, we must understand the following:

- Operating principles of alternating current (AC) and direct current (DC) electricity.
- Use of electrical safety equipment.
- Safety precautions to be observed.
- Conditions that cause an electrical shock.
- Effects of electrical shock.

Let's look at two terms before we get any further into this topic. Shock and electrocute are two words often used to describe electricity flowing through our body. Although they both involve electricity flowing through our body the end result of the action differ greatly. When you are shocked, you will experience discomfort and burns whereas electrocution causes death.

Many people don't understand one or more of the items listed above, which can cause them to get electrocuted while working on power generating and control equipment. They often don't understand the operation of their equipment. Voltage, current, and resistance are all part of the equation when an electrical shock accident occurs.

Voltage is an electrical pressure that causes the electrons to flow through a conductive material. The MEP–12 creates a voltage of 4,160 volts AC. This is higher than most of the generators we work with.

Current is the movement of these electrons through a conductive material. The movement of electrons through our body affects the muscles and the nervous system. When current exceeds a certain value, the muscles affected tighten up, paralyzing movement. This causes our heart to stop beating and our lungs to stop functioning. It doesn't take long for this condition to kill us.

Resistance is the factor that opposes the flow of current. The amount of resistance our body has depends on several conditions. The skin has a higher resistance when dry than when wet. This skin characteristic acts to protect us from electrical shock by low voltages. However, when the skin is wet or damp, it has a smaller amount of resistance. When our skin is wet, low voltage (about 100 volts) can electrocute us. When voltages are high, such as those developed and controlled by bare base equipment, even dry skin conducts a deadly current.

Effects of electric shock

Electric shock may cause instant death or unconsciousness, stoppage of breathing, and burns of all degrees. If a 60-cycle AC is passed through our body from hand to hand, or from hand to foot, the effects when current is gradually increased from zero are as follows:

- At about 1 milliampere (0.001 ampere), a slight shock can be felt.
- At about 10 milliamperes (0.010 ampere), the shock is severe enough to paralyze muscles so you may be unable to release the conductor.
- At about 100 milliamperes (0.100 ampere), the shock is fatal if it lasts for one second or more.

Carelessness or over-confidence, cause almost all electrical injuries. Most people are likely to think in terms of high voltages, but death lies in the low voltages too. The following facts illustrate the hazards of low voltage.

The resistance of our skin acts as a protector against electrical shock. This resistance to electrical current varies between 100,000 and 600,000 ohms for dry skin. It may be as low as 100 ohms for wet skin. The resistance of the internal body, hand-to-foot, is about 400 to 600 ohms, and from ear-to-ear, is about 100 ohms.

Assume that we have 120 volts AC or DC applied to our perspiring skin while we are standing on a good electrical ground. Further assume we have a total body resistance of 1,500 ohms, the current through you would be about 0.08 ampere or 80 milliamperes. Although this amount of current is not always fatal, it is painful. It causes severe muscular contractions and makes breathing difficult. If the current absorbed is between 100 and 200 milliamperes, our heart muscle fibers will work independently and without rhythm causing instant death.

Electrical maintenance

Whenever we perform electrical maintenance on equipment the possibility of injury to personnel, the danger of fire, and damage to equipment exists. Therefore, only authorized personnel should perform all repairs and maintenance work on electrical equipment.

Before any maintenance can be performed on a MEP–12 generator the equipment must be electrically isolated from the remainder of the power plant and rendered unable to start. The process of isolating the MEP–12 from the primary distribution center (PDC) must be conducted by qualified electrical systems personnel. Never disconnect safety devices such as interlocks, overload relays, and fuses except for replacements. Never change or modify the safety protective devices in any way without specific authorization. Remove and replace the fuses only after the circuit we have de-energized them. When a fuse blows, replace it only with a fuse of the same current and voltage ratings. When possible, carefully check the circuit before making the replacement since the burned-out fuse is often the result of a circuit fault.

If practical, do *not* perform repair work on energized circuits. When we must perform repairs on energized circuits in order to make proper adjustments, carefully observe every known safety precaution. Provide proper lighting and insulate yourself from ground with some suitable non-conducting material. Station a helper near the main switch that can immediately de-energize the circuit breaker in case of an emergency. Have a person qualified in first aid for electrical shock stand by during the entire period of the repair. While working on energized circuits, safety equipment in the form of gloves, blankets, covers and safety tools, to name a few, must be available.

In addition to electrical hazards involved when working with batteries, the danger of acid burns is also present. We can prevent these burns with the proper use of full-face shields or protective chemical goggles, rubber gloves, rubber aprons, and acid-resistant safety shoes or rubber knee length (safety-cap) boots. Another battery hazard is the danger of explosion due to the ignition of the hydrogen gas given off during the battery's charging or discharging operation. This is especially true where an accelerated charging method is used. Make sure there is no smoking or other open flames around a battery under charge, and hold the charging rate at a point that prevents rapid formation of hydrogen gas. Closely follow manufacturer's recommendations as to the charging rates for various size batteries; also, use an adequate shop exhaust system.

High voltage safety

High voltage is any voltage exceeding 600 volts, alternating current (VAC) and supplies power over long distances without significant line loss. The same safety principles and practices must prevail. The following are major safety guidelines you must consider:

- Only personnel receiving formal training have the authorization to conduct switching procedures on energized equipment. This training is part of the electrical systems technical training. Therefore, the site electricians will connect and disconnect high voltage cables.
- Use only qualified electrical personnel on high voltage distribution system maintenance and repair work.
- Use only qualified power production personnel on maintenance and repair of high voltage power generation equipment.
- Ensure only electrical and power production personnel participate in the installation and setup of the electrical system components.
- Review single line drawings of any in-place host nation electrical system or previously deployed electrical assets before commencing high voltage work (assumes tie in with existing systems).
- Use crew size appropriate to the task and safety requirements (normally at least two personnel).
- Conduct an onsite review of task requirements and safety precautions.
- De-energize lines and components whenever possible before starting work.
- Follow standard lockout/tag out procedures for isolating lines and systems.
- Provide temporary grounding on systems we are working on.
- Ensure all workers know and understand minimum working distances for high voltage work.
- Ensure all workers wear/use safety equipment and tools appropriate to the task.
- Ensure a job is under the direction of a full-time supervisor when performing work on live systems.

802. MEP-12 Construction features and components

The MEP–12 generator has been the mainstay for contingency operations for the past two decades. They are tough, battle tested systems that have provided power in the Middle East to meet multiple operations.

Features

This generator set is a trailer-mounted diesel engine-driven, prime power unit that produces 750 kW at 60 Hz and 625 kW at 50 Hz. It provides 2400/4160 volts, 3 phase, 4-wire, wye (2400 volts line-to-neutral; 4160 volts (line-to-line) for 60 Hz operation; and 2200-3800 volts, 3 phase, 4-wire, wye (2200 volts line-to-neutral; 3800 volts line-to-line) for 50 Hz operation.

Engine

The MEP-12 contains a 2,300 cubic ft. (37.7 liter) liquid cooled, 12 cylinders, and four cycle, turbocharged and after cooled diesel engine. It has an oil capacity of 36 gallons, and a coolant capacity of 66 gallons including the radiator.

Generator

The generator for the MEP-12 is brushless, rotating armature exciters, single bearing air cooled alternator. It is capable of 937.5 Kilovolt-amperes with a .8 lagging power factor at 1800 RPM and 781.3 kilovolt-amperes with a .8 lagging power factor at 1500 RPM.

Housing

The housing is a watertight enclosure that provides access for maintenance, overhaul or replacement of major components (fig. 1–1).

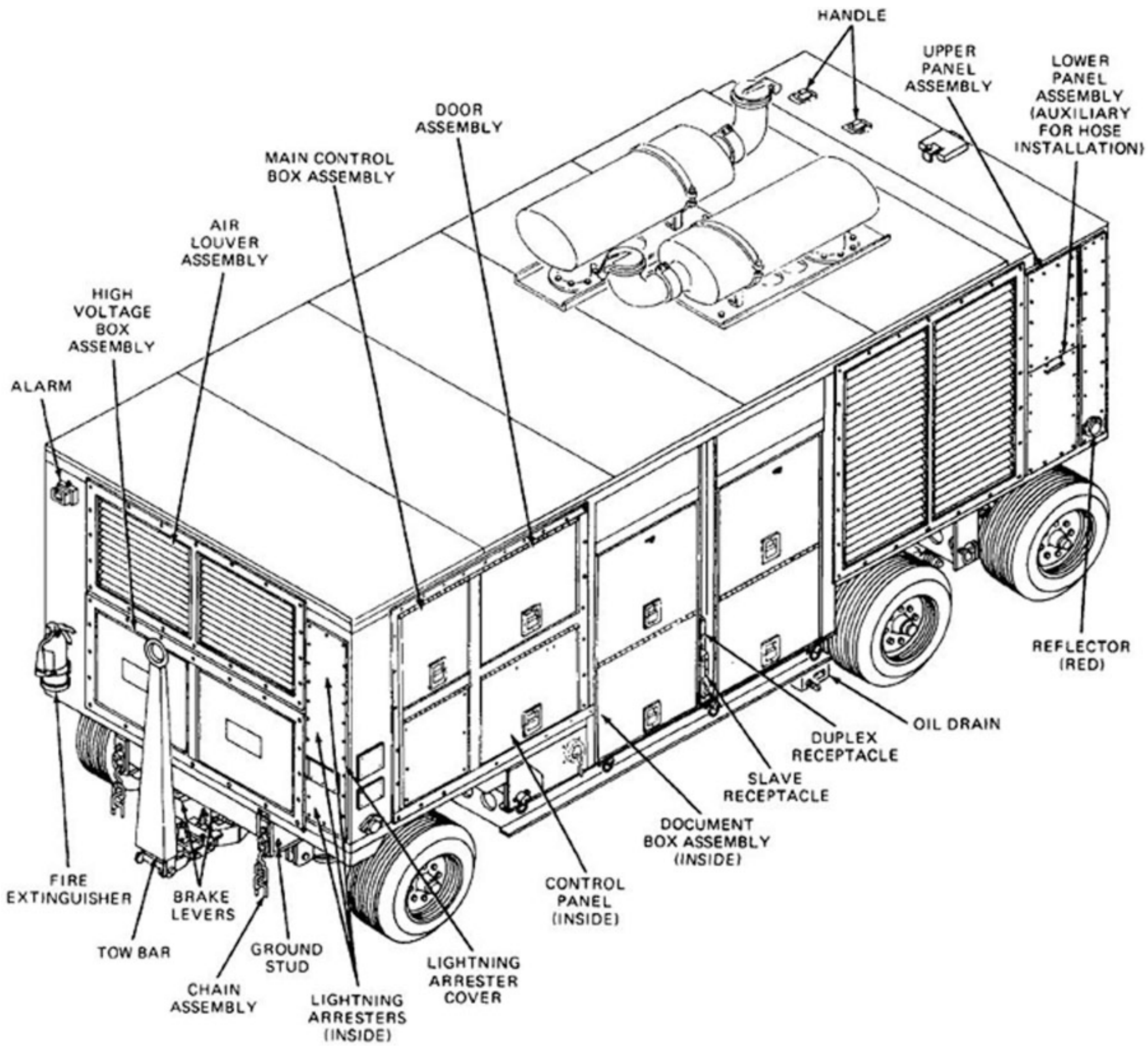


Figure 1–1. MEP–12 housing.

Main control panel assembly

The main control panel assembly allows remote start, stop, monitor and control of the generator set in operation (fig.1–2). This panel can be removed and put into an equipment rack to monitor and control several units at once (fig.1–3). This panel can operate as far as 150 feet away from the generator set.

Figure 1–2. MEP–12 control panel.

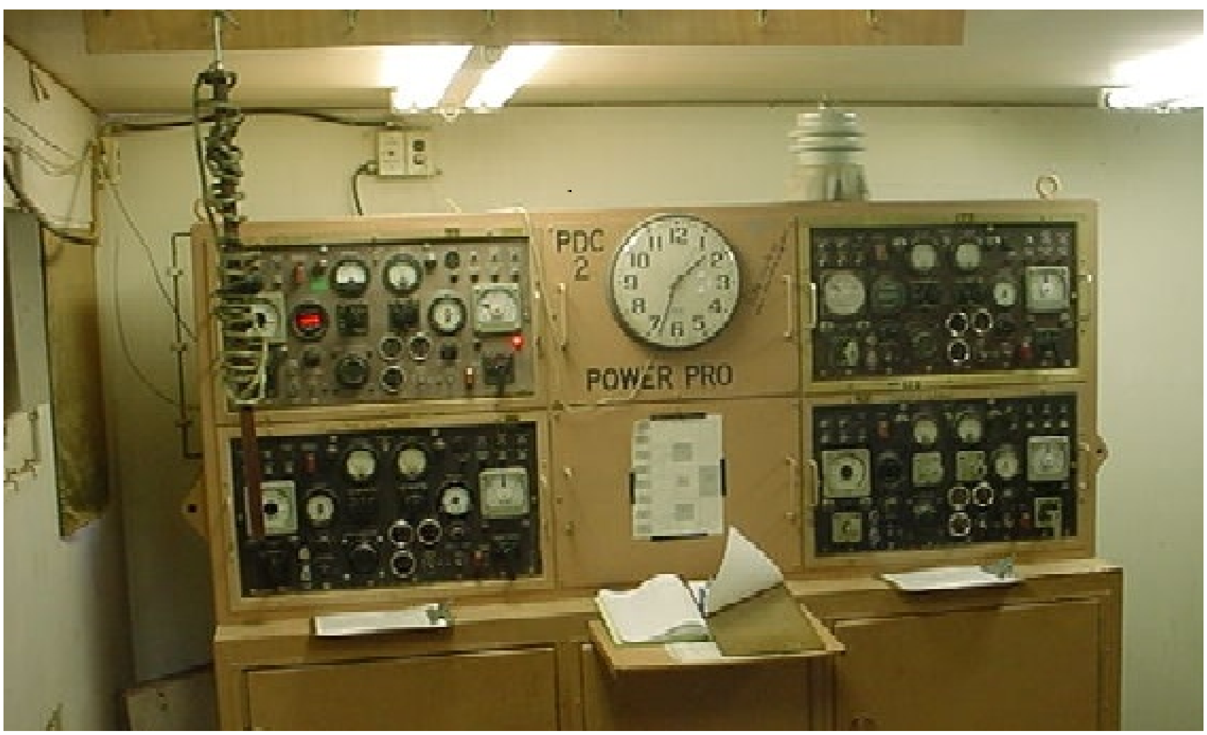


Figure 1–3. Equipment rack.

Generator positioning

Vehicle access is critical to primary plant operations, particularly for larger trucks and heavy equipment. Once a power plant site is established, larger vehicles will be required for delivery of generators units. Allow sufficient space to enable removal of an entire generator unit for depot level repair without tearing up plant equipment or moving assets around. As a minimum, plan your plant layout to allow complete accessibility to its entire perimeter.

When laying out a MEP-12 power plant line the generators up parallel with each other and at least 20 feet apart. We must make sure to position the generators so that prevailing winds aid in cooling by blowing along the long axis of the generators in the same direction as the radiator fan. For long duration deployments in hot regions, consider building sunshades over the generator sets to reduce solar heat buildup. Maintain at least a 2-inch clearance between the sunshade and the top-mounted muffler on the generator.

Movement of generator

The MEP–12 is a trailer-mounted generator set. The running gear assembly is a welded-steel structure, which provides a base for the generator set and allows it to be mobile. The unit has a tow bar assembly to tow the generator set. The tow bar assembly contains the components that comprise the actuator mechanism for the surge brake system. The surge brakes serve to provide immediate braking action should the trailer separate from the tow vehicle. During backing of the generator set, the surge brakes must be blocked to prevent applying the brakes as we begin to back up the generator.

To tow the MEP–12, remove the backing block from the backing position and secure it in the storage location. Remove the safety pin from the draw bar latch. Depress the draw bar latch and lower the draw bar onto the tow vehicle pintle hook. Close the pintle latch and secure it by replacing the draw bar safety pin. Connect the breakaway and safety chains by pulling the breakaway lever forward toward the tow vehicle. Pull the breakaway chain tight and connect it to the tow vehicle. Then connect the safety chains to the tow vehicle. Once we have done everything, we can remove the wheel chocks and release the parking brakes.

Do not exceed a turning angle of 30 degrees when towing the generator or we may damage the tow bar. The maximum towing speed is 20 miles per hour (MPH) on paved surfaces and 5 MPH on unpaved surfaces. After positioning the generator, disconnect it from the towing vehicle by chocking the wheels and setting the parking brake. Remove the safety chains from the tow vehicle and the breakaway chain. Remove the pintle latch safety pin, raise the latch, and lift the draw bar away from the pintle. Latch the draw bar into its stowed position, and secure it using its safety pin.

Grounding

To ground MEP-12 generators follow the steps below:

- Secure one end of ground cable to a slotted ground stud on generator set. Place ground cable through slot of ground stud and tighten nut.

- Drive ground rods into ground until rods protrude 6 inches above surface. Secure other end of round cable to ground rods (fig. 1–4). Connect clamps and ground cable to exposed ground rods and secure by tightening nuts.

WARNING: Do not operate the generator unless the ground terminal stud has been connected to a suitable ground. Electrical faults in the generator set, load lines, or load equipment can cause injury or electrocution from contact with an ungrounded system.

NOTE: Slotted ground studs are located at two positions: one on the exterior right front side of generator set behind the tie down ring. The other is on the interior right side of lower section power panel box assembly. Either one of these can be used to ground the generator set.

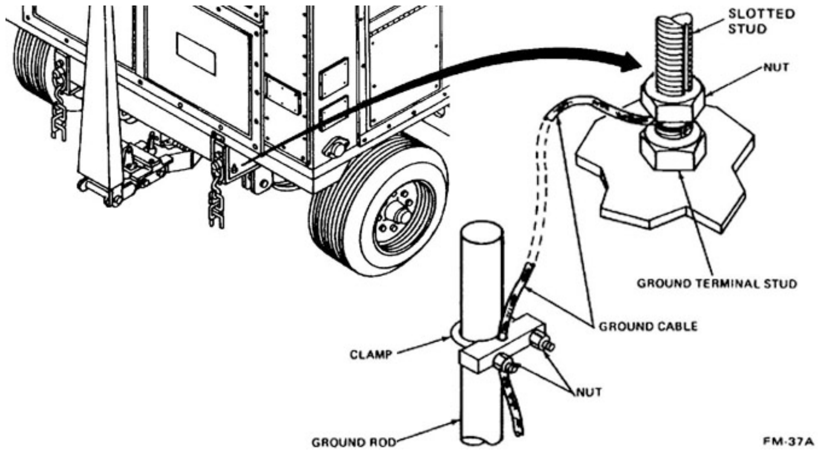


Figure 1–4. MEP–12 ground studs.

Fuel storage area

The fuel system consists of three different parts: the fuel source, fuel lines, and a generator. The fuel source could be a fuel bladder, a fuel truck, or a fuel tank, depending on the available resources. The fuel source outlet should be the 3-inch quick-disconnect type with safety-wired close connections.

A seven–day fuel supply must be maintained at each prime power generation location. This can be accomplished by using the 10,000-gallon fuel bladders, shown in figure 1–5. Bladders are soft fuel storage containers constructed of rubber and vinyl. A fuel bladder is approximately 4 feet high by 12 feet wide by 42 feet long once installed. The shipment container is approximately 12 feet long by 1.5 feet wide by 1.5 feet high and weighs 230 pounds. A bladder has three connections on its top surface: a 4-inch filler assembly to receive fuel, a 4-inch discharge assembly to supply fuel to generators, and a vent assembly. The vent assembly is simply a relief valve and standpipe and attaches to the fitting on the center of the bladder. A 4-inch 90 degree elbow and 4 to 3-inch reducer is included in the kit and is needed to reduce the size of the discharge assembly to meet the 3-inch discharge line size. Once the fuel source is in position, you will have to connect the fuel lines. Four 3-inch fuel lines that are 25 feet long are connected from the fuel source to the fuel manifold. These will also be the quick-disconnect type. The fuel source should be a minimum of 100 feet from the generators. Figure 1–6 shows a typical setup.

Figure 1–5. Power plant fuel bladders.

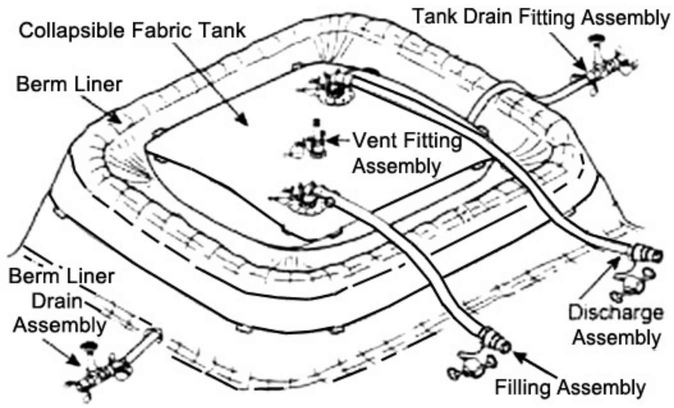


Figure 1–6. Fuel bladder setup.

After laying out the four 3-inch fuel lines, connect them to fuel manifold, shown in figure 1–7. This manifold has two 3-inch connections and two 1-inch connections. The two 1-inch lines leave the manifold assembly and attaches to the generators, shown in figure 1–8. Using the 1-inch threaded fuel lines, also in 25-foot sections, make two fuel line runs from the manifold to the generator. Each generator has the capability of receiving two fuel lines, shown in figure 1–9. In most cases, one fuel line will be coming from a main or primary fuel source and the other from a backup fuel source.

Figure 1–7. Fuel manifold.

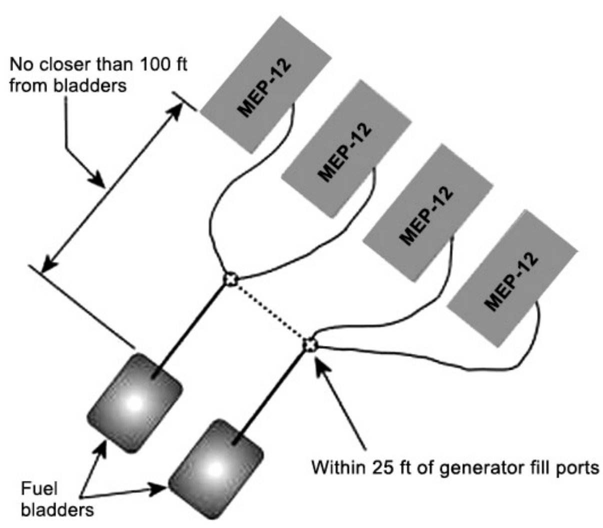


Figure 1–8. MEP–12 fuel system layout.

Figure 1–9. MEP–12 fuel connections.

Connection of the fuel system consists of selecting an area large enough to accommodate fuel bladders at least 16 feet by 46 feet. The area should be relatively flat to prevent the bladder from creeping (moving) and free of any sharp foreign objects to prevent rupturing of the bladder. Provide a 4-inch thick sand bed with 3½-foot tall berms, to contain a possible fuel spill. Make sure the area has reasonable drainage by installing a drain in the berms to remove water. Locate bladders away from water sources or other base areas. Develop a fuel spill containment plan. Make sure obstructions or irregular terrain do not inhibited access to site.

High voltage cables

Prime power is distributed throughout the bare base using a network of high voltage, 2400/4160, 3-phase, 50/60 Hz components. The main components of this distribution network are PDC, primary switching center (PSC), secondary distribution center (SDC), and the high voltage cables and connectors. Electricians fabricate the conductors from the 750 kW generators to PDCs onsite since not all power plants will look identical or have the same layout. The cables used for prime power distribution are single conductor shielded power cable suitable for direct burial underground, shown in figure 1–10. Only formally trained personnel will perform connections to energized high voltage circuits. This will typically be the site electricians since they receive formal training in this area.

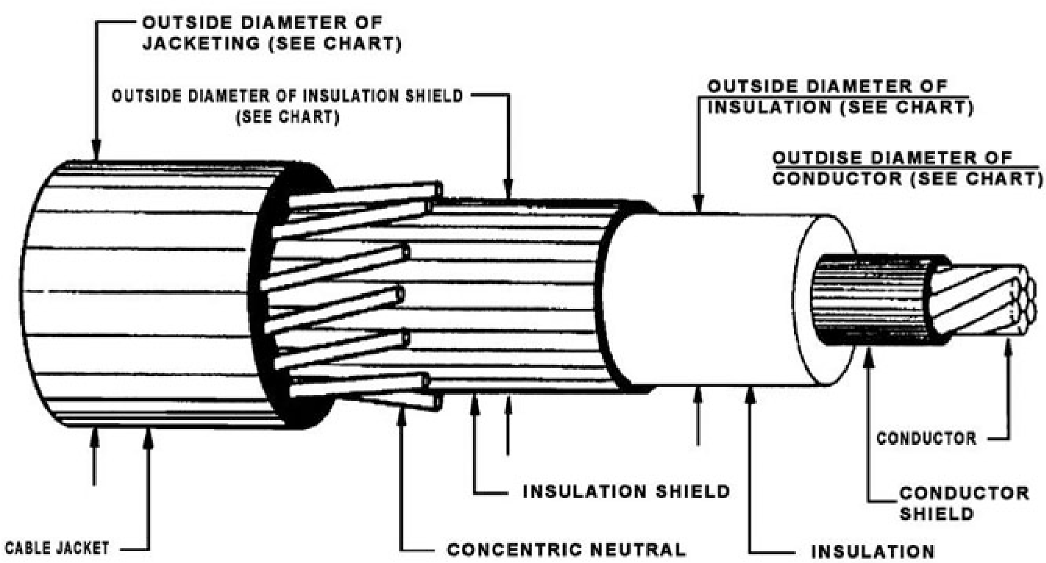


Figure 1–10. High voltage cable.

The cables contain a 1/0 Class B stranded aluminum conductor. A cross-linked thermosetting polyethylene and a concentric wrap of nine bare copper neutral wires insulate the cables. The cables arrive to the site on pallets of three reels, each containing 3,000 feet of cable. Electricians will have to cut this cable to length and install the load break elbows that fit the 750 kW generators, PDCs shown in figure 1–11, SDCs shown in figure 1–12, and PSC's shown in figure 1–13.

Figure 1–11. Primary distribution center.

Figure 1–12. Secondary distribution center.

Figure 1–13. Primary switching center.

Connectors used for the high voltage cables are load break elbow connectors rated for 15 kV and 200 amps. Figure 1–14 shows an illustration of a load break elbow.

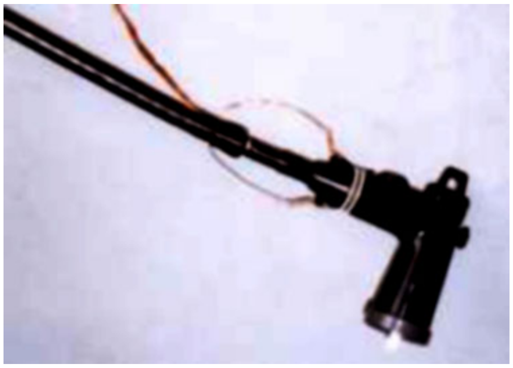


Figure 1–14. Load break connections.

803. Operations

We operate MEP–12 generators in single unit for several reasons. Sometimes the load only requires a single generator to operate. Other times, we will separate critical load to operate from a single generator so problems from non-critical areas do not drop the mission. First, we must inspect the generator before we can operate it.

Pre-operational inspection

We do pre-operational inspections before starting the generator set to ensure that the unit is in good operating condition. The pre-operational steps are listed below.

Step 1

Check fuel, oil and coolant for proper levels and check battery connections.

Step 2

Check source of fuel to fuel supply no. 1 and/or no.2 and place fuel selector valve located on the right side of generator set, in applicable position. (figure 1–15).

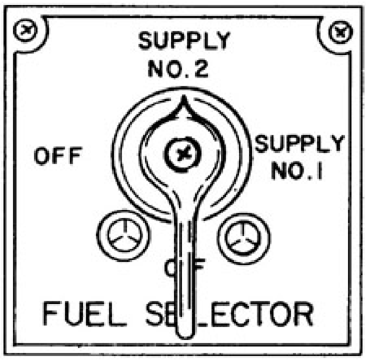


Figure 1–15. Fuel selector lever.

Step 3

Check ground terminal for connection to a suitable ground.

Step 4

Check that the radiator and housing louvers are open and all doors are closed unless required for control panel access.

Step 5

Check the parking brake to make sure it is engaged.

Step 6

Check the voltage regulator switch to ensure it is in the auto position (fig. 1–16).

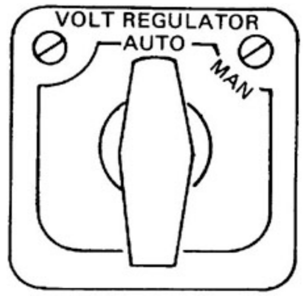


Figure 1–16. Voltage regulator switch.

CAUTION: Do not operate voltage regulator mode switch while unit is in operation.

Step 7

Check droop settings of governor, for single unit make sure it is at zero.

Step 8

Ensure parallel/single unit operation switch is in the single unit operation position (fig. 1–17).

Figure 1–17. Parallel and single unit operation switch.

Step 9

Check that the fuel transfer system toggle switch is in auto position (fig. 1–18).

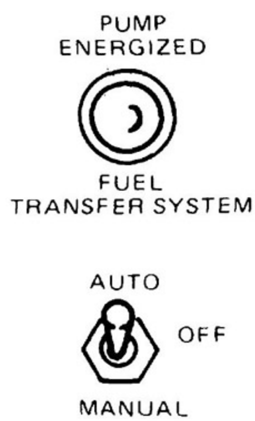


Figure 1–18. Fuel transfer system.

Step 10

Open control panel and ensure that the frequency mode selector switch is in 50 Hz or 60 Hz position as applicable (fig. 1–19).

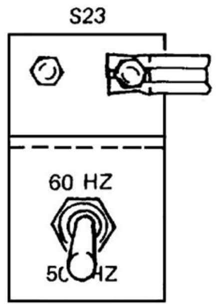


Figure 1–19. Hz Selector switch.

Step 11

Make sure the DC control circuit breaker is on, pushed in. (fig.1–20).

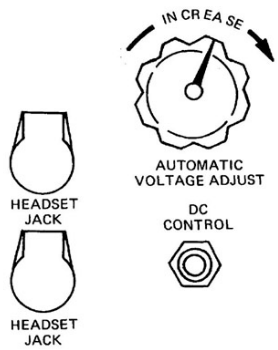


Figure 1–20. DC Circuit control breaker.

Step 12

Check the load circuit breaker control circuit breaker (CB4) is in the on position (fig. 1–21). The circuit breaker is located inside of the control box.

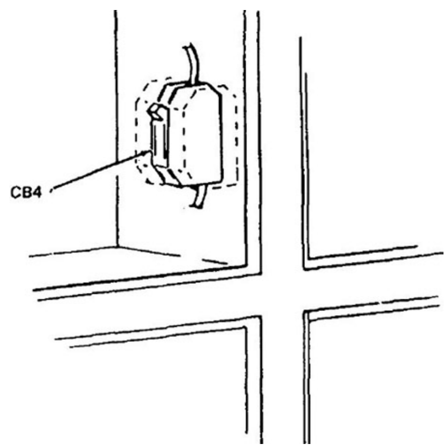


Figure 1–21. DC load circuit breaker.

Step 13

Check that the maintenance lockout switch located on the right side of the generator set is in the operation position.

Step 14

Ensure that the auxiliary power unit (start cart) is connected.

Step 15

Test fault lights with lamp test switch by pushing it in. All lights should turn on (except battery charger indicator light) (fig. 1–22).

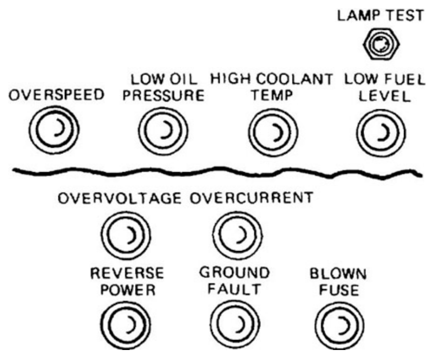


Figure 1–22. Fault panel.

Single unit operation

There may be time that you will operate a single MEP-12. It is very similar to operating any other generator in the single unit mode. Just remember that you are producing high voltages and to use the following steps safety and every precaution available.

Step 1

Place engine control toggle switch in the start position to crank engine. The engine will start and run at the preadjusted idle speed as long as the switch is held in the start position (fig. 1–23).

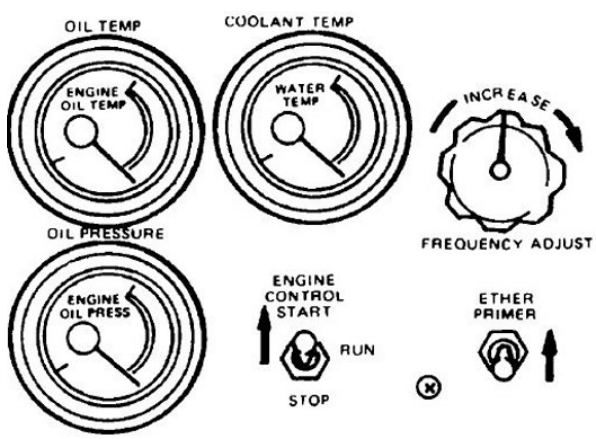


Figure 1–23. Start switch.

Step 2

Once the oil pressure gauge reads 25 to 80 PSI, release the engine control toggle switch to the run position, engine will accelerate to the frequency adjust rheostat setting. Additionally AC voltage will not build up until the engine control toggle switch is release to the run position (fig. 1–24).

Step 3

Adjust frequency and voltage to desired levels.

Step 4

Close breaker control selector switch by placing synchroscope selector switch in the on position then holding the breaker control selector switch in the closed position until the closed indicator light is energized (fig. 1–25).

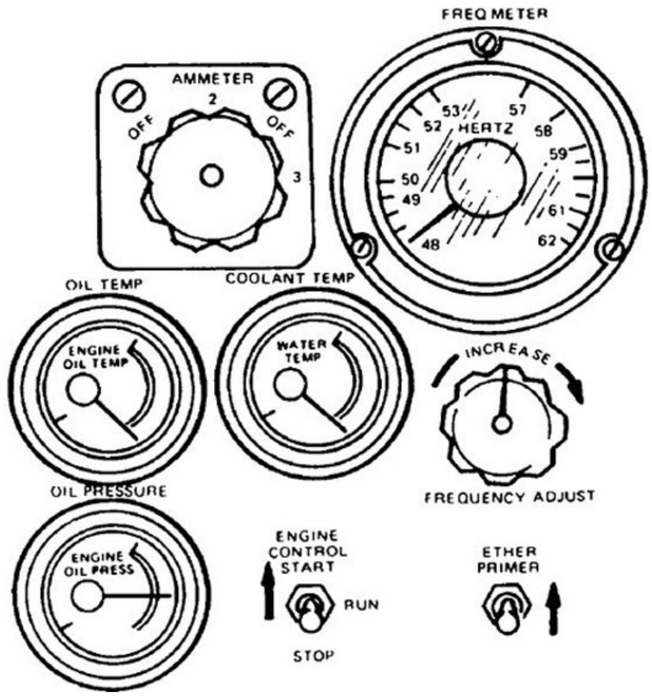


Figure 1–24. Gauges.

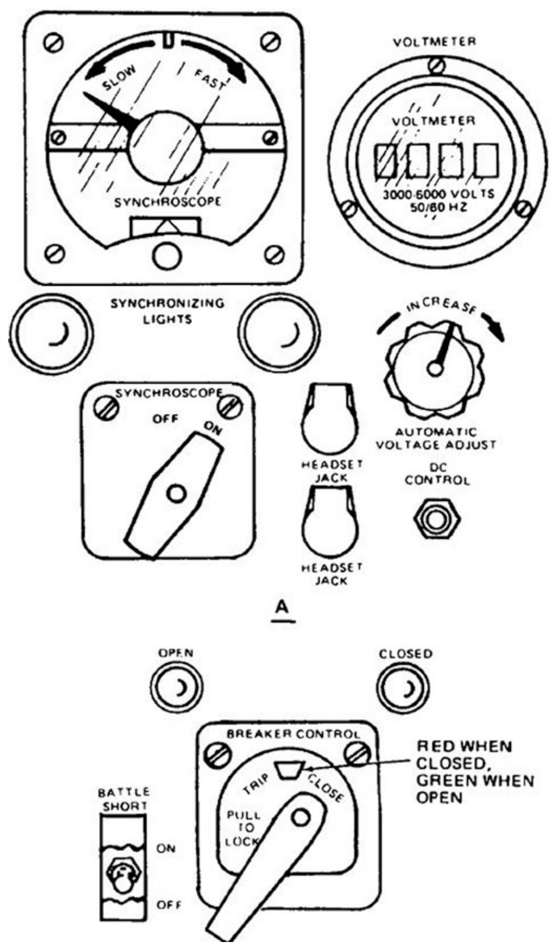


Figure 1–25. Breaker control.

Remote operation

The MEP–12 generator is capable of remote operation and that refers to the generator's operating location. Remote operation allows us to place all control panels into one place and make it a control room, as shown in figure 1–26. A control room allows us to operate several generators at one time quickly and easily. The following procedures outline the necessary steps for remote operation of the MEP–12 generator from an equipment rack:

1. Lift the access panel and latch it in the UP position.
2. Loosen the four captive screws from the two access plates at the rear of the main control box from inside the generator housing and remove the access plates.
3. Disconnect the two generator wiring harness connectors from the rear of the main control box.
4. Loosen the 10 captive screws from the front of the main control box and take the box out of the generator.
5. Connect the required number of remote cable sections together and pass one male and one female end through the cable opening in the generator housing.
6. Connect the remote cables to the wiring harness connectors.
7. Connect opposite ends of the cables to the receptacles at the rear of the main control box and move the box to the desired operating site.

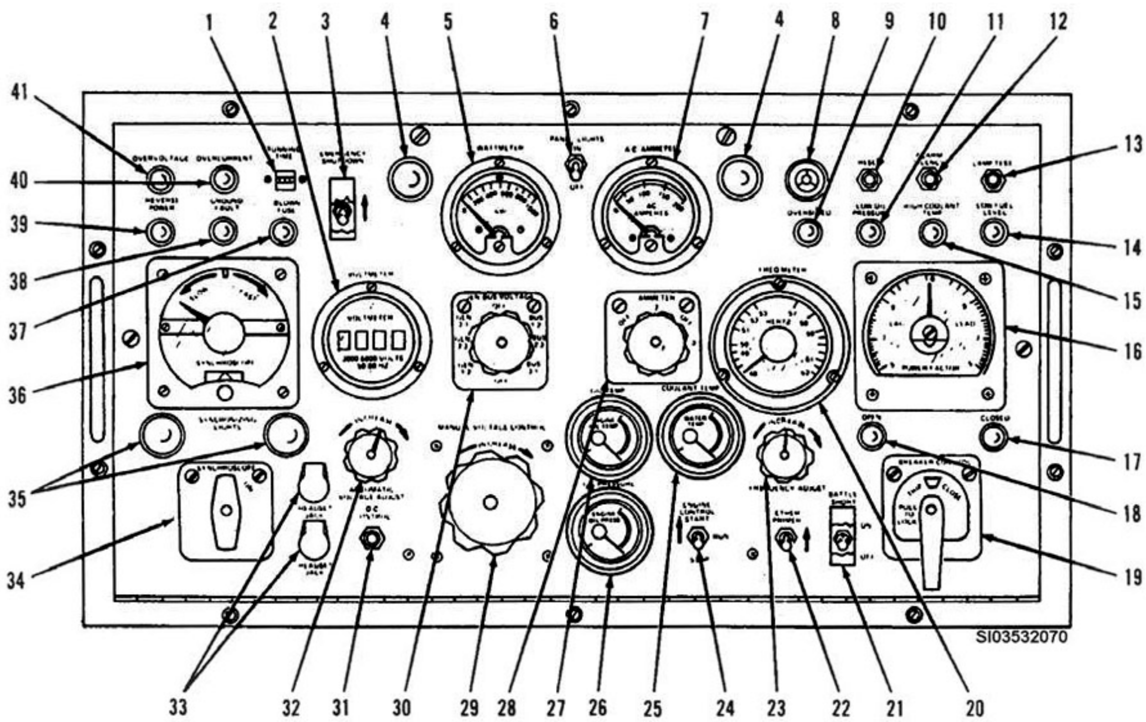
Figure 1–26. MEP–12 control rack.

Operational checks

During the time that the generator is on line, perform the following running checks at least once an hour. These checks are necessary to ensure the proper operation of the generator. The results of these checks frequently indicate that something is going wrong before a power outage; this allows you to take preventive action and maintain mission effectiveness. Do the following items hourly:

1. Record meter readings hourly. Adjust the frequency, figure 1–27, item 20, and voltage, figure 1–27, item 2, again as necessary.
2. Check and record oil pressure, figure 1–27, item 26; it should be between 25 and 80 psi.

3. Check and record coolant temperature, figure 1–27, item 25; it should be between 160 degree and 220 degree Fahrenheit.
4. Check the unit for unusual noises and leaks.
5. Check the engine oil level in the sight glass.
6. Walk around the generator looking, listening, and smelling for anything that catches your attention. Take your time and spend a few minutes doing this to prevent overlooking the faint indication of a problem.
7. To effectively maintain the generator sets, use an AF Form 1167, Daily Power Plant Operating Log (Diesel-Electric). There may be a locally developed form produced in the power plant for this purpose. In either case, these forms are very important because they tell the history of the unit to those personnel who follow.



1. RUNNING TIME METER
2. VOLTMETER
3. EMERGENCY SHUTDOWN TOGGLE SWITCH
4. PANEL LIGHT
5. WATTMETER
6. PANEL LIGHTS TOGGLE SWITCH
7. A.C. AMMETER
8. ALARM
9. OVERSPEED INDICATOR LIGHT
10. RESET PUSHBUTTON SWITCH
11. LOW OIL PRESSURE INDICATOR LIGHT
12. ALARM SILENCE PUSHBUTTON SWITCH
13. LAMP TEST PUSHBUTTON SWITCH
14. LOW FUEL LEVEL INDICATOR LIGHT
15. HIGH COOLANT TEMP INDICATOR LIGHT
16. POWER FACTOR METER
17. BREAKER CLOSED INDICATOR LIGHT
18. BREAKER OPEN INDICATOR LIGHT
19. BREAKER CONTROL SELECTOR SWITCH
20. FREQ METER
21. BATTLE SHORT TOGGLE SWITCH
22. ETHER PRIMER TOGGLE SWITCH
23. FREQUENCY ADJUST RHEOSTAT
24. ENGINE CONTROL START-RUN-STOP TOGGLE SWITCH
25. COOLANT TEMP GAGE
26. OIL PRESSURE GAGE
27. OIL TEMP GAGE
28. AMMETER SELECTOR SWITCH
29. MANUAL VOLTAGE ADJUST CONTROL
30. GEN/BUS VOLTMETER SELECTOR SWITCH
31. D.C. CONTROL 10 AMP CIRCUIT BREAKER
32. AUTOMATIC VOLTAGE ADJUST RHEOSTAT
33. HEADSET JACK
34. SYNCHROSCOPE SELECTOR SWITCH
35. SYNCHRONIZING LIGHTS
36. SYNCHROSCOPE METER
37. BLOWN FUSE INDICATOR LIGHT
38. GROUND FAULT INDICATOR LIGHT
39. REVERSE POWER INDICATOR LIGHT
40. OVERCURRENT INDICATOR LIGHT
41. OVERVOLTAGE INDICATOR LIGHT

Figure 1–27. MEP–12 main control panel.

Shutdown procedures

When the customer no longer needs the electrical support of the generator, it's time to shut the unit down. Place the breaker control selector switch in the TRIP position, figure 1–27, item 19. Allow the engine to cool down for approximately five minutes or until it reaches 180 degree Fahrenheit. Place the engine control toggle switch in the STOP position to shut the unit down, figure 1–27, item 24.

Parallel operation

The parallel operation of the MEP–12 generators is very much the same as the parallel operation of the smaller MEPs we have already discussed in a previous lesson. Parallel operation consists of operating two or more generators for the same load. This provides you with the capacity to provide facilities with enough power to accomplish the mission even if it is larger than your generator. There are two basic types of parallel operation— ZERO DROOP-DROOP and all generators in droop.

Determining the need for parallel operation

We must know when another generator is necessary to provide the power needed to sustain the mission. Understanding this concept leads to fluent operation that the customers are unaware of. They simply know the power is on and they can use it. We consider three factors when determining the need for parallel operation: exceeding a single unit's capability, peak demand periods, and large fluctuating load changes.

Requirements for paralleling

To parallel generators, we must meet four specific conditions before we can parallel the generators together. Many people initially think that generators we are paralleling must have the same manufacturer or have the same kilowatt rating; however, this is not true. As long as they have the same frequency, voltage, phase sequence, and phase relationship, we can parallel them. Severe damage may occur if we do not meet these requirements.

Zero Droop-Droop operations

With the ZERO DROOP unit on line and inspected, it's time to add the additional DROOP units to the system. We have performed the pre-operation inspections and engine warm-ups so the engine is ready. All control switches are in their proper positions with the voltage regulator switch in the AUTO position. The governor droop adjust rheostat is set to the proper setting, and the operation switch is in the PARALLEL position. The additional generators connected to the system will be called incoming units.

Adding incoming units

Once the incoming generator is ready, place it on line. Turn the scope switch to the ON position. Adjust the incoming generator frequency until the synchroscope is rotating at a slow rate of speed in the fast direction. Set the incoming generator voltage to match the bus voltage. Use the voltmeter and voltage selector switch on the incoming unit to check both the bus voltage and incoming generator voltage. When the synchroscope is reading approximately in the 11 o'clock position and the synchroscope lights are completely dark, place the output breaker control switch of the incoming generator to the CLOSED position. The output breaker should close. A red "closed" lamp above the breaker control switch indicates this.

We have now connected the generator to the bus. Immediately adjust the incoming generator frequency to pick up a slight load on the unit, thus preventing motorization. We will read about motorization later. To avoid a "NO LOAD" condition on any one generator, exercise extreme caution when you make frequency adjustments.

Running adjustments

Once we have paralleled the units, we must try to keep approximately 50 percent rated value load (375 kW) on the ZERO DROOP unit. The reason for this is that the ZERO DROOP unit receives all load changes. If too little load is on the ZERO DROOP unit and a large load decrease occurs on the bus, the ZERO DROOP unit may motorize. If too much load is on the ZERO DROOP unit, and a large load increase occurs on the bus, the ZERO DROOP unit will overload. In either case, the ZERO DROOP unit will automatically trip off the line.

Remember that the ZERO DROOP unit maintains the bus frequency. Do not try to use the ZERO DROOP unit's frequency adjust knob to balance the load. Any adjustment of the frequency knob on this unit will result in a change of the bus frequency. Adjust the frequency knobs of the DROOP units to balance all loads.

All generators in droop operations

We operate generators in parallel with each one of them having the governor set with droop for a facility that experiences large fluctuating loads and is not frequency critical. The load splits evenly over each of the generators, but the generators do not maintain the frequency. Adding generators to the bus in this setup is the same as the zero droop-droop setup.

Once we have paralleled the generators, we can move the load between the generators using the frequency control knobs. These adjustments also adjust the frequency on the bus. You should always make minor adjustments and wait until the generators have settled out before making further adjustments. Getting in a hurry and making large adjustments are the easiest ways to have a problem and drop power to the site. Use the following table to see the adjustments that you should make.

Load	Bus frequency	Adjustment
Different	High	Lower fuel to the high load generator
Different	Low	Raise fuel to the low load generator
Different	Normal	Lower fuel to the high load generator and raise fuel to the low load generator
Same	High	Lower fuel to all generators
Same	Low	Raise fuel to all generators

Parallel faults

Operating generators in parallel can be challenging. Since you are operating more than one generator, there are a large number of things that can go wrong. Two of the most common parallel faults are motorization and crosscurrents.

Motorization

Any time we operate generators in parallel, it's possible to motorize one of the generators. Motorization occurs when load leaves the generator while still connected to the bus. Motorization usually occurs when we are placing a unit on or removing from the bus. Usually it is a result of operator error. The kW meter is reading zero or lower, the AC ammeter is reading amperage, and the PF meter, if available, is reading off scale indicates motorization. Fortunately motorization is an easy problem to correct. Simply increase the fuel (raise the frequency) to the motorized unit until it picks up some load. Preventing motorization by paying attention to the load on the units is better than having to correct motorization after it occurs. Remember it's *impossible* to motorize a unit if it has any load on it.

Crosscurrents

Parallel operations cause crosscurrents that travel between paralleled generators and waste power. In addition, heat builds in the alternator windings and decreases the life of the alternator. Although we can never totally eliminate crosscurrents, we can minimize them.

The PF meters will give the best indication of crosscurrents. Any time the PF meters on all of the paralleled generators read the same, we have minimized the crosscurrents. If the PF meters are reading different, use the voltage adjust rheostat to adjust the output voltage in the generators to minimize the crosscurrents. The bus voltage determines the adjustments you make. Remember back

to an earlier training course when the words “raise the lead – lower the lag” were mentioned? This simple phrase will make it easier to correct for crosscurrents during parallel operations.
The following chart will also help identify the adjustments required to minimize crosscurrents.

BUS VOLTAGE	POWER FACTOR METER	CORRECTIVE ACTION
LOW	DIFFERENT	RAISE THE LEAD
HIGH	DIFFERENT	LOWER THE LAG
LOW	SAME	RAISE ALL UNITS
HIGH	SAME	LOWER ALL UNITS

Remember when making any adjustment to one generator connected in parallel to a bus, it will affect every unit on the same bus.

Governor control module adjustments

We may make four adjustments to the governor control module: gain, running speed, idle speed, and droop.

Running droop change

The purpose of a running droop is that it allows for a more flexible power control. If a problem should develop on the ZERO DROOP unit, personnel must be capable of changing one of the DROOP units into a ZERO DROOP unit without losing power to the bare base.

NOTE: Two units cannot operate on the same bus with their governors set at zero. These units will fight one another for control of load and frequency.

Start by changing the ZERO DROOP unit to a DROOP unit. Droop changes are a team effort with constant communication between the control panel operator and the assistant located at the operating generator. The generator relay access panel must be open for the assistant to gain access to the governor control module A4, shown in figure 1–28. The following are guidelines on the procedure of performing a running droop change:

1. Starting with the ZERO DROOP unit, the assistant will use a small flat-tip screwdriver to slowly turn the governor droop setting clockwise away from the ZERO setting. We must do this operation *very slowly*.
2. The operator at the control panel will increase or decrease the frequency (maintaining the frequency as close to 60 Hz as possible) by using the frequency adjustment knob on the unit while maintaining steady load division between the operating units.

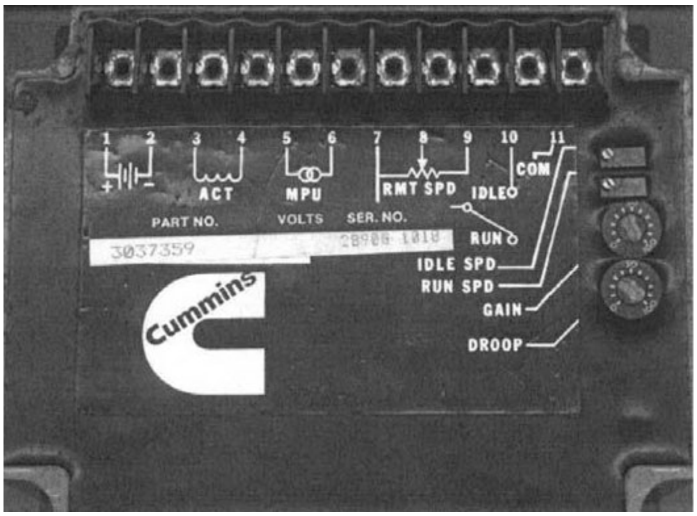


Figure 1–28. Governor control module.

The operator and assistant must be in constant communication at all times using the headphones and plug-in jacks provided on the equipment. The control panel operator will tell the assistant when to stop any adjustment and when to continue after stabilizing the equipment. In turn, the assistant will notify the operator when they have reached the 9 o'clock position or three percent droop setting. Both units are now operating in the droop configuration.

Once we have changed the ZERO DROOP unit to a DROOP unit, the operator and assistant are ready to change the original DROOP unit to a ZERO DROOP unit. We do this task in the same manner but on another unit. The assistant turns the governor droop setting counter clockwise, or closer to the ZERO position, while the control panel operator makes corrections to the frequency as necessary. Communication is still the *key* to a successful running droop change.

Removing the generator from the bus

The final task of operation is the removal of the units from the bus. The first thing to be aware of is the total load on the generators. Ask yourself this question: "Is one unit capable of handling all the load?" To remove units, you always start with the DROOP unit.

1. Remove the entire load from the DROOP units by using the frequency control and decreasing the frequency until the kW meter reads almost zero (approx. 20 kW).
2. Open the output breaker by placing the output breaker switch to the OPEN position.
3. Allow the unit to cool down for approximately five minutes.
4. Place the Start-Stop-Run switch to the STOP position.
5. Pull out the DC circuit breaker (CB1).

Remove additional units as required in the same manner. The final unit we remove is the ZERO DROOP unit; and, of course, this means that site will be totally without power. We remove the unit by opening the output circuit breaker, while load (kW) is still on the unit. We must allow the unit to cool down before completely shutting it down and pulling the DC circuit breaker out.

Operating in extreme conditions

The MEP-12 was designed to operate all around the world. With that being said there are things that must be done to operate in these conditions.

Extreme cold

Extreme cold is considered anything below -25F degrees. A few additional things that must be done are to change the grade of fuel and service the fuel strainers more frequently.

Extreme heat

When operating in extreme heat take extra care when servicing the unit. An efficient engine will run cooler, so ensure that the coolant and lubricating oil systems are serviced properly and the engine is kept clean. Finally make sure to run the engine at no load for five minutes before shutting down.

Dusty or sandy areas

Much of the world contains areas that are very dry, for the better part of 25 years we have been operating power plants in some of these areas. To operate in these areas here are some preventative steps you can take to operate your MEP-12 power plant better.

1. Keep generator set as clean as possible.
2. Replace air filters more frequently.

High altitudes

At high altitudes the density of the air decreases. Because of this some de-rating must occur if working in these areas. Consult the TO for specific de-rating procedures.

Battle override (battle short) operation

During emergency (battle short) operation the BATTLE SHORT toggle switch is placed in the ON position, thus bypassing all fault shutdown relays, (except the overspeed relay). To prevent damage to the generator set make sure that you only run the generator in this mode when it is absolutely necessary.

Demolition

In the case a base is being overrun the battle short can be used to keep a generator running until it destroys itself. A few things that can be done are.

1. Drain the coolant and let the generator run until it overheats.
2. Drain the oil and let the generator run until it seizes.

These are just a couple of ways to destroy a generator to avoid it from being used by the enemy. This should only be done when directed by the installation commander.

Operation of the power plant is one of the most critical jobs on a bare base. Without power, the site comes to a standstill. The best thing to remember is the human factor. We all make mistakes but with properly trained personnel everyone's job becomes easier. Think before you act, taking only the needed actions. We cannot stress safety enough. Don't be careless and do not become overconfident. Always remember we cannot see electricity, but once it comes in contact with a human body, it can kill. Follow all procedures and make sure to brief all personnel on the correct operating procedures, and ensure they are aware of the high voltages we produce.

804. Maintenance and repair

The MEP–12 typically operates continuously as prime power for the site and requires maintenance at regular intervals. We typically schedule the generator for maintenance every 300 hours of operation. We can adjust this interval to a shorter time depending on the operating conditions of the site. We must perform thorough maintenance if you expect the generators to function properly. Remember we will be operating these generators as the site's prime power in a contingency situation. If the generator fails because of inadequate maintenance, we have just put the mission in jeopardy. We can break the maintenance into two major sections—the engine and the electrical system.

Engine maintenance

The quality of the maintenance that we do on the engine is essential for the generator to operate for its life expectancy. Be sure not to cut any corners as maintenance comes due. We should allow the generator to cool for several hours before we start the maintenance. This will prevents hot fluids from a hot engine from burning us.

As with all maintenance ensure that you use the proper technical reference when accomplishing 300, 1500, and 3000 preventative maintenance inspections that are listed in the following tasks:

300 hour mechanical preventative maintenance inspection (PMI)

1. Run engine up for five minutes.
2. Shut the engine down and place the maintenance lockout switch into the maintenance position.
3. Test the coolant for DCA levels. Replace coolant filters if the DCA level is out of specified levels.
4. Drain the crankcase oil. The MEP-12 has a capacity of 30 gallons so make sure that you have a large enough receptacle to hold all of the waste oil. Additionally make sure to comply with all applicable laws when storing and handling waste oil.
5. Remove and replace the two bypass and four main oil filters.
6. Remove and replace the two fuel filters.

7. Clean the fuel strainer.
8. Prime and bleed the fuel system.
9. If the primary air filters air restriction is above 15 inches, replace them. Replace the secondary filter every other time the primaries are replaced.
10. Check coolant level and add if necessary.
11. Inspect batteries for tightness, leaks, cracks, or corrosion.
12. Inspect alternator belts.
13. Lubricate idler pulley and idler arm support.
14. Clean radiator.
15. Place maintenance lockout switch into operation position.
16. Run up engine to ensure that no leaks are present.
17. Update the historical records.

1500 hour mechanical preventative maintenance inspection (PMI)

1. Complete 300 hour PMI
2. Adjust crossheads, valves, and injectors in accordance with proper technical manual.

3000 hour mechanical preventative maintenance inspection (PMI)

1. Complete 300 hour PMI.
2. Complete 1500 hour PMI.
3. Lubricate front engine mount.

Electrical system maintenance

We can divide the MEP–12 generator electrical system into the following two areas—the high voltage system and the low voltage system. Before you do any maintenance on the electrical system, you must remove the load cables first from the PDC and then from the generator. If you fail to do this, the PDC will back feed the generator electrical system. This spells disaster for anyone who opens the high voltage panel. Always remove the cables from the PDC before you remove the generator cables.

High voltage system

Hazardous voltages may be present even with the unit shut off, always refer to the proper TO prior to conducting maintenance to ensure the unit is safe.

> **WARNING:** Hazardous voltages may be present that can cause injury or death by electrocution, refer to proper TO before proceeding.
>
> Ensure unit and high voltage cables are isolated from the buss. Discharge the entire electrical system prior to proceeding, components can and will hold a residual voltage even when the units is off.
>
> Hazardous voltages may be present even with the unit shut off, always refer to the proper TO prior conducting maintenance to ensure the unit is safe.

The following checks are essential in ensuing that the system is running properly, consult TO for correct reading.

T4-T9 Checks

1. Ensure that all of these transformers are 20:1 ratio transformers.
2. Use ohmmeter to check for proper resistance readings. (Consult TO for correct readings).
3. Check fuses for continuity. (Consult TO for correct readings).
4. Clean transformers and surrounding areas of dust and dirt.

Load break connector checks

1. Check that connectors are tight and clean.
2. Check lugs on bushings for tightness.

CB5 Checks

1. Check 170 Amp fuses for continuity. Clean fuse ends and holder and reinstall fuses.
2. Check fuse on the back diode of CB5.Ensure the correct fuse is installed and test for continuity.
3. Check for burned wiring.
4. Check coil resistance.
5. Check resistors for proper resistance.
6. Inspect ceramic vacuum bottle for damage.
7. Check for broken springs under the vacuum bottle.
8. Check each normally open and normally closed contact for proper operation.
9. Activate micro switches and check for blown fuse indicator on control panel and that they electrically open and close.
10. Clean the breaker and surrounding area.

T2 and T3 Checks

1. Isolate transformers by pulling fuse and perform resistance checks.
2. Check that the base is grounded.
3. Ensure fuse ends are secure, test for continuity and lightly sand fuse ends and fuse holders.
4. Clean the area of dust and dirt.

WARNING: Ensure all personnel are clear of the unit when conducting this test.
Ground the capacitor and entire electrical system again after using megger.

Capacitor checks

1. Remove sires from capacitor.
2. Use a 500V Megometer to check continuity between each terminal and ground. Consult TO for proper readings.
3. Check that capacitor is not damaged or leaking and that all wires are tight.
4. Clean the capacitor and surrounding area.

WARNING:
Ground capacitor and entire electrical system again after using merger**.**

Lighting arrestor checks

1. Check arrestors for damage.
2. Use Megger to check resistance between lugs and ground, this should be infinity.
3. Clean the arrestors and surrounding area.

WARNING: Ensure all personnel are clear of the unit when conducting this test. Ground capacitor and entire electrical system again.

> **WARNING:** Ground arrestors and entire electrical system again after using merger.

Current transformer checks

1. Check wire pins for security.
2. Take ohm readings.
3. Check for damaged wiring.
4. Clean the transformers and surrounding area.

Rectifier assembly checks

1. Check the rotating rectifier for damage and security.
2. Clean rotating rectifier.
3. Check for grounding and correct resistance between terminals.
4. Clean alternator housing.

Low voltage system

We must follow safety precautions when we are working on the low voltage system. It consists of fuses, relays, and circuit cards. Test each fuse using an ohmmeter and inspect it for damage. As with any maintenance make sure to consult the technical order for the proper procedures for accomplishing these tasks.

> **WARNING:** Hazardous voltages may be present and can cause injury or death by electrocution, refer to TO before proceeding.
>
> Ensure unit's and high voltage cables are isolated from the buss.
>
> Discharge the entire electrical system prior to proceeding, components can and will hold a residual voltage even when the units is off.
>
> Hazardous voltages may be present even with the unit shut off, always refer to the proper TO prior to conducting maintenance to ensure the unit is safe.

Checks when generator is off

1. Disconnect cannon plug J12 and J 17.
2. Clean all low voltage panels.
3. Check relay holders for cracks and security.
4. Check that the proper relays are installed.
5. Check all CR's for damage.
6. Check continuity on CB4 and CB6.
7. Check governor settings.
8. Check fuse holders for security.
9. Inspect voltage regulator.
10. Check current boost module for burnt or damaged components.
11. Check all fuses.
12. Check all wires security.
13. Check syncroscope coils for proper readings.
14. Reconnect cannot plug J12 and J17.
15. Check all cannon plugs on the entire unit are installed completely and on tight.
16. Check all wires around engine are tight.

17. Remove the magnetic pickup and clean it and reinstall.
18. Check battery voltage and for cleanliness and proper water levels.
19. Inspect all wires in control panel for tightness.
20. Ensure all switches operate on control panel.
21. Check fault lights.
22. Check power factor meter reads zero.

WARNING:

Ensure all personnel and equipment are clear of the unit and that the engines fluid levels are good.

Checks when engine is running

1. Zero ammeter and KW meter.
2. Calibrate voltmeter.
3. Check voltage rheostat for smooth voltage adjustment.
4. Calibrate frequency meter.
5. Check frequency rheostat for smooth adjustments.
6. Check fault lights.
7. Check idle speed is set at 1000 RPM or about 33 Hz.
8. Check overspeed setting.
9. Check emergency shutdown switch.

Troubleshooting

As with all equipment a MEP-12 will have some malfunctions from time to time. We will cover some of the basic problems and what may cause them. As always consult the proper T.O. when maintaining and repairing any piece of equipment. Troubleshooting is a process that can be applied to diagnose and repair faults. When troubleshooting a MEP-12 it is important to remember that there is lethal voltage applied to parts of the generator even if it is not running. Using the schematic in the *fold out supplement* we will go over these areas and discuss how to go about safely troubleshooting a MEP-12 generator.

Alternating current (AC) circuits

The MEP-12 AC wiring diagram is set up similar to most diagrams. There is a legend, and two sheets. To highlight the danger of working on a MEP-12 we will trace a path for high voltage to travel if the generator is not isolated from the bus by having the electricians pull the load break elbows of the MEP-12. Looking at figure 1–29 below, red represents 2400 VAC and yellow represents 120 VAC. If the load break elbows are connected to the generator and the bus is live 2400 VAC will travel up to CB5 (main circuit breaker). At the same time it will travel to fuses F12, F13 and F14 then through transformers T7, T8 and T9. These are potential transformers and are taking the 2400 VAC and stepping it down to a more usable 120 VAC for the purpose of monitoring bus voltage and syncing. Once through the transformers, 120 VAC will pass through fuses F15, F16, and F17 then onto the sync check relay (K21), voltmeter selection switch (S11) and high voltage indicating lights DS30 A and B; DS31 A and B; and DS32A and B. This illustrates the importance of isolating the generator from the bus.

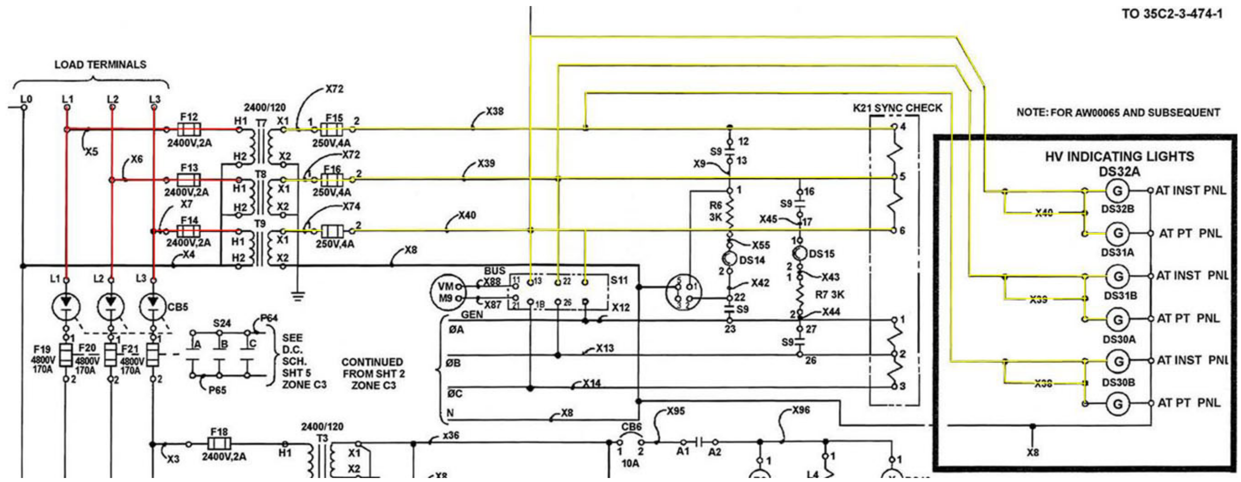


Figure 1–29. MEP-12 AC diagram.

Direct current (DC) circuits

The MEP-12 DC wiring diagrams as ladder diagrams. Even though they are different from many diagrams, once you get use to them they become a very fast way to troubleshoot problems. One easy way to look at ladder diagrams is think of each one laid out from left to right with the first sheet being on the left. When laying them out this way you will notice that through the entire diagram positive is on top and negative is on the bottom. So as you are tracing a circuit you may have something at the very end of the diagram affecting something at the beginning. We will now go over a few of the circuits using the DC diagrams.

Crank circuit

The start circuit contains three separate circuits which include the crank, engine 700 RPM, and run circuits. Refer to the fold out to see the traced circuit, (Red) the crank circuit goes as follows.

Starting with foldout 1, when CB1 (DC Control Circuit Breaker) is pressed to the closed position, 28 VDC is applied to normally closed contacts of K16 (Shutdown relay) to S2 (Start-Stop-Run switch).

When S2 is placed in the START position, the coil of relay K12 is energized causing its contacts to reconfigure. When the coil of relay K12 is energized, two sets of normally open contacts will close energizing the coils of relays K10 and K11. When the coils of K10 and K11 are energized, their respective contacts will close energizing L1 and L2 (Starter Solenoids). This allows 28 VDC to be applied to B1 and B2 (Starter Motors).

Field Flash circuit

The field flash circuit works off another set of normally open contacts of K12, which upon K12 being energized close sending power to A3, the voltage regulator. This is illustrated in orange on foldout 3.

Idle circuit

The idle circuit, illustrated in green, holds the generator speed at 700 RPM, also during this time several other items start working.

When the coil of K13 is energized, one set of its normally open contacts will close allowing 28 VDC to be applied to DS5 (Low Oil Pressure Lamp) (foldout 5). A second set of normally open K13 contacts close to energize the coil of L3 (Engine Fuel Solenoid), and energize meters MT1 (Oil Pressure Gauge), MT2 (Oil Temp Gauge), MT3 (Coolant Temp Gauge), M4 (Elapsed Time Meter), and M9 (Gen Bus Voltmeter). This set of contacts will also allow relays K22 (Ground Fault) and K25 (Overcurrent) to start sensing (foldout 4). A third set of normally open K13 contacts will close which will start to complete a path for current flow to relay K20 (Oil Pressure, Time Delay). When the coil of K30 is energized, one set of its normally open contacts will close to keep the K30 coil energized, (foldout 3). A second set of K30 normally open contacts will close completing a path between pins 7 and 10 in A4 (Governor Control Unit) causing the governor to hold the engine at idle speed (foldout 4). As you can see tracing a circuit on the ladder diagram can seem confusing as first but once you are used to them they become very easy to use.

Troubleshooting engine systems

Troubleshooting a MEP-12 engine requires the same steps and procedures needed to troubleshoot any other diesel engine. Remember to follow these troubleshooting steps.

1. Perform an operational check.
2. Analyze the malfunction.
3. Locate the malfunction.
4. Perform corrective action.
5. Perform operational check.

When troubleshooting these engines a good place to start is the troubleshooting charts. These charts guide you in finding what is causing your malfunction. When using the operator/crew troubleshooting chart and it tells you to refer to the next higher level of maintenance the charts are telling you to refer to the organizational troubleshooting chart.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

801. Electrical hazards, safety practices, and maintenance

1. At what amperage can a slight shock typically be felt?

2. Who may perform maintenance on high voltage distribution systems?

802. MEP-12 construction features and components

1. How many days of fuel should you have at your power generation site?

2. Who may perform maintenance on high voltage circuits?

803. Operations

1. What is the droop setting on the A4 electronic governor for single unit operation?

2. What switch must be activated prior to closing the output circuit breaker?

3. What is motorization?

4. What are crosscurrents?

804. Maintenance and repair

1. How often should the oil be changed on the MEP–12?

2. How often should the fuel filters be replaced on the MEP–12?

1-2 Basic Expeditionary Airfield Resources (BEAR) Power Unit (BPU) Generator

The BPU is the replacement for the MEP-12 Generator. It is a state of the art generator with digital controls of both engine systems and power generation. Over time these will take over the bulk of the work in deployed areas. You will see these types of generators so it is important for you to be familiar with them and how they work. As always, refer to the TO before operating or performing any maintenance.

Figure 1–30. BPU.

805. Construction and system features

The BPU was specifically designed to work with current BEAR base assets. However there are several things that are updated that make this unit a huge advancement over the MEP-12.

Description

The BPU is a fully enclosed, trailer mounted, mobile generator set. It uses a 3 phase 4 wires system and has an alternated rated for a .75 lagging power factor. The alternator allows for the harsher load conditions that are encountered in contingency environments. It is capable of producing 800 kilowatts of power at 4160/2400 VAC at 60 Hz and 435 kilowatts of power at 3800/2200 VAC at 50 Hz. Additionally the BPU keeps this rating at altitudes of up to 4000 feet and temperatures from -25 degrees to 122 degrees Fahrenheit.

Operational modes

The BPU has several operating modes, they are as follows:

- Standalone (single unit)
- Three different paralleling modes, Isochronous, Droop and Utility.
    - The Isochronous mode provides constant voltage and frequency and is used when paralleling with other BPUs.
    - Droop mode allows for variable voltage and frequency. This mode allows the BPU to be synced with other generators such as a MEP-12.
    - Utility Mode allows parallel operation with a utility power grid (commercial power grid).
- Up to 12 BPUs may be paralleled together, making a single plant capable of producing 9600 kilowatts at 60 Hz and 5220 kilowatts at 50 Hz.

Systems

There are several systems that make up the BPU they are the trailer, enclosure, digital control system (DCS), engine, AC electrical, cooling, fuel, air intake, exhaust and DC electrical systems.

Trailer and trailer assembly

The trailer assembly contains the main support structure and provides the mobility platform (fig. 1–31). The enclosure is constructed mostly of aluminum and has numerous access doors and panels.

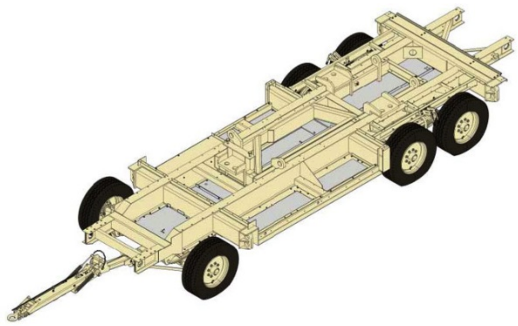


Figure 1–31. BPU trailer.

Digital control system (DCS)

The DCS is the brain of the BPU. It allows for configuration and operation; annunciation, fault and warning reporting and emergency stop control (fig. 1–32 and 1–33). When connected to a suitable laptop the remote operator panel (ROP) software allows for full operation from a remote location.

Figure 1–32. DCS.

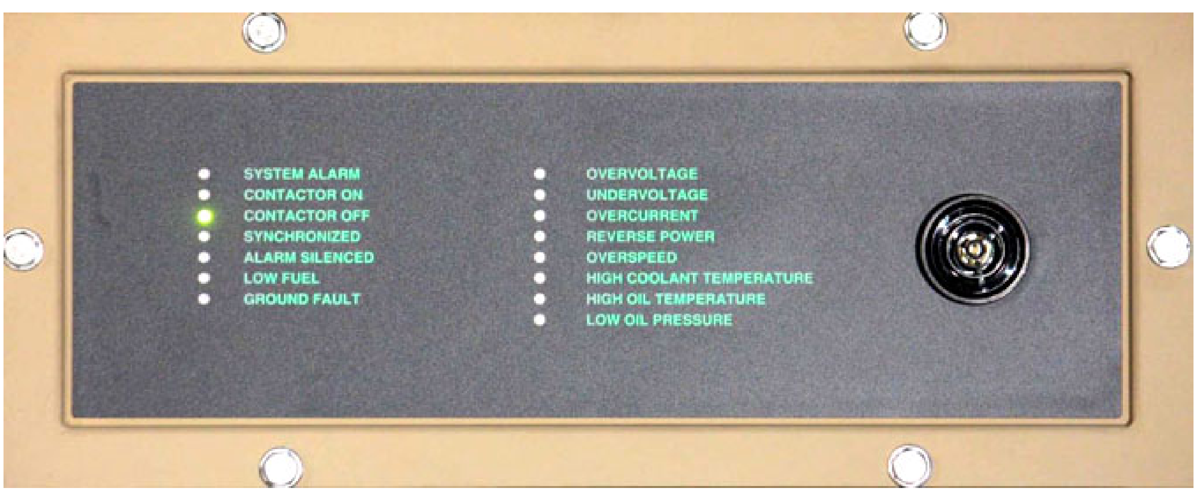


Figure 1–33. Fault Annunciator.

Engine assembly

The engine is a 12 cylinder, 38 liter, Cummins QSK38-G5 diesel engine. It is controlled with a pair of engine control modules (ECM) and the DCS's automatic voltage regulator (AVR). The two ECMs regulate fuel for the modular common rail system. It is also equipped with a DC electric pump to re-lubricate internal engine parts. Figure 1–34 below shows the engine assembly.

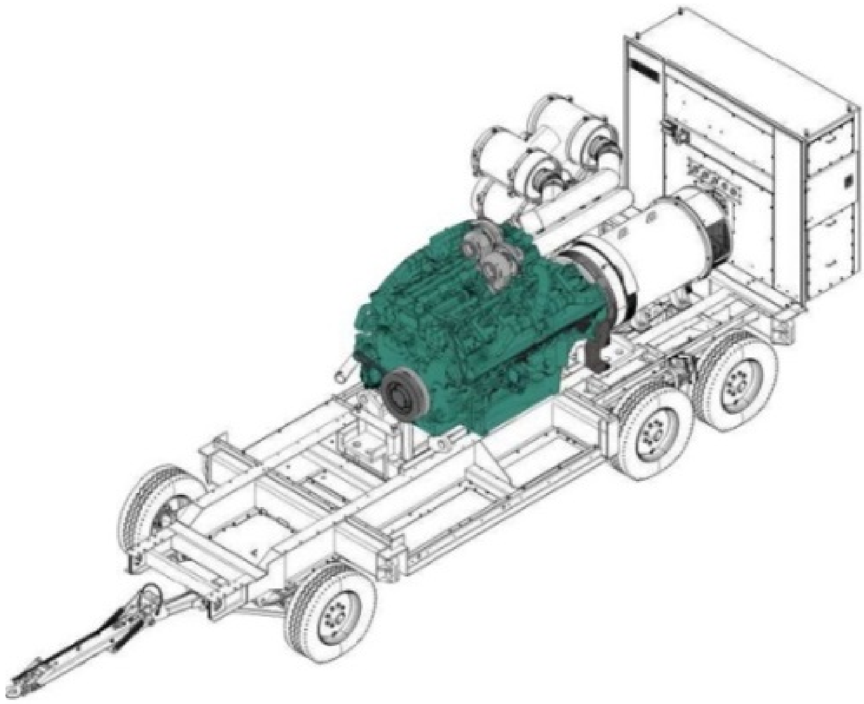


Figure 1–34. Engine Assembly.

The engine also has three fuel filters, and three oil filters. Figure 1–35 shows these and the ECMs.

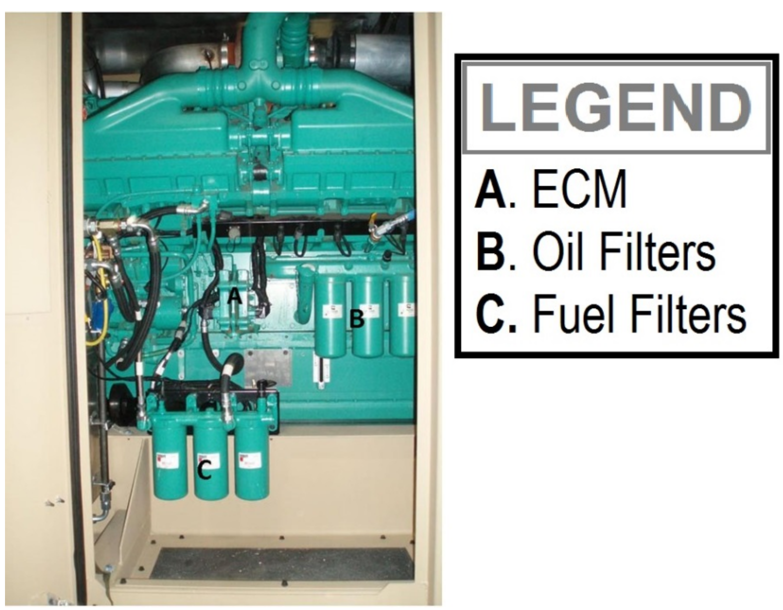


Figure 1–35. Engine.

AC system

The AC system is located to the back of the trailer and is made up of two main systems, the switchgear and the main alternator.

Switchgear

The switchgear contains the high voltage power interrupting devices, buses and load break connections. Figure 1–36 shows the location of the switchgear components. In addition it also provides voltage, frequency, and current sensing circuits for DCS metering and circuit protection. The main contactor provides the mains for circuit interruption and is rated for up to 15 kilovolts (kV). Also located in the switchgear cabinet is the 75 kilovolts-Amperes (kVA) power transformer that provides power to the radiator and engine compartment cooling fans. The 2 kVA power transformer provides power for the charging circuit of the output contactor, fuel transfer pump, humidistat, thermostat and heater strips. Additionally there are lightning arrestors, surge capacitors along with the external connection points for the load break elbows. Finally for safety there are door interlocks that will shut down the generator if the high voltage compartment doors are opened.

Figure 1–36. Switchgear.

Main alternator

The main alternator was specifically designed for the BPU and is dual speed and rated for a .75 power factor. The alternator compartment is separated from the rest of the generator, making accessing it a challenge.

Cooling system

The cooling system contains a dual-core radiator with a 72 inch, seven blade variable speed fan which pulls air through the radiator. The speed is controlled from a viscous clutch that uses oil from the engine at varying flow rates to engage or disengage the fan from the electric motor. The water pump uses a two loop system, it also contains a coolant heater that runs off of DC and burns fuel to warm the engine up before starting in cold environments. Because the radiator is in a separate compartment (fig.1–37) the BPU has two AC fans that pull air into the engine compartment to help keep it cool.

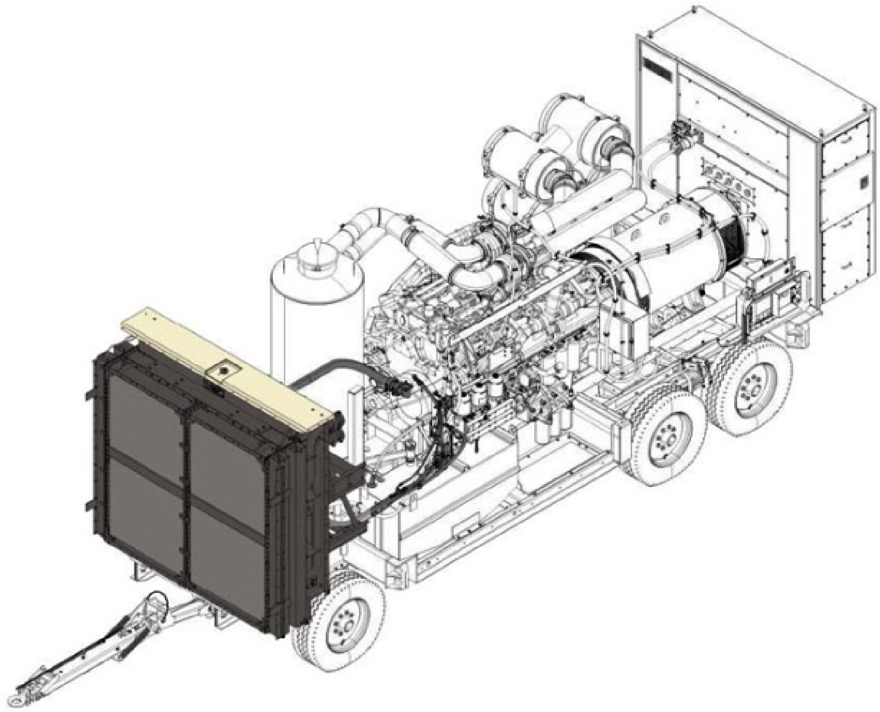


Figure 1–37. Cooling system.

Fuel system

The fuel system is a Modular Common Rail System that uses electronic fuel injection to deliver high pressure fuel to the cylinders. The preferred type of fuel is JP-8, but can run on diesel without any issues.

Day tank

The fuel tank supplies enough fuel for one hour of operation at full load and communicates fuel levels to the DCS with the fuel level sensor. Figure 1–38 shows how it is set into the frame.

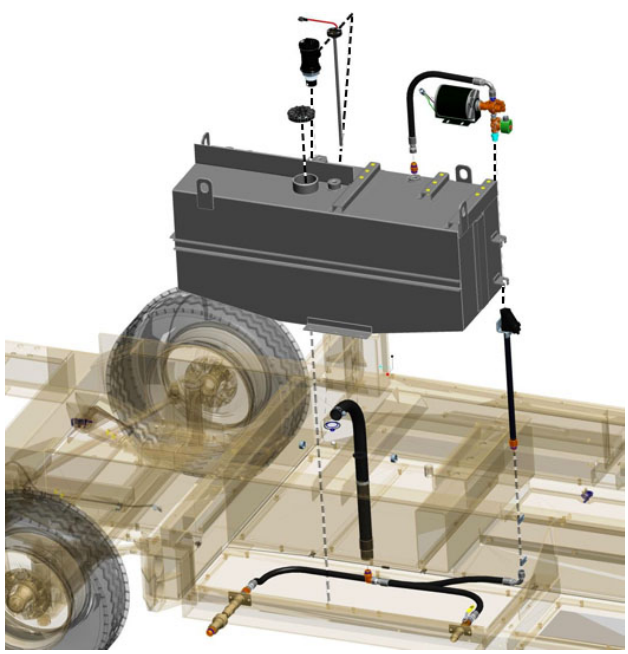


Figure 1–38. Day tank assembly.

Fuel filters

There are three primary filters/water separators and three secondary fuel filters. See figure 1–39 and 1-40 for the location.

Figure 1–39. Primary fuel filter assembly.

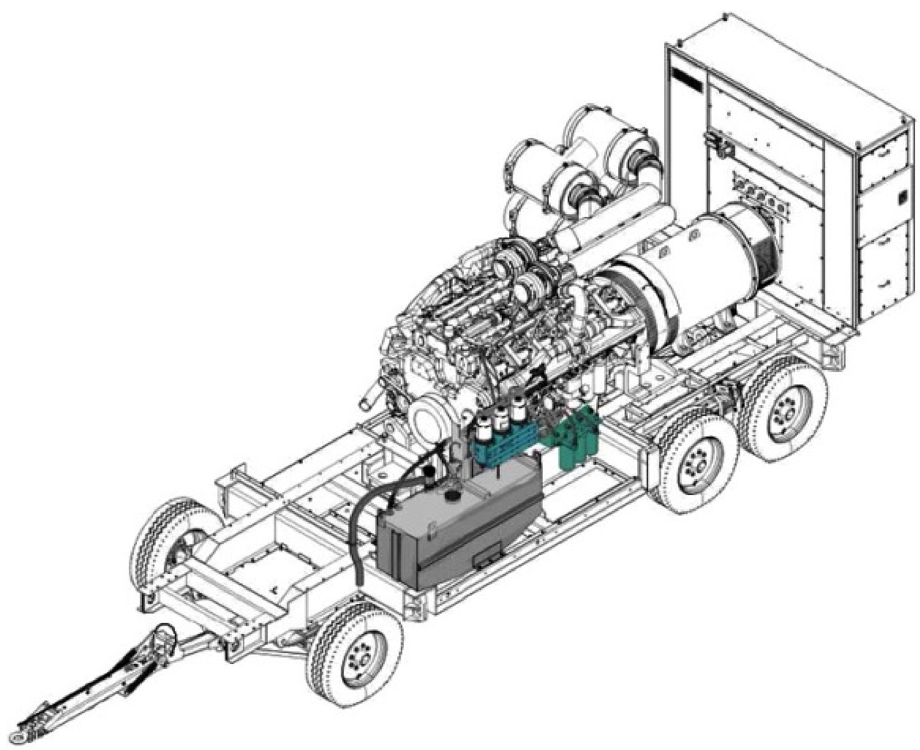


Figure 1–40. Fuel system.

Fuel transfer system

Just like the MEP-12 there is a fuel transfer system that allows for use of an external fuel supply.

Air intake system

The air intake system has four large capacity, dual stage filters with centrifugal pre-cleaner. There is also an exhaust aspiration system that takes large particles and sends them into the exhaust system to be burned up (figs 1–41 and 1–42). The air filter restriction indicators display when the filters need to be changed.

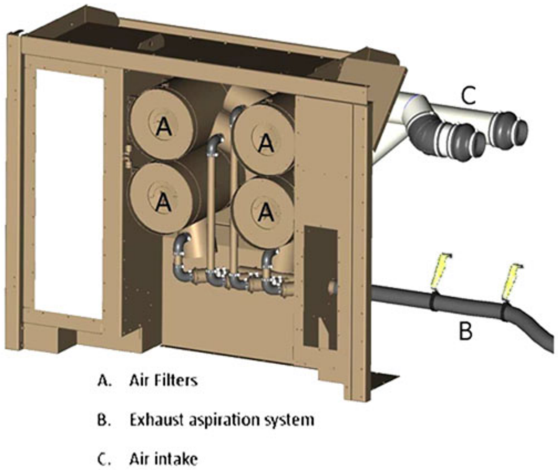


Figure 1–41. Air intake system.

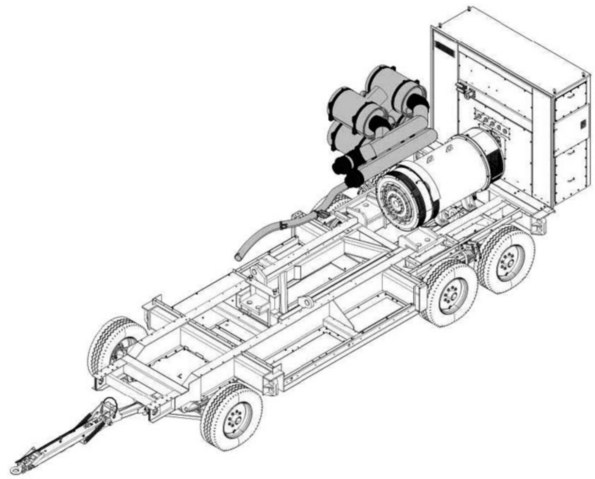


Figure 1–42. Air intake system location.

Exhaust system

The BPU is dual turbocharged and has on large single-can muffler that is located in the same compartment as the radiator fan. Exhaust gases leave through the top of the muffler. See figure 1–43 for location.

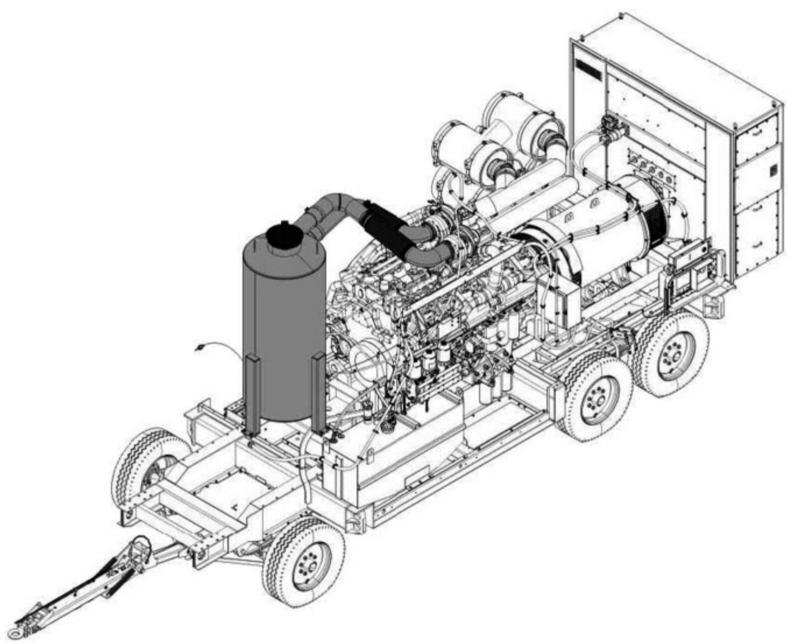


Figure 1–43. Exhaust system location.

DC Electrical system

The DC electrical system is power by 4 12 volt Absorbent Class Mat (AGM) batteries. (Figure 1–44) The battery-charging alternator is used to charge them. These supplies power to the DCS, ECM's, engine starter motors and engine pre-lubrication pump. There is a DC electrical disconnect switch which isolated the DCS and ACM's from the batteries when shutting down the engine. There is

NATO slave and Aircraft receptacles that allow for a battery cart to plug-in to jump start the engine or use while using the winterization kit. See figure 1–45 and 1–46 for system arrangement.

Figure 1–44. Batteries.

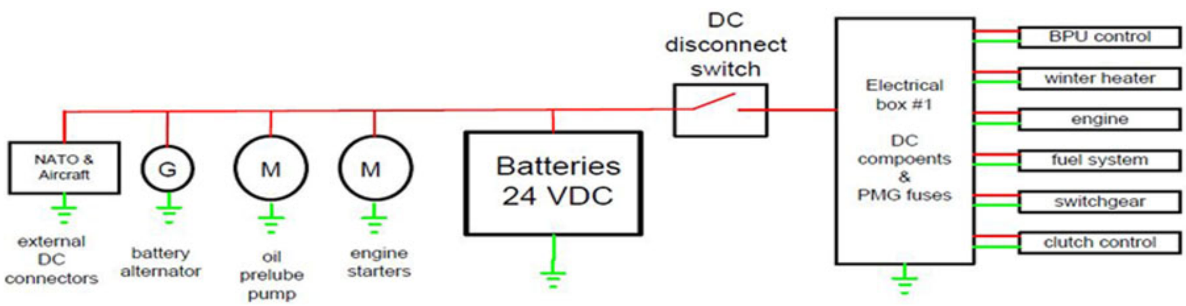


Figure 1–45. DC block diagram.

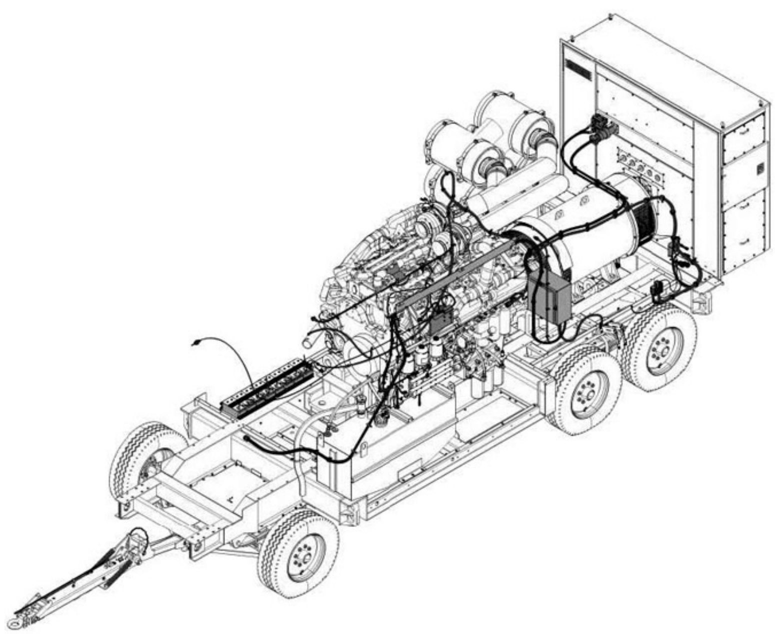


Figure 1–46. DC electrical system.

Safety features

The BPU is equipped with three emergency stop switches, one on each side of the engine compartment and one by the DCS. There are seven safety interlocks in the switchgear that shutdown the generator if one of the high voltage panels is opened. There is a fire extinguisher located on the right side of the generator, to include parking brakes, and audible alarms to alert in the case of faults or warning.

806. Controls and indicators

All local control of the BPU is done through the DCS. It consists of five multifunction soft keys, an alarm silence toggle switch; soft keys for panel lights, AC circuit interrupt, Unit or parallel and fault reset. There is a multifunction switch that has an off, remote, local, and start positions and an emergency stop push button. Finally there are three connectors, the USB connector allows for download of the remote operating panel (ROP) software, Empowers BPU software and the digital technical order. The service connector is available to plug in InPower BPU for diagnostics. Lastly the remote parallel connector allows for remote operations using the ROP software. See figure 1–47 for the digital control system.

Figure 1–47. DCS.

Annunciator

The annunciator gives visual and audible signs of troubles and status of systems within the BPU. It is located directly above the DCS. The indicator lights can reflect a fault, warning or normal operating condition. Refer to figure 1–48.

Green – is for the contactor or synchronization status.

Yellow – Warning condition, this allows for quick repair before it becomes a fault condition.

Red – Fault condition, the alarm will sound when a fault or warning is detected.

Figure 1–48. Annunciator.

Lube oil level sight glass

Like many generators that designed to be ran as prime power the BPU has an oil level sight glass (fig.1–49). It is located next to the oil filters and has two ranges one for when it is running and one for when it is stopped.

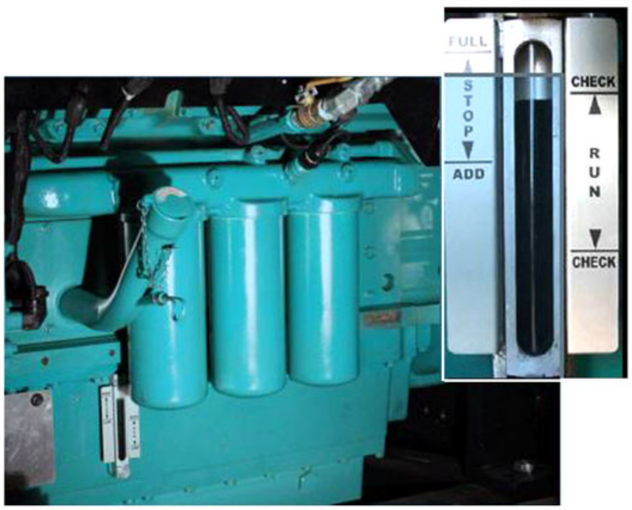


Figure 1–49. Oil site glass.

Coolant level indicator

The coolant level indicator is located in the radiator compartment in the front of the BPU as shown in figure 1-–50.

Figure 1–50. Coolant level indicator.

Other controls

There are several other smaller controls that run smaller systems throughout the BPU. We will go over them based on the electrical box they are located in.

Electrical box 1

Electrical box one is located directly to the left of the DCS. It contains the hour meter, several small relays, fuses and breakers. This area contains the bulk of non-solid state controls for the BPU.

Electrical box 2

Electrical box 2 contains the motor protectors for the cooling fan motor along with the radial and axial fans used to cool the engine compartment.

Box 3

Electrical box three has a humidistat and thermostat. These control heat strips in this compartment to help regulate moisture content. This box also contains a 100 Amp circuit breaker that feeds the cooling fans.

807. BPU operations

This section will cover how position, setup and operate the BPU. Many considerations are the same as the MEP-12, such as laying out a power plant. First subject that we will cover is positioning the generator.

Positioning

Before positioning the generator make sure to consult technical order for the correct procedures. A few things that must be done, they are as follows.

1. Ensure the decompression doors are closed; these are located at the bottom of the generator.
2. Choose a smooth, level surface capable of support the BPU’s weight.
3. Position the BPU so there is a minimum of 15 feet of clearance all around for maintenance and that there is not any overhead obstructions.
4. If position multiple generators, place them close enough together so that the paralling cable can be connected to the DCS of each BPU.
5. Engage the parking brakes, then check the wheels, then disengage the parking brakes.

Grounding

Each BPU contains 3, 3 foot sections, use these to ground the generators.

1. Drive the ground rod 8 feet or more into earth within 6 feet of the BPU, leaving a minimum of 6 inches above ground.
2. When using more than one BPU, create a central ground grid by connecting all BPUs ground rods together with #2 AWG copper conductor ground grid cables.
3. Connect ground cable between slotted chassis ground stud on the rear of the BPU and the ground rod (fig. 1–51 and 1–52).

Figure 1–51. Ground stud trailer location.

Figure 1–52. Ground stud location.

4. Test ground resistance, this must be lower the 25 ohms.

External fuel supply

Fuel connections are made with quick disconnects and fuel at the BPU manifold. See figures1–53 and 1–54 below for location.

Figure 1–53. External fuel supply trailer location.

Figure 1–54. External fuel supply location.

Load break connectors

The load break elbow connectors are compatible with current expeditionary power systems. See figures 1–55 and 1–56 below for locations.

Figure 1–55. Load Break trailer location.

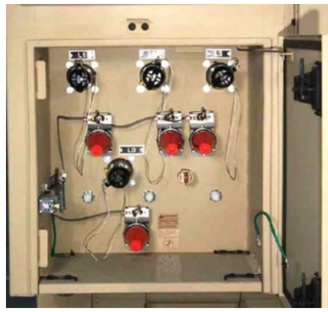


Figure 1–56. Load Break location.

Parallel cable connections

Connect parallel/remote cable to the parallel/remote port on the DCS. Connect additional BPU’s using the parallel remote jumper (fig. 1–57).

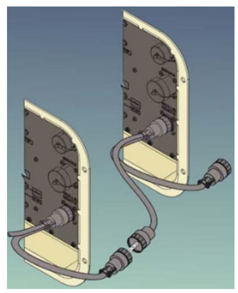
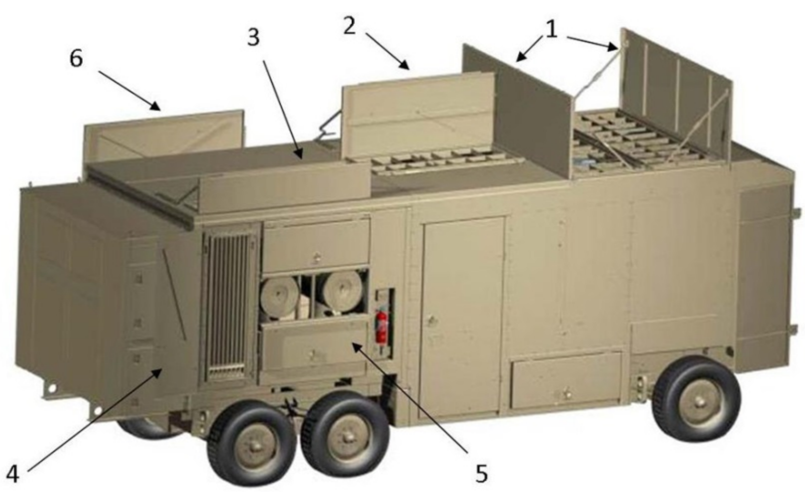


Figure 1–57. Parallel cables.

Pre-operational inspection

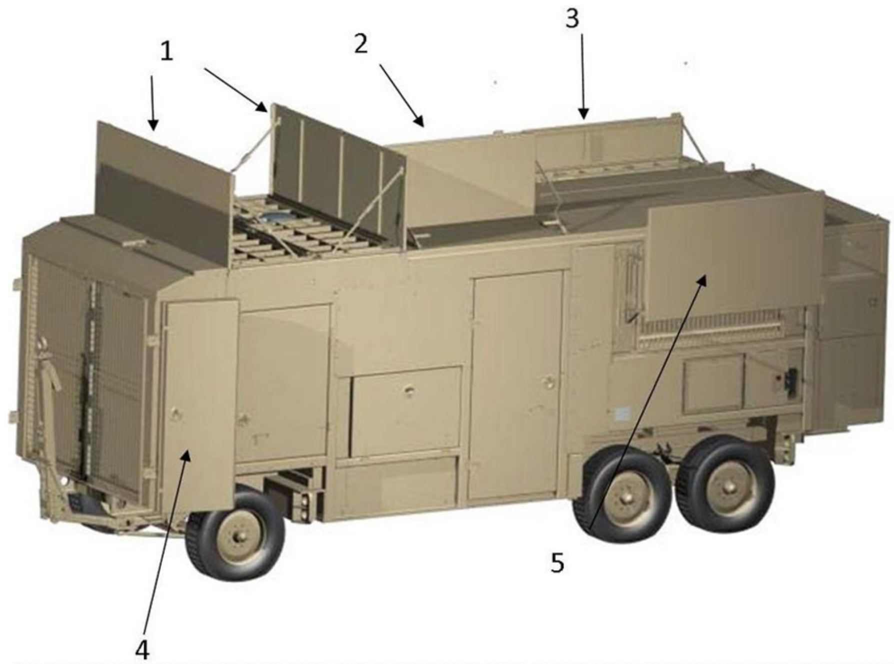
Before starting the generator you must do your preoperational inspections. As always consult the TO before performing this inspection.   We will go over a few of the steps involved in preparing the BPU for operation. Refer to figures 1–58 and 1–59.

1. Ensure the correct grade of oil and coolant is being used.
2. Open and lock air inlet and exhaust doors, see figures below for locations.



1. Radiator outlet door	4. Alternator inlet door
2. Engine outlet door	5. Air cleaner inlet door
3. AC alternator outlet door	6. Cooling air inlet door

Figure 1–58. Inlet doors.



1. Radiator outlet doors	4. Radiator inlet door
2. Engine outlet door	5. Cooling air inlet
3. AC alternator outlet door	

Figure 1–59. Inlet doors.

3. Stow the tow bar and install tow bar lock pin.
4. Ensure tire pressure is at 100 PSI.
5. Ensure wheel chocks are in place.

Starting Procedures

1. Use the labeled figure 1–60 below for reference. Turn DC electrical disconnect switch (1) to the on position. Set local master control switch (2) to local. Pull out the emergency stop switch (3). Push fault reset switch (4) to clear faults.

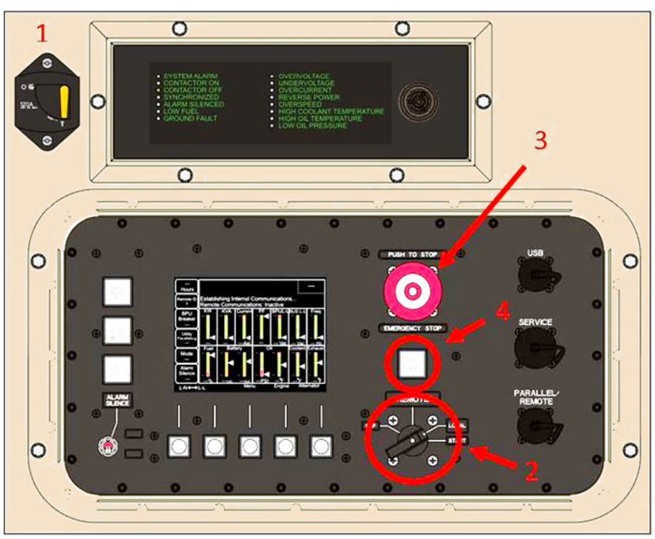


Figure 1–60. DCS.

2. Using the DCS navigate make the following adjustments.
   - On the adjustments screen and set your remote ID and frequency as required.
   - On the service adjustments screen test the alarm and annunciator
   - Go back to main screen and choose your fuel source.
3. Start the BPU by turning the local master control switch to start.
4. Allow the BPU to warm up until status line shows [Running].
5. Monitor operations and ensure the annunciator displays no warning or fault conditions.

Connecting generator to load

Before closing the contactor, ensure no personnel are in contact with load break cables or other switch devices. Once you are sure the area is clear push the AC circuit interrupt key on the operators control panel. The main control screen will display [BPU Contactor Closed] and display values of current bus loading.

Continuing operation

While operating the BPU continue to monitor for fault or warning conditions, monitor your fuel levels, and additionally ensure that proper documentation is completed for power plant operations. If an unsafe or damaging condition occurs you should activate the emergency stop switch.

Shutdown procedures

Once the BPU is no longer needed you will need to shut down the unit.

1. Turn off the supplied load.
2. Push the AC circuit interrupt on the control panel and you should ensure that the BPU contactor indicator says OPEN.
3. Turn local master control switch to OFF.
4. Operate the engine without load until cool down mode ends, the unit will shut down by itself.
5. Push the emergency stop in.
6. Wait until DCS has completed the power down sequence. Then turn off the DC electrical disconnect switch. Failure to comply may result in damage to equipment.
7. Inspect coolant and oil levels, check for leaks and perform any necessary maintenance.

Parallel operations

As discussed before the BPU has three paralleling modes. We will cover running the BPUs in the Isochronous mode.

Setup

To setup for parallel operations you need to ensure the parallel/remote cables area attached to all of the BPUs that are going to be paralleled. There are two paralleling modes, manual and automatic.

Manual paralleling

To manually parallel the BPUs navigate to the adjustments screen and change parallel mode to manual, see figure 1–61.

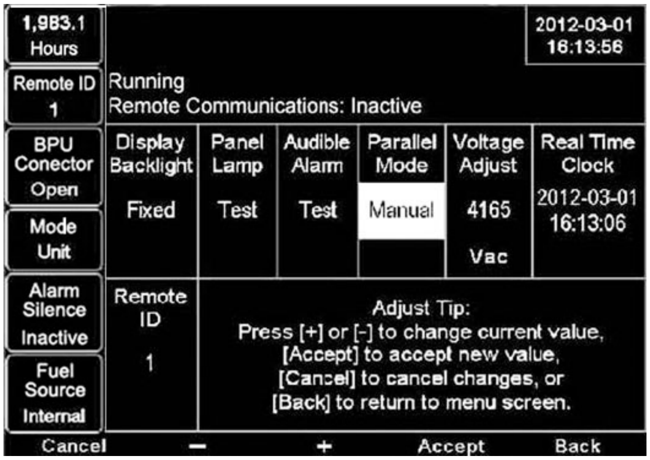


Figure 1–61. Manual parallel mode.

Once switched navigate to the synchroscope screen. Push the AC circuit interrupt button to close the contactor once the generator is synchronized see figure 1–62 below. The speed is automatically adjusted by the DCS and once in phase it will stay in phase.

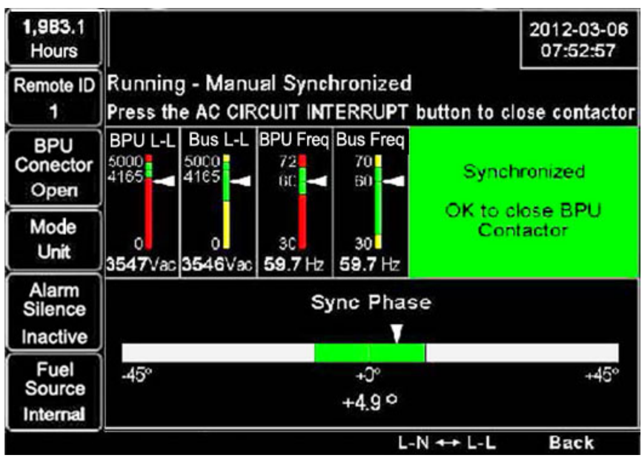


Figure 1–62. Synchroscope screen

Automatic paralleling

Automatic paralleling is exactly how it sounds. Simple go to adjustments screen and make sure parallel mode is in auto, see figure 1–63.

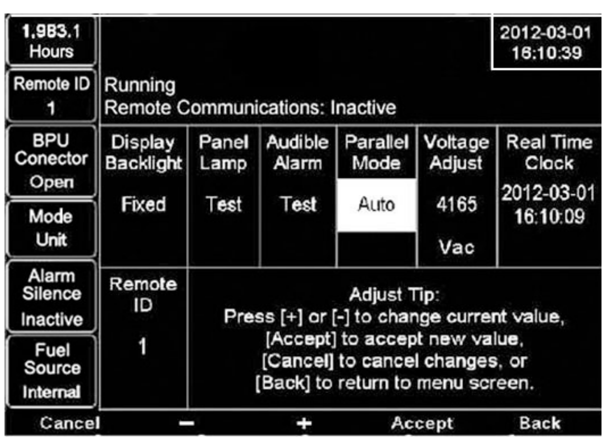


Figure 1–63.Auto parallel mode.

Once you have set the paralleling mode to auto, navigate back to the main screen. Once there simple push the auto/parallel mode button, this will allow the synchronization of the unit and will close the contactor.

Remote operations

Up to this point we have talked about operating the BPU from the control panel on the side of the unit. We will now go into remote operations, before doing this you will have to set-up the remote operating platform (ROP). In order to do this you will need the following items.

- The technical order.
- Suitable computer.
- Remote cable with RS 485 converter and USB cable (included with BPU).

When in the remote mode you can operate up to 12 BPUs with the ROP software. See figure 1–64 for the configuration.

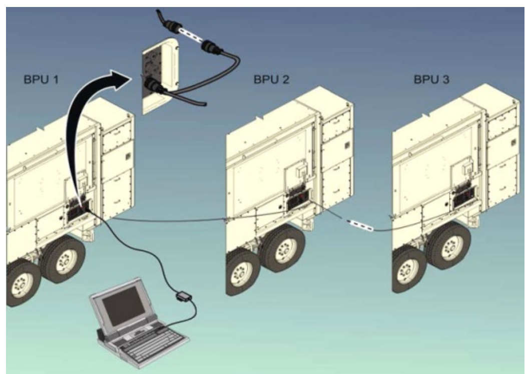


Figure 1–64. ROP cable setup.

Operating using the ROP

When operating BPUs with the ROP, there will be a master screen a detail screen and a configuration screen. The summary screen shows monitoring information for BPU power plant. From this screen you can navigate to individual BPUs and the configuration tabs located at the top of the screen (fig 1–65).

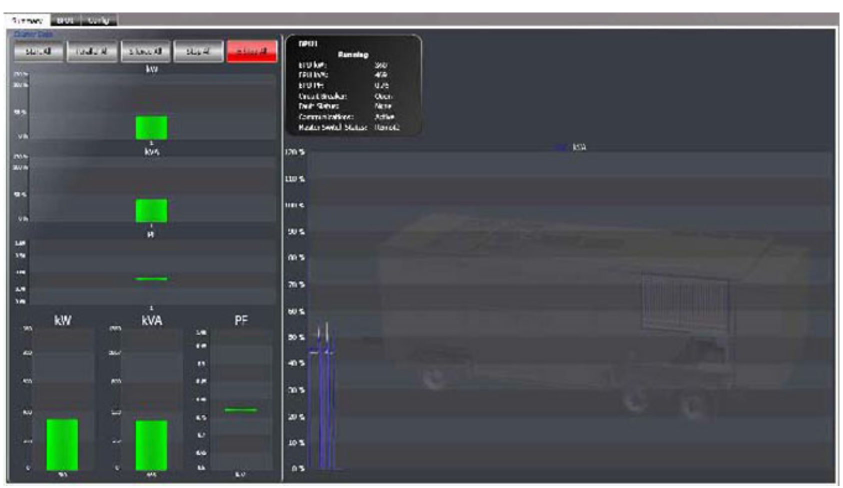


Figure 1–65. ROP Master screen.

The configuration screen provides communication information for each BPU (fig. 1–66).

- Black – Inactive communications.
- Green – Active, non-faulted communications.

- Red – Active, faulted communications .
- When you click on the individual BPU tab you can select the BPU you want to control. Once selected, you will see a screen that looks exactly like the control panel on the BPU, (fig. 1–67) and is operated using a mouse.

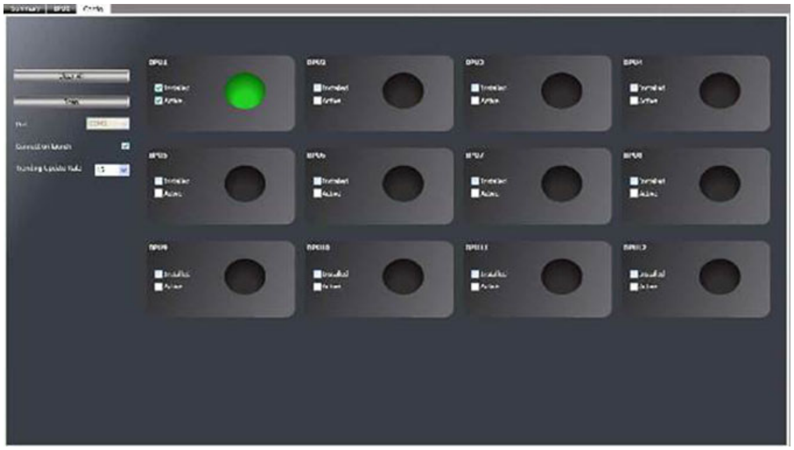


Figure 1–66. ROP Configuration screen.

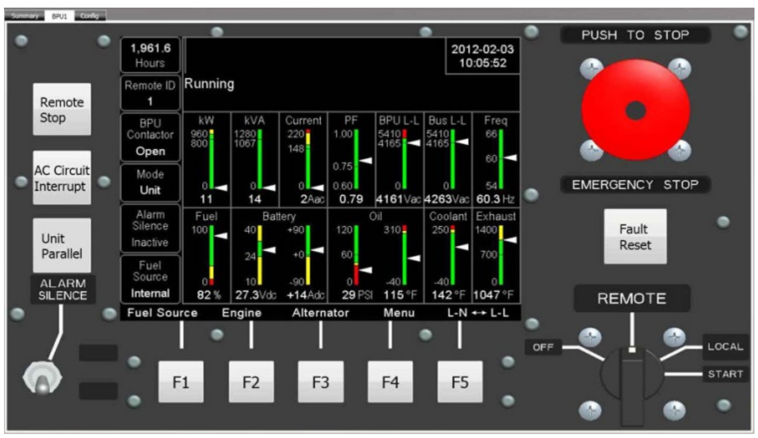


Figure 1–67. ROP individual BPU screen.

Extracting capture files

From the factory the BPU is programmed with parameters that have been tested to operate the BPU at peak efficiency. When you set up your power plant it is a good idea to extract this program, it is called a capture file. This capture file has all the parameters that the BPU uses to control itself. In order to extract these files you must first install the program “InPower BPU.” Just like the ROP software it is stored in the DCS. To download InPower BPU you will need the following items:

- Technical order.
- Suitable laptop.
- USB cable (located in storage box).

Once you download and install EnPower BPU you will be ready to pull capture files, to do this you will need the following:

- Technical order.
- Suitable laptop.
- Remote cable with RS 485 converter and USB cable (included with BPU).

Once you save the capture files you can use them to restore the factory setting on your BPU.

808. Maintenance and repair

Maintenance and repair are essential to running a BPU power plant. We will cover both scheduled and unscheduled maintenance along with troubleshooting is this section. Before we get into the actual work we will cover how to use the BPU technical order.

Technical order

The technical orders for the BPU vary from the standard TO that you may be use to. The TO is divided in to work packages (WP) and subordinate-work packages (SWP). The WP provides major task information and the SWP provide information for tasks with the WP. See figure 1–68 below on how it will appear.

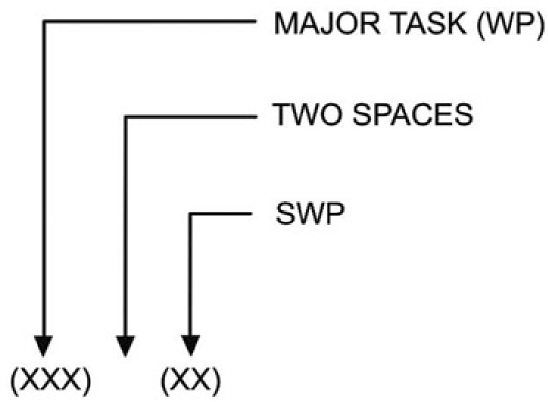


Figure 1–68. Manual structure.

In the table of contents the TO will list where major tasks will be located. From there go to the appropriate work package, that table of contents will tell you where within that work package that task is. For example, refer to figure 1–69 below; let's say that you want to know information on operating the BPU. Look at the title column for operations, to the left, under the WP/SWP No. column, it says 005 00. This means work package 5. So you then will turn to work package 5.

Once in work package 5, figure 1–70 you will see another table of contents that lists out tasks and information and what page it is on. So while looking at the table of contents you can find that pre-operation preparation is in paragraph 7, page 15.

NUMERICAL INDEX OF EFFECTIVE WORK PACKAGES

NOTE

Only those work packages and subordinate work packages assigned to this manual are listed in this index, therefore, WP/SWP numbers may not be sequential.

WP/SWP No.	Change No.	Model Application	Title
001 00	0		ALPHABETICAL INDEX
002 00	0		FOREWORD
003 00	0		MASTER LIST OF SPECIAL TOOLS, TEST EQUIPMENT, AND CONSUMABLES
004 00	0		THEORY OF OPERATION
005 00	0		OPERATIONS
006 00	0		PREPARATION FOR MAINTENANCE

Figure 1–69. Table of contents.

TECHNICAL PROCEDURES

BASIC EXPEDITIONARY AIRFIELD RESOURCES (BEAR) POWER UNIT (BPU)

OPERATIONS

EFFECTIVITY: All

LIST OF EFFECTIVE WP PAGES

TOTAL NUMBER OF PAGES IN THIS WP IS 48 CONSISTING OF THE FOLLOWING:

*Zero in this column indicates an original page.

Page No.	*Change No.	Page No.	*Change No.	Page No.	*Change No.
1–48	0				

TABLE OF CONTENTS

Figure 1–70. Work package 5 table of contents.

Scheduled maintenance

All scheduled maintenance is located in work package 007 00. This work package contains instructions for the following items:

- Periodic and special maintenance.
- Scheduled maintenance.
- Replacement schedule.
- Servicing.
- Corrosion prevention.
- Cleaning.

The DCS will display maintenance item codes once they come due, see figure 1–71.

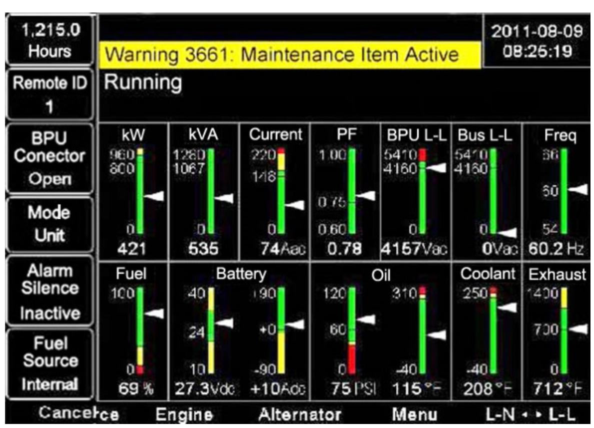


Figure 1–71. DCS maintenance due display.

Periodic and special maintenance

These maintenance items are done in daily intervals and consist of visual and audible inspection to ensure mission readiness. There are tables that list what is required, where in the TO to find the procedures for the item, the interval, applicability which will relates to when it applies and the amount of time it should take to do the task. See special inspection table figure 1–72.

Scheduled maintenance

These intervals are based on operating hours and coolant heater run time. Before performing these tasks make sure to perform the preparation for maintenance in WP 006 00. Always perform post-maintenance operational checkout, located in WP 010 00 after completing the task. The table contains much of the same information at the periodic and special inspection, see figure 1–73.

Table 1. Periodic/Special Inspection Requirements.

Inspection Requirements	Type of Inspection Periodic | Special	Applicability	Man-Minutes
Inspect overall integrity of BPU, check for evidence of corrosion, and remove and replace labels (SWP 009 02) that are damaged.[1]	Daily	All	24
Check radiator for proper coolant level before starting; replenish as required IAW paragraph 6.9. [3]	Daily	All	2
Ensure all coolant heater coolant valves are open before starting.	Daily	All	5

Figure 1–72. Periodic and special inspection table.

Table 2. Periodic/Special Inspection Requirements.

Inspection Requirements	Type of Inspection Periodic | Special	Applicability	Man-Minutes
Drain 5W-30 engine oil IAW paragraphs 6.2, replace oil filters IAW paragraph 6.4, and fill oil IAW paragraph 6.3.	250	All	60
Inspect fire extinguisher (Figure 2) per manufacturer's instructions, and verify charge is correct; recharge or replace as required.	400	All	2
Inspect chassis for proper ground (Figure 2) connection tightness and resistance IAW BPU grounding (WP 005 00).	400	All	1

Figure 1–73. Scheduled maintenance inspection table.

The replacement schedule identifies how often consumables are replaced. Just like scheduled maintenance, the intervals are based on BPU operating hours and coolant heater run time.
Also just like the scheduled maintenance, before performing these tasks make sure to perform the preparation for maintenance in WP 006 00 an always perform post-maintenance operational checkout, located in WP 010 00 after completing the task. The table will list replacement frequency, System

No., Nomenclature, Part No., Quantity, and Man-minutes required for completing the task. See figure 1–74 for an example.

Replace-ment Frequency	System No.	Nomenclature	Part No.	Quantity	Man-Minutes
250 (5W-30)/400 (15W-40)		Oil filters	LF9050	3	60
400		Corrosion resistor	3318319	2	12
400		Primary fuel filters	FS19763	3	45
400		Secondary fuel filters	FF5782	3	45
400		Coolant heater nozzle	330 00 222	1	6
1200		Coalescers	CV5063300	3	60
2400		Check valve	A034P397	1	30
2400		Hose	A034P241	2	30
2400		Clamp	0503-1133	3	30
3200		Coolant heater burner	25 2501 99 10 00	1	30
4000		Battery-charging alternator belt	3649080	1	60
4800		Coolant heater heat exchanger	25 2501 06 00 00	1	30
12000		Battery-charging alternator	4086503	1	60

Figure 1–74. Replacement schedule table.

Electrical maintenance

There are several electrical maintenance checks to be done. These are done in two separate intervals. Just like all inspections these are located in WP 007 00. The two intervals are at 400 and 8800 hours. The BPU T.O. refers as to the switchgear area and medium voltage. Do not let this fool you this unit produces 4160 VAC and that voltage can be present in the switchgear cabinet.

WARNING:
Before conducting any maintenance, ensure that the generator has been made safe for the maintenance that you are going to perform. Failure to do so may result in severe injury or death.

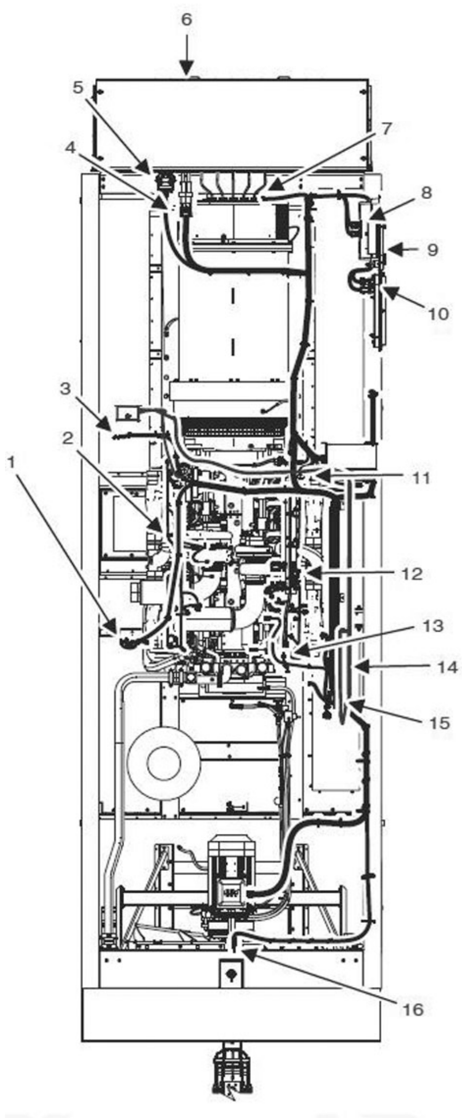
400 hour electrical maintenance

Other than visual inspections of wiring the only required maintenance is to inspect switchgear terminals for proper ground connections. Check the resistance of the terminals; they should have less than 25 ohms. Also check the chassis grounds for security.

8800 hours electrical maintenance

Along with the 400 hour maintenance; the 8800 hour inspection includes inspecting all AC and DC connections and verify proper connection torque. To do this, follow the steps outline in the figure below.

- Open doors for Electrical box 1, 2 and 3, see figure 1–75.
- Remove DCS.
- Remove the switchgear panels, the right side louver panel.
- Remove electrical cover from cooling fan motor.
- Remove the cover from the NATO and aircraft receptacles connections.
- Inspect all AC and DC wiring for insulation chaffing, nicks, cuts, crimps/crushing, corrosion, loose connections, or any other type of damage. As you can see from the figures 1–75 and 1–76 below there are a ton of areas to inspect.



CONNECTION DESCRIPTION	ITEM NUMBER
AC BOX	11
ANN	8
AMBIENT PRESSURE	12
BATTSEN	1
BREAKER	6
CAMSHAFT SPEED/POSITION	13
CAN	11
CHILD ECM CONNECTOR #1	12
CHILD ECM CONNECTOR #2	12
CN1	10
CN2	10
COOLANT LEVEL	16
COOLANT PRESSURE SENSOR	2
CRANKCASE PRESSURE	2
CRANKSHAFT SPEED/POSITION	11
DCS	9
ECM (FUEL PRIMING PUMP)	14
ENG	11
ENGINE COMPARTMENT TEMPERATURE	13
ENGINE COOLANT TEMPERATURE	13
ENGINE OIL RIFLE PRESSURE	12
E–STOP1	14
E–STOP2	3
FFHTR1	15
FFHTR2	15
FFHTR3	14
FIELD	7
INJECTOR ACCUMULATOR PRESSURE	12
FUEL PRIMING PUMP	14
FUEL PUMP	14
FUEL PUMP DELIVERY PRESSURE	12
FUEL SEN	15
FUEL SOL	14
FUEL TEMPERATURE	12
FUELSW	15
HEATER1	1
HEATER2	1
HORN	12
INTAKE MANIFOLD PRESSURE	12
INTAKE MANIFOLD TEMPERATURE	12
LEFT BANK EXHAUST TEMPERATURE	12
LEFT BANK TO RIGHT BANK	11
LIFT PUMP	2
OIL TEMPERATURE	14
OILSW	11
P1	8
P2	8
P3	8
PARENT ECM CONNECTOR #1	12
PARENT ECM CONNECTOR #2	12
PC1	5
PC2	5
PC3	4
PMG	7
RIGHT BANK EXHAUST TEMPERATURE	2
RIGHT BANK TO LEFT BANK	11
SOLENOID	13
VALVE SOLENOID	13
WATER IN FUEL	14

Figure 1–75. BPU wiring harness.

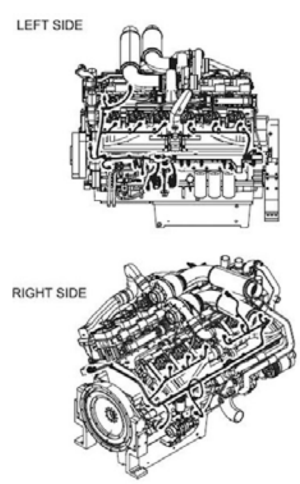


Figure 1–76. ECM wiring harness

- Torque all connections as required by the technical order. There are over 30 items that must be torqued during this inspection.
- Repair any damaged wiring.
- Tighten all of the switchgear connections.
- Reinstall the DCS.
- Reinstall the switchgear panels and right side louver panel.
- Reinstall the covers for the cooling fan motor, NATO and aircraft receptacles.
- Close the doors to electrical box, 1, 2 and 3.

Mechanical Maintenance

When operating BPUs, following the periodic inspection requirements will guide you in developing a good maintenance program. The required maintenance is at a minimum, there are several other things that can be done based upon the environment you are operating in. We will cover the basic mechanical inspection; this takes place in a 400 hours interval.

400 hour mechanical inspection

The 400 hour inspection will occur on a generating running prime power every 16 days or so. Refer to the technical order for precise information on performing these maintenance tasks.

- Inspect coolant heater, clean sir supply and exhaust systems. Replace nozzle only after 400 hours of actual winterization kit run time or annually. The run time can be found on the service adjustments screen on the DCS.
- Replace corrosion resistors.
- Change the oil (15W-40) and oil filter. If you are using 5W-30 oil it must be replaced every 250 hours.
- Replace primary and secondary fuel filters.
- Grease front engine support.

1200 hours mechanical inspection

The 1200 hour inspection consists of performing a 400 hour inspection along with the following items.

- Inspect and clean crankcase breather and replace coalescers.
- Cycle parking brake.
- Inspect fuel strainer.

1600 hours mechanical inspection

Perform the 400or 1200 hour inspection plus the following.

- Inspect isolators for cracking.
- Grease cooling fan drive belt tensioner.

These are some of the mechanical maintenance items that need to be accomplished. Check the T.O. for the rest of the items that have to be accomplished.

Troubleshooting

When operating a BPU you will eventually have to troubleshoot a problem. As always remember the troubleshooting steps.

1. Perform an operational check.
2. Analyze the malfunction.
3. Locate the malfunction.
4. Perform corrective action.
5. Perform operational check.

Troubleshooting the BPU is unlike any other military spec generator that the Air Force has used. It contains an on board diagnostic program that is integrated with the DCS. In other words, it will tell you information of what is wrong and where to go to isolate. Within the TO it is called fault isolation with can be found in WP 008 00.

Fault isolation

There are three methods to fault isolation for the BPU.

- DCS fault code isolation.
- Symptom-based fault isolation.
- Individual component testing.

DCS fault code isolation

When you get a code on the DCS reporting a problem you will want to go to the fault isolation and corrective action troubleshooting chart located in WP 008 00. On the left hand side will be the code number. In the middle will be the probable cause and on the right is the corrective action. If you notice in figure 1–77 [Warning 144: Coolant Temp OOR High] the OOR means out of range.

Table 1. Fault Isolation and Corrective Action - Continued.

Trouble	Probable Cause	Corrective Action
	2. Open or short.	Test engine oil rifle pressure sensor IAW paragraph 8.10.
[Warning 143: Oil Rifle Pressure Low]	Oil pressure malfunction.	Isolate fault IAW code 415.
[Warning 144: Coolant Temp OOR High]	Engine coolant temperature sensor malfunction.	Test engine coolant temperature sensor IAW paragraph 8.10.
[Warning 145: Coolant Temp OOR Low]	Engine coolant temperature sensor malfunction.	Test engine coolant temperature sensor IAW paragraph 8.10.
[Warning 146: Coolant Temp High]	High engine coolant temperature.	

Figure 1–77. DCS fault isolation.

Symptom-based fault isolation

There may be times where a fault occurs and the BPU will not have a fault code. At this point you will want to go to the symptom base fault isolation table located in WP 008 00. It will list the trouble, probable cause and corrective measure. Figure 1–78 shows an example.

Individual component testing

When testing individual components you can refer to settings table in WP 008 00. This will allow you to see what the parameters are for a certain setting or component. It will also show how it is adjusted weather manually with the DCS or with InPower BPU. See figure 1–79 below for an example.

Table 2. Fault Isolation and Corrective Action.

Trouble	Probable Cause	Corrective Action
DCS does not illuminate or power on.	1. DCS EMERGENCY STOP switch pushed in or DC electrical disconnect switch off or tripped.	1. Ensure DCS EMERGENCY STOP switch is off and fully extended.
		2. Ensure DC electrical disconnect switch is in ON position.
		3. Perform test preparation IAW paragraph 6 without starting BPU. If DC electrical disconnect switch trips once moved to ON position, proceed to probable cause 4.
		4. If DC electrical disconnect switch will not reset, test IAW paragraph 8.9.
	2. Low battery voltage.	Test batteries IAW paragraph 8.8.
	3. Loose connection.	

NOTE

Grounding straps do not need to be removed when removing DCS. Each connector (P1, P2, and P3) will be removed and installed to ensure proper seating and installation.

Trouble	Probable Cause	Corrective Action
		Remove DCS (SWP 009 03), and ensure each connector (P1, P2, and P3) is fully seated into DCS. Replace DCS (SWP 009 03) once all connectors have been checked.

Figure 1–78. Symptom base fault isolation.

Parameter	Default	Lower Limit	Upper Limit	Units	Description
[Alternator L3 Current Calibration] (InPower BPU)	100	90	110	%	Calibrates the alternator L3 current displayed value by the given percentage.
[Average Voltage Adjust] (InPower BPU)	1.000	0.9	1.1	%	Used to field calibrate the BPU output voltage against an external meter.
[AVR Gain] (DCS), [AVR Gain Adjust] (InPower BPU)	1	0.05	10	#	Used to adjust the AVR gain.
Axial Fan Motor Protector in ELECTRICAL BOX #2	2.6	2.5	4.0	amps	Used to set the overload protection for the axial fan.
Battery-Charging Alternator and Voltage Regulator Switch Set Point	28	27.5	28.5 or 29	VDC	Switch on rear of voltage regulator is used to set the maximum output voltage of the battery-charging alternator.

Figure 1–79. Settings table

Wiring diagrams

Being familiar with the diagrams for the BPU is important during troubleshooting. These diagrams will help you guide your way through the generator to locate components and faults. We will briefly go over the diagrams and how to extract a circuit.

Identifying sheet numbers

BPU diagrams are unique to Cummins Power Generation and are different than the diagrams you may have used before such as for the MEP-806 Mil-Spec generator. To assist in tracing circuits across several sheets, the diagrams use continuation indicators that will provide direction to a specific sheet to continue tracing the circuit to another sheet.

Each BPU diagram, or sheet, has a number assigned to it. As a circuit path leaves the page you will see circle with two letters and a number, this is a continuation indicator. The two letters are a reference point and the number designates what sheet you need to refer to. If you look at the continuation indicator in figure 1–80A below, it tells you to refer to sheet 1, reference point AH.

Figure 1-80B shows a side-by-side comparison. If you look at the top reference circle on sheet 1 you will see an AA over a number 5. Now look to sheet 5 for the reference AA. This is the same *black* wire that has just continued onto a different sheet.

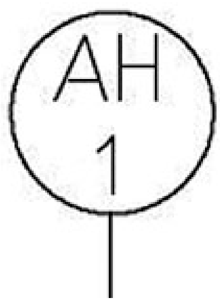


Figure 1–80A. Continuation Indicator.

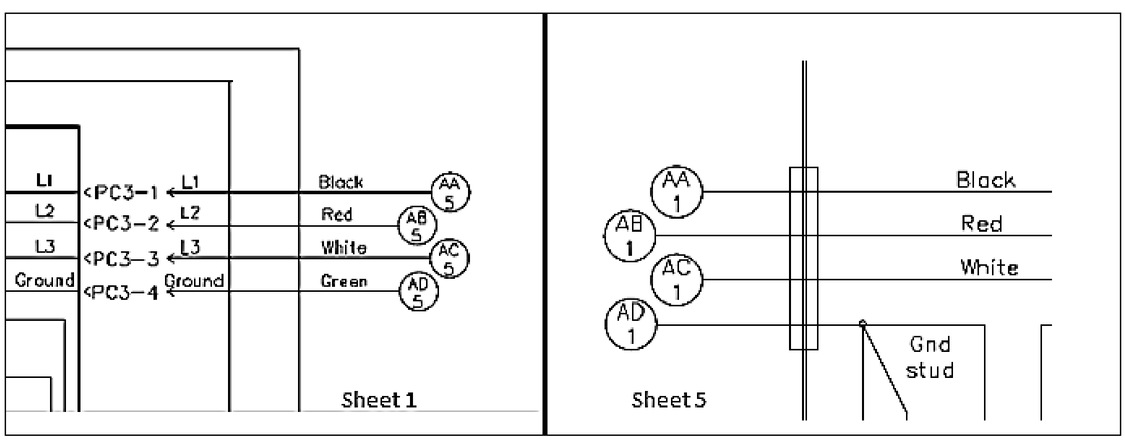


Figure 1–80B. Example of continuation indicators

Navigating sheets

As an example, if you are unable to read the generator current on A phase. Go to foldout 10 and look for the highlighted lines. This is where the signal for A phase current comes into the DCS. On this page you will see that the path for the signal goes through connect P3 pins A and b. Next look at the reference it is telling you that this continues on sheet two. Sheet 2 is located on foldout 11. Find the highlighted lines. As you can see the reference on the bottom is BE and BF, the same as on sheet 3. The path continues through connector PC2 through pins 1 and 2.

Now that you know the path it is time to find the connectors. To determine this look at foldout 12 in the TO it is labeled at sheet 1 of 11. Then first locate PC2, it shows that it is item five and located in the alternator compartment. To see what the connection looks like and what tines it goes through the sheet refers you to figure 1 of sheet two. Foldout 13 is what sheet 2 looks like. It shows a graphical representation of the connector and which pin is which, additionally, it tells you the destination of each wire in the connector. When reading the table it says “From Station” this means where it start on this sheet. The “To Station” column tells you what connector it goes to and the pin number on that connector. As you can see it is telling us it goes to P3-A and P3-b. This is located on sheet 6 and is figure 1. Go to foldout 14, this is sheet 6 as it appears in the T.O. In this foldout it shows the layout of your pins and how the connector goes into the DCS.

Electrical Safety

Just like the MEP-12 if not properly isolated from the bus portion of the BPU lethal voltages will be present even the generator is shut down. Refer to foldout 11 to see these areas. Once again we are dealing with the bus sensing. Start at the BPU electrical output terminals. Remember that this is 4160 VAC at this point. Follow the red highlights to see where the voltage goes. As you can see there is 4160 present all the way up to the main circuit breaker. Additionally, voltage travels through three fuses then through voltage transformers 4, 5, and 6. From there, now 120 VAC, it travels through connector PC 2 pins 13, 14, 15 and 16. Next you will have to go to sheet 3 (foldout 10) there you can see it connects to the DCS through P1 pins G, T, S and E.

The BPU is the Air Force’s newest prime power plant. In the future these will be making it out to deployed locations and replacing the MEP-12 fleet, so it is important to be familiar with the system so you will be able to operate and maintain them effectively.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

805. Construction and system features

1. How many kW are provided when the BPU is operating at 60Hz?

2. How many PP paralleling modes are available for the BPU, and what are they?

3. What component(s) are supplied power from the 75 kVA power transformer in the switchgear?

4. What type of fuel system does the BPU use?

5. The four large capacity, dual-stage filters are part of which system?

6. Which component will isolate current between the DCS and the batteries?

806. Control and indicators

1. What are the three colors of lights on the annunciator and what do they tell us about the generators operation?

2. What are the two ranges on the lube oil site glass?

3. Where is the 100 amp circuit breaker that feeds the cooling fans located?

807. BPU operations

1. Where are the decompression doors located?

2. How much clearance is required when positioning BPU?

3. What distance must a ground rod be from a BPU?

4. What is used to guide you through a pre-operational inspection?

5. Which DCS screen is used to test the annunciator?

6. Why must you wait for the DCS to shut down?

7. What button is used to manually sync the BPU?

8. What button do you push to automatically sync the BPU?

9. What is needed to download the ROP software?

10. What are the three color indicators on the configuration screen and what do they mean?

11. What is needed to download the InPower BPU software?

808. Maintenance and repair

1. How is the BPU's technical order organized?

2. What type of maintenance is found in WP 007 00?

3. Where are the preparations for maintenance instruction found?

4. Where is the post-maintenance operational checkout instructions located?

5. What electrical inspection requires the removal of the DCS?

6. How often do you change 15W-40 oil and oil filter on the BPU?

7. How often do you inspect and clean crankcase breather and replace coalescers?

8. What are the three ways to troubleshoot the BPU?

Answers to Self-Test Questions

801

1. 1 miliampere (.0001 amps).
2. Use only qualified electrical personnel.

802

1. Seven-day fuel supply.
2. Only formally trained personnel.

803

1. Zero droop.
2. The synchroscope must be activated in order for the output circuit breaker to close.
3. Motorization is when a generator is connected to the bus but is not carrying any load. Additionally when this occurs the generator is being powered by the other generators on the bus, thus acting as a motor.
4. Crosscurrents are wasted power. Crosscurrents are normally caused by differences in output voltage of generators sharing a common bus.

804

1. The oil should be changed every 300 hours of operation.
2. The fuel filters should be changed every 250 hours of operation.

805

1. 800kW
2. 3 modes: Isochronous, droop and utility.
3. Radiator and engine compartment cooling fans.
4. Modular Common Rail System.
5. Air intake system.
6. DC electrical disconnect switch.

806

1. Green is for Contactor or synchronization status. Yellow is for a warning condition and red is for a fault condition.
2. (1) Running
   (2) Stopped
3. Electrical box 3

807

1. The bottom of the generator.
2. 15 feet on all sides.
3. Within 6 feet.
4. Technical order.
5. Service adjustments screen.
6. Equipment damage.
7. AC circuit interrupt button.
8. Auto/parallel mode button.
9. The technical order, Suitable computer and remote cable with RS 485 converter and USB cable (included with BPU.
10. (1) Black – Inactive communications
    (2) Green – Active, non-faulted communications
    (3) Red – Active, faulted communications
11. Technical order, Suitable laptop and USB cable (located in storage box).

808

1. Into work packages (WP) and subordinate work packages (SWP).
2. Periodic and special maintenance, scheduled maintenance, replacement schedule, servicing, corrosion prevention and cleaning.
3. WP 006 00.
4. WP 010 00.
5. 8800 hours.
6. 400 hours.
7. 1200 hours.
8. (1) DCS fault code isolation
   (2) Symptom-based fault isolation
   (3) Individual component testing

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to ECI (AFIADL) Form 34, Field Scoring Answer Sheet.

Do not return your answer sheet to AFIADL.

1. (801) Normally the alternating current (AC) volts found within the mission essential power (MEP)–12 bare base equipment can be how high?
   a. 120.
   b. 208.
   c. 600.
   d. 4,160.

2. (801) What happens if electrical current between 100 and 200 milliamperes is absorbed by the body?
   a. Skin burns.
   b. Muscles relax.
   c. Contacted areas blister.
   d. Instant death from heart failure.

3. (801) Who *must* perform the isolation of a mission essential power (MEP)–12 generator from a primary distribution center (PDC)?
   a. Qualified electrical systems personnel.
   b. Qualified power production personnel.
   c. Qualified electrical systems and/or power production personnel.
   d. Any civil engineer personnel.

4. (801) Identify the voltage that is considered *high* voltage. High voltage is any voltage exceeding
   a. 120 volts, alternating current (VAC).
   b. 600 VAC.
   c. 480 VAC.
   d. 277 VAC.

5. (802) The mission essential power (MEP)–12 generator is rated for which power factor?
   a. .75.
   b. .85.
   c. .8.
   d. .9.

6. (802) What is the *maximum* distance a MEP–12 can be operated when using a remotely located control panel?
   a. 150 yards.
   b. 15 yards.
   c. 50 feet.
   d. 150 feet.

7. (802) Mission essential power (MEP)–12 generators are positioned so that the prevailing winds blow
   a. across the radiator fan.
   b. across the side of the generators.
   c. in the same direction as the radiator fan.
   d. in the opposite direction the radiator fan.

8. (802) What can you do to prevent the brakes from being applied during backing of a mission essential power (MEP)–12 generator?
   a. Use a tow strap.
   b. Block the surge brakes.
   c. Back the vehicle quickly.
   d. Disconnect the brake lines.

9. (802) What is the *maximum* towing speed you are allowed to tow a mission essential power (MEP)–12 diesel generator on paved surfaces?
   a. 5 miles per hour (MPH).
   b. 10 MPH.
   c. 20 MPH.
   d. 30 MPH.

10. (802) At a bare base site, how many days of fuel is expected to be maintained at each prime power generation location?
    a. ⅓.
    b. 3.
    c. 7.
    d. 10.

11. (802) How many connections does a fuel bladder have?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

12. (802) How many feet tall should the berms be to contain a possible fuel spill at a mission essential power (MEP)–12 fuel system layout?
    a. 1½.
    b. 3.
    c. 3½.
    d. 4.

13. (803) During a pre-operation inspection on a mission essential power (MEP)–12 generator the voltage regulator switch should be in which position?
    a. Manual.
    b. Auto.
    c. Asynchronous.
    d. 30 droop.

14. (803) When starting a mission essential power (MEP)–12 which event(s) take place when the engine toggle switch is released to the run position?
    a. The engine will accelerate to rated speed.
    b. The voltage regulator will flash the field.
    c. The engine will shut down.
    d. The engine will accelerate to rated speed and the voltage regulator will flash the field.

15. (803) How often should you perform running checks during the time that the mission essential power (MEP)–12 generator is online?
    a. At least once a shift.
    b. At least once an hour.
    c. No more than once a shift.
    d. No more than once an hour.

16. (803) Meter readings are recorded on a mission essential power (MEP)–12 generator every
    a. half hour.
    b. hour.
    c. two hours.
    d. four hours.

17. (803) Motorization of a generator occurs when
    a. there is some load on the generator while it is still connected to the bus.
    b. all load has been removed after the generator is disconnected from the bus.
    c. all load has been removed from the generator while it is connected to the bus.
    d. there is some load on the generator after it has been disconnected from the bus.

18. (803) Which meter readings indicate motorization of a generator?
    a. The kilowatts (kW) meter is above zero, the ammeter is reading amperage, and the power factor (PF) meter is moving off scale.
    b. The kW meter at zero or lower, the ammeter reading zero, and the PF meter is moving off scale.
    c. The kW meter at zero or lower, the ammeter is reading amperage, and the PF meter is reading unity.
    d. The kW meter at zero or lower, the ammeter is reading amperage, and the PF meter is moving off scale.

19. (803) How are crosscurrents between parallel generators *minimized* if the bus voltage is low and the power factors (PF) are different?
    a. Lower the voltage to all units.
    b. Raise the voltage to the lag unit.
    c. Raise the voltage to the lead unit.
    d. Lower the voltage to the lead unit.

20. (803) How are crosscurrents between parallel generators *minimized* if the bus voltage is low and the power factors (PF) are the same?
    a. Raise the voltage to all units.
    b. Raise the voltage to the lag unit.
    c. Lower the voltage to the lead unit.
    d. Lower the voltage to the lag unit.

21. (803) How are crosscurrents between parallel generators *minimized* if the bus voltage is high and the power factors (PF) are the same?
    a. Lower the voltage to all units.
    b. Raise the voltage to the lag unit.
    c. Raise the voltage to the lead unit.
    d. Lower the voltage to the lead unit.

22. (804) Typically mission essential power (MEP)–12 generators are scheduled for maintenance after operating for
    a. one year.
    b. thirty days.
    c. 300 hours.
    d. 1,000 hours.

23. (804) When removing mission essential power (MEP)–12 oil filters how many *main* filters are replaced?
    a. 4.
    b. 3.
    c. 2.
    d. 1.

24. (804) What is the *last* step in performing a 300 hour mechanical preventative maintenance inspection (PMI) on a mission essential power (MEP)–12 generator?
    a. Run up the engine to ensure that no leaks are present.
    b. Update the historical records.
    c. Clean radiator.
    d. Add oil.

25. (804) What is the ratio of the T4-T9 transformers on a mission essential power (MEP)–12 generator?
    a. 10:1.
    b. 15:1.
    c. 20:1.
    d. 30:1.

26. (804) What size fuses are inspected on the CB5 during a high voltage inspection on a mission essential power (MEP)–12 generator?
    a. 175 Amp.
    b. 155 Amp.
    c. 140 Amp.
    d. 170 Amp.

27. (804) When using a MEP–12 ladder diagram the positive side of the diagram is located on the
    a. left side.
    b. right side.
    c. top of the diagram.
    d. bottom of the diagram.

28. (804) When using a crew/operator troubleshooting chart in a mission essential power (MEP)–12 TO what should you do if you see the following statement: refer to the next higher level on maintenance?
    a. Call your boss.
    b. Turn in the generator to depot.
    c. Guess what is wrong.
    d. Proceed to the organizational troubleshooting chart.

29. (805) How many paralleling modes can a basic expeditionary airfield resources (BEAR) power unit (BPU) operate in?
    a. 3.
    b. 2.
    c. 1.
    d. 4.

30. (805) Which power factor is the basic expeditionary airfield resources (BEAR) power unit (BPU) alternator rated?
    a. .80.
    b. .85.
    c. .75.
    d. .70.

31. (805) How is the radiator fan speed controlled on the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. Thermostat.
    b. Viscous clutch.
    c. Humidistat.
    d. Variable frequency drive (VFD).

32. (805) What is the preferred fuel for the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. JP–8.
    b. Diesel.
    c. JP–4.
    d. Jet A1.

33. (805) What is the *maximum* time the basic expeditionary airfield resources (BEAR) power unit (BPU) can run on a full day tank?
    a. 1 hour at 50 percent load.
    b. 30 minutes at full load.
    c. 1 hour with no load.
    d. 1 hour at full load.

34. (806) Where is the coolant level indicator located on the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. Inside the engine compartment.
    b. Outside the radiator compartment.
    c. Inside the radiator compartment.
    d. Next to the control panel.

35. (806) Where are the motor protectors located on the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. Electrical box 1.
    b. Electrical box 2.
    c. Electrical box 3.
    d. Electrical box 4.

36. (806) What resource is used to regulate moisture in electrical box 3 on the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. Cooling fans.
    b. Heat strips.
    c. Circuit breakers.
    d. Fuel fired heaters.

37. (807) Where are the decompression doors located on the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. The top.
    b. In the front.
    c. At the rear.
    d. On the bottom.

38. (807) If more than one basic expeditionary airfield resources (BEAR) power unit (BPU) is installed which copper conductor ground grid cable size *must* be used to connect them to the ground grid?
    a. #6 AWG.
    b. #2 AWG.
    c. #8 AWG.
    d. #10 AWG.

39. (807) Which screen on the basic expeditionary airfield resources (BEAR) power unit's (BPU) digital control system (DCS) is the fuel source selected?
    a. Main.
    b. Adjustments.
    c. Service adjustments.
    d. Engine adjustments.

40. (807) What are the three tabs in the basic expeditionary airfield resources (BEAR) power unit's (BPU's) remote operating platform (ROP) software?
    a. Master, configuration, and setup screens.
    b. Details, communication, and configuration screens.
    c. Communication, configuration, and master screens.
    d. Master, detail, and configuration screens.

41. (807) In the basic expeditionary airfield resources (BEAR) power unit's (BPU's) remote operating platform's (ROP) configuration screen what three colors provide information on communication?
    a. Black, green, and red.
    b. Red, green, and yellow.
    c. Blue, yellow, and green.
    d. Red, blue, and black.

42. (807) What is used to extract capture files from the basic expeditionary airfield resources (BEAR) power unit (BPU)?
    a. Remote operating platform (ROP) software.
    b. InPower BPU.
    c. The digital control system's (DCS) diagnostics program.
    d. BPU capture program.

43. (808) The basic expeditionary airfield resources (BEAR) power unit's (BPU's) technical order dived up into
    a. work packages and subordinate work packages.
    b. work packages only.
    c. chapters.
    d. paragraphs and sub-paragraphs.

44. (808) When performing a 400 hour electrical inspection on the basic expeditionary airfield resources (BEAR) power unit's (BPU's) switchgear, what is the required resistance reading for the ground connections?
    a. Less than 30 ohms.
    b. Less than 35 ohms.
    c. Less than 26 ohms.
    d. Less than 25 ohms.

45. (808) When performing a 400 hour mechanical inspection on the basic expeditionary airfield resources (BEAR) power unit (BPU) where can total run time for the coolant heater be found?
    a. Engine run hour meter.
    b. Hour meter on the heater.
    c. The auxiliary hour meter.
    d. The service adjustments screen on the digital control system (DCS).

46. (808) How often is the oil changed on the basic expeditionary airfield resources (BEAR) power unit (BPU) when using 15W–40?
    a. Every 250 hours.
    b. Every 400 hours.
    c. Every 300 hours.
    d. Every 500 hours.

47. (809) Which type of electrical distribution *layout* provides two or more paths for current flow to a facility?
    a. Loop.
    b. Open.
    c. Radial.
    d. Closed.

48. (810) How many 60-amp outputs are included on the secondary distribution center (SDC)?
    a. 10.
    b. 12.
    c. 14.
    d. 16.

49. (810) What is the amperage rating of the mission essential circuit breaker on the secondary distribution center (SDC)?
    a. 60 amps.
    b. 100 amps.
    c. 150 amps.
    d. 250 amps.

50. (811) How many lights make up the light mast on the TF–2 light cart?
    a. 2.
    b. 4.
    c. 6.
    d. 8.

51. (812) How often is oil changed on the TF–2?
    a. Every 250 hours.
    b. Every 300 hours.
    c. Every 400 hours.
    d. Every 350 hours.

52. (812) How long does it take for the light bulbs on the TF–2 to warm up?
    a. One to two minutes.
    b. Four to six minutes.
    c. Two to four minutes.
    d. Four to five minutes.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Contingency Equipment

WHEN WE DEPLOY to a bare base, we will work with some equipment we are not as familiar with. Understanding this equipment is necessary to the completion of the mission. Looking at the equipment, we sometimes wonder why we are working with it because it is the electrician's primary job. Remember we work hand-in-hand with electricians during contingency operations. We must know their equipment so we can assist them whenever needed. Likewise they learn about our equipment to provide us with help. Let's start with the electrical distribution systems.

2-1 Electrical distribution

Electrical distribution is divided into two areas, primary and secondary. Primary distribution voltage of the bare base environment is 4160 VAC and is used for distribution to each secondary distribution center (SDC). Secondary is the usable voltage after it is transformed by the SDC into 120/208 VAC. Secondary circuits are the low voltage circuits providing the customer with power to operate equipment. These next two lessons look at both primary and secondary distribution systems. The first area we will cover is primary distribution.

809. Primary distribution system

The distribution of power throughout the base is essential to the completion of the mission. Distribution includes both primary and secondary circuits and all of the equipment associated. The primary circuits are the high voltage circuits distributed throughout the base. This lowers the amount of line loss of voltage getting to the customer.

Primary distribution

The primary distribution electrical system basically consists of two major components: power generation and high-voltage primary distribution. Mobile Electric Power–12 (MEP) or Bear power unit (BPU) generators are capable of producing 4,160 volt, alternating current (VAC), which usually provide the *primary* high-voltage power. High-voltage cables route the power to a primary distribution center (PDC) or a primary switching center (PSC) and then to the secondary distribution center (SDC).

The electrical systems personnel have the primary responsibility to layout and install the distribution system. We provide additional labor to install the system so we can power the base more quickly. Having an understanding of the requirements allows us to be better assistants, as well as point out areas that do not make sense.

Safety

Safety during installation and continued safety for personnel using the equipment are the primary concern. Remember we are working with a high-voltage system. The work crews responsible for installing the electrical system at the bed down location must include qualified electricians. They must also have the proper tools to accomplish the job. The labor crew must have working knowledge of the system to make sure to meet all safety requirements. This is not an area where inexperienced volunteers can augment the workforce.

Construction factors

Installation of the electrical system is basically a two-phase approach. The first phase provides power to critical facilities through the use of low-voltage Mobile Electric Power (MEP) generators. Critical facilities typically include the airfield, command post, initial deployment kitchen (IDK) complex, water plant, fire department, as well as other necessary facilities. The second phase establishes the high-voltage distribution system. This is when we install the power plant and other associated equipment.

Distribution layout

There are two general methods of arranging a distribution system to the various facilities at the force bed-down location. These methods are the radial layout and the loop layout.

Radial layout

The radial layout, shown in figure 2–1, has individual branch lines that run from the PDC or PSC to the various SDCs. We often use this layout for small contingencies and during the initial stages of the deployment.

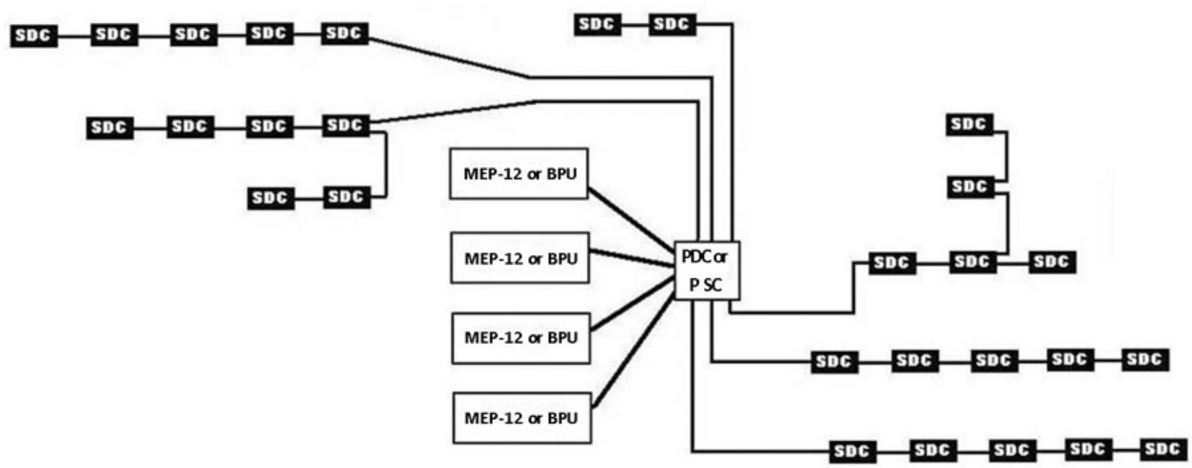


Figure 2–1. Electrical distribution, radial layout.

The primary *advantage* of the radial system is that it requires considerably less material, manpower, and time to construct. A key *disadvantage* of the radial system is that it is more susceptible to damage from disasters or enemy attacks. One well-placed shell can disrupt large portions of the camp through electrical failure.

Loop layout

A loop layout, shown in figure 2–2, is a layout in which two or more PDC or PSC feeder circuits supply power to the customer. A physical connection from the output bushings of one SDC or PSC to the input bushings of another SDC or PSC makes the looping.

The loop system has the *advantage* of having two or more paths for current flow to a facility. This creates an inherent resistance to complete loss of power to facilities. This is a critical feature to prevent complete power outages after an attack. The main *disadvantage* of the loop system is that it requires more material and time to construct than the radial system.

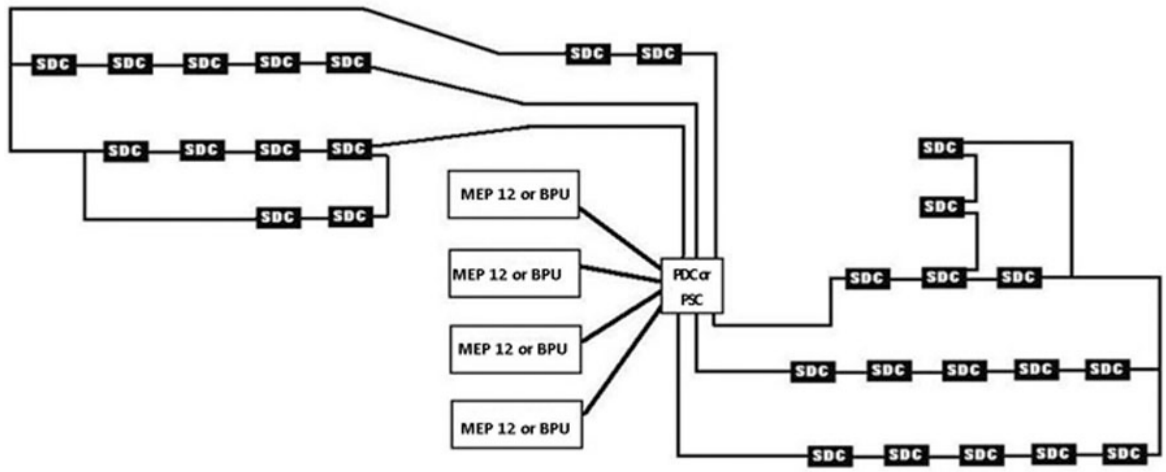


Figure 2–2. Electrical distribution, loop layout.

Primary distribution center

The PDC, shown in figures 2–3 and 2–4 are a high-voltage switching station. It serves as a connection point for the power plant generators and a connection and isolation point for the primary distribution circuits.

Figure 2–3. Primary distribution center.

Electrical configuration

The PDC has four three-phase inputs on the line side and six three-phase outputs on the load side. The connection points use bushing wells and bushing well inserts that accept 200-amp load-break elbow terminations.

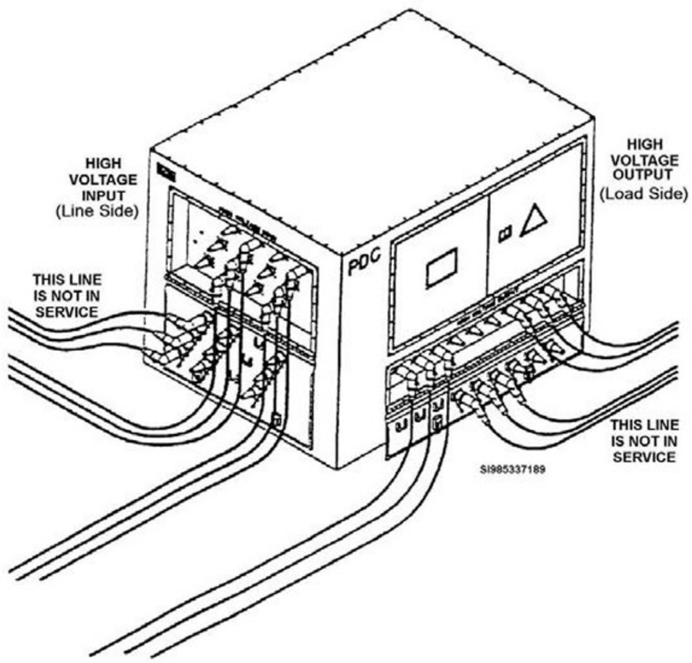


Figure 2–4. Primary distribution center.

Primary switching center

The PSC is a high-voltage switching station (fig. 2–5). Like the PDC, serves as a connection point for the power plant generators and a connection and isolation point for the primary distribution circuits.

Since the PSC is also quite large, we should use a 10K adverse terrain forklift to set it in place. Choose nearly level ground surface with a minimal slope to prevent it from moving for the installation of the PSC. The area should also provide adequate water drainage to prevent puddles from forming.

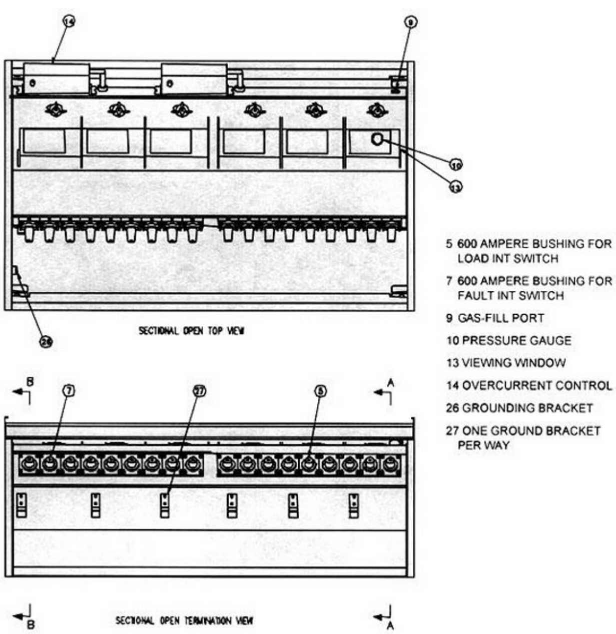


Figure 2–5. Primary switching center.

Electrical configuration

The PSC has six connections called ways, shown in figure 2–4. Two of these ways have load interrupter switches while the other four have fault interrupter switches. Way 1 and 2 have the load interrupter switches. We use these as inputs from the generators. Way 3, 4, 5, and 6 have fault interrupter switches we use as output feeders. We can use way 1 or 2 as outputs, but we lose circuit protection. The fault protection settings, trip points, can be set on way 3 thru 6. The factory setting for way 3, 4, and 5 is 200 amps. The 200 amp setting is based on the current limitations of the high voltage cable. The factory setting on way 6 is 400 amps. The 400 amp setting is based on using way 6 to parallel TWO primary switches together to support 4 BPUs or MEP-12 generators.

810. Secondary distribution center

During the initial phases of bed down, critical facilities require power immediately. Those facilities can't wait weeks for us to establish the high voltage system; therefore, we install the secondary distribution first. The power needed for those facilities receives power from SDCs, powered by low voltage MEP generators. We can anticipate that MEP generators will power SDCs for up to 15 days before completing the installation of the high voltage grid. The secondary distribution includes the SDC, power distribution panel (PDP), and the low voltage cable.

Installation

We base the layout of each facility on obtaining maximum dispersal compatible with the electrical distribution system assets that are available in the bare-base equipment package. In the event our deployment is to a low-threat area not requiring maximum dispersal, we may use minimum spacing between facilities. This non-dispersed pattern reduces cable requirements considerably. Exercise caution by not extending any individual branch circuit beyond the point where the cable has a voltage drop greater than three percent. As a general practice, limit the maximum length of any branch circuit to not more than 800 feet. The site for the electrical equipment should be level, well drained, and clear of any brush, large rocks or other obstacles that might make the equipment unstable.

Secondary distribution center

The SDC is your main point for distribution of secondary voltage; it consists of a dry-type transformer that steps down the 4,160–VAC primary to 120/208–VAC, three-phase, low-voltage power. The SDC is capable of accepting power directly from a PDC, a loop feed from another SDC, or through a low-voltage generator. The components of the SDC are broken down in TO 35CA2–2–10–1.

The secondary side of the SDC consists of the panel board bus, circuit breakers, and 60-amp cannon plug connectors. These connectors provide connection points for the secondary feeder cables, which in turn feed out to the PDPs in the various facilities. A manual transfer switch enables the secondary side (secondary bus) of the SDC to accept power directly from the MEP generator or from the secondary transformer windings.Therefore, in the case of a primary power failure or maintenance actions, the SDC can accept power from a MEP generator that is connected through the mission essential receptacle.

CAUTION: During normal operations, this MEP generator may remain connected while the SDC receives the primary 4,160-volt power. However, we should never accomplish transfer from MAIN to MISSION ESSENTIAL power under load.

Each SDC has sixteen 120/208-output circuits that are capable of supplying 60 amps per phase, shown in figure 2–6. The secondary feeder cables are five-wire, #6 AWG copper wires with 600-volt THW insulation; they have a rating of 60 amps. Some SDCs have provided storage space large enough for four 100-foot and two 50-foot lengths of secondary cable.

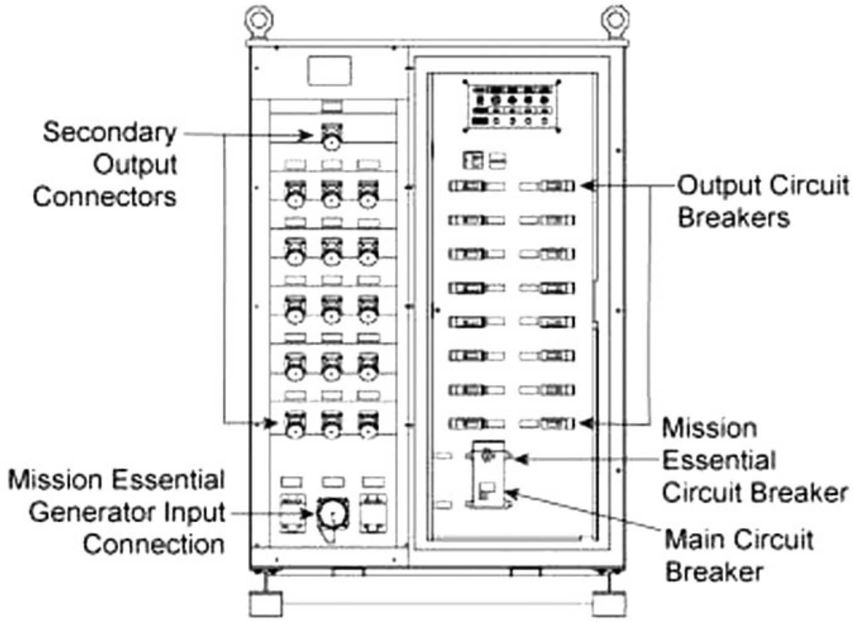


Figure 2–6. Secondary side of SDC.

Power distribution panel

The PDPs are circuit breaker panels that receive 120/208-volt power from the SDC and divide it into separate circuits to run a facility's heating, ventilation, and air conditioning (HVAC), lighting, and utility outlet systems. PDPs are placed where power is required, and electrical cables are connected.

The PDPs are available in a wide range of sizes (15 kW, 25 kW, 30 kW, 60 kW, 100 kW, and 200 kW) and serve a wide range of functions. The larger PDPs (i.e., 60 kW, 100 kW, and 200 kW) can provide service as distribution centers to other PDPs and major loads, as shown in figure 2–10. Smaller PDPs usually serve a single facility. The 25 kW and the 15 kW PDPs normally support a single facility and its associated environmental control unit. See figures 2–7, 2–8, and 2–9 for examples.

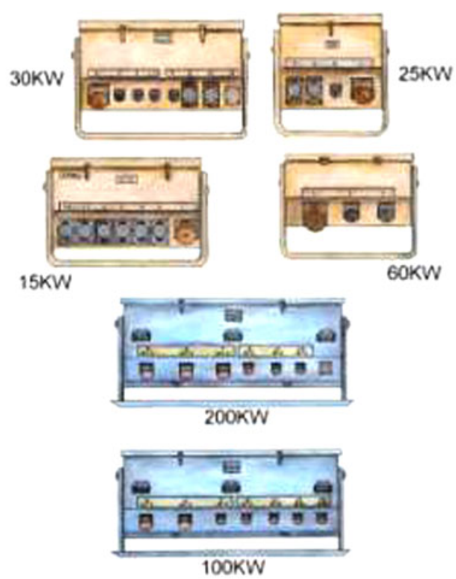


Figure 2–7. PDP.

Abbreviations and Acronyms

AC	alternating current
AFCEC	Air Force Civil Engineer Center
AGM	absorbent glass mat
BEAR	basic expeditionary airfield resources
BPU	BEAR power unit
DC	direct current
DCS	digital control system
EA	engineering assistant
ECM	electronic control module
IDK	initial deployment kitchen
kV	kilovolts
kVA	kilo Volt-Amps
MEP	mobile electric power
mph	miles per hour
NATO	North Atlantic Treaty Organization
OOR	out of range
PDC	primary distribution center
PDP	power distribution panel
PSC	primary switching center
RM	risk management
ROP	remote operating panel
RPM	revolutions per minute
SDC	secondary distribution center
TO	technical order
USB	U serial bus
VAC	volts alternating current
VDC	volts direct current
WP	work packages

Student Notes

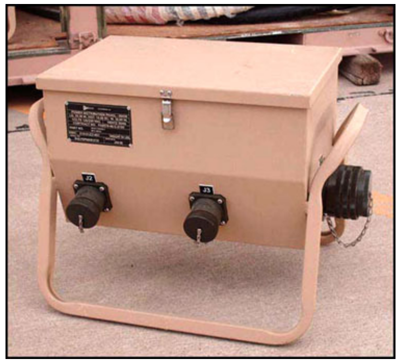


Figure 2–8. PDP.200 Amp.

Figure 2–9. PDP.60 Amp.

We associate the 25 kW PDP with the tent extendible modular personnel (TEMPER) tent. It has one 120/208-volt cannon plug input; one 120/208-volt cannon plug output (usually for an environmental control unit), four 20-amp 120-volt outputs for lighting, and one 25-amp 120-volt convenience outlet.

The 15 kW PDP has one 120/208-volt cannon plug input, one 120/208-volt cannon plug output for an environmental control unit, and twelve 20-amp 120-volt outputs for lighting/convenience outlets.

The 15-, 25-, and 30-kW PDPs have smaller, 60-amp cannon plug connections. In the case of the 60-, 100, and 200-kW PDPs, we may have to hard-wire some models through the bottom of the unit, or they may have the larger 200-amp cannon plug connection.

Secondary cable assemblies

Bare-base secondary cable assemblies come in 200-amp and 60-amp sizes. The 200-amp cable is 25 feet long, used to connect the low-voltage MEP generator to the SDC (fig. 2-10). One 200-amp cable comes with each 60- and 100-kW MEP generator. The 60-amp cables come in lengths of 50 and 100 feet, shown in figure 2–11. We use these cables to connect shelters and electrical equipment to the SDCs or PDP. Figure 2-11 and 2-12 show a typical installation using these cables.

Figure 2–10. Secondary power cable.

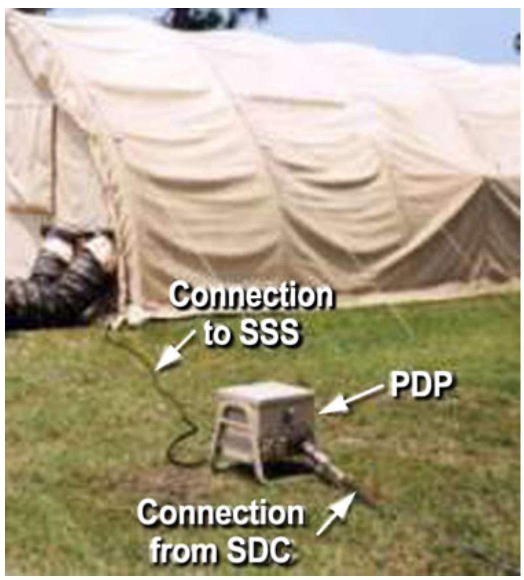


Figure 2–11. Secondary power cable connections.

Figure 2–12. Secondary power cable connections to ECU.

Secondary distribution center

As we know, the SDC changes the high voltage created by the power plant generator into a usable voltage for the customer. We can connect both high voltage and low voltage generators directly to the SDC to provide the necessary power required to support the mission.

High voltage

The high voltage connections work the same way as connecting the generator to the PDC. The electricians will make these connections since they receive the proper training and have the necessary personal protective equipment. The generator connects to the high voltage inputs of the SDC.

Low voltage

We also have the capability to connect a standard MEP series generator to the SDC. We use this configuration during the initial setup of the electrical grid to provide power to the customers while we are setting up the power plant and electrical grid. Once the power plant is operational, we use these smaller MEP series generators as emergency backups.

We use a 200 amp cable to connection the MEP series generators to the SDC. The connection point is under the output connections. The cable uses quick connect ends with keyed slots to make sure the connection is correct. The generator may or may not have a quick connect plug on it.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

809. Primary distribution system

1. How many three phase outputs does a PDC have?

2. How many PSC are needed to support four generators?

810. Secondary distribution system

1. How can a SDC receive power?

2. Bare-base secondary cable assemblies come in what two sizes?

3. What size of cable is used to connect a MEP series generator to a SDC?

2–2 Telescopic floodlight set

Telescopic floodlight sets play an important in both the building and the maintenance of a bare base. These are used to light up work sites, tent areas and even aircraft parking ramps. When deployed you will definitely need to know how to operate and repair these units.

811. Overview

There are several different types of light carts. However TF-2 light carts are the primary bare base portable lighting system. Within this lesson we will cover the construction features, installation operating, and repair of these units.

TF-2 construction features

The TF-2 telescopic floodlight set, shown in figure 2–13, consists of a three cylinder, water cooled, 6 kW diesel engine driven generator mounted on a two-wheel trailer. The trailer has a parking brake to keep it in place during operation. The trailer also has outriggers to stabilize it during operation. This allows us to raise the mast of the light tower while limiting the possibility of tipping the trailer over.

The mast consists of a three-section steel tube that extends up to a height of 29 feet. The mast includes self-lubricating nylon guide pads and a 360-rotatable light bar that holds four floodlights. The mast uses a hand crank winch to raise the mast from its horizontal position for travel to the vertical position for operation. The mast also uses a second hand crank winch to extend the telescoping sections. This raises the floodlights into position.

The floodlights are 1,000 watt, clear BT–37 Metal Halide lamps that produce 110,000 lumens of light per lamp. These lamps require between two and four minutes to warm-up to provide maximum lighting. They also require ten to fifteen minutes to restart if the lamp goes out during operation. This is due to the need to cool down before restarting.

The trailer consists of a welded steel frame and a protective housing. This allows the generator and control circuitry to remain out of the weather. The trailer contains a pintle hook and landing gear, which allows us to tow the unit up to 55 miles per hour (MPH) on smooth surfaces and 10 MPH on uneven surfaces. The trailer is also equipped with fork lift pockets mounted on the mast that can be used as an alternate mode of movement.

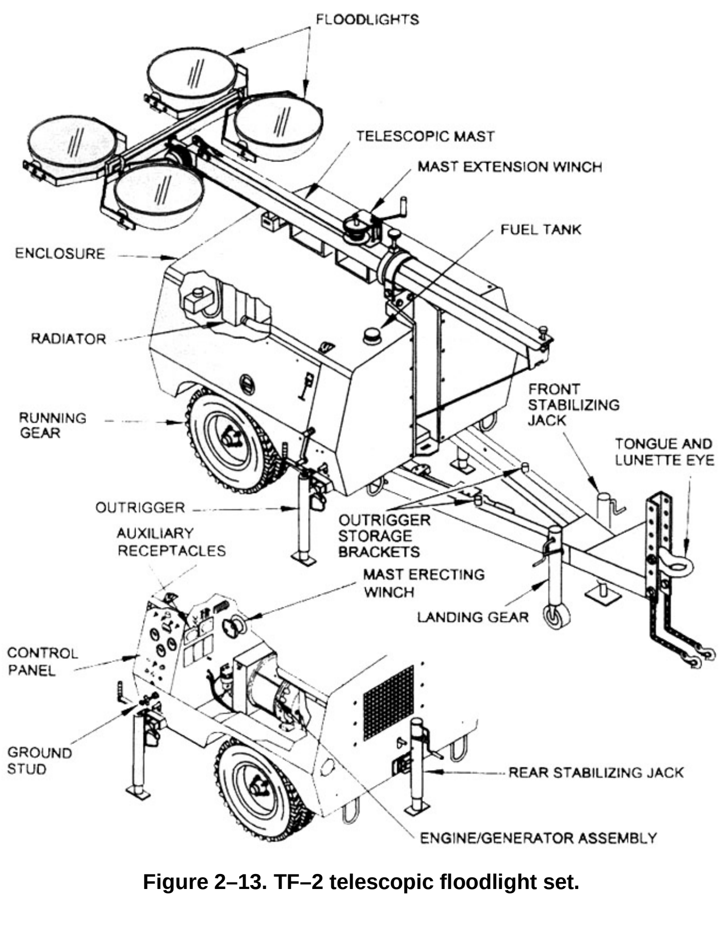


Figure 2–13. TF–2 telescopic floodlight set.

Installation

We must install the floodlight set properly before we can operate it. Figures 2–14 and 2–15 show the installation components. This begins as we pull the floodlight into position. The areas should be as level as possible. Set the parking brakes and lower the front stabilizer before unhooking the trailer from the vehicle pintle hook. Place the rear jack and both outrigger jacks into the vertical position. These jacks have securing pins that should secure them into place.

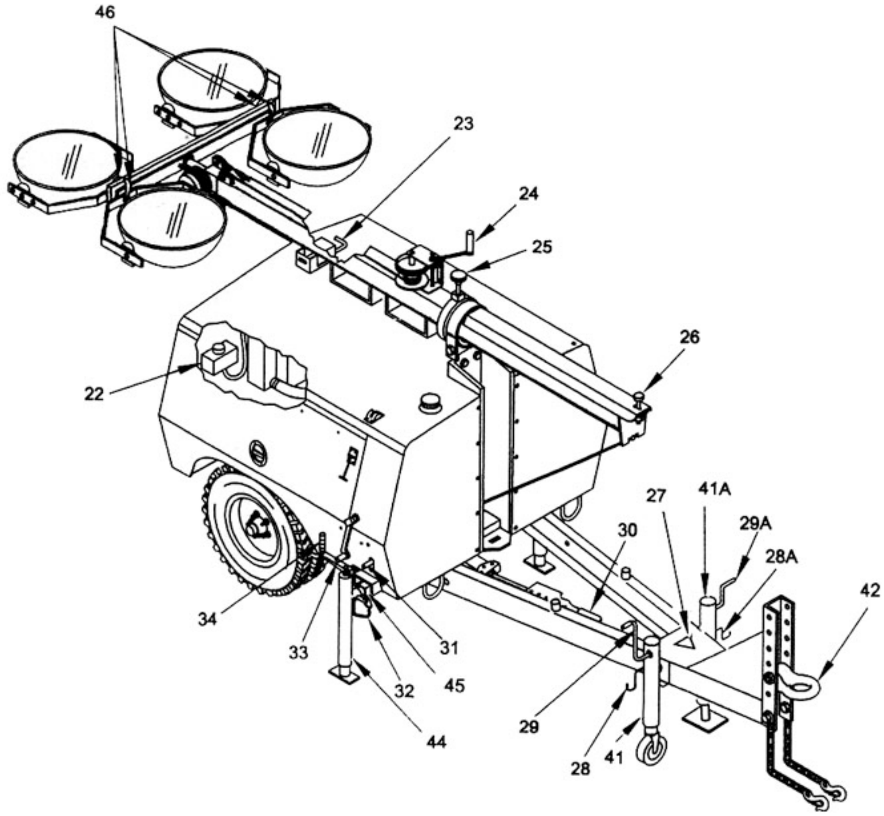


Figure 2–14. Front controls and indicators.

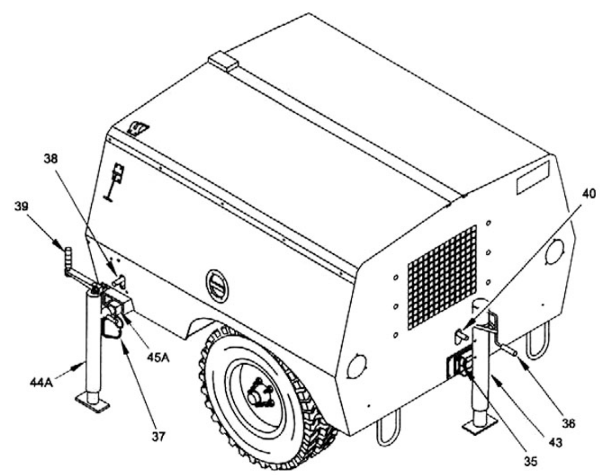


Figure 2–15. Rear controls and indicators.

Once all of the jacks are in the vertical position, lower them to the ground. Once all of the jacks are on the ground, look at the level gauge on the front of the trailer. Adjust the jacks using the hand cranks until the gauge indicates the trailer is level.

Once the trailer is level, open the engine compartment doors, locking them open. The lights mount inside the engine compartment. We must remove them to attach them to the mast. Be sure to tighten the handle nuts and plug in the receptacles. The last item in the installation is to install a ground rod and connect it to the ground stud on the trailer.

Now that we have positioned and installed everything, we raise the mast. To do this, release the mast support saddle latch. Rotate the mast erection crank to raise the mast from the horizontal to the vertical position. Once the mast is completely erect turn the vertical mast lock knob clockwise to engage the striker plate. Then tighten the knob with the lock engaged into the striker plate. This locks the mast into the vertical position. We are now ready to inspect and operate the floodlight set.

812. Maintenance and operation

We must inspect the floodlight set before operation to make sure it is in safe operating condition and all of the systems meet the operational requirements.

Inspect

Start by checking the oil level of the engine. The level should be at the full mark. Add the proper grade of oil as necessary and change the engine oil every 250 hours of operation. Next check the coolant level by looking at the engine coolant recovery bottle. The level should be at the COLD level mark. Add the proper mixture of coolant as necessary. Make sure the fuel level is at the level necessary to accommodate the length of the planned run. Finally, take a look at the entire system to see if anything looks out of place. We must use our hands, nose, and eyes as we do this.

Operation

Understanding how to operate the floodlight set allows us to light areas with and without power available. The operations include starting the generator, raising and lowering the mast, and turning on and off the lights. Refer to figure 2–16 while reading through the operations of the floodlight set.

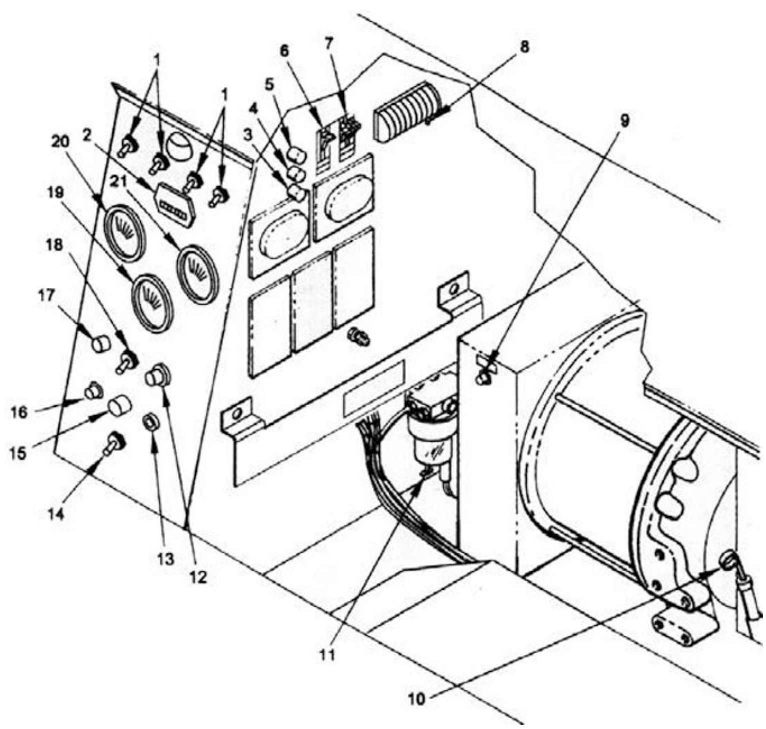


Figure 2–16. Control panel.

First we must make sure all four of the tower lamp circuit breaker switches are in the OFF position. Then we turn the master control switch to the ON position. Next press and hold the fault bypass push button switch. We will hold this switch until the generator has started. Next press and hold the glow plug engage switch for ten seconds. While still holding the fault bypass and glow plug engage switches, press the starter switch. The engine will begin to turn. Once the engine starts, release the starter switch while continuing to hold the fault bypass and glow plug engage switches for another five to ten seconds before releasing. Observe the gauges to make sure the generator is operating normally.

To raise the mast, we rotate the mast extension crank clockwise until the mast reaches the appropriate height. We can also rotate the mast by loosening the mast rotation lock knob and using the rotate handle to position the mast to the desired position. Once we have the mast where we want it, turn the lamp circuit breakers to the ON position. The lamps will not immediately illuminate because they must warm up first. This may take two to four minutes. To shut the floodlight set down, place the lamp circuit breakers to the OFF position. Also make sure to turn off any other items plugged into the convenience receptacles. Allow the engine to operate for approximately five minutes. Shut the engine down by placing the master switch in the OFF position.

To lower the mast, loosen the mast rotation lock and align the mast forward. Rotate the mast extension crank counterclockwise, lowering the mast. Continue lowering the mast until it reaches the lowest point. Rotate the mast erection clockwise to place some pressure on the cable. Loosen the vertical mast lock knob and lift the knob to release the lock from the striker plate. Tighten the knob with the lock disengaged from the striker plate. Turn the mast erection crank counter-clockwise, lowering the mast to the horizontal position.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

811. Overview

1. How high can the TF-2 mast extend?

2. What are the maximum towing speeds for the TF-2?

812. Emergency airfield lighting system

1. What three switches must be pressed when starting a TF-2?

2. How long does it take for the lights to warm up on the TF-2?

Answers to Self-Test Questions

809

1. The PDC has 6-three phase outputs.
2. Two primary switches are needed to support four generators.

810

1. Directly from a PDC, a loop feed from another SDC, or through a low voltage generator.
2. 60 Amp and 200 Amps.
3. 200 Amp.

811

1. 29 feet.
2. 55 miles per hours on smooth surfaces and 10 miles per hour on uneven surfaces.

812

1. (1) Fault bypass push button switch.
   (2) Glow plug engage switch.
   (3) Starter switch.
2. Two to four minutes.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

47. (809) Which type of electrical distribution *layout* provides two or more paths for current flow to a facility?
    a. Loop.
    b. Open.
    c. Radial.
    d. Closed.

48. (810) How many 60-amp outputs are included on the secondary distribution center (SDC)?
    a. 10.
    b. 12.
    c. 14.
    d. 16.

49. (810) What is the amperage rating of the mission essential circuit breaker on the secondary distribution center (SDC)?
    a. 60 amps.
    b. 100 amps.
    c. 150 amps.
    d. 250 amps.

50. (811) How many lights make up the light mast on the TF–2 light cart?
    a. 2.
    b. 4.
    c. 6.
    d. 8.

51. (812) How often is oil changed on the TF–2?
    a. Every 250 hours.
    b. Every 300 hours.
    c. Every 400 hours.
    d. Every 350 hours.

52. (812) How long does it take for the light bulbs on the TF–2 to warm up?
    a. One to two minutes.
    b. Four to six minutes.
    c. Two to four minutes.
    d. Four to five minutes.

Student Notes

Glossary Abbreviations and Acronyms

AC	alternating current
AFCEC	Air Force Civil Engineer Center
AGM	absorbent glass mat
BEAR	basic expeditionary airfield resources
BPU	BEAR power unit
DC	direct current
DCS	digital control system
EA	engineering assistant
ECM	electronic control module
IDK	initial deployment kitchen
kV	kilovolts
kVA	kilo Volt-Amps
MEP	mobile electric power
mph	miles per hour
NATO	North Atlantic Treaty Organization
OOR	out of range
PDC	primary distribution center
PDP	power distribution panel
PSC	primary switching center
RM	risk management
ROP	remote operating panel
RPM	revolutions per minute
SDC	secondary distribution center
TO	technical order
USB	U serial bus
VAC	volts alternating current
VDC	volts direct current
WP	work packages

Student Notes

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