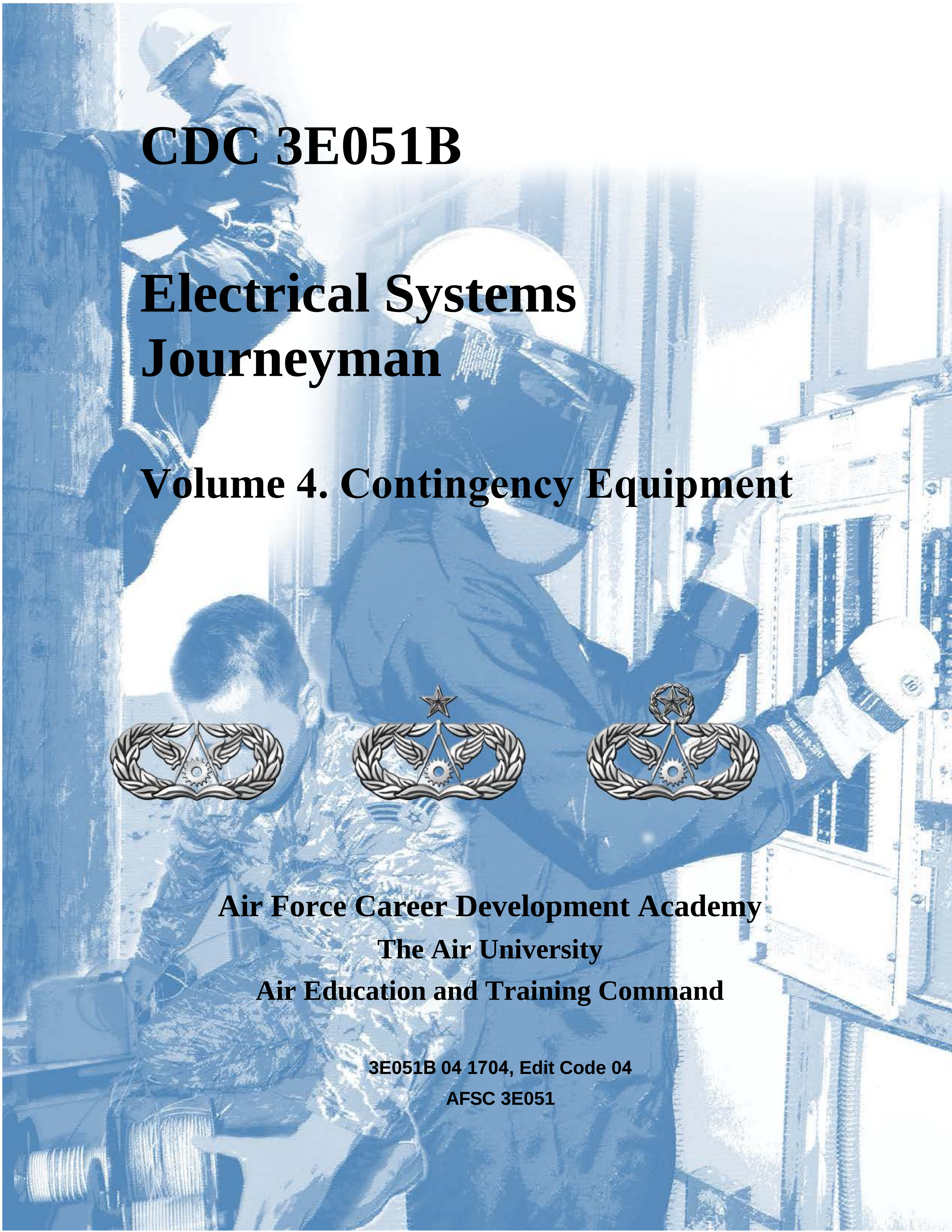

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Electrical Systems Journeyman

Volume 4. Contingency Equipment

Air Force Career Development Academy
The Air University
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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

This is the fourth volume of CDC B3E051, *Electrical Systems Journeyman*. This volume contains four units. Unit 1 discusses Contengiency Airfield Support. Units 2, 3, and 4 broadly cover expedient beddown methods. Unit 2 covers the Basic Expeditionary Airfield Resources Electrical System. Unit 3 covers the Basic Expeditionary Airfield Resources assets. The volume concludes with Unit 4 which covers the Basic Expeditionary Airfield Resources electrical distribution system.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. 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.

Unit 1. Contingency Airfield Support

CONTINGENCY IS DEFINED as "a possible unforeseen or accidental happening." From this definition, you can gather that the Air Force must have a contingency plan to meet any possible, unforeseen, or accidental happening. These "happenings" may be in the form of natural disasters, accidents, or acts of aggression from our adversaries.

During your Air Force career, you will no doubt take part in a contingency operation in one way or another; therefore, you must be ready at all times to meet any possible contingency deployment tasking. In this unit, you will learn about your contingency responsibilities as an electrical systems technician.

The emergency airfield lighting system (EALS) is designed to be a rapidly installed runway lighting system for contingency airfields and other locations that need temporary airfield lighting. The EALS supports flying operations at night and during periods of reduced visibility. The system can light a runway, or minimum operating strip (MOS), up to 150 feet wide by 10,000 feet long. In this unit, we will discuss the procedures for installing, operating and maintaining EALS components. Detailed information can be obtained in TO 35F5–3–17–1, *Lighting System, Airfield, Emergency A/E82U–2*.

601. Installation of emergency airfield lighting system components

The EALS is packed on six trailers that can be safely towed at speeds under 25 mph on paved surfaces or 5 mph on unpaved surfaces (fig. 1–1). The trailers can be towed in a convoy of three or less. They are *not* designed for use on public roads and highways, as they are *not* equipped with tail lights, brakes, or clearance lights.

EALS components

The major components of the EALS are runway edge lighting, approach lighting, threshold/end lighting, taxiway lighting, precision approach path indicator (PAPI) lighting, distance-to-go (DTG) marker lighting, obstruction lighting, and power and control systems. After reading and studying this lesson, you should know the procedures for installing, operating, and maintaining each of these components.

Power and control systems

The EALS comes with two MEP 805A, 30 kW tactical, quiet generator sets (three-phase, four-wire, 120/208 or 240/416 volt). One generator serves as a primary power source and the other serves as a backup during maintenance. The EALS regulator can also be powered from any other power source that is capable of providing a minimum of 15 kVA, 240/416 volts alternating current (VAC). The power supply provides input power for the 20 kW constant-current regulator (fig. 1–2). The regulator, then, powers the airfield lighting series circuit through a #10 AWG conductor. The series circuit powers all EALS lighting equipment, *except* the obstruction lights.

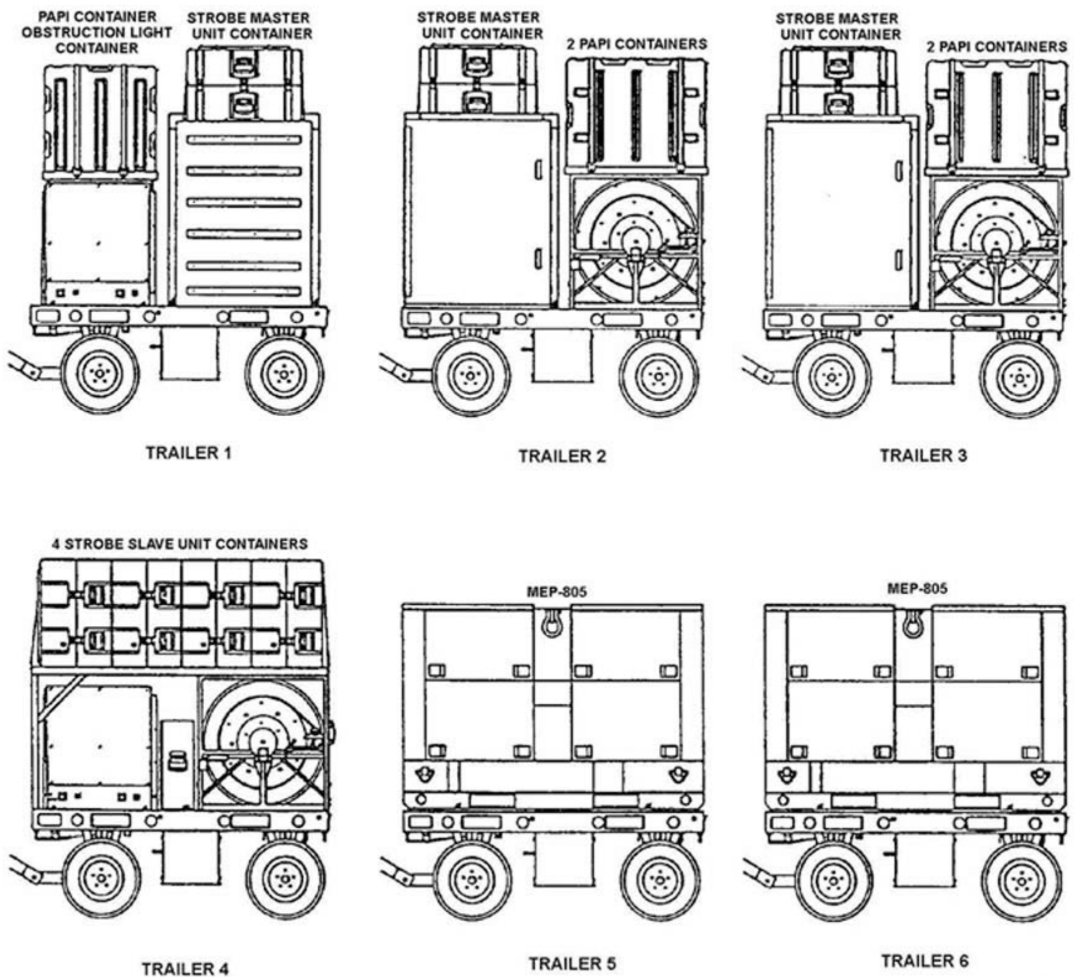


Figure 1–1. EALS trailers.

Figure 1–2. EALS regulator and generator.

Runway edge and approach lights

The runway edge and approach lights are omni-directional fixtures with a clear glass lens and a 45-watt quartz-halogen lamp. A 45-watt isolation transformer (IL) is used with each fixture (fig. 1–3).

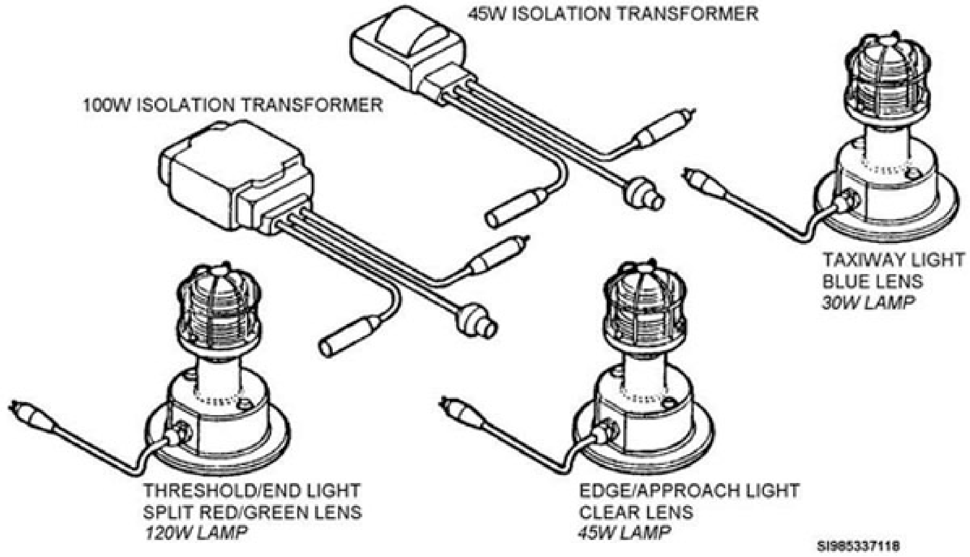


Figure 1–3. EALS light fixtures and isolation transformers.

Threshold lights

The threshold lights are bidirectional fixtures and have a split red and green lens over a 120-watt quartz-halogen lamp. A 100-watt IL isolates each lamp from the circuit (fig. 1–3).

Taxiway lights

The taxiway lights are omni-directional fixtures with a blue lens and a 30-watt lamp. The taxiway lights use a 45-watt IL for series circuit isolation. Also, taxiway reflectors are provided for use on the taxiway sections that cannot be illuminated by taxiway lights (fig. 1–3).

Approach strobes

There are two approach strobe systems, one located at each end of the runway in line with the runway centerline. Each system contains one master strobe unit, two slave strobe units, and one series circuit adapter (SCA) (fig. 1–4). The EALS also contains one spare master strobe unit.

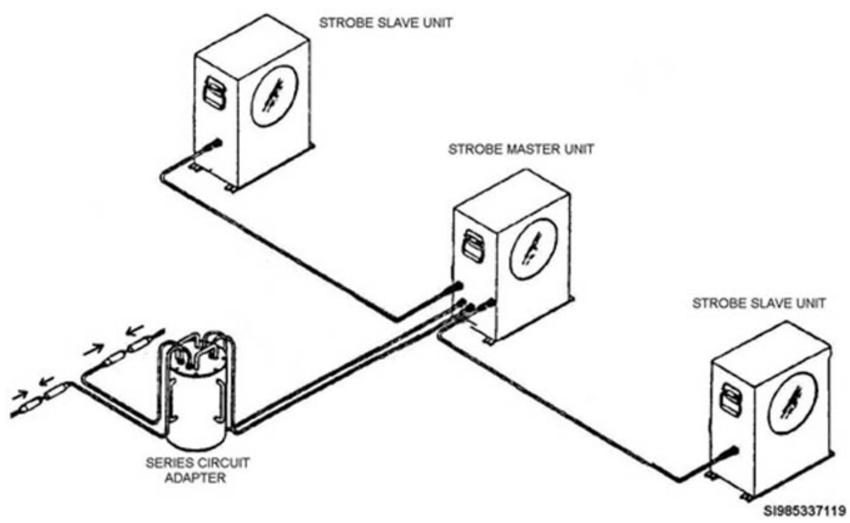


Figure 1–4. Approach strobes.

Approach Strobe Systems	
Unit	**Description**
Strobe slave units	The strobe flasher units flash in sequence, starting with the unit farthest away from the threshold. The strobe flasher receives its power and sequencing (trigger) signals from the master strobe unit.
Strobe master unit	The strobe master unit functions as a control unit for the strobe slave units. It receives its power from the series circuit adapter, and contains the circuitry necessary to control the other two strobe units.
Strobe series circuit adapter	The series circuit adapter (SCA) converts the constant current, which is provided by the series circuit, into a 120/240 VAC constant voltage supply to the strobe master unit. The series circuit adapter functions similar to the isolation transformer: it isolates the strobe system from the rest of the series circuit in the event of strobe circuit failure.

Figure 1–5. PAPI system.

PAPI

The PAPI provides the pilot with a visual reference to the aircraft's vertical glide slope during landing. The EALS includes two PAPI fixtures and a series circuit adapter (fig. 1–5) for each end of the runway, plus a spare PAPI unit. The series circuit adapter for this system is identical to the adapter used with the strobe system. It provides 120 VAC, and has the same isolation capability as the strobe system adapter.

DTG lights

The EALS provides DTG marker lights (fig. 1–6) that illuminate DTG marker signs. These signs inform pilots of the remaining runway length in thousands of feet and must be illuminated at night. The marker signs are *not included* in the EALS kit, but they can be fabricated by the deployed structures shop. The DTG marker lights are unidirectional and use a 45-watt PAR–38 lamp. A 45-watt IL is used to isolate the fixture from the rest of the circuit.

Obstruction lights

The obstruction lights provided with the kit are battery-powered and require no external power source (fig. 1–7). The lights produce a flashing red signal and are used to inform the pilots of any obstructions on or around the operating strip. Each unit uses two 6-volt lantern batteries as a power supply.

EALS installation procedures

Six people organized into two teams—team A and team B—with one general-purpose vehicle per team, can easily set-up the EALS. Each team has a vehicle driver, an individual laying the series circuit cable and placing the equipment on the ground, and another individual referred to as the *TAG*. The TAG follows on foot and connects the components to the primary series circuit.

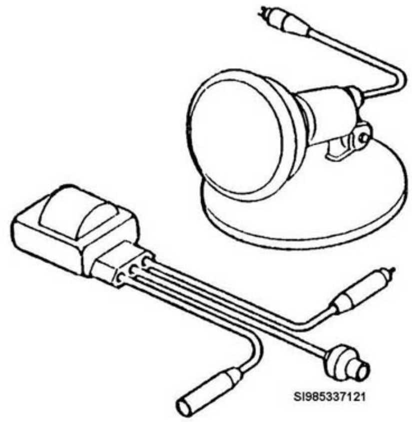


Figure 1–6. DTG fixture and isolation transformer.

Figure 1–7. Obstruction light.

Team A and Team B start at the threshold on opposite ends of the runway and perform identical tasks, with two exceptions. Team A installs all PAPI lighting, while team B sets up the regulator and generators. When the runway installation is complete, team A installs taxiway lighting, while team B places obstruction lights and then returns to the taxiway to assist team A if necessary. If the runway/MOS is to be bi-directional, both teams will install approach lights/strobes on their respective ends of the runway. If it is *not* bi-directional, *only* the team A installs approach lights/strobes and team B begins installing at the threshold of their designated end of the runway.

The following installation procedures are taken from TO 35F5–3–17–2, *Technical Manual Operation and Maintenance Instructions, Lighting System, Airfield, Emergency A/E82U2*. This document is the EALS TO and should be your reference for installation, operating, and troubleshooting procedures.

Approach strobes

The first lighting system to be installed is the strobe lights (fig. 1–8).

Installing Strobe Lights	
Step	**Action**
1	Begin strobe installation by laying 200 foot runway cable segments along the extended runway centerline from the threshold to the master strobe location (1200 feet from the threshold). At this location, unload and unpack: • 1 strobe master. • 2 strobe slaves. • An SCA. • 2 strobe SCA cables. • 2 ground rod segments with couplings. • 2 ground lugs. • Two 125-foot ground cables. • The ground rod driver. You will also need hand tools and a shorting stick.
2	The *next* step is to *ground* the SCA and master strobe cabinet. Join the two ground rod segments and drive this ground rod at *least* 5 feet into the ground. Then connect the 2 ground cables to the ground rod using a separate ground lug for each cable.

Installing Strobe Lights	
Step	**Action**
	Connect the other ends of the ground cables to the SCA and the master strobe cabinet.
3	After the SCA and master strobe have been grounded, the *next* step is to *discharge* capacitors C401 and C402 in all three strobe cabinets. Connect the shorting stick to the ground lug on the strobe master unit. Then use the tip of the shorting stick to short across the capacitor terminals. **WARNING:** You *must* do this *before* performing any work inside the strobe cabinet; if not done *serious injury or death* may result.
4	Now install the flash tubes in all three strobe cabinets. Do *not* touch the flash tubes with your bare hands; use the tube packing material to grasp the tubes. After installing the flash tubes, place the empty flash tube box and packing materials inside the fixture.
5	Next, set the switches to the proper position in all three units. • Set the ON-OFF switches (S401) inside all three strobe cabinets to the ON position. • Inside the strobe master, set the strobe master switch (S301) to REMOTE and the strobe segment selector switch (S302) to correspond with the proper runway end: 1–3 or 19–36. Once the switches in all three units are set to the proper position, reload the strobe slave units into the vehicle.
6	At this point, the TAG begins separate activities (see the following table). The rest of the team proceeds to lay out the strobe cables. Unwind and lay a 200-foot strobe cable from the strobe master to the inboard strobe slave unit. Make sure the strobe cable's male end stays at the strobe master. Turn the vehicle around and return to the master strobe location. Then drive to the position of the outboard strobe slave unit while laying a 200-foot strobe cable.
7	Now unload and position the strobe slave unit. Level the unit and face its window away from the runway. Then connect the strobe cable to the connector marked SLAVE INPUT. This also applies if you are using the spare strobe master as a slave.
8	After installing the outboard slave unit, return to the strobe master location and pick up the tools used by the TAG. Ensure there is slack in the runway cable leading to the SCA. Leave a 10-foot runway cable segment if necessary. Then drive towards the position of the inboard strobe slave unit while paying out a 200 foot runway cable. Now unload, position, and connect the second strobe slave unit, as before.

After loading the strobe slave units into the vehicle, the <u>*TAG*</u> *begins these separate activities.*

TAG Actions in Installing Strobes	
Step	**Action**
1	Position the strobe master unit so that the unit's window *faces away* from the runway. Then level the unit by adjusting the unit's leveling feet.
2	Next, place the SCA next to the strobe master and make the necessary cable connections. • Connect the SCA primary leads to the runway cable. • Then connect the strobe SCA cables to the secondary leads of the SCA and to the POWER INPUT connections on the strobe master. The SCA secondary leads have different pin sizes that correspond to different size holes in the strobe SCA cables. Make sure the pins and holes line up properly. Do *not* force the connection.
3	After connecting the SCA to the master strobe unit, the next step is to connect the 200-foot strobe cables to the strobe master. Be sure to connect the cables to the correct output connectors. When this is finished, proceed to the position of the inboard strobe unit/1000-foot crossbar.

The next activity is to install the approach lights.

Approach lights

After the strobes are positioned and connected, the next lighting systems to install are the 1000-foot crossbar and the approach centerline lights (fig. 1–8). Once again, two of the team members will simply place the components on the ground and the TAG member will make the connections.

Installing Approach Lights	
Step	**Action**
1	At the inboard strobe location, drop off: • 3 approach lights. • 3 isolation transformers (45W). • 3 stakes. • 2 (10-foot) runway cables for the 1000-foot crossbar.
2	Next, attach 2 RAC containers (one with edge/approach lights and one with 30/45W isolation transformers) to the trailer mounting pegs.
3	Then, drive toward the threshold and place an approach light and a 45W isolation transformer every 200 feet along the extended runway centerline while paying out runway cable.
4	Stop when you reach the threshold.

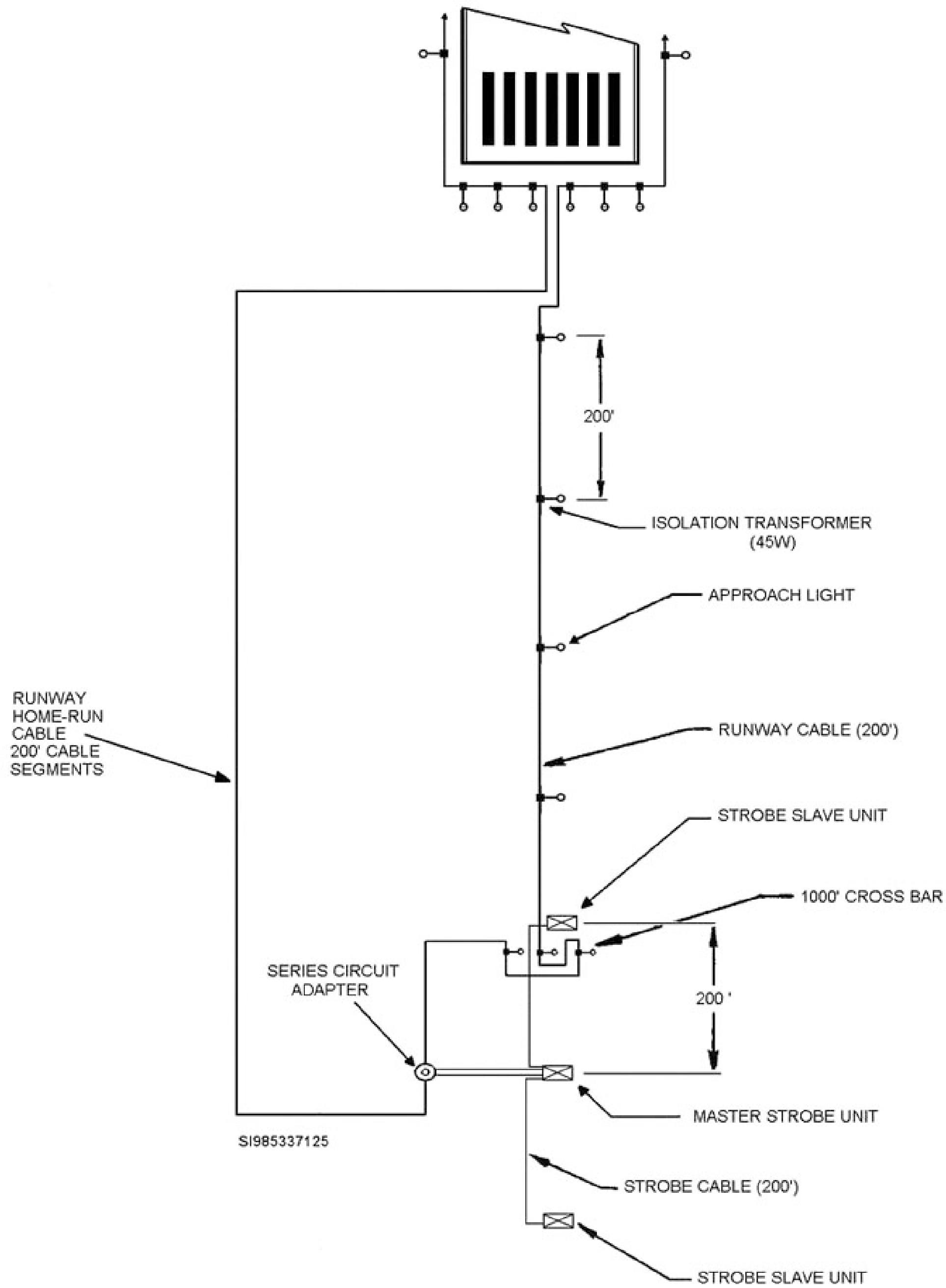


Figure 1–8. Approach and strobe layout.

At this point, the **TAG** does the following**.**

TAG Actions for Installing Approach Lights	
Step	**Action**
1	At the inboard strobe location, position and connect the 1000-foot crossbar lights. • First, position the lights so that they form a straight bar which is perpendicular to the runway centerline. Space the lights fixtures 10 feet apart and 3 to 5 feet in front of the strobe light STQ4. • Next, connect the light fixtures to the isolation transformers. • Lastly, connect the transformers to the lighting circuit.
2	After installing the 1000 foot crossbar, proceed to the threshold installing approach lights as you go. • First, position each approach light along the extended runway centerline, ensuring that each fixture is in line with the other approach light fixtures. • Then connect the fixture to its transformer. • Finally, connect the transformer to the primary series circuit.

Threshold lights

Once the approach light circuit is finished, you are ready to begin installing the threshold lights (fig. 1–9).

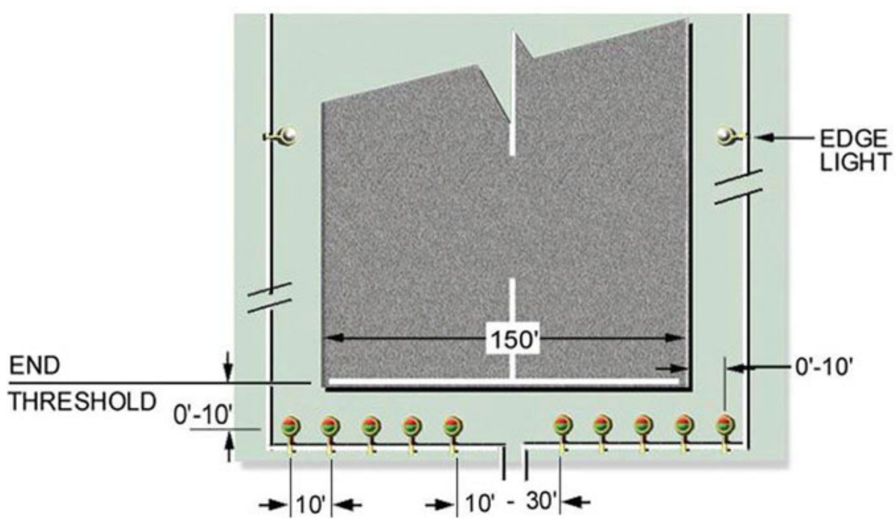


Figure 1–9. Threshold/end light layout.

At the threshold, drop off the threshold/end lights, 100W isolation transformers, 10-foot runway cables, and 2 ballast rings (or 1 stake) per fixture. To determine the *appropriate* number of fixtures, divide the width of the runway or MOS by 10, and add one additional light fixture. Place the light fixtures outboard of threshold markers if they are in position. Do *not* connect a 10-foot cable between the middle two lights in the threshold bar. Place the runway cables and transformers so that the male ends of the connectors point in a clockwise direction around the runway.

The **TAG** does the following when installing threshold lights.

TAG Activities When Installing Threshold Lights	
Step	**Action**
1	Begin by positioning the lights no more than 10-feet from the threshold and approximately 10-feet apart.
2	Adjust the spacing between the light fixtures so that the outboard lights are in line with the runway edge lights. Then face the green side of the fixture lens toward the approach lights (red side towards the runway).
3	Place the isolation transformers outboard of the lights and connect the isolation transformers to the light fixtures. Keep the cable between the transformer and the light taut.
4	Now connect the transformers together using the 10 foot cables and connect the approach lighting circuit into the threshold circuit between the two middle threshold fixtures.
5	Finally, secure each fixture with 2 ballast rings or 1 stake.

When finished installing the threshold lights, proceed to installing the runway edge and DTG lights.

Runway edge and DTG lights

With the threshold lights installed, the next lighting systems to install are the runway edge and DTG lights (fig. 1–10).

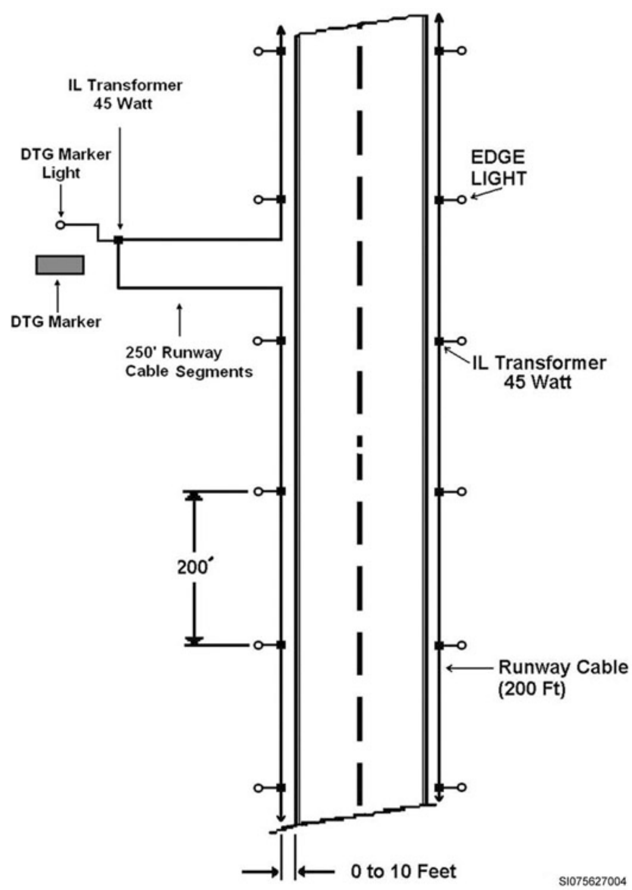


Figure 1–10. Edge light and DTG light layout.

Installing Runway Edge and DTG Lights	
Step	**Action**
1	To begin, drive along the left side of the runway paying out runway cable. • Every 200 feet, place an edge light with a 45W isolation transformer on the ground. • Leave 1 stake or 2 ballast rings at each light. Do *not* place lights at taxiway intersections or in aircraft arresting system tape sweep areas. Along with the runway edge lights, place a DTG marker light, a 45W isolation transformer, and 3 (50 foot) runway cables every 1000 feet. The TAG will follow behind, connecting and installing the lights and cables.
2	When you reach the PAPI location, stop (A team *only*) and install the PAPI system. (We will discuss the PAPI installation procedures later.)
3	After installing PAPIs, continue placing edge lights, DTG lights, and laying primary series circuit cable until you reach the threshold at the opposite end of the runway from where you started.
4	If the runway is to be set up for bi-directional operations, drive to the other PAPI location and install the second PAPI system (A team *only*).
5	Once this is accomplished, return to the B team threshold.

TAG activities in installing the runway edge lights are as follows.

TAG Activities in Installing Runway Edge Lights	
Step	**Action**
1	Position each runway edge light no more than 10 feet from the edge of the runway/MOS, and inboard of its edge marker. Place an isolation transformer outboard of the lights. Connect the runway cables to the isolation transformer and then connect the transformer to the light, keeping the cable between the transformer and the light taut. Anchor each light fixture with two ballast rings or one stake.
2	As you come to the position of the DTG lights (every 1000 feet.), install them. Position each DTG light to illuminate its respective DTG marker. Then connect the light to the transformer and the transformer to the runway circuit using 50-foot cables as needed.
3	Continue positioning and connecting edge lights, DTG marker lights, and transformers until meeting up with the rest of the team.

PAPI lights

At the pre-determined location(s), A team will install the PAPI lights (fig. 1–11).

Before beginning installation, unload all the items needed for PAPI installation.

You will need:

- 2 PAPI units and the 30 foot PAPI cable that connects them together.
- An SCA.
- A PAPI SCA cable.
- 2 (50-foot) runway cables.

- A photocell.
- Six stakes.

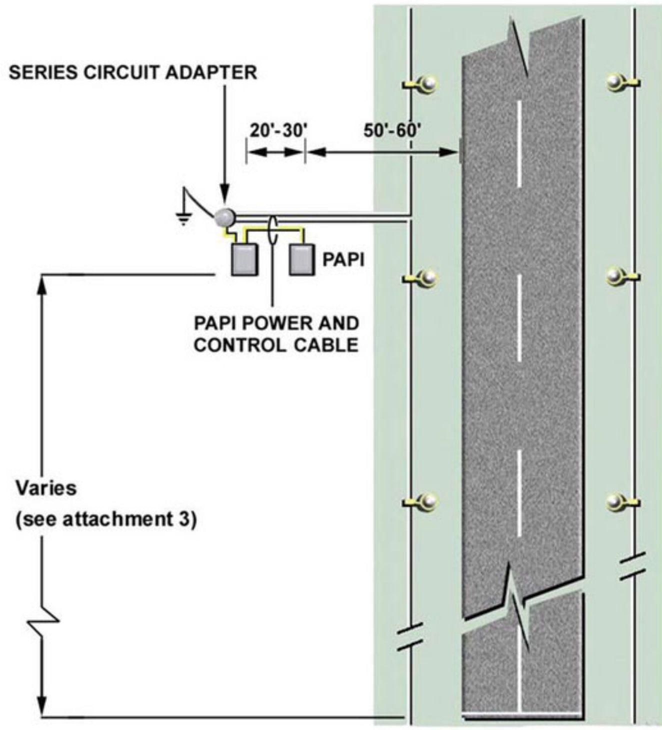


Figure 1–11. PAPI layout.

You will also need 2 ground rod segments and couplings, a ground clamp, a ground cable, the ground rod driver, and hand tools.

Installing PAPI Lights (Team A)	
Step	**Action**
1	Connect the 50-foot runway cables to the primary circuit along the runway/MOS edge and carry the loose ends to the inboard PAPI location.
2	Place the inboard PAPI 50 to 60 feet from the edge of the runway, followed by the outboard PAPI at 20 to 30 feet from the inboard unit.
3	Position the SCA and connect the runway cables to the SCA primary leads P1 & J3. Also connect the PAPI cable to J1 or J2 of the SCA (fig. 1–12). If enough cable is available, the preferred SCA location is behind the outboard PAPI unit, as far away from runway edge as the PAPI SCA cable assembly will allow. At this time, connect the tilt switch cable to the TILT SWITCH jack on the PAPI unit.
4	Secure and align the PAPI units. • Level the terrain and remove the PAPI cabinet from its base. • Align the base so it is parallel with runway centerline, and then stake it down. • Reinstall the cabinet on its base. Repeat these steps for the outboard PAPI. If the elevation difference between the two PAPI units *exceeds* 1 inch, raise or lower the outboard unit or relocate both units to a more level location.

Installing PAPI Lights (Team A)	
Step	**Action**
5	Now install the photocell. The preferred installation location is on the outboard PAPI unit. Aim the photocell eye away from the threshold and towards the darkest area on the airfield.
6	Before going any further, you must ground the SCA and connect it to the PAPIs. • First, drive a ground rod at least 5 feet into the ground. • Then connect one end of a 25-foot ground cable to the rod and the other end to the ground lug on the SCA.
7	Connect the SCA cable to the J1 secondary lead on the SCA and to the POWER/CONTROL IN connector on the back panel of the outboard PAPI. Now connect the 30-foot PAPI cable to the POWER/CONTROL OUT connector on the outboard PAPI and to the POWER/CONTROL IN connector on the inboard PAPI.

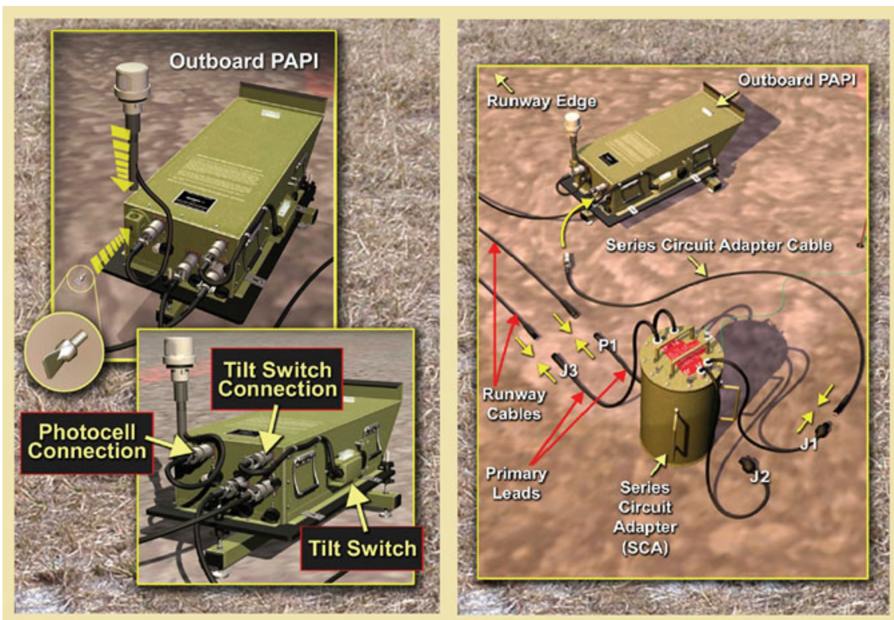


Figure 1–12. PAPI layout.

At this time, you should *level and aim the PAPI units.*

Levelling and Aiming PAPI Units	
Step	**Action**
1	Level the PAPI from side to side by adjusting the front 2 knobs to center the bubble in the level.
2	Now get the PAPI aiming device and set it to the specified approach slope/aiming angle. • Add 15 minutes (0.25°) to the specified angle for the *inboard* PAPI. • Reduce the angle by 15 minutes for the *outboard* PAPI.
3	Place the aiming device on the PAPI on the tilt switch side and turn the rear-adjusting knob to center the aiming device bubble.
4	Lastly, tighten the three securing knobs.
5	The *final* step is to *adjust* the tilt switch so that the bubble is in the middle.

> **WARNING:** Approach angles other than 3° may *cause accidents, injury, or loss of life* during landings. If *obstacles* are in the 3° approach, contact the appropriate authority for *approval to change* the visual glide path angle.

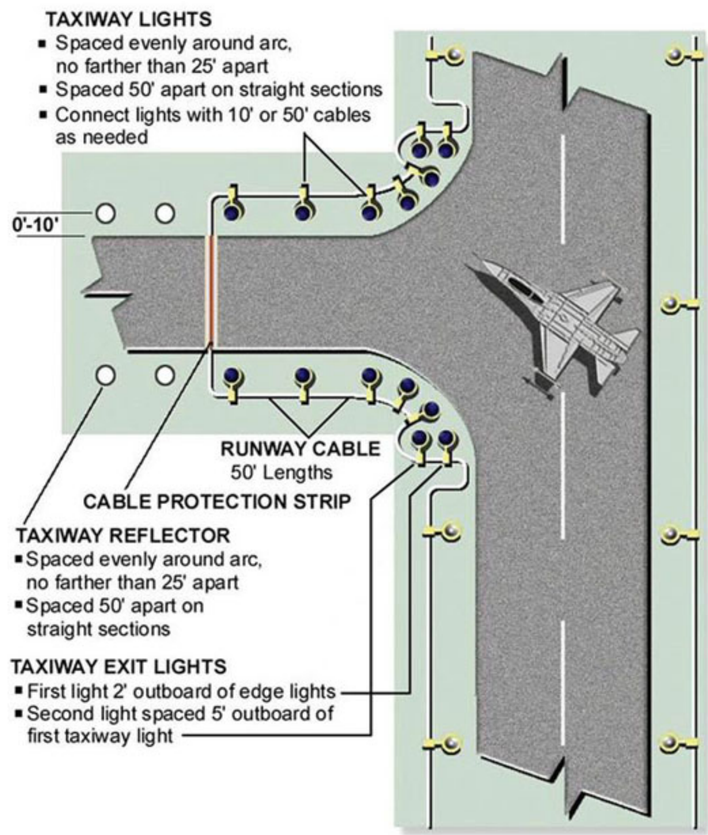
Taxiway and obstruction lights

As has already been mentioned, team A installs taxiway lighting while team B places obstruction lights and then returns to the taxiway to assist team A if necessary.

Taxiway lights

> **WARNING:** Ensure that the runway circuit has been *de-energized and disconnected* from the regulator *prior* to installing the taxiway lights or *serious injury or death* due to electrical shock may result.

Installing Taxiway Lights	
Step	**Action**
1	Start taxiway circuit installation by placing two lights and their transformers at the beginning of the taxiway near the edge of the runway. These are the taxiway exit lights. • Set the first light 2 feet outboard of the edge lights. • Place the second light 5 feet outboard of the first light on a line perpendicular to the edge of the runway.
2	Place the remaining taxiway lights and transformers 25 feet apart around curves and 50 feet apart in the straight sections of the taxiway. Place the lights within 10 feet of the edge of the taxiway. At the same time, lay (50-foot) runway cable segments between the lights (fig. 1–13).

Installing Taxiway Lights	
Step	**Action**
	 **Figure 1–13. Taxiway layout.**
3	Place a (200-foot) runway cable across the taxiway at the taxiway fixture farthest from the runway. Use a 200 foot cable to avoid placing a cable connection in the middle of the taxiway. Protect the cable with cable protection strips according to the procedures listed below.
4	Continue placing fixtures, transformers, cables, and ballast rings/stakes on the other side of the taxiway until you reach the taxiway exit light location at the far taxiway/runway connection.

The next step is to *connect the taxiway lights into the runway circuit.*

Connecting Taxiway Lights to the Runway Circuit	
Step	**Action**
1	First disconnect and remove the runway cable that crosses the taxiway at the edge of the runway.
2	Then, on both sides of the taxiway, connect the closest runway cable end to the taxiway exit light transformer and light fixture. Use (50-foot) or (10-foot) cable segments, as needed, to make this connection.
3	Now walk the taxiway circuit to connect the other lights, transformers, and cables.

Connecting Taxiway Lights to the Runway Circuit	
Step	**Action**
4	Place the isolation transformers outboard of the light fixtures. Keep the cable between the transformer and the light fixture taut.
5	Lastly, anchor each fixture subject to being hit by jet blast with two stakes or ballast rings.

Cable protection strips

Cable strips must be installed to protect the 200 foot cable that crosses the taxiway. Install the cable protection strips and insert the cable according to the following procedures.

Installing Cable Protection Strips and Inserting Cable	
Step	**Action**
1	First, lay out the cable protection strips needed to cross the taxiway. The number of strips needed will vary but it should be a sufficient number to completely cross the taxiway.
2	Next, mate the cable protector sections and pin them together.
3	After the cable protection strips are completely installed and pinned together, insert the cable into the slot. To do this, • Hold the cable connector and press the end of the cable just behind the cable connector into the slot. • Then, using the connector while holding it to the slot, pull the cable through the slot to the opposite side.
4	Finally, secure the cable protection strips on either side of the taxiway with sandbags.

Obstruction lights

While team A begins taxiway installation, team B installs obstruction lights. You begin by installing the batteries into the fixtures. Next, survey the MOS and taxiways for the 10 most prominent obstructions. Then, simply turn each unit's switch to the ON position and place them at the identified obstructions.

Regulator/ generator

While team A is installing the PAPI lights, team B will install the regulator and generator according to the following procedures.

Installing Regulator and Generator	
Step	**Action**
1	Begin by laying a 200-foot runway cable from the regulator location to the nearest cable connector on the edge of the runway. Open the series circuit at that cable connector and connect the female end of the just laid cable to the male end of the open series circuit. Then connect the male end of a second runway cable to the female end of the open series circuit, and lay a return cable back to the regulator.
2	Before proceeding further, set all switches on the control panel to the OFF position. On the regulator panel: • Set circuit breaker (CB1) to the off position (down). • Turn intensity selector switch (S1) to the OFF position.

Installing Regulator and Generator	
Step	**Action**
3	*Next*, establish a common ground for the generator, the regulator trailer, and the control panel at the regulator location and then ground the regulator and control panel. Using three 3 foot ground rod sections, drive a ground rod 8 feet deep into the soil. Then connect ground cables from the regulator and control panel to the common ground. Connect each ground cable to a separate ground lug on the ground rod.
4	Now move the generator to its predetermined location. The generator should be as level as possible during operation, well ventilated, and within 25 feet of an auxiliary fuel supply. The soil must be able to support the weight of the generator.
5	The *next* step is to install all the necessary cables from the generator to the regulator. First, connect the pigtails of the generator unit power cable to terminal board 2 (TB2) of the generator. Use terminals L1-L2, L1-L3, or L2-L3. Do *not* use terminal L0. Then connect the generator power cable to the generator unit power cable just installed on TB2 and connect the generator control cable to the connector on the blackout switch box. Now run these cables over to the location of the regulator. *Next* connect a ground cable to the common ground at the regulator and run it to the generator. Then connect it to the generator grounding terminal on TB2.
6	Now, connect the generator power cable and the generator control cable to the regulator control panel. First, ensure the generator control switch (on the control panel) is in the OFF position. Then connect the generator power cable to the connector on the side of the control panel marked GENERATOR POWER IN and connect the control cable to the connector on the side of the control panel marked GENERATOR CONTROL.
7	Next, install the cables from the regulator control panel to the regulator. Connect the (6-foot) regulator control and power cables to the REG CONTROL and REG POWER connectors on the control panel and to the REMOTE CONTROL INPUT and the INPUT VOLTAGE connectors on the regulator.
8	Finally, connect the two leads of the runway cable to the OUTPUT CURRENT connectors on the regulator. Use the male/male runway cable adapter to complete the connection.

602. Operation of emergency airfield lighting system components

Use *extreme caution* when operating the EALS equipment.

> **WARNING:** Hazardous voltages and currents capable of causing *serious injury or death* may be present. Account for and locate *all* team members *prior* to performing a functional check or operating the system.

Generator set up

Prior to operating the EALS, the generator must be set up so that it is controllable from the control panel located on the regulator trailer. Observe the following procedures when setting up the generator for operation.

Before doing anything to the generator, you *must* accomplish some *safety* steps.

EALS Generator Safety	
Step	**Action**
1	First, ensure all switches on the regulator control panel are in the OFF position.
2	On the regulator: • Set the circuit breaker (CB1) to the OFF position (down). • Turn the intensity selector switch (S1) to the OFF position.
3	Next you must ensure that the generator has been grounded. Never attempt to start the generator set if it has *not* been properly grounded or serious injury or death by electrocution could result.

Now that the system is safe to work on, complete the following generator set up procedures.

<table>
<tr><th colspan="2">EALS Generator Set Up</th></tr>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>First, place the generator’s DEAD CRANK switch in the NORMAL position and ensure the voltage reconnection terminal board (TB1) is set for 240/416.</td></tr>
<tr><td>2</td><td>

The next step is to set up the generator control panel.

- The first thing to do is push in the DC CONTROL POWER circuit breaker to apply power to the control panel.
- Then set the 50/60Hz frequency select switch to 60Hz.

Both of these items are located on the control bracket behind the control panel (fig. 1–14).

SI075627006

Figure 1–14. DC breaker and 50/60Hz switch.

</td></tr>
<tr><td>3</td><td>

Next, set the AM-VM transfer-switch to match the pigtail connections on the generator output terminal board (TB2).

Now:

- Place the PARALLEL/UNIT switch to the UNIT position.
- Set the MASTER switch to the PRIME AND RUN position.

</td></tr>
</table>

EALS Generator Set Up	
Step	**Action**
4	Next, push the PRESS TO TEST button on the malfunction indicator panel. All lights should light up, and all lights should go out when the button is released. Lastly, press the BATTLE SHORT and AC CIRCUIT INTERRUPTER test buttons and verify the indicator lights illuminate.

You are now ready to start the generator. Refer to figure 1–15 during the following discussion.

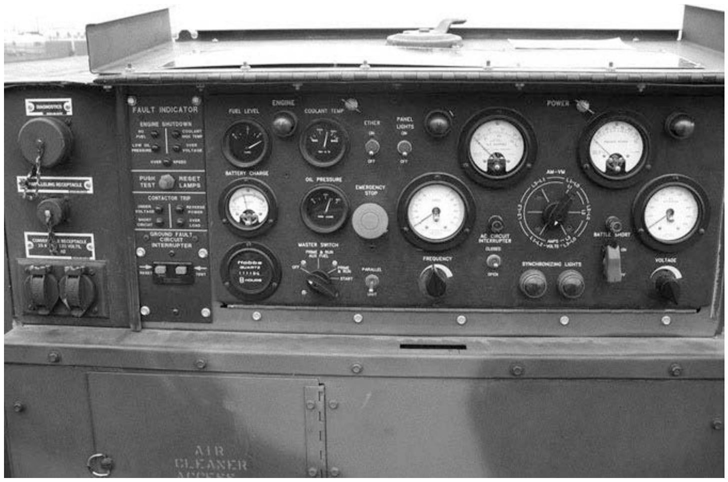


Figure 1–15. Generator control panel.

Starting the Generator	
Step	**Action**
1	First, rotate the MASTER switch to START. Hold it there until the engine starts and the oil pressure reaches 25 PSI.
2	Immediately release the switch and, if using the auxiliary fuel source, rotate the MASTER SWITCH to the PRIME AND RUN AUX FUEL position. Now warm the engine *without load* for 5 minutes (unless immediate load is required). Then check the COOLANT TEMP (170 to 200 °F) and OIL PRESSURE (25 to 60 PSI) indicators for normal readings.
3	Next, adjust the FREQUENCY knob until the FREQUENCY METER indicates 60Hz. Then turn the voltage adjustment potentiometer until the AC voltmeter (VOLTS AC) indicates 416 volts.
4	Now press the GROUND FAULT CIRCUIT INTERRUPTER TEST button. The indicator window should be CLEAR.
5	Then press the RESET button and ensure the indicator turns RED.
6	Next, place the AC CIRCUIT INTERTRUPTER switch in the CLOSED position. Recheck the voltage and frequency.
7	The next step is to stop the generator. • First, place the AC CIRCUIT INTERRUPTER switch in the OPEN position. • Then allow the generator to operate for 5 minutes *without a load* for a cool down period. • After this, place the MASTER SWITCH in the OFF position.

The generator is now ready to be started remotely from the regulator control panel.

Regulator/control panel functional check

Once the generator is good to go, you must perform a check of the regulator and control panel to make sure they are functioning properly. The following procedures are taken from AFH 10–222, Vol. 7, checklist 8.11. Refer to figure 1–16 during the following discussion.

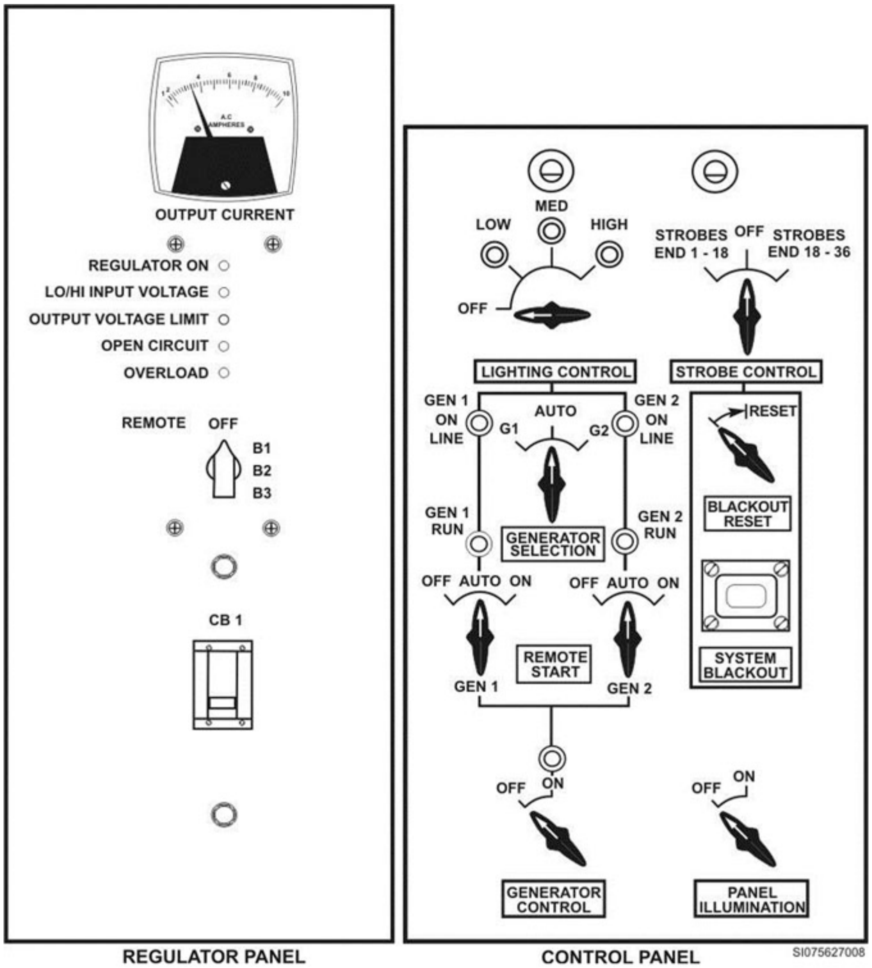


Figure 1–16. Regulator panel and control panel.

Regulator/Control Panel Functional Check	
Step	**Action**
1	Begin by placing the switches on the regulator panel in the proper positions. • Set the *Intensity selector switch* (S1) to the REMOTE position. • Then, set the *master circuit breaker* (CB1) to the OFF (down) position.
2	Next, set the switches on the control panel to the proper positions. • Place the GENERATOR CONTROL switch in the OFF position. • Then set the GEN1/GEN2 REMOTE START switch to the OFF position. • Next turn the GENERATOR SELECTION SWITCH to AUTO. • Now turn the LIGHTING CONTROL and STROBE CONTROL switches to the OFF position.

Regulator/Control Panel Functional Check	
Step	**Action**
	If needed, turn the PANEL ILLUMINATION switch to the ON position.
3	After setting the switches on the regulator and control panel to the proper position, connect the male-to-male adapter cable to both OUTPUT CURRENT connectors on the regulator.
4	Now you are ready to start the generator from the control panel. • First turn the GENERATOR CONTROL switch to the ON position. • Then turn the REMOTE START switch to AUTO. The generator should start. The RUN and ONLINE indicators for the generator should illuminate.
5	With the generator running, turn the *circuit breaker* (CB1) on the regulator control panel to the ON position. The REGULATOR ON indicator light on the regulator panel should light up.
6	The next step is to check the lighting controls on the control panel. • Turn the LIGHTING CONTROL switch to LOW and pause while the regulator performs internal checks. The *low intensity indicator* should light up, and the *ammeter* on the regulator panel should read between 4.6 and 4.9 amps. • Then turn the LIGHTING CONTROL switch to MED intensity. The *ammeter* should read between 5.3 and 5.7 amps. • Next, turn the LIGHTING CONTROL switch to HIGH intensity. The *ammeter* should read between 6.4 and 6.7 amps. • Now push the SYSTEM BLACKOUT button. The *ammeter* reading should drop to zero. Lastly, reset the BLACKOUT switch and return the LIGHTING CONTROL switch to the OFF position.
7	After checking the lighting controls on the control panel, check the lighting controls on the regulator. • Turn the *intensity selector switch* (S1) from REMOTE to the low (B1) setting and ensure the *ammeter* reads between 4.6 and 4.9 amps. • Next turn the *intensity selector switch* to the medium (B2) setting and ensure the *ammeter* reads between 5.3 and 5.7 amps. • Then turn S1 to the high (B3) setting and ensure the *ammeter* reads 6.4 to 6.7 amps. Now return the *intensity selector switch* to the OFF position.

8	The next step is to perform a regulator open-circuit test.
	• First, turn the *circuit breaker* (CB1) to the OFF position.
	• Then remove the male-to-male adapter cable from the output current plugs on the regulator.
	• Now turn the *circuit breaker* to the ON position.
	• Next, turn the *intensity selector switch* to the <u>low intensity setting</u>.
	    o The regulator should de-energize within 2 seconds and the OPEN CIRCUIT and OUTPUT VOLTAGE LIMIT indicator lights on the regulator panel should light.
	    o Immediately turn the intensity selector switch to OFF if the open circuit protective device does *not* activate within 2 seconds.
	• Now turn the *intensity selector switch* to the OFF position.

Regulator/Control Panel Functional Check	
Step	**Action**
	• Repeat the test. After repeating the test: • Turn the *intensity selector switch* to the REMOTE position. • Turn the *circuit breaker* to the OFF position.

After completing the above steps, you have successfully completed the functional test of the regulator and control panel. Now, turn the REMOTE START and GENERATOR CONTROL switches on the control panel to the OFF position. The generator will shut down.

Activating the EALS

The EALS kit contains a primary generator and a backup generator. It also contains a primary control panel and regulator on trailer #1 and a backup control panel and regulator on trailer #4. The procedures to activate the EALS from either control panel are almost the same. The only difference is that *you can only hook up one generator to the backup control panel* and therefore you do not have the option to choose between the two generators.

Activating the EALS	
Step	**Action**
1	Begin by setting the switches on the regulator panel to the proper position. • Set the *intensity selector switch* to REMOTE. • Then set the *master circuit breaker* to the OFF position.
2	Next, set the switches on the control panel to their proper positions. • Set the GENERATOR CONTROL switch to OFF. • Then set the GEN1and GEN2 REMOTE START switches to OFF. • Next, set the GENERATOR SELECTION switch to AUTO. • Finally, turn the LIGHTING CONTROL and STROBE CONTROL switches to OFF.
3	Now start the generator. • First turn the GENERATOR CONTROL switch to ON. • Then turn the REMOTE START switch of the primary unit to AUTO. The RUN and ONLINE indicators should light. Wait 5 seconds and then turn the REMOTE START switch of the backup generator to AUTO.
4	After the generator is running you can energize the lighting circuit. • First, turn the *circuit breaker* on the regulator panel to ON. • Then set the LIGHTING CONTROL switch to the desired intensity. The intensity indicator light should illuminate. • Lastly, set the STROBE CONTROL switch to 1–3 or 19–36 depending on which set of strobes you want on.

System shutdown procedures

The EALS may be shut down in one of three ways depending on the situation. You have the option of initiating a system blackout, a normal shutdown, or an emergency shutdown.

System blackout

System blackout is used when the airfield is under attack and you want to turn the lights off in a hurry. All you have to do to blackout the system is push the SYSTEM BLACKOUT switch on the control panel. The lights will go out immediately, but the *generator will continue to run*. To turn the lights back on, all you have to do is rotate the BLACKOUT RESET switch to the RESET position and release it. The lights come back on to whatever intensity you had them set at.

Normal shutdown

To turn the lights and generator off during normal conditions, follow these procedures.

Normal EALS Shutdown	
Step	**Action**
1	Turn the LIGHTING CONTROL switch on the control panel to the OFF position.
2	At the regulator panel, turn the *circuit breaker* and the *intensity selector switch* to the OFF position.
3	After the generator has run for 3 minutes with *no load*, turn the generator off by turning the REMOTE START switch on the control panel to the OFF position.
4	Turn the GENERATOR CONTROL switch on the control panel to the OFF position.

Emergency shutdown

The system may be shut down from any of three locations in an emergency.

- To *shut the system down at the control panel*, turn the GENERATOR CONTROL switch OFF or press the SYSTEM BLACKOUT button.
- To *shut the system down at the regulator*, turn the *regulator circuit breaker* OFF or turn the *intensity selector switch* to the OFF position.
- If you need to perform *an emergency shutdown at the generator*, push the EMERGENCY STOP button on the *generator control panel*.

603. Maintenance of the emergency airfield lighting system

Maintenance of the EALS is an extremely important job. The loss of any strobe flasher unit, any PAPI unit or 20 percent or more of any other lighting subsystem is considered a *critical* failure and requires immediate attention. When you perform maintenance on the EALS, keep in mind that all of its light systems are interconnected as *one series circuit*. Be sure that you apply safety procedures at all times. You conduct a daily operational check of the system to ensure proper operation. All other “periodic” maintenance is done at 6 month intervals, unless otherwise required.

Regulator

Maintenance for the regulator consists of making a short circuit test and an open circuit test. Follow the procedures listed here to perform these tests.

Short Circuit Test	
Step	**Action**
1	Remove input power to the regulator by turning the *main circuit breaker* and *the intensity selector switch* OFF.
2	Disconnect the lighting circuit from the output current plugs and then short the output plugs using the male-to-male adapter.
3	Energize the regulator and then turn the *intensity selector switch* to LOW, then MEDIUM, and then HIGH. Check the output current on each step using a true rms ammeter.

Short Circuit Test	
Step	**Action**
	The values should be within these limits: • Low: 4.66 to 4.94. • Medium: 5.33 to 5.67. • High: 6.40 to 6.70.
4	Turn the *intensity selector switch* to OFF and then turn the *breaker* to OFF.
5	Disconnect the male-to-male adapter and reconnect the lighting circuit.

Open Circuit Test	
Step	**Action**
1	Remove input power to the regulator by turning the *main circuit breaker* and the *intensity selector switch* to OFF.
2	Disconnect the lighting circuit from the output current plugs.
3	Turn the *main circuit breaker* back ON.
4	Turn the *intensity selector switch* to LOW. The open circuit protective device should automatically de-energize the regulator in less than 2 seconds.
5	Turn the *intensity selector switch* back to OFF. The open-circuit protective device should reset.
6	Repeat steps 3 and 4.
7	Turn the *intensity selector switch* to OFF. Turn the main breaker OFF. Reconnect the lighting circuit.

Light fixtures

The primary maintenance task associated with the runway light fixtures is replacing the lamps. To re-lamp a DTG light, simply unscrew the old lamp in a counter-clockwise direction and then screw in the new lamp in a clockwise direction. The taxiway, runway edge, approach, and threshold/end lights are all basically the same fixture. The only differences in these fixtures are the color of the lenses and the lamp wattage. The procedures to change the lamps are the same in all four fixtures.

Changing Lamps in Light Fixtures	
Step	**Action**
1	Remove the three acorn nuts holding the stainless steel guard to the fixture.
2	Remove the guard, lens, and gaskets by lifting straight up.
3	Remove the silver clip from the light fixture socket. Use a screwdriver if necessary.
4	Grip the lamp by its ceramic base and pull straight up to remove it. Install a new lamp and reassemble the fixture.

Obstruction lights

The maintenance of obstruction lights consists of changing the batteries and/or changing the flash tube.

Changing Obstruction Light Batteries	
Step	**Action**
1	Remove the bolt from the side of the obstruction light.
2	Turn the obstruction light over so that the red lens is facing down.
3	Push a screwdriver tip into one of the slots on the side of the unit and pry off the bottom cover.
4	Remove the old batteries from the unit and install the new batteries.
5	Replace the bottom cover and the bolt.

Changing Obstruction Light Flash Tube	
Step	**Action**
1	Remove the batteries from the obstruction light.
2	Loosen the three screws holding the red lens in place and then remove the lens by turning it to the right and then pulling straight up.
3	Remove the flash tube by pulling it straight up and then install a new flash tube.
4	Replace the red lens and tighten the three screws.
5	Place the batteries back into the unit.

Strobe system

Check the strobe system for any signs of internal or external damage and corrosion. Also, check the operation of the interlock switches and door latches. To change the flash tubes in the strobe lights, the system must be de-energized and the capacitors must be shorted. Perform the following procedures to change out the flash tubes.

Changing Out Strobe System Flash Tubes	
Step	**Action**
1	After opening the door, turn the *on/off switch* to OFF.
2	Short the capacitors.
3	Grasp the flash tube by the base and pull it straight out.
4	Grasp the new tube by the base, line up the key on the base with the slot in the socket and then push the tube straight into the socket. Do *not* touch the glass with your hands.
5	Close and latch the door.

PAPI

When you check the PAPI cabinets, inspect front lens and red filter for cleanliness. Ensure unit is set to proper approach angle, and adjust the unit as necessary. Follow the procedures listed below to replace the PAPI lamps.

Replacing PAPI Lamps	
Step	**Action**
1	Ensure the lighting circuit has been de-energized. Then disconnect all cables connected to the PAPI and remove the front securing knobs.
2	Loosen the four wing nuts securing the hood clamps and slide the clamps until they are free of the hood flange. Remove the 9 screws securing the hood to the back cover.
3	Lift the hood straight up and remove it from the unit.
4	Remove the electrical connections from the lamp by pushing in the connector and turning it counterclockwise.
5	Remove the lamp by compressing the retaining springs on the socket while turning the lamp in a counter-clockwise direction. Withdraw the lamp from the rear of the reflector.
6	Installing a new lamp is the reverse of the above steps.

Safety

Ensure that trailer brakes are engaged before performing any operations on or around the trailer. Don't forget that containers and under-trailer storage units are very heavy. Exercise proper lifting techniques when handling this equipment. The EALS equipment is very heavy and requires at least two people to lift it. Capacitors installed in the strobe systems can carry an electrical charge and must be discharged prior to servicing. Always wear leather gloves to protect your hands from cuts and abrasions during installation work.

Self-Test Questions

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

601. Installation of the emergency airfield lighting systems components

1. How many people are needed to install the EALS?

2. How far from the threshold is the *master strobe* location?

3. After unloading the strobe units and other equipment at the master strobe location, what is the next step?

4. How far apart do you place the 1000-foot *crossbar lights*?

5. When installing the *threshold lights*, how do you determine the appropriate number of fixtures to install?

6. The runway edge and DTG lights use what size *isolation transformer*?

7. What is the *preferred* installation location for the PAPI photocell?

8. When leveling and aiming the PAPI units, what do you do *first*?

9. What is the *first* step in installing the *taxiway light circuit*?

10. How should the ground cables from the regulator and control panel be *connected to the common ground rod*?

602. Operation of emergency airfield lighting system components

1. What position should the switches on the regulator and control panel be in *before* setting up the generator for *operation from the control panel*?

2. What is the *first* thing you *must* do when setting up the generator control panel?

3. What is the *first* step in starting the generator *from the control panel*?

4. What is the *last* step in activating the EALS *from the control panel*?

5. How long should you let the generator run with no load before shutting it down during *normal shutdown*?

603. Maintenance of the emergency airfield lighting system

1. What is considered a *critical* failure of the strobe lights?

2. What two types of tests are performed on the *regulator* during maintenance?

3. What can be used to remove the clip from a light fixture socket when replacing a lamp on a runway edge light?

4. What is the *first* step in changing out the batteries of an *obstruction light*?

5. What should you do *immediately after* opening the door of a strobe cabinet when replacing the unit's *flash tube*?

6. How do you remove the electrical connections from the lamp of a PAPI unit?

Answers to Self-Test Questions

601

1. Six.
2. 1200 feet.
3. Ground the SCA and master strobe cabinet.
4. 10 feet.
5. Divide the width of the MOS by 10, and add one additional light fixture.
6. 45 watt.
7. On the *outboard* PAPI unit.
8. Level the PAPI from side to side by adjusting the front 2 knobs to center the bubble in the level.
9. Place two lights and their transformers at the beginning of the taxiway near the edge of the runway.
10. Connect each ground cable to a separate ground lug on the ground rod.

602

1. Off.
2. Push in the DC CONTROL POWER circuit breaker and set the 50/60Hz frequency select switch to 60Hz.
3. Turn the GENERATOR CONTROL switch to the ON position.
4. Set the STROBE CONTROL switch to 1–3 or 19–36 depending on which set of strobes you want on.
5. 3 minutes.

603

1. The loss of any strobe flasher unit.
2. A short circuit test and an open circuit test.
3. A screwdriver.
4. Remove the bolt from the side of the obstruction light.
5. Short the capacitors.
6. Push in the connector and turn it counterclockwise.

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).

1. (601) What is the *next* step in installing strobe lights after you *ground the series circuit adapter and master strobe*?
   a. Set the on-off switches to the on position.
   b. Set the strobe master switch to remote.
   c. Discharge the capacitors.
   d. Install the flash tube.

2. (601) What is the TAG's *first* step in *installing the strobe units*?
   a. Position the strobe master unit so that its window faces away from the runway.
   b. Position the strobe master unit so that its window faces toward the runway.
   c. Position the series circuit adapter (SCA) next to the strobe slave.
   d. Connect the strobe unit to the SCA.

3. (601) What is the *next* step after the TAG installs the 1000 foot crossbar?
   a. Go back to the outboard strobe location and install it.
   b. Go directly to the threshold and position the lights.
   c. Position the inboard strobe slave unit.
   d. Install the approach lights.

4. (601) What is the *final* step in installing the *runway edge lights*?
   a. Connect the fixture to an isolation transformer.
   b. Connect the fixture to the rest of the airfield circuit.
   c. Install an isolation transformer inboard of the fixture.
   d. Anchor each light fixture with two ballast rings or one stake.

5. (601) What do you do *first* when leveling and aiming a precision approach path indicator (PAPI) unit?
   a. Level the unit from side to side by adjusting the unit's two front knobs.
   b. Level the unit from front to back by adjusting the unit's rear knob.
   c. Adjust the aim of the unit to provide a 3-degree glide slope.
   d. Adjust the PAPI unit's tilt switch.

6. (601) What is the *final* step in installation of the precision approach path indicator (PAPI) units?
   a. Install a photocell on either unit.
   b. Stake each unit securely to the ground.
   c. Align each unit so that it is parallel with the runway.
   d. Adjust the tilt switch so that the bubble is in the middle.

7. (601) How do you *begin* the procedure for installing the emergency airfield lighting system *obstruction lights*?
   a. Install the batteries into the fixture.
   b. Connect the fixture straight into the runway circuit.
   c. Connect the fixture to the runway circuit through a transformer.
   d. Connect the fixture to the runway circuit through a series circuit adapter (SCA).

8. (602) When performing an open circuit test on the regulator, what is the *next* step after *turning the circuit breaker off*?
   a. Turn the intensity selector switch to the OFF position.
   b. Turn the intensity selector switch to the LOW intensity setting.
   c. Install the male-to-male adapter cable into the output current plugs.
   d. Remove the male-to-male adapter cable from the output current plugs.

9. (603) When replacing a lamp on a *runway edge light*, how do you remove the lamp from its base?
   a. Grip the lamp by its ceramic base and pull straight up.
   b. Turn the lamp in a counter-clockwise direction.
   c. Loosen the screws holding the lamp in place.
   d. Turn the lamp in a clock-wise direction.

10. (603) How do you remove the red lens from an *obstruction light*?
   a. Unscrew the lens in a clock-wise direction.
   b. Unscrew the lens in a counter-clockwise direction.
   c. Remove the screws holding the lens in place and pull the lens straight up.
   d. Loosen the screws holding the lens in place, turn it to the right, and pull it straight up.

11. (603) Which of the following is a step in the process of changing out a *lamp in a strobe unit*?
   a. Disconnect the fixture from the series circuit adapter.
   b. Disconnect the fixture from the airfield circuit.
   c. Connect the fixture's case to ground.
   d. Short the capacitors.

12. (603) What is the procedure for *removing the electrical connection* from a precision approach path indicator (PAPI) lamp?
   a. Loosen the terminal screw and remove the connection from the lamp.
   b. Push in the connector and turn it counterclockwise.
   c. Pull the connection straight back off the lamp.
   d. Push in the connector and turn it clockwise.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Basic Expeditionary Airfield Resources Electrical System

WITH FOREIGN GOVERNMENTS becoming more reluctant in permitting the United States to establish permanent military facilities on their soil, the Basic Expeditionary Airfield Resources (BEAR) concept has become a viable solution to contingency and wartime basing shortfalls. As an electrical systems specialist, you are required to know the BEAR electrical distribution system and its associated contingency assets. You must be able to properly install, operate, maintain, troubleshoot, and remove all of these systems and assets.

BEAR electrical packages consist of both high- and low-voltage systems. These packaged systems are part of a war reserve materiel (WRM) support system. The two systems have some commonalties and you may interface them to meet mission requirements. The equipment you are responsible for may vary from one WRM support system to another. In the following lesson, you will learn about the low voltage electrical distribution system

604. Power generation

The BEAR electrical system provides low voltage power to various users of the BEAR package. This power is supplied by any number of low-voltage generators, *primarily* the 30 kilowatts (kW) and 60-kW generators.You will typically see generators in the 30kW through 200kW range in the field when deployed; so, that's the models what this unit will focus on.

Mission essential power generators

There are many types of mission essential power (MEP) generators you may encounter in support of contingency operations. Normally the power production shop is responsible for installing, operating, maintaining, and removing these units, but you should be familiar with this equipment in the event that Power Pro support isn't available.

The MEP "800" series generators are also known as tactical quiet generators (TQG); as the name suggests, these generators are designed with noise reduction in mind. The table below lists the different MEP models along with their generation capabilities. All of the MEP generators included in this table are capable of both 50 Hz and 60 Hz power. The generation capacity (kW) ratings below represent a 60Hz output (light green columns), and a 50Hz output (blue columns).

MODEL	RATING	VOLTAGE	AMPERAGE	VOLTAGE	AMPERAGE
MEP 805	30 kW	120/208	104	240/416	52
MEP 806	60 kW	120/208	208	240/416	104
MEP 807	100 kW	120/208	347	240/416	174
MEP 809	200 kW	120/208	695	240/416	347

Model suffix

The MEP generators have either an A or B suffix after the model number according to the controls package it is equipped with.

- The *A suffix* identifies that the generator has *analog* components.
- The *B suffix* indicates that the generator is equipped with *digital* controls.

The B series normally has a ruggedized computer screen (fig. 2–1) for operating and troubleshooting the generator. As you see in the image below, this generator is configured for 120/208 VAC operation.

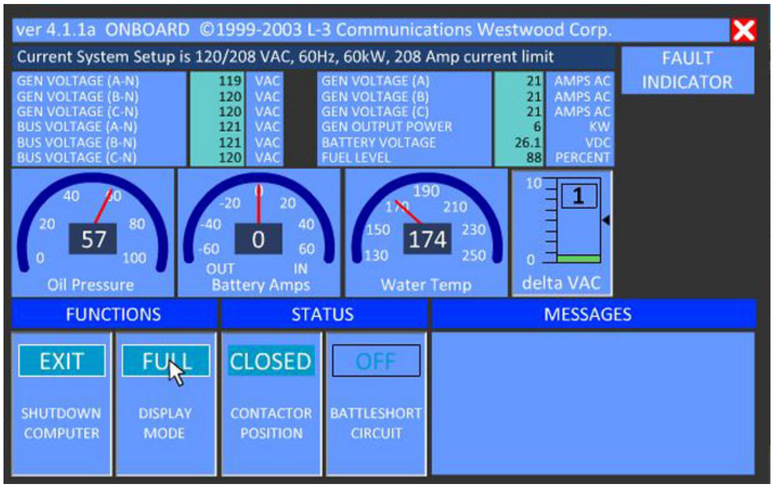


Figure 2–1. MEP 806B generator operator screen.

MEP Generators	
Model	**Description**
MEP 805A/B	The MEP 805 is a 24/30-kW generator that is capable of providing 120/208V, three-phase power. This generator typically supplies power to the kitchen set, and the Emergency Airfield Lighting System (EALS).
MEP 806A/B	The MEP 806A is a 50/60-kW unit that supplies 50/60 Hz, and offers either 120/208 or 240/416 VAC (fig. 2–2). • It is used as mission essential power for small cantonment operations (operations that involve up to 750 personnel) that are normally short in duration (usually up to 3 months) and require low voltage. • This generator is used to power the Reverse Osmosis Water Purification Unit (ROWPU), as well as mission essential support facilities, such as communications centers, command post, aircraft support, and computer infrastructure facilities. • When the mission essential requirement is justified, this unit is used for emergency backup for mission essential facilities.

MEP Generators	
Model	**Description**
	 **Figure 2–2. MEP 806A low-voltage generator.**
MEP 807A	The MEP 807A is a 100/83-kW unit that supplies 50/60 Hz, and offers either 120/208 or 240/416 VAC. • It is used to support the same mission requirements as the MEP 806A, but just provides more load capabilities. • When the mission involves more than 750 personnel, or when the load requirement justifies a mobile prime power plant, this unit is used for emergency backup for mission essential facilities.
MEP 809A	The MEP 809A is a 200/166-kW unit that supplies 50/60 Hz, and offers either 120/208 or 240/416 VAC. It supports the same mission requirements as the MEP 806A, but provides more load capabilities.

Legacy and Next Generation Systems

Prior to the MEP 800 Series Generators, the first generation of MEP Generators were utilized (MEP 005 through MEP 009). The kW ratings were similar to the 800 Series, but the first generation equipment lacked the Tactical Quiet feature. Therefore a MEP 006 had the same power generation capabilities as an MEP 806.

As with anything, change is inevitable and this holds true for military generator technology. The next generation for military power generation is the Advanced Medium Mobile Power Sources (AMMPS); this is the 3rd Generation of DoD military standard generators. The newer designs of these generators are capable of providing significant operational improvements that greatly decrease the logistics footprint on the battlefield. Key features are reduced fuel consumption & reduced electromagnetic interference, as well as built-in diagnostics and automatic paralleling features. The current family of AMMPS consists of five versions: the 5 kW, 10kW, 15kW, 30kW, 60kW generators, as shown in Figure 2–2a. As with the previous generations, this equipment can be either mounted on a trailer or lifted with a forklift.

Preparing generators

Properly preparing the generator set for operation provides trouble-free operation for an extended period of time. It is very important that you ensure the generator is grounded and that all electrical connections are properly made.

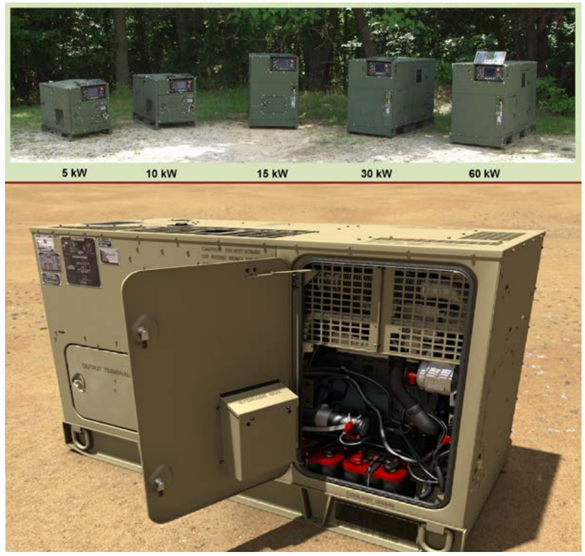


Figure 2–2a. AMMPS low-voltage generators.

The generator set must be grounded prior to operation. The ground can be any of the *preferred* methods described in the table below.

Preferred Generator Set Grounding Methods	
Method	**Description**
Ground Rod	When using a solid ground rod (fig. 2–3), it must have a *minimum* diameter of $^{5}/_{8}$-inch. To be effective, the ground rod must be driven to a *minimum depth* of 8 feet.
Buried Metal **Plate**	A buried metal plate ground (fig. 2–3) must be: • ¼-inch thick. • Have a *minimum area* of 9 square feet. • Buried at a *minimum depth* of 4 feet. The ground lead from the plate must be at least #6 AWG (American wire gauge) copper wire.
Buried Metal **Pipe**	Another grounding method is to use an existing metal water pipe. Additionally, you should supplement this method with a metal rod or with a buried metal plate ground. As you learned in the grounding volume of the A3E051 CDC, the earth is a poor conductor of electricity. The water pipe must have *at least* 10 feet in contact with the earth and be a *minimum* of ¾-inch in diameter.

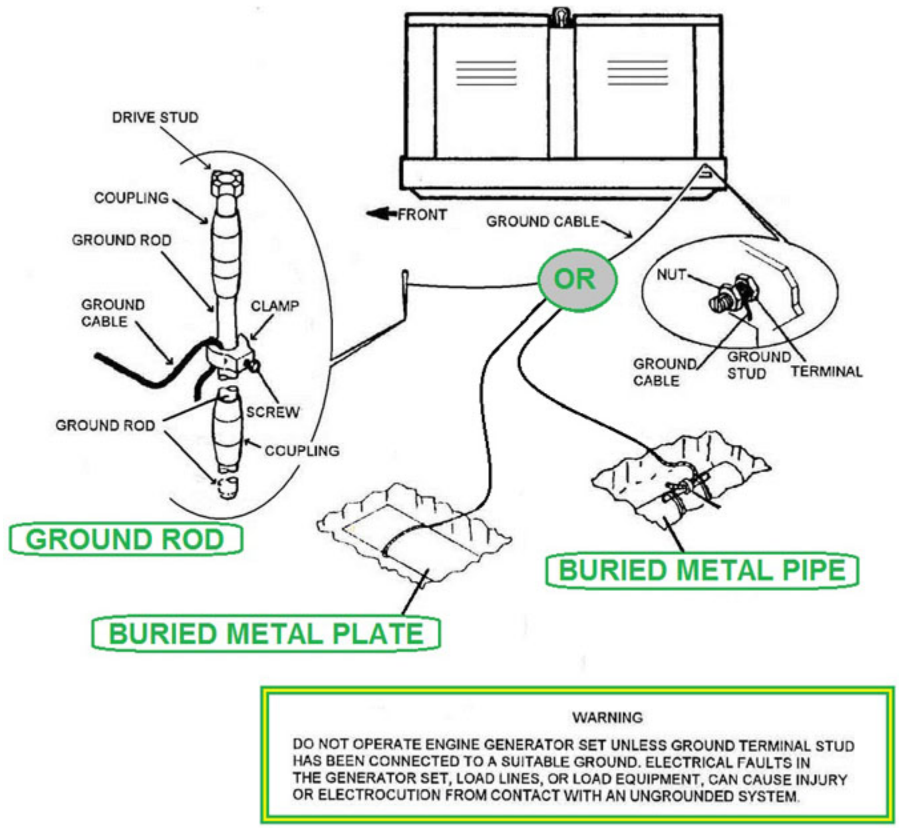


Figure 2–3. Generator grounding.

605. Generator installation

The same general principles of installation, operation, and maintenance apply for all generator equipment. A dedicated crew of electrical personnel is required for generator installation. In this lesson, we focus on the requirements for generator installation.

Visual inspection

First, make a visual inspection of the generator set. Look for broken or loose electrical and hose connections, loose bolts, and obvious damage. Check the wiring diagrams to ensure all wire connections located on the panel are properly attached. Immediately correct any faults you find during the inspection. Ensure the unit is serviceable in accordance with the appropriate technical manual *before* placing the unit into operation.

Location

The types and locations of the individual loads in the area to be served determine the location of the generator. In order to reduce the amount of cable required, minimize voltage drop, and provide adequate voltage control, consider locating the generator near points of large demand.

Site selection and preparation

Select the location by studying an area map with the individual demands plotted. The location should provide a strong foundation for the generator as this reduces vibration. For parallel generator operation, additional units may be needed and provisions for these units should be made. If possible, select areas that are clear, level, dry, and well drained. Once the site for the generator has been selected, prepare the site for generator operation. When you prepare a site for temporary installation, move the generator as close as possible to the worksite. Use planks, logs, or other materials that are suitable for a foundation if the ground is soft, and ensure the site is as level as possible. Most portable generator sets are designed to operate satisfactorily at angles *up to* 15° out of level.

Voltage configuration

Since we are worldwide deployable, various voltage configurations are required to support both American and foreign electrical equipment. As stated earlier, all MEP generators are capable of either 120/208 VAC or 240/416 VAC. On the 3kW to 15kW generators, voltage adjustment is achieved by a selector switch. The 30kW to 200kW units are configured with a voltage reconnection panel.

You must make certain to provide the correct voltage by using the voltage reconnection panel. The reconnection panel allows the alternator windings to be connected in either series or parallel. Remember,

- *Voltage increases and current remains constant* in a *series* circuit.
- *Voltage remains constant and current increases* in a *parallel* circuit.

By making an adjustment on the reconnection board, you can obtain two different voltage values on a single generator. Before generator start-up, make sure the arrow on the reconnection board matches the arrow of the voltage the customer is using (fig. 2–4). It only takes a second to look at the reconnection panel to interpret the voltage set value—look on the left side of the board and see what arrows match up. You must ensure that ALL of the nuts are tightly screwed back down prior to generator operation.

NOTE: The generators in the illustrations below are *not ready to start up*.

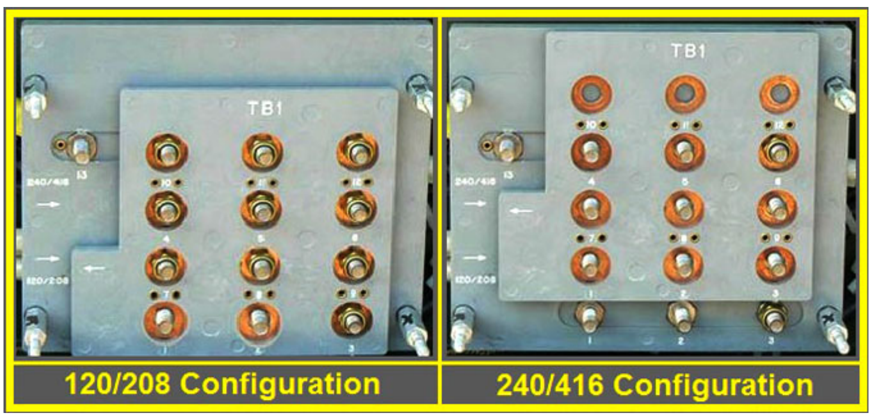


Figure 2–4. Voltage configurations.

NOTE: When reconfiguring voltages on the MEP–807A and MEP–809A you will also have to program the auto voltage regulator (AVR) for the applicable voltage.

Reducing voltage drop

Voltage drop (VD) is the difference in voltage between two points within a circuit caused by the resistance within that circuit. When voltage drop becomes excessive, equipment can be damaged or ruined. You should make every effort to reduce this problem. There are two important factors to consider in *reducing voltage drop*:

- Circuit distance.
- Conductor size.

Factors Affecting Voltage Drop	
Factor	**Description**
Circuit distance	The first thing to take into account is the distance from the power source to the equipment. Even though the conductor may be large enough to safely carry the load current, its length could result in a collective resistance that produces an excessive drop in voltage. This combined resistance results in an inability to operate the

Factors Affecting Voltage Drop	
Factor	**Description**
	equipment properly because of insufficient voltage. The NEC *recommends limiting* voltage drop for branch circuits to 3 percent. For example, suppose the voltage at the generator end is 120 volts and the voltage at the motor is 108 volts. Calculating these numbers, you can determine that there is a difference between the output voltage of the generator and the input voltage at the motor. This difference is a drop of 12 volts. **120V – 108V = 12V** Voltage drop is usually expressed as a percentage. For this case, the values given in figure 2–5 calculate to a 10 percent drop in voltage. **(voltage difference) ÷ (power supply voltage) = (voltage drop percent)** **12 ÷ 120 = 0.10 or (10%)** In this instance, a 12-volt drop would be unacceptable as the calculated 10 percent value is more than the allowed 3 percent drop and could cause serious problems within that circuit and the motor.
Conductor size	The second thing to take into account is the size of the conductor. If the conductor used in the circuit is too small, various troubles may occur. A conductor that is not large enough to carry the current required by the load heats up and may cause a fire or damage the equipment. If you look at figure 2–5, you will see that the conductor being used is #14 AWG. While this conductor, in most cases, can safely handle the 6.5 amperes (amps) of current draw, it is still too small for this circuit because of the distance involved.

What is the solution for this problem of a 10 percent voltage drop in this circuit? Look at figure 2–5 again. As you can see, a generator is supplying power to electrical equipment and a motor that is located 300 feet away. The voltage output of the generator is 120 volts and will be carried to the equipment by a two-conductor, #14 AWG, rubber insulated (RHW) UF cable with ground. The load is the motor's full load current of 6.5 amps.

Once you know that a 10 percent voltage drop is unacceptable, you must figure out what size conductor you need in order to correct the problem.

The next step is to choose a conductor that is sufficient for the load. According to the National Electrical Code (NEC®), Table 310–16, a #12 AWG RHW conductor should be capable of carrying 20 amps. However, since you have an unacceptable voltage drop, you must increase the conductor size to reduce this drop in voltage to a satisfactory level.

What effect would a #8 AWG conductor have? Use the formula shown below for calculating voltage drop to determine if your choice of conductor size is adequate.

VD (voltage drop) = I (load current) × R (total conductor resistance)

Look at the conductor properties table that follows. This table lists the physical properties of standard copper conductors.

Use this table to determine the amount of resistance that the load current meets if you use #8 AWG, stranded conductor.

CONDUCTOR PROPERTIES		
AWG SIZE	***STRANDING***	***UNCOATED COPPER (OHM/1000 FT)***
14	1 7	3.07 3.14
12	1 7	1.93 1.98
10	1 7	1.21 1.24
8	1 7	0.764 0.778

From this table, you can determine that a #8 AWG stranded copper conductor has 0.778 ohms of resistance for each 1,000 feet of length. Convert this value to ohms per foot by dividing 0.778 by 1,000.

0.778 ohms ÷ 1,000 feet = 0.000778 ohms/foot

Now you know that #8 AWG stranded copper conductor has 0.000778 ohms of resistance for each 1 foot of length.

Next, substitute values into the formula for voltage drop (above), and multiply the load current I (6.5 amps) by the total conductor resistance R (0.4668 ohms).

6.5 amps × 0.4668 ohms = 3.03 volts (3 volts)

The result is 3.03 volts. You can round this figure down to 3 volts.

You can now calculate the percentage voltage drop to check whether it is within the 3 percent limit. You accomplish this by calculating the ratio of the voltage drop and the output voltage at the generator (dividing 3 volts by 120 volts).

(voltage difference) ÷ (power supply voltage) = (voltage drop percent)

3 ÷ 120 = 0.025 or 2.5%.

It is now apparent that the voltage drop of the circuit is within the 3 percent limit. You can use the #8 AWG conductor. If the actual drop had been greater than the allowable value, you would have to use the next larger size conductor.

Load panels

All generator sets are equipped with load panels that have connection points marked L_1, L_2, L_3, and L_0 or N (fig. 2–5). These load panels are where the electrical distribution cable attaches to the generator. Check the applicable technical reference for the location of this panel on the particular unit you are using.

Once you have positioned the generator, grounded it, selected the cables, and configured the voltage, you need to connect the cables. You must observe all of the safety precautions to prevent shock or electrocution. Always wear work gloves and use the non-metallic boxed-end wrench provided with the generator. This adds an extra layer of protection as you connect the cables.

Figure 2–5. Generator connections.

> **WARNING:** Lethal voltages are present at the load connection board of the generator set during operation. Do *not* attempt to connect or disconnect load leads while the generator is operating. Do *not* attempt to connect or disconnect load leads with the generator shut down if the generator remains connected in parallel to another power source through the load cables

Connecting Cables to Generator	
Step	**Action**
1	Begin by shutting down the generator set.
2	Open the output load terminal door.
3	Using the terminal nut wrench, loosen the terminal nuts on the selected terminals.
4	Insert the ends of the load cables through the load cable entrance box and insert the ends of the cables into the slots of the load terminal studs. The easiest way to do this is to completely remove the nut and slide the cable straight down through the opening.
5	Reinstall the nut, being careful not to cross-thread it, and tighten the load terminal nuts using the terminal nut wrench. Be careful not to over tighten the nut to prevent stripping the nut and stud. Due to carelessness, the lugs may become damaged and need replacing.
6	Check the phase rotation of all three phase equipment. Mark the cable appropriately.

Correct configuration of generators and cables is essential to power the mission. If these steps are not completed properly, you could cause serious damage to both the generator and load you are powering. Additionally severe personnel injury or death may occur. Remember, if you have a question on a cable or voltage always verify the information before running the generator.

Cable locations

When you install the electrical distribution cable, decide if the cable is to be buried or laid on the ground. Naturally, the type of material available, existing conditions, and the time factor will determine the method you choose for installing the cable.

Cable burial

When conditions permit the burial of cable, follow a few simple precautions to ensure uninterrupted service. Dig a trench so that the cable is at *least* 18 inches deep to prevent disturbance by subsequent surface digging. Be sure to select cable suitable for its environment

Next lay the cable over a sand cushion. If this is not practical, loosen the trench base so it is cleared of rocks or stones. Uniformly separate the cables for further mechanical and electrical protection. A *minimum* of 6 inches between cable centers is desirable. After you lay the cable, cover it with earth that is free of stones, rocks, and so forth. This prevents the cable being damaged in the event flooding or frost heaving disturbs the surrounding earth.

On the ground

Laying the cable on the ground is the most widely used method because of the timesaving involved. Since portable generator sets can be moved almost to the point of use, it may only be necessary to lay the cable over the ground to the load. Lay the cables so that there is a minimum of interference with normal personnel operation. Protection in the form of cable protectors—normally plastic or rubber trays designed for this purpose—prevents mechanical or physical damage in places that are subjected to vehicular and foot traffic.

606. Generator operation

In most instances, these tasks will be accomplished working in coordination with power production personnel. It is important to take certain factors into account when you prepare to operate the generator. These factors include checking for proper phase rotation and paralleling the generators for increased load requirements.

Phase relationship

First and foremost, you must make sure the phase relationship of your generator output matches the needs of your three-phase loads. You can accomplish this by performing a phase rotation test. There are several ways to check the phase rotation of generator sets by using a phase rotation meter. You have already learned about using the phase rotation meter in previous lessons, so we won’t cover it again.

Phase rotation

The following procedures are used to check the phase rotation of a generator:

Checking the Phase Rotation of a Generator	
Step	**Action**
1	Be sure the generator is *not operating* and *all circuit breakers are open* prior to installing the phase sequence indicator.
2	Connect the phase rotation meter to the *incoming* side of the distribution center bus or to the incoming side of the facility’s circuit breaker. Clip one lead of the phase sequence indicator to the bare wire of each of the three phases. Start the engine generator set. Bring it up to the proper frequency, and adjust it to the rated voltage.
3	Close the generator breaker, and note the rotation of the meter. • If the proper direction is displayed on the meter, then the generator leads are connected properly and no further action is required. • If the phase rotation is in the wrong direction, the generator phases are *not* connected properly and must be corrected.

Checking the Phase Rotation of a Generator	
Step	**Action**
4	To change generator phase rotation: • Turn off the power. • Disconnect any two generator leads. • Switch their positions. (If you disconnect A and C, connect C to the position A occupied and A to the position C occupied.)
5	After you interchange the generator leads, repeat the above steps to assure correct phase rotation has been established.

Single unit operation

Since the previous unit provided you with information on how to operate the MEP–805A, this lesson will focus on operating an MEP–806B. If you know how to operate these two generators, you will have the knowledge to operate other MEP generators.

To run the MEP 806B in single unit mode you must first complete of the preoperational checks. Once they have been complete you will need to ensure the CIM display screen is in the MAIN mode (fig. 2– 6); you can do this by using the Select button to click the FULL/MAIN button.

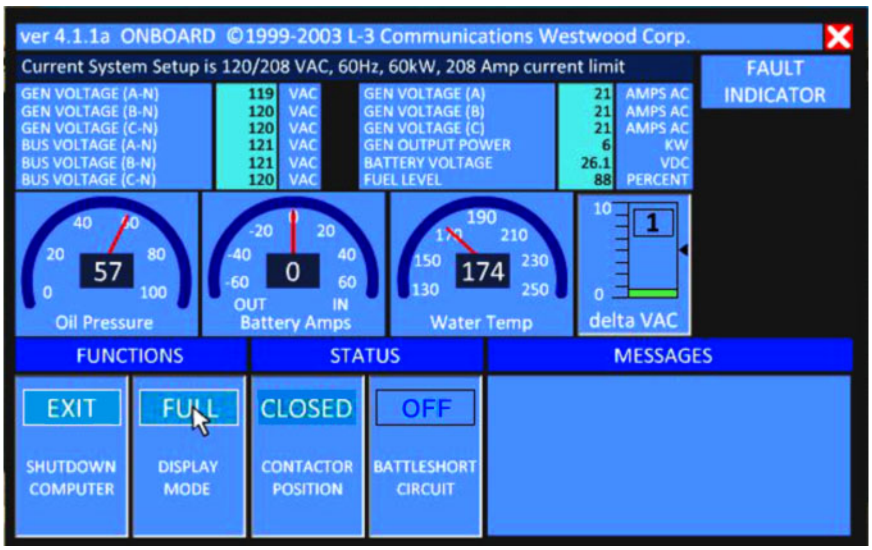


Figure 2–6. MEP 806B CIM main display mode

Next, hold the FAULT RESET switch in the ON position for 2 seconds. Then, release the FAULT RESET switch.

Starting the engine

The process for starting the engine is described in the following table.

Starting The Engine	
Step	**Action**
1	To start the engine Hold ENGINE CONTROL switch in START position (for 2 seconds) and observe CIM display screen until oil pressure reaches at least 25 psi, voltage has increased to its approximate rated value, and engine has reached stable operating speed.
2	Release ENGINE CONTROL switch to PRIME & RUN position.
3	If operating with an auxiliary fuel source, rotate ENGINE CONTROL switch to PRIME & RUN AUX FUEL position.

Starting The Engine	
Step	**Action**
4	Check WATER TEMP (170 to 200 °F) and OIL PRESSURE (25 to 60 psi) meters on CIM display screen for normal readings.
5	Use keypad arrow buttons to move cursor to DISPLAY MODE on CIM display screen. Use SELECT button to click FULL/MAIN button to toggle between full and main mode screens. Access FULL mode screen. **NOTE:** Warm up engine without load for 5 minutes. (If necessary, load can be applied immediately.)
6	Use VOLTAGE ADJUST switch and FREQUENCY ADJUST switch to adjust values for voltage and frequency until required values are displayed on VOLTAGE and FREQUENCY gages on CIM display screen.
7	Press TEST pushbutton on GROUND FAULT CIRCUIT INTERRUPTER. Ensure RESET pushbutton is in in position.

Connecting to load

Once the load is ready to be powered follow the steps below.

Connecting to Load	
Step	**Action**
1	Hold AC CIRCUIT INTERRUPT switch in CLOSED position until CONTACTOR POSITION on CIM display screen reads CLOSED.
2	With CIM display in Main Display Mode, ensure VOLTAGE and FREQUENCY gages still indicate rated values. Adjust if necessary.
3	With CIM display in Full mode screen, if more than rated load is indicated on GEN CURRENT indicator for any phase, reduce load.
4	With CIM Display in Main Mode, observe POWER gage on CIM display screen. If indication is *more than* 60KW, reduce load.
5	Perform all DURING (D) PMCS requirements in accordance with technical order.

Shutting down the generator

Once the generator is no longer needed; follow the procedures below to disconnect the unit from load and shutdown.

Shutting Down the Generator	
Step	**Action**
1	Hold AC CIRCUIT INTERRUPT switch in OPEN position until CONTACTOR POSITION on CIM display screen reads OPEN.
2	Allow generator set to operate 5 minutes with no load applied.
3	Place ENGINE CONTROL switch in the OFF position.
4	Perform all AFTER (A) PMCS requirements in accordance with the technical order
5	Use keypad arrow buttons to move cursor to SHUTDOWN COMPUTER on CIM display screen. Use SELECT button to click on |EXIT| button to exit the DCS software.

Shutting Down the Generator	
Step	**Action**
6	When CIM display screen displays message that it is safe to turn off the computer; place MASTER CONTROL switch in the OFF position. Turn off panel lights.
7	Place DEAD CRANK switch in the OFF position.

607. Generator maintenance

Depending on the location of the deployment, the generator set may have to be operated under adverse conditions, such as extreme cold, extreme heat, and dust. The following paragraphs discuss the adverse operating conditions you may encounter and the maintenance steps you need to take for keeping a MEP generator in operation. This holds true for EALS Generator since it uses a MEP805 generator.

Operation in extreme cold (below 0 °F)

During cold weather, generator sets are designed to start and operate at temperatures from 0 °F down to *minus* 25 °F without a winterization kit. To start and operate at temperatures *below minus* 25 °F, operate the winterization kit (which includes a heater) prior to startup, and accomplish the cooling, electrical, fuel, and lubrication checks described below.

Checking the Cooling System for Extreme Cold Operations	
Step	**Action**
1	Make sure the antifreeze solution has been checked and is correct for the lowest temperature expected.
2	Inspect the level of the coolant in the radiator. Correct a low coolant level.
3	Inspect the cooling system frequently for leaks, paying particular attention to gaskets and hose connections.
4	Make sure the shutters, shutter controls, and thermostats are functioning properly. Correct *all* defects prior to engine operation. Observe the thermometer (water temperature gauge) for abnormally low indications during operation.

Checking the Electrical System for Extreme Cold Operations	
Step	**Action**
1	Keep batteries fully charged to prevent freezing.
2	Inspect the electrolyte level frequently. The electrolyte level must be $^{3}/_{8}$-inch *above the plates*.
3	Keep the batteries free and clean of ice, moisture, and corrosion.
4	See that the battery connections are clean, tight, and lightly greased.
5	See that the battery cap vent holes are *not* plugged.
6	Inspect all electrical wiring insulation for cracks, frays, and breaks.
7	Tighten loose connections and correct all defective wiring.

> **CAUTION:** Water added to a battery may freeze, unless it is is *immediately* mixed with electrolyte by charging.
>
> - Do *not* add water, unless you immediately operate the engine for at least 1 hour.
> - Disturb the electrical wiring as little as possible since the insulation becomes *brittle* in extremely cold temperatures.

Checking the Fuel System for Extreme Cold Operations	
Step	**Action**
1	Keep the fuel tanks as full as possible to reduce the accumulation of moisture.
2	Service the filters more often than usual to remove water from the fuel system.
3	Keep the fuel tank cap and filler neck as free as possible of ice, snow, and moisture during operation and refilling.
4	Drain the fuel tank if it becomes contaminated, and refill it with clean fuel.

Lubrication system

Lubricate the generator set for cold weather conditions in accordance with the current lubrication guidelines.

Cleaning

Wipe the generator set free of snow, ice, or other moisture before each period of operation.

Generator stabilization period

When the generator is operated in extreme cold, allow it to warm up to operating temperature *before* you apply the load. This prevents damage to the engine.

Operation in extreme heat (above 125 °F)

When you operate the generator in areas of extreme heat, make the following cooling, electrical, lubrication, and generator ventilation checks.

Checking the Cooling System for Operating in Extreme Heat	
Step	**Action**
1	Inspect the cooling system level frequently and add clean, fresh water as necessary. Keep the cooling system free of rust and scale by adding an approved rust inhibitor and flushing the cooling system at regular intervals.
2	Check that the radiator core fins and screens are free of obstructions.
3	Check the fan drive V-belt tension for proper adjustment.
4	Inspect the radiator shutter for improper operation. If the automatic shutter control fails, manually open and close the shutter.
5	Close all doors and panels during operation. Open small vents for circulation.
6	Frequently watch the water temperature gauge for excessively high temperatures.

Checking the Electrical System for Operating in Extreme Heat	
Step	**Action**
1	Inspect the electrolyte level of the batteries frequently and add distilled water as necessary. The proper electrolyte level is $^3/_8$-inch *above the plates*.
2	Keep the batteries free and clean of corrosion. Inspect the connections for corrosion and loose connections. Corroded and loose connections generate heat during operation.
3	Extreme heat causes wire insulation to swell and soften. Chafing and fraying due to *vibration* are more frequent than normal.

Lubrication

During operation in extreme heat, lubricate the generator set in accordance with the current lubrication guidelines.

Generator ventilation

- If the generator set is operated in an enclosed shelter, provide ample circulation of air around the generator set and to the outside of the shelter.
- Keep the main generator ventilating screens and louvers free of obstructions.
- Inspect instruments frequently for overloads. Overloads cause the main generator to overheat and may cause the main circuit breaker to open.

Operation in dusty and sandy areas

When you operate the generator in dusty and sandy areas, perform the actions for wind protection and system operation checks described below.

Wind protection

- If the installation is permanent, erect a protective shield for the generator set. Dust and sand shorten the life of the generator set and causes mechanical failure.
- If the installation is temporary, use natural barriers as much as possible. Whenever possible, locate the generator set on the prevailing windward side of dusty areas, roadways, and construction sites.
- Clean the generator set at frequent intervals with an approved solvent.
- When water is plentiful, wet the surrounding terrain beyond the immediate operating area.

WARNING: Keep the immediate operating area *dry* or use insulating materials around the unit to avoid serious shock hazard.

System Checks for Operating Generators in Dusty and Sandy Areas	
System	**Checks**
Cooling	• Inspect the cooling system frequently for leaks. • Inspect the radiator and shutter for obstructions and improper operation. • Keep the radiator cap tight. • Drain and flush the cooling system more frequently than during normal operation. • Take all necessary precautions to keep dust and sand from entering the cooling system when you add or install coolant.
Lubrication	• Lubricate the generator set in accordance with the current lubrication guidelines. • Clean all lubrication points *before* you apply lubricants.

System Checks for Operating Generators in Dusty and Sandy Areas	
System	**Checks**
	• Clean the area around the oil filler cap and crankcase oil level gauge *before* you add oil or check the oil level. • Service the engine oil, oil filter, and air cleaner more frequently than during normal operation.
Generator	• Keep the generator free of grease and oil. • Inspect the ventilation screens for obstructions. • Blow dust and sand from electrical components with low pressure, dry, compressed air.

Operation under rainy or humid conditions

When you operate the generator in rainy or humid conditions, perform the actions described below.

Rain protection

- Locate the generator set in a protected place if possible.
- Erect a suitable shelter, or cover the unit with a waterproof covering and close all doors and panels when the unit is not in use.
- Remove the cover and open all doors and panels during dry periods to dry the unit.
- Dry the unit as thoroughly as possible with dry cloths and ventilate it well before you operate it.

WARNING: Keep immediate operating area *dry*, or use insulating materials around the unit to *avoid* serious electrical shock.

Operating the Generator Under Rainy or Humid Conditions	
System	**Checks**
Electrical	• Keep all electrical equipment dry. • Inspect all electrical wiring for cracks, breaks, and frays.
Fuel	• Keep the fuel tanks as full as possible to avoid accumulation of moisture. • Take precautions to prevent water from entering the fuel system when you add fuel. • Keep reserve fuel containers tightly closed. • Drain the fuel tank if it becomes contaminated, and refill with clean fuel.

608. Basic Expeditionary Airfield Resources electrical distribution

The BEAR electrical distribution system is designed to support modern air, space and cyberspace operations to meet rapid deployment requirements. In this lesson we focus on BEAR base planning and electrical planning.

BEAR Base Planning

When a contingency arises, the AF is pre-postured with assets that can be tasked and deployed within a moment's notice. Like when you order a meal, you don't tell the chef each ingredient that you want added when your food is prepared; you just order your item. The head chef already has a list of ingredients that go into each item on the menu. Well, the Air Force bare base asset deployment planning is very similar.

The two key features of the AF doctrine make us the premier Air Force that can strike anywhere and anytime around the globe—agile combat support (ACS) and Air and Space Expeditionary Task Force (AETF) "force modules." The AF developed a force module concept that tailors force packages to specific expeditionary tasks and allows systematic presentation of capabilities to rapidly open an airfield, generate a certain level of sorties, establish operational capability, and sustain air, space, and cyberspace operations. AETF force modules integrate combat unit type codes (UTC) with combat support UTCs to sustain a base.

The Basic Expeditionary Airfield Resources Order of Battle (BOB) is the basis of a bare base contingency planning. The idea is that the base is starting from scratch, with no aircraft or personnel on the ground and building up to a 3,500 personnel camp. The BOB is based on 250-person increments so that the base grows as personnel arrive. This organized setup allows flexibility and efficiency for establishing a base.

Electrical planning

The bare base electrical power requirements should be based on 4.5 kW per tent; if industrial capabilities are added, the planning factor may increase. For longer term bare base locations, anticipate an increase in electrical power production to support quality of life requirements. You can refer to AFPAM10–219 and volumes from the AFH10–222 series for additional guidance on setting up a bare base.

The tents, typically Alaskan sized small shelter systems (SSS), are laid out in groups of eight (fig. 2–7). A secondary distribution panel is capable of powering 10 tents with field deployable environmental control units (FDECU) under normal conditions, but only eight tents when the ambient temperature is over 125 ˚F. To prevent any confusion and additional work in the summertime, it is the best practice to plan on eights tents per secondary distribution center (SDC). Initial power is provided to each SDC using MEP generators; high voltage is supplied once the primary distribution system is operational. Each MEP generator is connected via a 200-amp BEAR secondary distribution cable to the SDC. In turn, power is supplied to a separate 25-kW power distribution panel (PDP) for each tent, using a 60-amp BEAR secondary distribution cable. This specific PDP is designed with a 60 Amp output for supplying power to the FDECU.

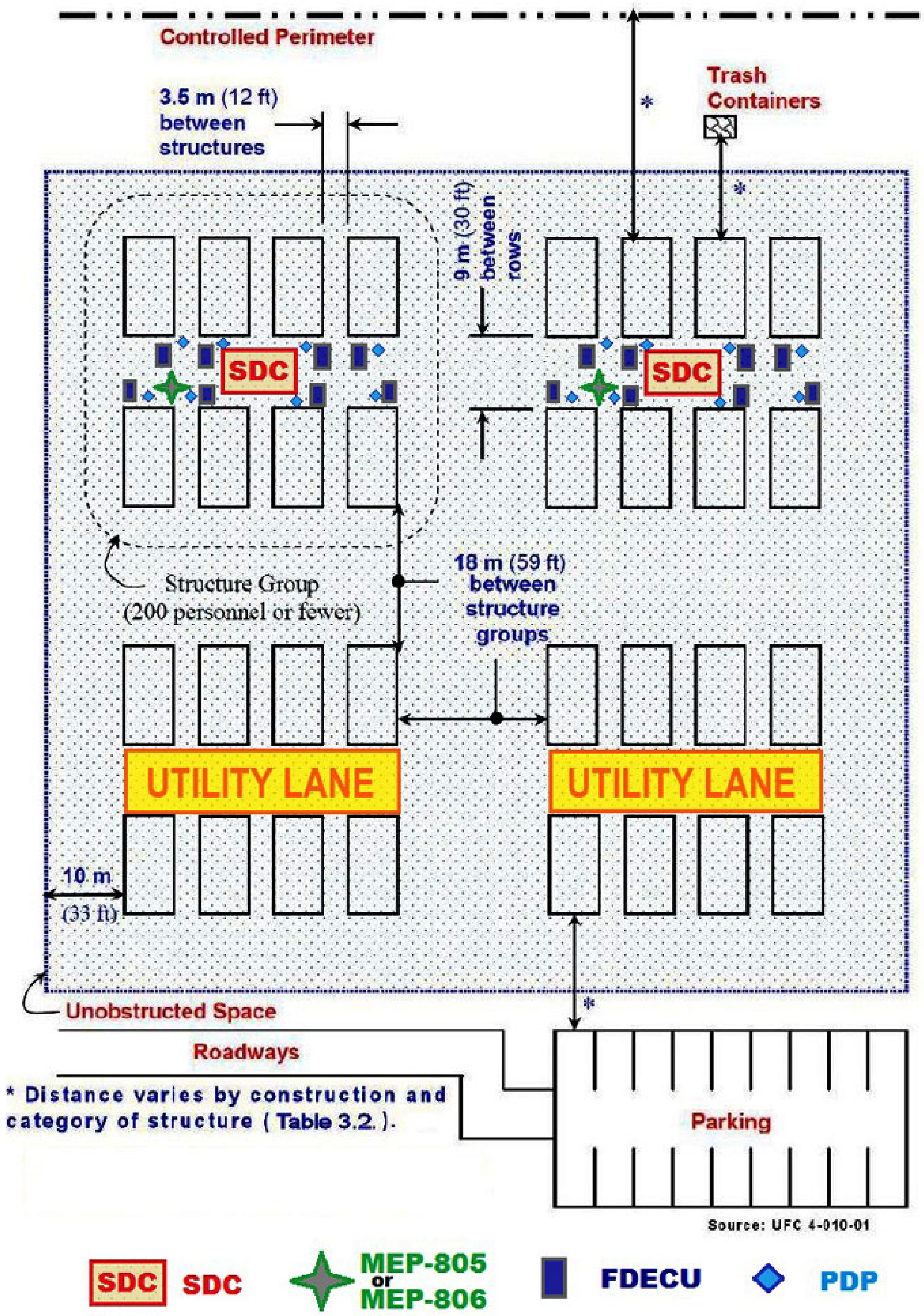


Figure 2–7. Tent spacing layout.

Self-Test Questions

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

604. Power generation

1. What generators are rated at 50/60 kW?

2. What are the kilowatt and voltage ratings for the MEP 007A?

3. What is the *minimum* diameter for a solid ground rod?

605. Generator installation

1. What determines where you place a generator?

2. When you install the generator, what is the *maximum* out-of-level angle allowed?

3. What is the *maximum* voltage drop allowed for branch circuits?

4. What is the *minimum* depth for buried cable?

606. Generator operation

1. When *must* generators be paralleled?

2. What is the *first* step when placing a generator back on line *after* maintenance?

607. Generator maintenance

1. When you operate a generator in extreme heat, what *must* you do if the automatic shutter controls fail?

2. When you operate a generator under rainy and humid conditions, what four precautions *must* you take to protect the fuel system from accumulation of moisture?

608. Basic Expeditionary Airfield Resources electrical distribution

1. What are the two key features of the AF doctrine make us the premier Air Force that can strike anywhere and anytime around the globe?

2. What documents can you reference for additional guidance on setting up a bare base?

3. How is initial power is provided when setting up a bare base?

4. What size PDP is used supply power to each tent?

Answers to Self-Test Questions

604

1. MEP 006A.
2. 100/83 kW and either 120/208 or 240/416 VAC depending on the connections.
3. $^{5}/_{8}$ inch.

605

1. Types and locations of the individual loads.
2. 15°.
3. 3 percent.
4. 18 inches.

606

1. When the load requirement exceeds the kilowatt rating of any one generator.
2. Open the circuit breakers and start the largest generator and one or two others.

607

1. Open and close the shutters manually.
2. Keep the fuel tanks as full as possible. Take precautions to prevent water from entering fuel system when you add fuel. Keep reserve fuel containers tightly closed. Drain the fuel tank if it becomes contaminated, and refill with clean dry fuel.

608

1. ACS and AETF "force modules."
2. AFPAM10–219 and volumes from the AFH10–222.
3. Power is provided to each SDC from a MEP generator using a 200-amp secondary distribution cable.
4. 25-kW PDP.

Complete 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 the Field-Scoring Answer Sheet.

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

13. (604) What generator is used for *emergency backup* of *facilities that are mission essential*, such as communications centers and command posts?
    a. Mission essential power (MEP) 805.
    b. MEP 805A.
    c. MEP 806A.
    d. MEP 807.

14. (605) Besides conductor size, what is another important factor to consider when *reducing voltage drop* in an electrical circuit?
    a. Conduit size.
    b. Insulation type.
    c. Equipment load.
    d. Circuit distance.

15. (605) You have a #8 AWG stranded copper conductor with 0.778 ohms of resistance for each 1,000 feet of length. If you run that cabling 100 feet between the power plant and the load, the *total resistance* would be
    a. 77.8 ohms.
    b. 155.6 ohms.
    c. 0.1556 ohms.
    d. 0.00778 ohms.

16. (606) How do you start the engine of a mission essential power (MEP) 806B generator?
    a. Turn on ENGINE CONTROL switch.
    b. Close the ENGINE CONTROL switch.
    c. Close the ENGINE CONTROL circuit breaker.
    d. Hold ENGINE CONTROL switch in the START for 2 seconds.

17. (606) What is the **first** step to shutting down a generator?
    a. Turn off the generator.
    b. Place ENGINE CONTROL switch in the OFF position.
    c. Select SHUTDOWN COMPUTER on CIM display screen.
    d. Hold alternating current (AC) CIRCUIT INTERRUPT switch in OPEN position to open the load contactor.

18. (607) When operating in extremely cold climates, what *must* you do to prevent the battery from freezing when you add water?
    a. Reposition the battery closer to the engine.
    b. Use a weak salt solution to fill the battery.
    c. Immediately mix the fluid by charging the battery.
    d. Do *not* add fluid when below freezing temperatures are expected.

19. (608) The Basic Expeditionary Airfield Resources Order of Battle (BOB) is based on increments on of how many personnel?
    a. 250.
    b. 500.
    c. 750.
    d. 1,000.

20. (608) On a 25-kw power distribution panel (PDP), what is the 60-amp output utilized for?
    a. To connect another PDP.
    b. This PDP does not have 60-amp output.
    c. Backfeed connection from the secondary distribution panel (SDC).
    d. To connect a field deployable environmental control unit (FDECU).

Please read the unit menu for unit 3 and continue ➔

Unit 3. Basic Expeditionary Airfield Resources Assets

A CONTINGENCY BEAR BASE may be near a town, or it may be in the middle of the desert. In either case, some support items are going to be required for 24-hour operations. You will need equipment such as area lighting, laundry facilities, and water supply to sustain our war fighting capabilities. In this unit, you will learn about the remote area lighting system, telescopic floodlight set, reverse osmosis water purification unit (ROWPU), and the BEAR kitchen set.

609. Remote area lighting system

When you are deployed to a bare base site, time is of the essence. Your team is required to get the base mission ready within 72 hours. In order to meet this deadline, your team has to work around the clock; and therefore, you will need a reliable lighting source that can illuminate the work areas during the hours of darkness. The remote area lighting system (RALS) satisfies this need. Of course, there are other areas, such as aircraft parking, munitions storage, and roadway lighting, where the RALS can be useful. For further guidance on RALS installation, operation and maintenance, refer to the RALS TO 35F5–5–22–1, *Commercial Technical Manual, Remote Area Lighting System (RALS).* Each RALS unit is an air transportable cabinet that weighs approximately 1,500 pounds and contains everything needed to construct a 1,500-foot-long lighting system (fig. 3–1). The cabinet contains two 750-foot lighting cable assemblies, 13 light masts, 13 light fixtures, 12 light mast bases, and 17 high pressure sodium (HPS). This system can be energized from any source that provides 120/208 VAC, three-phase power. The RALS is typically fed power from a SDC via a 60 Amp cable (fig. 3–2).

RALS installation

Proper site selection is your first consideration when you install the unit. When you select this site, keep in mind the limitations of the lighting cables and the extent of the circuit. While it is not critical that the RALS unit be perfectly level, the site should be as nearly level as possible for convenience.

Clear the selected site of any brush or rocks that would make the unit unstable. The surface should also be firm and well drained to prevent the soil from washing out during heavy rains. Once the RALS cabinet is in place, you need to lay your cable.

Figure 3–1. RALS cabinet.

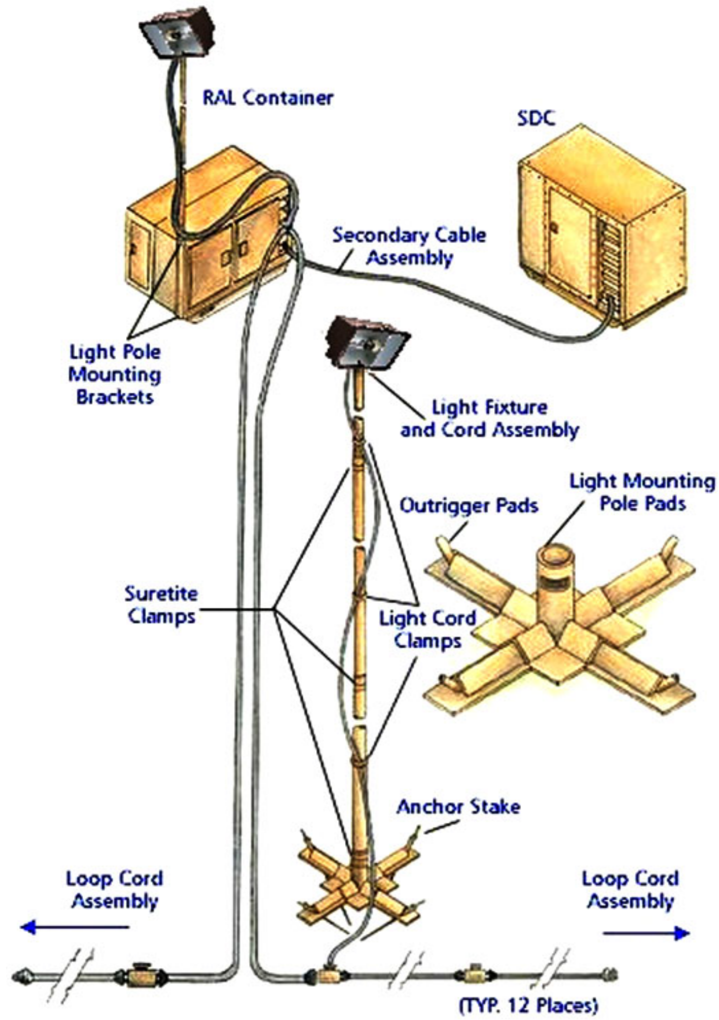


Figure 3–2. RALS components.

Cable

The lighting cables come in four 375-foot sections (fig. 3–3). All four of these sections make up a complete 1,500-foot lighting loop. Lay out two 375-foot cables and using the 208 VAC 3-phase blue canon plug, connect them together to make a 750-feet loop cord assembly (fig. 3–4). Repeat with the remaining two 375-foot cables for the other half of the loop. Then, connect each 750-feet half-loop to the RALS cabinet. Both 750-foot half-loop cables should be extending out to the end of each circuit. Like the feeder cables, install these cables above ground, except in high-traffic areas. Connect each circuit to the appropriate plug on the RALS receptacle panel.

Figure 3–3. RALS cord loop assemblies.

Figure 3–4. RALS cord loop canon plug.

Lights

Figure 3–5 shows the different hardware components that make up the RALS lighting mast. See figure 3–6 for a drawing of RALS layout. As you can see, there is a junction box every 125 feet along each lighting loop assembly.

Install the light assemblies in the following manner:

Installing RALS Light Assemblies	
Step	**Action**
1	Remove and assemble the 12 light mounting pads from the RALS unit.
2	Position and anchor one pad at each of the 12 junction box locations.
3	Attach a light fixture on the telescoping pole.
4	Place 12 of the 13 telescopic light poles in each of the mounting pads. Secure the 13th pole to the RALS cabinet.
5	After you have secured all of the poles, install the lamps.
6	With the lamps and fixtures in place, extend the light poles up to their full height.

Installing RALS Light Assemblies	
Step	**Action**
7	Secure the power cord from each fixture to the poles, and connect it to the junction box.
8	Before you perform the operational checks, connect the feeder cable to the SDC.

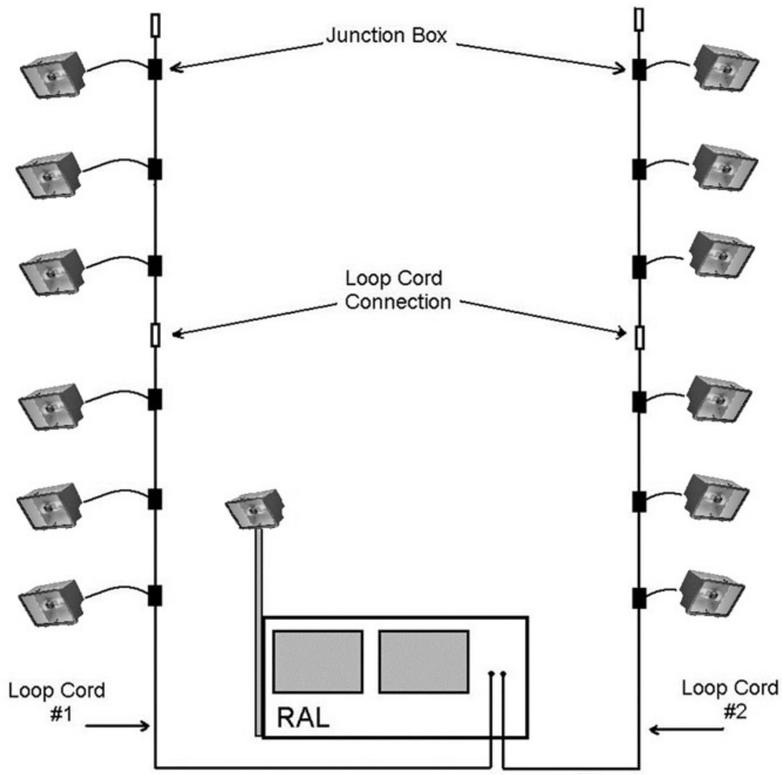


Figure 3–5. RALS lighting layout.

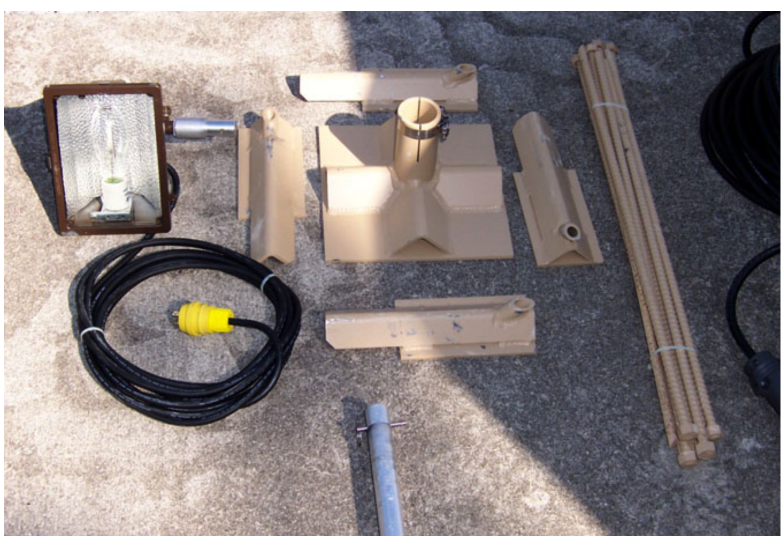


Figure 3–6. RALS light mast components.

RALS operation

The following post-installation checks must be made before the system is ready for operation. You must ensure that:

- The light fixture and pole assemblies are firmly in place and the *proper* lamps (150-watt, High Pressure Sodium) are installed.
- All fixture power cords and junction boxes are securely connected.
- The two loop assemblies are securely connected to the RALS receptacle panel.
- The mating ends of the secondary feeder cables linking the RALS with the SDC are properly connected.

Once you make these checks, the system should be ready for initial turn-on procedures. The procedures in the table below are designed to check the operation of the system and must be performed in the order indicated.

RALS System Operation Check	
Step	**Action**
1	At the SDC, set the circuit breaker that energizes the feeder cable receptacle to the ON position. This energizes the circuit breaker panel located on the RALS.
2	Turn on the circuit breakers at the RALS panel.
3	Now set the magnetic lighting contactor and the photocell override switch on the RALS breaker panel to ON. All of the lights should come on at this time. If you notice any problems with any of the fixtures, repair them at this time. Ensure you turn off power.
4	After any repairs are made, apply power and set the photocell override switch to OFF. At this time, all lights in the circuit go out.
5	Set the override switch to AUTO and cover the window of the photocell with an opaque object. The lights should turn on again in about 30 to 120 seconds.
6	Remove the opaque object from the photocell. The system is now fully operational.

RALS maintenance

The RALS is a very reliable lighting system if you install it properly. However, like any lighting system, recurring maintenance is required to keep it that way. Keep in mind that this system can be mobilized at a moment’s notice. Therefore, the entire system *must* be maintained in a fully operational status, including the storage cabinet itself. You perform all inspections and maintenance described in the following table *quarterly*, unless otherwise required.

RALS Maintenance and Inspections	
Item	**Action**
Lamps and fixtures	Check the lamp fixtures and mounting poles for security, condition, and corrosion. Also, check the condition of the lamps. Correct any discrepancies found.
Circuit breakers and fuses	Check the breakers and fuses for condition and operability.

RALS Maintenance and Inspections	
Item	**Action**
	Also, check the fuse holders, breaker mounts, and electrical connections for corrosion and broken items. Repair or replace any defective items.
Lighting loop assemblies	Make sure all connections are secure and free of corrosion. Make a thorough inspection of the cables to check for damaged insulation. Repair any discrepancies. Excessive corrosion warrants replacing the connectors.
RALS container	Check the RALS structure *semiannually* for structural damage, condition of paint, cleanliness of storage compartments, and corrosion. Repair any structural damage and clean all storage compartments. If you find any corrosion, remove the corrosion with sandpaper or wire brush, and repaint the affected area. Also, paint chipped or scratched areas to prevent corrosion.

610. Telescoping floodlight set

The telescoping floodlight set (fig. 3–7) is a completely self-contained lighting unit that is ideal for contingency operations. The Air Force has used several types of floodlight sets; the TF–2 is the most recent. All sets have been designed as fast deployable floodlighting units for use as emergency and remote area lighting.

This floodlight set has many distinct advantages over the RALS. One advantage is the time it takes to set the package up, and a second advantage is how easy it is to move around. The *biggest* advantage, however, is that this system produces its own power. This lighting package is ideal for the first day or so of your deployment when site electrical distribution has not yet been established. Figures 3–8 and 3–9 are provided as pictorial references for this lesson, you may want to refer back to it when a component is mentioned (with a corresponding number).

Figure 3–7. Telescoping floodlight set.

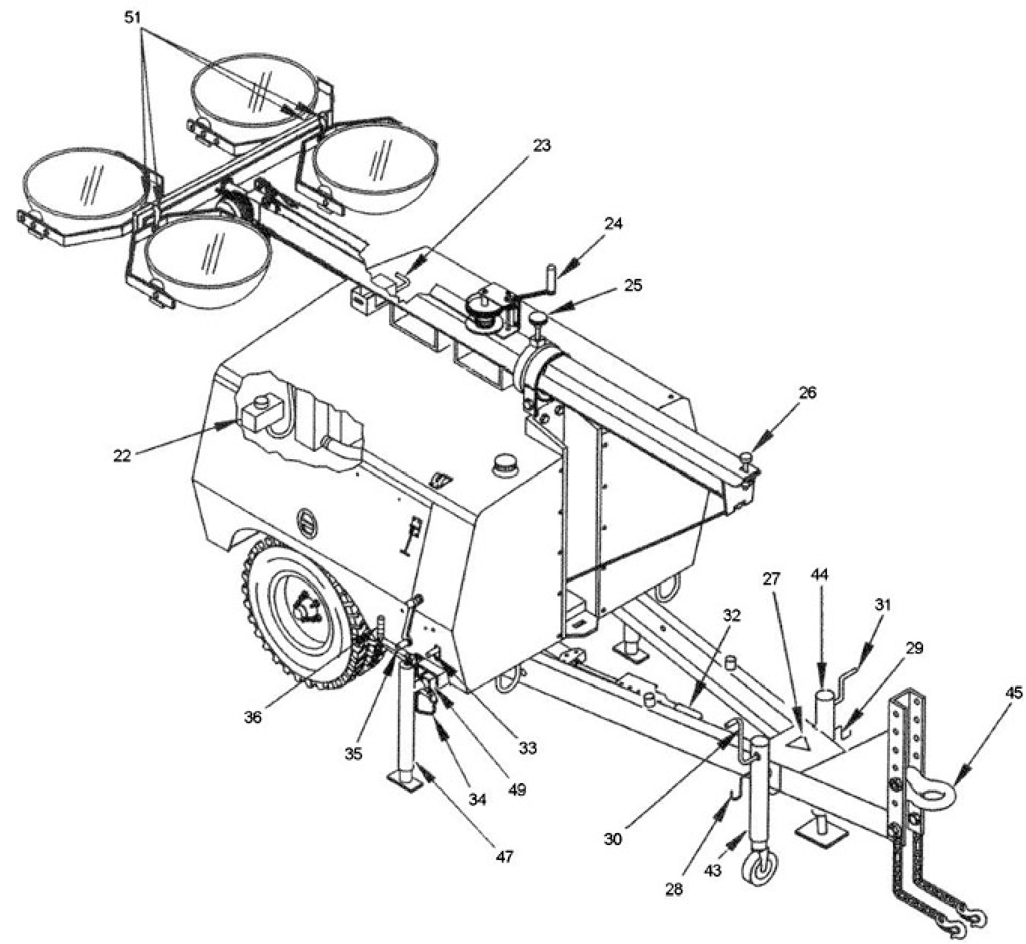


Figure 3–8. TF–2 Telescoping floodlight set nomenclature (Front).

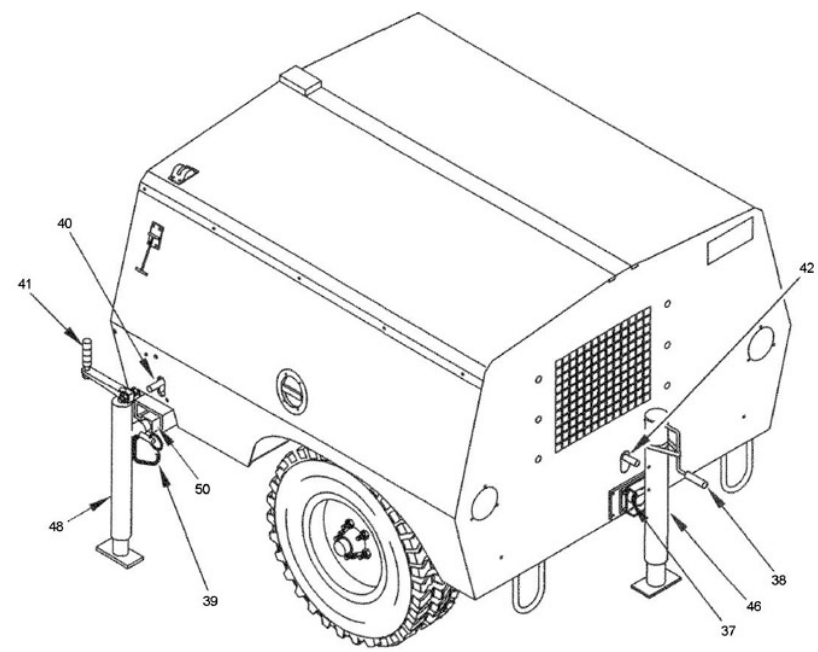


Figure 3–9. TF–2 Telescoping floodlight set nomenclature (Rear).

Floodlight set installation

Select a site for the unit that is as level as possible. It must also provide a stable surface that prevents washout in the event of heavy rains. Once the unit is in position and the parking brake (32) set, extend and lower the four leveling jacks. They provide the added stability that is required when the trailer light tower is extended. Make your best attempt to completely level the trailer.

Floodlight setup

Once you stabilize the trailer, you can raise the main tower. Before doing so it is a good idea to pre-position the lights. Once the tower is raised, positioning the lights will require a ladder. Therefore it is easier to position the lights *before* raising the mast. Position the floodlights from the rear end of the trailer while the tower is the horizontal position (fig. 3–10). It is easiest to point the reflectors of the fixtures outwards about 45 degrees and slightly downwards. If 360 degree lighting coverage is required, then point 2 of the lights in the opposite direction. Each scenario is different, so aim the fixtures as required by your task. Now you are 100 percent ready to raise the tower.

Figure 3–10. Tower floodlight fixtures.

To raise the tower in the vertical position, follow the steps below.

Raising Floodlight Tower to Vertical Position	
Step	**Action**
1	Release the mast support saddle latch. Figure 3–8 (23)
2	Open the right side engine compartment door and secure it in the open position.
3	Remove the crank handle from its storage position and install it on the winch shaft.
4	Rotate crank clockwise to raise mast from horizontal to vertical until tower stops against tower support. Figure 3–8 (35). As you crank the handle, the base should move down as the lights move up into the full upright position. Figure 3–11 shows a tower that is in the process of being raised.
5	Rotate knob counter-clockwise to loosen vertical mast lock knob and allow latch plate to drop down and engage striker plate. Turn knob clockwise to tighten and lock mast in vertical position. **NOTE:** When the mast lock engages locking the mast in the vertical position, it also disengages the mast sections allowing the mast to be rotated to position (aim) the lights.

Figure 3–11. Placing tower in upright position.

Tower extension

Before the system is made fully operational, raise the trailer tower to its full height (29 feet) by using the tower hand crank that is located about 4-feet up from the base of the tower. The tower hand crank is illustrated in fig. 3–8 (24) and fig. 3–12. As the mast extends, guide the power cable through the split rings to prevent damaging it.

Figure 3–12. Tower Hand Crank.

Floodlight set operation

Inside the trailer is a three cylinder, 10.5–horsepower (hp), water-cooled, diesel engine that drives a 6 kW generator capable of supplying the system with 120/240 VAC. Before you start the generator, make the following checks:

- Engine oil level.
- Engine coolant level.
- Fuel level.
- Air filter and all intake duct work is securely clamped.

Generator startup

A control panel, which is located on the side of the trailer, houses all of the circuit breakers and generator controls. To start the generator, open the control panel and perform the steps in the following table.

Floodlight Generator Startup Procedures	
Step	**Action**
1	Ensure all circuit breakers are turned OFF.
2	Set master control switch to ON.
3	Press and hold fault bypass push button switch.
4	Press and hold glow plug engage switch for 10 seconds and continue to hold for 10 seconds after starting. **CAUTION:** Do *not* operate starter motor for more than 10 seconds. It may over heat.
5	Press starter switch (17) to crank engine. Allow a 60 second cool down time between cranking intervals.
6	Release starter switch when engine begins to run.
7	Release fault bypass switch after engine has run 5 to 10 seconds.
8	Observe that volt meter indicates 12 to 14.5 volts.

When engine RPM stabilizes, place the main circuit breaker in the ON position. Observe the voltage reading on the AC voltmeter. For *proper* operation, the voltage range should be from 233 to 247 volts AC.

Circuit breakers

There is one circuit breaker for each of the 120-volt outlets as well as for each of the 1,000-watt lamps on the trailer tower. To energize the lights, simply turn on the breaker for that specific circuit. Engage the loads slowly to allow the generator time to regulate the power. Since the telescoping floodlight set does *not* have a control circuit like the RALS, turn it on manually.

Floodlight set maintenance

The following is a simplified schedule that contains maintenance procedures that are recommended to prevent downtime due to major failures. Conducting this maintenance increases the reliability and life expectancy of the floodlight system.

Floodlight Set Maintenance		
Interval	**Item**	**Service Procedure**
Daily or as required. *Before operating.*	Fuel level.	Check and fill as necessary to prevent condensation.
	Engine oil.	Check level and condition.
	Air filter.	Clean under dusty conditions.
	Engine coolant.	Check level in recovery bottle. Add recommended coolant mixture as necessary to bring to cold full line.
	Fuel filter bowl.	Check for presence of water. Provide suitable container to catch drainings and open drain to remove all water from bowl.
	Steel winch cables. (Each Use)	Inspect for proper routing and signs of damage. Make sure ends are properly secured.
	Engine.	Check for fuel and oil leaks.
	Tires.	Check for proper inflation pressure. • *Maximum* - 60 psi. • *Minimum* - 20 psi. Check for cuts or other damage.
250 Hours	All daily items.	Same as above.
	Engine oil.	Change oil and filter.
	Air filter.	Change element if necessary or clean element under moderately dusty conditions.
	Coolant.	Check level and condition.
	Fan belt.	Check tension and condition.
	Hardware.	Check to ensure all mounting hardware is present and tight.
	Battery.	Clean and tighten terminals as necessary.
500 Hours	All 250 hour items.	Same as above.
	Fan belt.	Replace. Refer to engine manufacturer's manual for procedures.
	Radiator.	Use water or compressed air to clean out fins.
	Fuel filter.	Change filter element.
	Fuel tank.	Inspect tank for sediment, clean tank if necessary.
750 Hours	All 250 hour items.	Same as above.
	Lubricate mast.	Refer to TO 35F5–5–21–1, Table 5–2.
1000 Hours or Annually	All 500 hour items.	Same as above.
	Cable pulleys on mast.	Inspect for wear, clean, and lube.

Floodlight Set Maintenance		
Interval	**Item**	**Service Procedure**
		Remove nut and capscrew to remove pulley. Inspect pulley bushing for wear with capscrew. If excessively worn, replace pulley and capscrew. Clean and lubricate lightly with grease per MIL-G–10924D.
	Wheel bearings.	Inspect for grease leakage and looseness indicated by wheel wobble. Clean, repack with MIL-G–10924D grease if necessary.

611. Reverse osmosis water purification unit

The Air Force has several pre-selected sites throughout the world that are at its disposal in the event of contingency requirements. The only two prerequisites for these sites are that there is a suitable landing area and there is a water source within one mile. This water must be made potable in order to sustain the base's operation. The water purifier used most frequently on deployments is the reverse osmosis water purification unit (ROWPU).

For further guidance on installation and maintenance of this unit, refer to TO 40W4–20–1, *Operation and maintenance instructions with illustrated parts breakdown –1500 Reverse Osmosis Water Purification Unit (ROWPU)* (fig. 3–13).

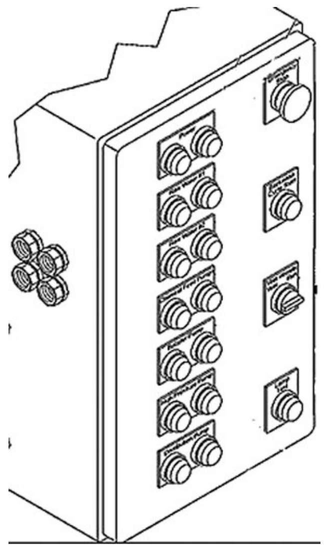
Figure 3–13. ROWPU 1500.

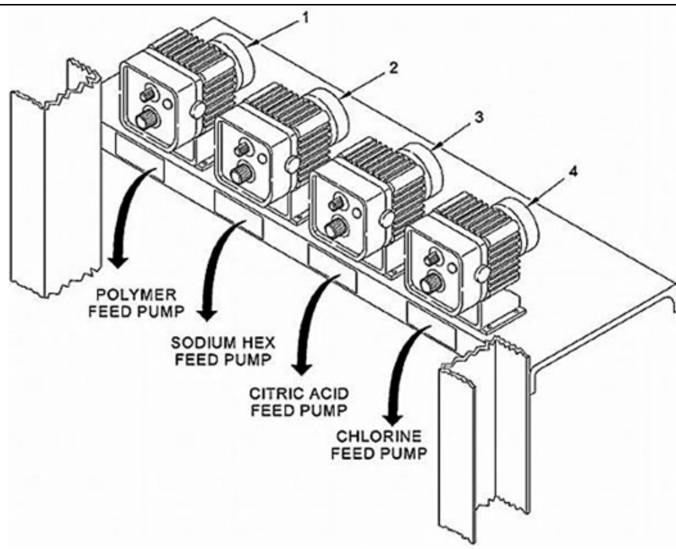
The 1,500 GPH ROWPU was developed to replace the 600 GPH ROWPU. It produces 1,500 gallons of potable water each hour when operated on water with *less than* 1,000 parts per million (ppm) of total dissolved solids (TDS). If the raw water has *more than* 45,000 ppm TDS, its output capabilities will be reduced to 1,200 gallons per hour. The product water will meet the Tri-Service Field Water Quality Standards for long term consumption. The 1,500 GPH ROWPU will operate in temperatures ranging from –25 to +140 °F. It uses state of the art technology to increase the 600 GPH ROWPU's output without increasing its size or weight. The 1,500 GPH ROWPU is operable either on the ground or mounted on a 5 ton trailer or a 5 ton truck.

It is designed to be air, rail, and truck transportable and flexible in its application in the field to meet various requirements. It can be powered by a 35 kW generator or commercial power and has an easily accessible, useful control panel. The ROWPU's most outstanding feature is that it is designed to be compact, allowing for the packing of all the required hoses, bladders, pumps, tools, and test equipment within the structural confines of the unit itself. When shipped to your deployed location, this unit is literally designed to have everything you need to purify water.

ROWPU overview

The unit should be sited upstream from camp and *no more than* 250 feet from the raw water source. The ROWPU unit is placed on firm ground that is level.

ROWPU Components	
Type	**Description**
Pushbutton Control Box	The pushbutton control box (fig. 3–14) is a major component located on the ROWPU control panel. This control panel component is important because this is where all the electrical components necessary to operate the ROWPU are controlled. The pushbutton control box also has a pushbutton to reset and test all indicator lamps.  **Figure 3–14. Control box.**
Pilot Light Enclosure	The pilot light enclosure contains all the indicator lights to indicate operation mode of all electrical components on the ROWPU. It also contains trouble indicator lights to warn you of potential trouble to the Unit and components.
Chemical Feed Pump Controls	The chemical feed pumps dispense the four chemicals used when the unit operates. These chemical feed pumps are unique in that they separately feed the four different chemicals the ROWPU uses at the same time. The suction lines are at the bottom of each feed body while the feed lines are on top of the feeder body. Each feed body is designed to feed the chemical indicated in figure 3–15. From left to right these are polymer, sodium hex, citric acid, and chlorine.

ROWPU Components	
Type	**Description**
	 **Figure 3–15. Chemical feed pumps.**

ROWPU electrical installation

The electrical requirements for the ROWPU consists of power for the ROWPU unit itself as well as the various pumps that are required to move large amounts of raw and treated water (fig. 3–16). Primary power requirements for this unit are 208 VAC, 104 amps (max), three-phase power. The electrical supply can be provided from any 208 volt power source, using a 200 amp BEAR power cable.

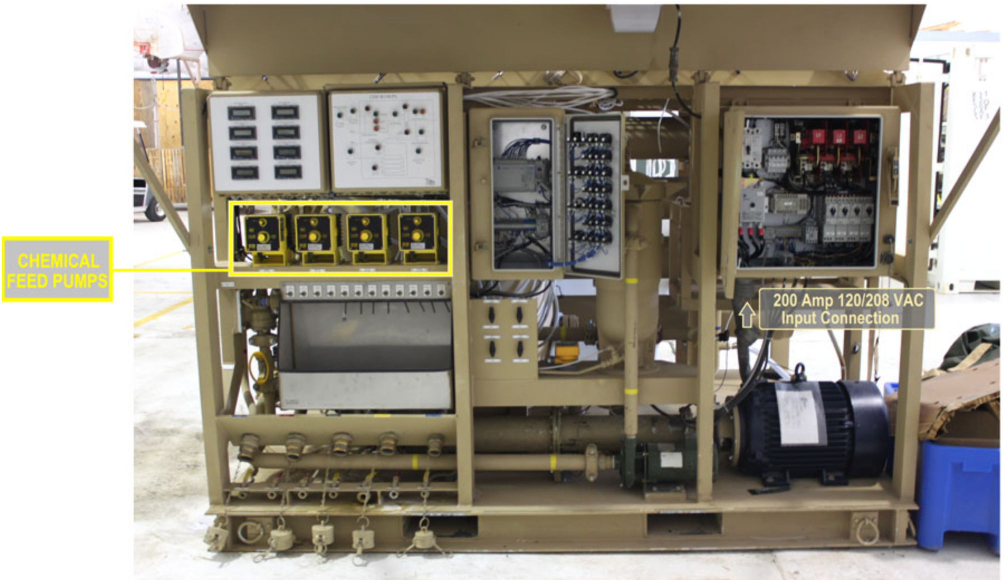


Figure 3–16. Control box.

Programmable logic controllers

A programmable logic controller (PLC) is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or lighting fixtures. PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output (I/O) arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. Figure 3–17 shows the ROWPU PLC.

Figure 3–17. ROWPU PLC.

Data Flow

The ROWPU uses information from various input sensors and makes decisions based on the input information. Output signals from the PLC are used to control the overall water purification process. Figure 3–18 illustrates how digital information flows with in the ROWPU control infrastructure.

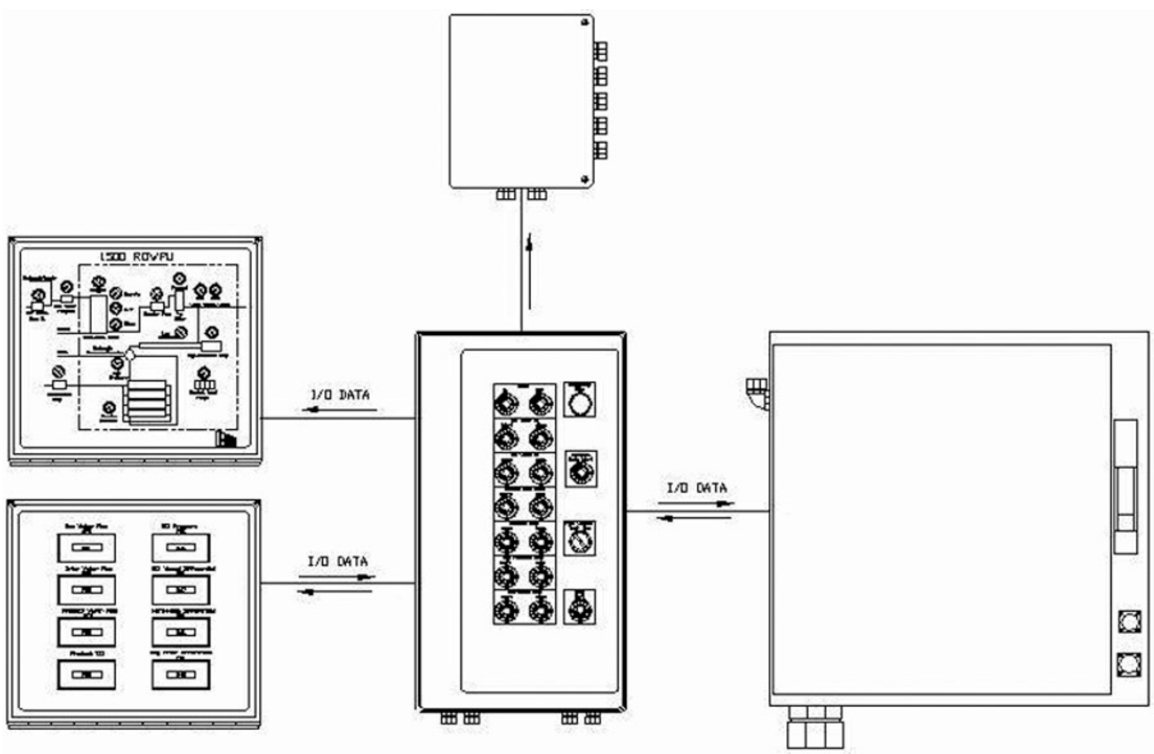


Figure 3–18. ROWPU Logic (I/O) data flow.

Junction box

The junction box (fig. 3–19) is located immediately to the right of the control panel. It contains the main system disconnect, circuit breakers, control relays, motor starters, as well as an I/O module.

Reverse osmosis pump

The reverse osmosis pump is located under the electrical Junction Box. The motor that drives this pump is rated at 208VAC 3-Phase, 40 hp, and 99.5 amps. A switch on the control box labeled "R.O. PUMP" controls the motor control circuit.

Booster pump

The booster pump is located to the left of the RO Pump as you view the ROWPU unit from the front (fig. 3–20). The motor that runs the pump is rated at 208VAC, 1 hp, and 3.4/1.6 amps. The switch on the control box that is labeled BOOSTER PUMP controls the circuit.

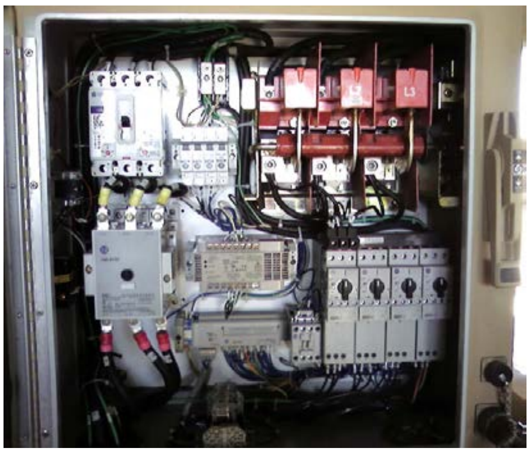


Figure 3–19. Junction Box.

Figure 3–20. RO and Booster water pumps.

Raw water pumps

The ROWPU contains two raw water pumps (fig. 3–21). One or both of the pumps are placed between the raw water source and the ROWPU unit; use of 1 or 2 pumps depends on the installation scenario. The motor that drives each pump is rated at 208VAC, 3 hp, and 8.1 amps. The control box has two switches, labeled RAW WATER PUMP NO. 1 and RAW WATER PUMP NO. 2 which control each respective pump. The first pump is powered through receptacle J2-A on the junction box. The second pump is powered from an electrical cannon plug on the first pump. As the pumps are controlled from the control box, the pump *closer to the source* acts as Pump No. 1 and Pump No. 2 is closer to the unit.

Figure 3–21. ROWPU raw water pump.

Backwash pump function

The raw water pumps can be operated as a backwash pump. This is done to clean out the ROWPU during maintenance operations performed by the WFMS personnel. There is a 2-way valve that must be turned prior to backflow operations.

Distribution pump

The distribution pump is located next to the potable water storage container (fig. 3–22). The motor is rated at 208/460 VAC, 1 hp, and 3.4/1.6 amps. The fourth switch from the left on the control box, which is labeled DISTRIBUTION PUMP, controls the circuit. The pump is fed through receptacle J5 and is protected by the three-phase, 15-amp CB5. The only installation requirement is the interconnection between the motor cable plug and junction box.

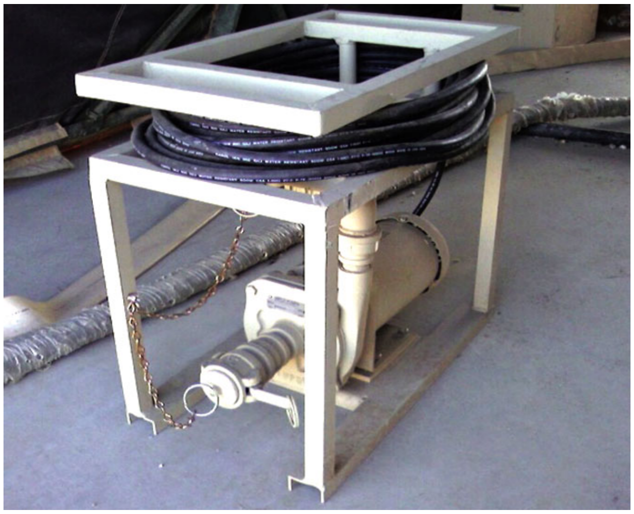


Figure 3–22. ROWPU distribution pump.

Booster pump

The booster pump is located on the trailer. The motor that runs the pump is rated at 208/460 VAC, 1 hp, and 3.4/1.6 amps. The switch on the control box that is labeled BOOSTER PUMP controls the circuit. The pump is fed through a cannon plug connection on the bottom of the circuit breaker box and is protected by the three-phase, 15-amp CB6. The only installation requirement is the interconnection between the motor cable plug and the receptacle on the breaker box.

Chemical feed pump

The chemical feed pumps are located in the unit, to the left of the control box (fig. 3–23). The pumps are low amperage diaphragm pumps that only move 2.67 gallons per hour. They are responsible for injecting chemicals required for the water treatment process.

Ground connection

Due to the possibility of electrical shock, you *must ground* the ROWPU using a ground rod, grounding conductor, and proper connections *before it can be used*. The unit comes equipped with a three-piece ground rod, which is stored on the control panel. To install the ground rod, drive each section in one at a time. Insert the rod-driving bolt into the coupler of the first section to be installed. This bolt is designed to protect the coupler and rod while they are being hammered into the ground.

Drive the rod section into the ground until about 6 inches of the rod remains exposed. Remove the driving bolt and insert the next section of rod into the threaded coupler. Repeat this process until all ground rod sections are installed. Then secure the grounding conductor between the ROWPU and the ground rod. After you install the rod, check the security of the connections and make sure the *maximum* ground resistance does *not exceed* 25 ohms (Ω).

Figure 3–23. ROWPU chemical feed pumps.

ROWPU troubleshooting

Troubleshooting procedures for the ROWPU are not much different from those used for other pieces of electrical equipment. The system contains several motor control and relay circuits as well as digital control software to operate the PLC. Reference TO 40W4–20–1 for specific steps on troubleshooting.

> **WARNING:** ROWPU piping and equipment can contain extremely high pressure during and after operation. If this pressure is not relieved *before* working on these pipes or equipment, *serious injury or death* may result. Be sure to *open all drains and vents before* beginning any disassembly.

612. Basic Expeditionary Airfield Resources kitchen sets

Providing the necessary power and light to a BEAR base is very important in mission accomplishment. Providing this power and light to the dining facility is equally important. This lesson covers installation and maintenance of the BEAR kitchen set electrical systems.

Expeditionary kitchen facility

The BEAR kitchen facilities are completely portable food preparation and serving complexes. The BEAR kitchen facility (fig. 3–24a) is designed to serve up to 550 personnel and to seat 120. All tools, supplies, and equipment, with the exception of electrical and water supplies, are supplied in the kits. Refer to the Harvest Eagle section of TO 35E4–169–1, *Erection, Operation, Storage, Inspection, and Maintenance Instructions with Illustrated Parts Breakdown –Harvest Falcon/Eagle Kitchen Facility* and/or TO 35E4–169–11, *Operation and Maintenance – Harvest Falcon/Eagle – Kitchen – Power Distribution System* for further guidance on installation and maintenance.

Power supply installation

The BEAR kitchen is much smaller than the old Harvest Falcon kitchen. Due to its reduced size and load requirements, this facility gets all the power it needs from one 225 Amp, 208 Volt, 3 phase, 60 Hz power source. The power will be distributed to the *entire* BEAR kitchen by two dedicated 150 KVA secondary distribution centers (SDC) initially fed by one 60-kW generator and one 30-kW generator. Once the base electrical distribution system is operational, the SDCs can be connected to it and the generators can be used for backup power. Figure 3–24b shows the *primary* power (main low-voltage power) circuits. The generators provide power to the entire facility by way of the two SDCs. The SDCs not only serve as distribution points, they *also* provide circuit protection.

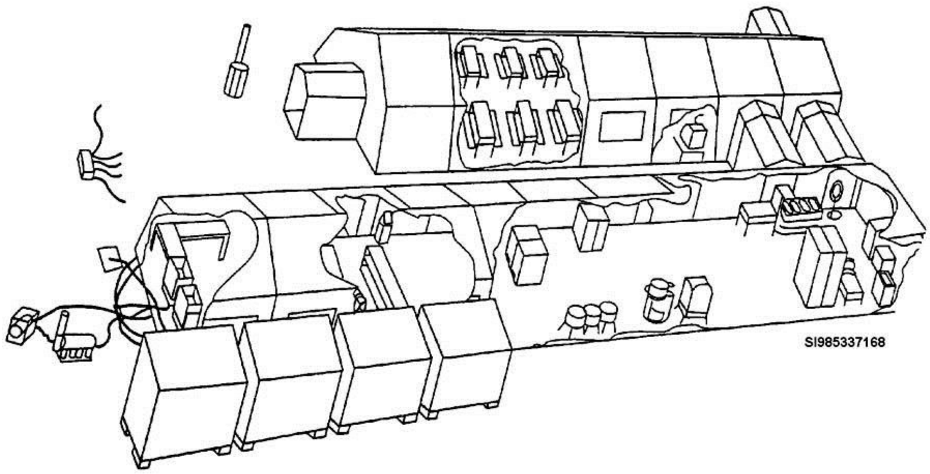


Figure 3–24a. BEAR kitchen.

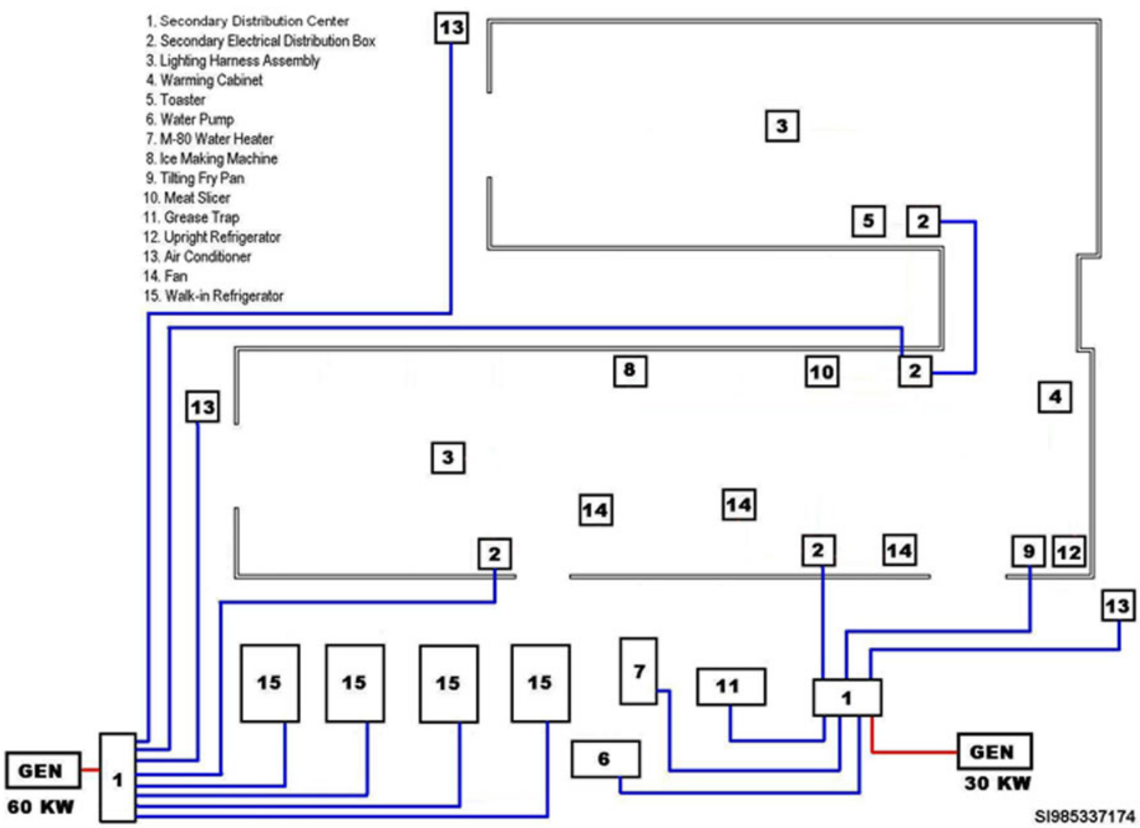


Figure 3–24b. BEAR kitchen primary distribution.

One of the SDCs feeds the four walk-in refrigerator units, two air-conditioners, and three of the four secondary electrical distribution boxes. The other SDC feeds the grease trap, water heater, water pump, tilting fry pan, air-conditioner, and one of the four secondary electrical distribution boxes.

The *secondary* circuits are shown in figure 3–24c. You will see that the secondary electrical distribution boxes feed three fans, two light circuits, an upright refrigerator, meat slicer, warming cabinet, and a toaster.

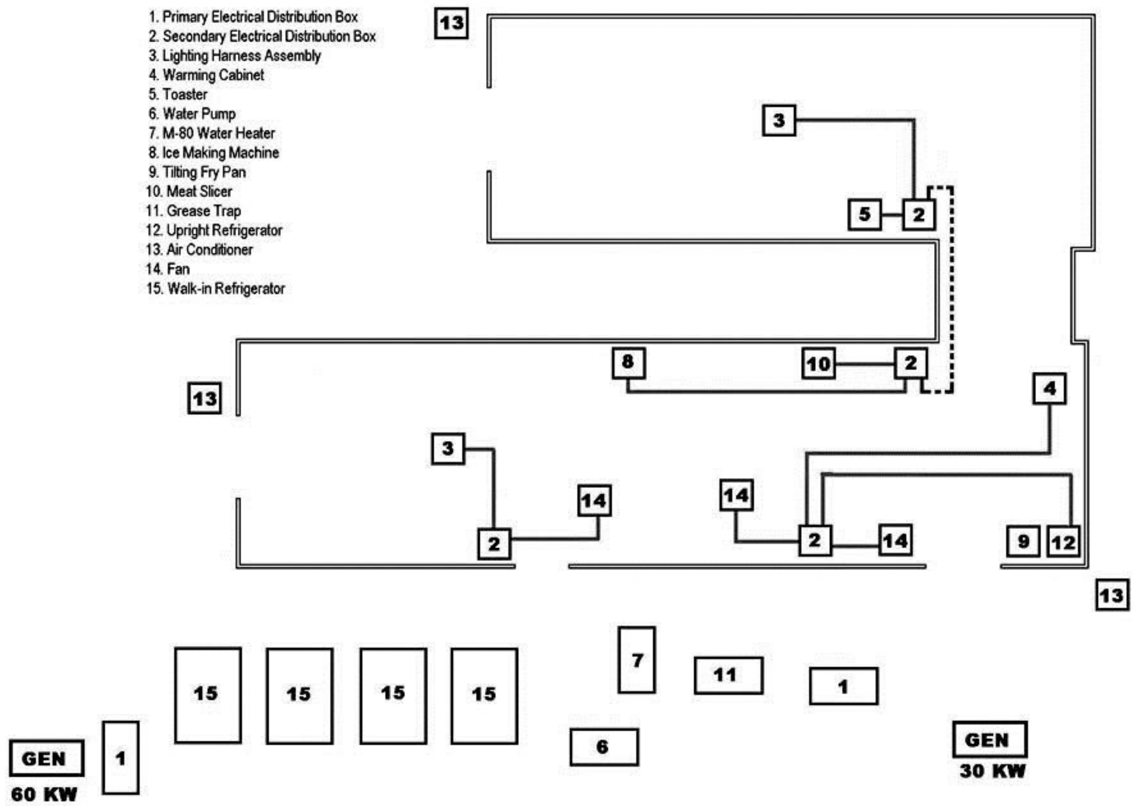


Figure 3–24c. BEAR kitchen secondary distribution.

Actual installation of the electrical distribution system for the BEAR kitchen will need to be coordinated with the services personnel. The placement of certain components may need to be adjusted to meet varying circumstances. Nevertheless, the installation of the components should follow the general procedures outlined in the following paragraphs.

After coordinating the placement of the components with services personnel, the first thing to do is install the SDCs and connect them to a power source. Following installation of the SDCs, you should install your secondary circuits to the four secondary distribution boxes and the kitchen equipment that gets plugged directly in to the SDCs. The final step is to install the facility lighting.

One important thing to keep in mind when you install the BEAR kitchen is the protection of your distribution cables. Remember, the BEAR facility is designed to feed 550 people per meal. That many people walking around could destroy your distribution cables in no time. Bury the cables in any area where you expect a high volume of traffic. If for any reason you are unable to bury them, fabricate a platform so people can walk over them.

Maintenance of the BEAR kitchen

Your responsibilities for the maintenance of the kitchens are really quite limited. Check all of the following areas *prior* to operation, *every* week while in operation, and *prior* to disassembly.

- Check all electrical connections of cables, receptacles, circuit breakers, and light assemblies for damage, burned contacts, and insulation breakdown.
- Check the attachment security of all electrical items.
- Check light assemblies for burned out lamps.
- Ensure equipment is installed correctly and functions properly.

Electric Single Pallet Expeditionary Kitchen

The Electric Single Pallet Expeditionary Kitchen (ESPEK) is a complete field kitchen facility designed to provide all initial hot meals. This enables the feeding capability to Expeditionary Air Force (AEF) deployments in austere locations using primarily the UGR-Heat and Serve (UGR-H&S) rations with the newly added capability to prepare UGR-A rations (with additional power and refrigeration). The ESPEK can prepare 550 UGR-H&S rations and 350 UGR-A rations in less than 2 hours. The ESPEK is a compact, quick response, light and lean kitchen system consisting of a tent based kitchen and optional dining areas, all electric appliances, and sanitation system transported in standard ISO shipping containers or on 463L air cargo pallets to support air, land, and ocean transport.

ESPEK components

The main components include a CAMSS 20EX–24 shelter system, portable flooring system, all electrical commercial off-the-shelf (COTS) appliances, various utensils, insulated food containers, support equipment, prep-tables and a three-compartment sink that is heated by an electric tankless hot water heater system (fig. 3–25a).

The ESPEK consists of 1 to 2 24 foot CAMSS20EX Shelters integrated to form 480 square feet of kitchen, food preparation, sanitation, storage, and serving line areas. The following food service equipment is included: 1 manual tilt braising pan, 1 convection oven, 2 pressureless steamers, portable flooring system, 5 lightweight food preparation worktables, 1 three compartment sanitation sink, 5 insulated food & beverage containers, portable drying and storage racks, utensil, hotel pans, and other miscellaneous food service equipment items. The separate (optional) dining facility consists of a second CAMSS 20EX24 shelter system coupled to one end of the kitchen shelter and all of the associated tables and chairs necessary to support in shelter dining. Due to limited power, the ESPEK is *not air conditioned or heated by an environmental control unit*. The shelter is designed with the standard 15 inch fabric ECU intake and exhaust ports on each end of the shelter should the CE community have additional ECU's and electric power available to support the ESPEK (fig. 3–25b).

Figure 3–25a. ESPEK.

Figure 3–25b. ESPEK.

ESPEK electrical requirements

Power is supplied to the kitchen via a 60kW MEP–806B generator through a 200 amp power cable that feeds power to a 60 kVA power distribution panel (PDP). The PDP has five 60 amp class L box mount receptacles mounted on it which provide power to the individual 208 VAC, 3 Phase appliances. Each electrical circuit has its own circuit breaker. In addition, 110VAC GFCI duplex convenience outlets are added to provide convenience power, lighting, secondary sump pump, etc. Each commercial appliance is modified to add a 60 amp Class L box mount connector on the rear of the appliance to support field plug and operate capabilities. Although redundant, each appliance is also retrofitted with a circuit breaker and panel assembly to support safety of the operators and equipment.

Self-Test Questions

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

609. Remote area lighting system

1. How many light fixtures come with the RALS?

2. What are the power requirements for the RALS?

3. How long is one lighting loop assembly?

4. What is the spacing of the junction boxes along the lighting loop assembly?

5. Once the light poles are secure and lamps installed, what is the *next* step in the installation process?

6. What is the *first* step in initial turn-on procedures for the RALS?

7. How often do you inspect light loop assemblies, and what do you look for?

610. Telescoping floodlight set

1. What is the kW rating of the generator that comes with the floodlight set?

2. What are three advantages of the floodlight set over the RALS?

3. What fixtures are attached to the top of the tower?

4. How do you know when you have the tower in the full upright position?

5. What is the wattage of each lamp that is installed on the portable stands?

6. Why *must* the preheat button be held for at *least* 30 seconds prior to starting the generator?

7. How is the trailer tower raised into its extended position?

8. At what frequency do you check the generator engine oil?

9. How often *must* you clean the engine air filter under *normal* operating conditions?

611. Reverse osmosis water purification unit

1. What is the power requirement for operating the ROWPU?

2. What device controls all electrical circuits of the ROWPU?

3. Which ROWPU pumps *require* the installation of electrical power cable?

4. What *must* be installed with the ROWPU to eliminate the possibility of electric shock?

5. What is the *maximum* allowable ground rod resistance?

6. What *must* you do *before* disassembling systems on the ROWPU?

612. BEAR kitchen set

1. What is the voltage requirement for the BEAR kitchen?

2. Which dedicated pieces of electrical equipment are used to distribute power to the entire BEAR kitchen facility?

3. The SDCs in the BEAR kitchen *initially* receive their power from what?

4. What steps should you take to protect your distribution cables?

5. What maintenance checks do you perform on the Harvest Eagle kitchen electrical system?

Answers to Self-Test Questions

609

1. 13.
2. 120/208 VAC, three-phase.
3. 750 feet.
4. 125 feet.
5. Extend the light poles up to their full height.
6. Turn on the circuit breaker feeding the RALS at the SDC.

7. Quarterly. Ensure connections are secure and free of corrosion; check for insulation damage.

610

1. 7 kW.
2. (1) Time it takes to set it up.
   (1) Ease of movement.
   (2) The fact that it has its own power supply.
3. 1,000-watt light fixtures.
4. You hear a distinct “snap.”
5. 500.
6. To give the glow plugs time to heat up.
7. Rotate crank clockwise to raise mast from horizontal to vertical until tower stops against tower support.
8. Every 8 hours during operation or after every operation, whichever occurs first.
9. Every 50 hours.

611

1. 120/208 VAC, 104 amp, three-phase power.
2. Control box.
3. Backwash pump, raw water pumps 1 and 2, and the distribution pump.
4. Ground rod and grounding conductor.
5. 25 Ω.
6. Open all drains and vents.

612

1. 120/208 VAC.
2. An SDC.
3. One 60-kW generator and one 30-kW generator.
4. Bury them or provide a platform over them to keep people from walking on them.
5. Check all electrical connections of cables, receptacles, circuit breakers, and light assemblies for damage, burned contacts, and insulation breakdown; check for security of attachment of all electrical items; check light assemblies for burned out lamps; ensure equipment is installed correctly and functions properly.

Complete 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 the Field-Scoring Answer Sheet.

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

21. (609) How many light masts come with the remote area lighting system (RALS)?
    a. 11.
    b. 12.
    c. 13.
    d. 14.

22. (609) What is the *proper* wattage and lamp type used on the remote area lighting system (RALS)?
    a. 500-watt quartz.
    b. 250-watt halogen.
    c. 100-watt low-pressure sodium.
    d. 150-watt high-pressure sodium.

23. (609) You can establish automatic operation of a fully operational remote area lighting system (RALS) by positioning the override switch to
    a. ON.
    b. OFF.
    c. AUTO.
    d. MANUAL.

24. (610) What is the *output rating of the diesel generator* on the telescoping floodlight set?
    a. 30 kilowatt (kW).
    b. 15 kW.
    c. 10 kW.
    d. 6 kW.

25. (610) For *proper* operation, you need to keep the telescoping floodlight set generator output *between*
    a. 97 and 110 volts alternating current (VAC).
    b. 119 and 125 VAC.
    c. 197 and 210 VAC.
    d. 233 and 247 VAC.

26. (610) What is the *full* height of the telescoping floodlight set *trailer tower*?
    a. 26 feet.
    b. 29 feet.
    c. 30 feet.
    d. 35 feet.

27. (610) How often *must* you clean the air filter in the generator on the telescoping floodlight set when operating under *dusty* conditions?
    a. Once a day.
    b. Once a week.
    c. Every 8 hours.
    d. Every 16 hours.

28. (611) The reverse osmosis water purification unit (ROWPU) requires a power supply capable of providing
    a. 240/416 volts alternating current (VAC).
    b. 120/208 VAC.
    c. 240 VAC.
    d. 120 VAC.

29. (611) What is used to ground the reverse osmosis water purification unit (ROWPU)?
    a. The contact between the earth and the frame of the unit is a sufficient ground.
    b. A three-piece ground rod that is stored on the control panel.
    c. A ¾ inch ground rod that is 10 feet in length.
    d. A 10 foot metal discharge pipe.

30. (611) What safety precaution should be taken prior to disconnecting any pipes or equipment on the reverse osmosis water purification unit (ROWPU)?
    a. Close all control valves.
    b. Open all drains and vents.
    c. Turn off chemical feed pumps.
    d. Prime the reverse osmosis pump.

31. (611) Where is the reverse osmosis water purification unit (ROWPU) *ground rod* stored?
    a. Under the circuit breaker box.
    b. In the generator compartment.
    c. Under the junction box.
    d. On the control panel.

32. (612) Which contingency asset requires two dedicated secondary distribution centers (SDC) to meet its high load demands?
    a. Field laundry unit.
    b. Harvest Eagle kitchen.
    c. Reverse osmosis water purification unit (ROWPU).
    d. Basic expeditionary airfield resources (BEAR) kitchen.

33. (612) The basic expeditionary airfield resources (BEAR) kitchen is powered by two generators, one 60 kW and one
    a. 5 kilowatt (kW).
    b. 30 kW.
    c. 100 kW.
    d. 200 kW.

34. (612) When *operating* how often is the basic expeditionary airfield resources (BEAR) kitchen electrical system *inspected*?
    a. Quarterly.
    b. Monthly.
    c. Weekly.
    d. Daily.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Basic Expeditionary Airfield Resources Electrical Distribution System

FOR MOST CONTINGENCY situations, the electrical system used to support force beddown operations is required immediately. The distribution of power throughout the base is essential to the completion of the mission. The limited available time dictates that you use expedient methods to complete the system. Electrical distribution is divided into two areas—primary and secondary—including all of the equipment associated with each distribution system. The *primary circuits* are the high voltage circuits distributed throughout the base. *Secondary circuits* are the low voltage circuits providing the customer with power to operate equipment. Secondary is the usable voltage after it is transformed by the SDC into 120/208 VAC. We'll cover primary distribution in the first two lessons. The first area we will cover is primary distribution.

613. Basic Expeditionary Airfield Resources primary distribution system, part 1

This lesson focuses on the primary distribution system. It is easier to view it similarly to a home station electrical grid. Like the high voltage power grid on your home installation, the higher voltage lowers the amount of line loss experienced by the customer. Primary, in the bare base environment, means the voltage is 4160 VAC and is used for distribution to each SDC.

Primary distribution planning

The BEAR primary electrical system is basically composed of two major components: a high-voltage power source and a high-voltage primary distribution network. One or more Basic Expeditionary Airfield Resources power unit (BPU) generators, which are capable of producing 4,160 VAC, usually fill the role as the power source and provide the *primary* high-voltage. The power is routed from the power source(s) to the contingency switchgear equipment, this is going to be a primary switching center (PSC) discussed in further detail later in this lesson. After the switchgear, power is delivered to the SDC(s) on the circuit, through high-voltage cable(s).

In setting up the electrical utility for a force bed down operation, adherence to certain construction principles ensures that effective use is made of available manpower and resources. The following procedures are for the power generation and the primary distribution system for a fully air-conditioned bare base concept.

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 BEAR electrical system is basically a two-phase approach. The first phase provides power to critical facilities using low-voltage MEP generators. Critical facilities typically include the airfield, command post, kitchen complex, water plant, fire department, and so forth. The second phase establishes the high-voltage distribution system—this is when the power plant and other associated equipment are installed.

Gather data

You should collect data that concerns any existing electrical systems and their capabilities, as well as any determination of bed down power requirements. Also check existing electrical plans and review the specifications for accuracy. If plans are not available, they must be developed, giving consideration to the location, function of existing structures, and arrangement of the distribution system.

Workmanship

After reviewing the plans and deciding on a layout, you will begin installing the cable and equipment. Instructions to workmen must be clear and complete so they understand what is to be done and how it is to be accomplished. The person in charge of the operation must maintain constant supervision over the installation of electrical wiring to ensure that all established safety requirements are met.

One essential function of the supervisor is to provide proper coordination with plumbers, carpenters, and other craftsmen who are working in the same area. This coordination ensures that the various bed down tasks complement, rather than contradict, each other.

Distribution layout

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

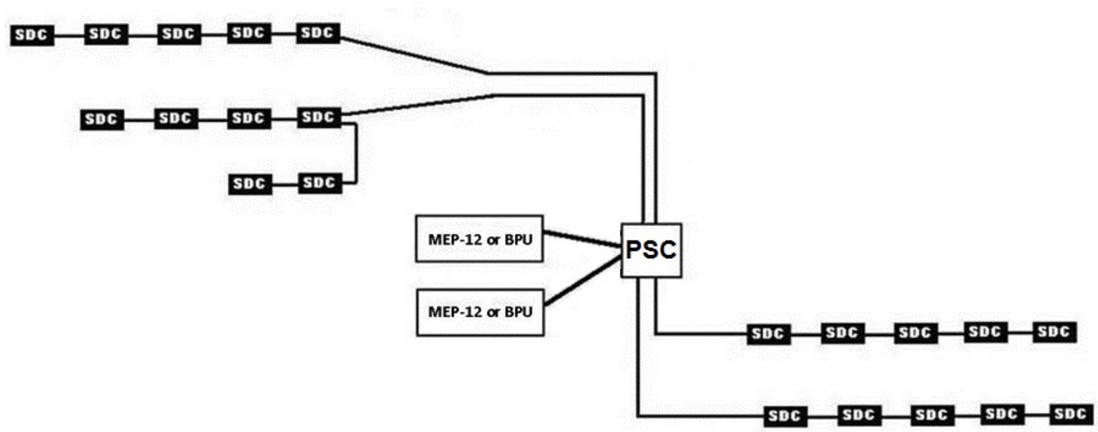
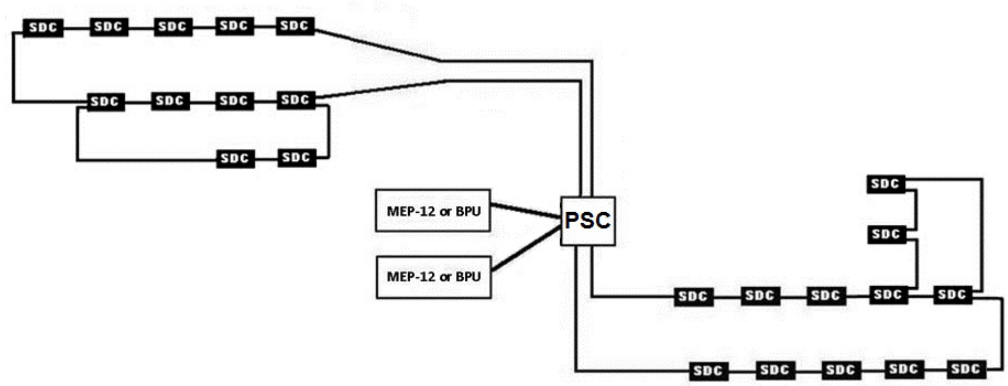
<table>
<tr><th colspan="2">Distribution Layout Types</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td>Radial layout</td><td>The radial layout (fig. 4–1), has individual branch lines that run from the PSC to the various SDCs. We often use this layout for small contingencies and during the initial stages of the deployment.


Figure 4–1. 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.</td></tr>
<tr><td>Loop layout</td><td>A loop layout (fig. 4–2) is a layout in which to two or more PSC feeder circuits supply power to the customer. A physical connection from the output bushings of one SDC to the input bushings of another SDC makes the loop complete.</td></tr>
</table>

Distribution Layout Types	
Type	**Description**
	 **Figure 4–2. Electrical distribution loop layout.** 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 that prevents 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.

Notice that the positions of the SDCs is nearly identical in both figures. It is a good practice to quickly establish the base in a radial pattern then come back and install the loop conductors once the installation is operational. The loop cables are normally left in the open, de-energized position and are only used when the need arises. Like home station switching operations, you must ensure that everyone in the electric shop is accounted for and aware of the abnormal conditions.

Power source types

The BEAR electrical system requires 4,160 VAC to operate. There are two basic power source types that may be used to supply the electrical needs of the base. Power can be supplied from either commercial power sources or high-voltage generators. The selection of a power source depends primarily on availability at the force bed down location. In many cases, a combination of both methods offers the best solution to power source requirements. Typically, the high-voltage generator is used as the power source due to local conditions and unavailability of a suitable commercial power source.

Commercial power plant

If available, an existing commercial power production facility can be used to supply power to the electrical distribution system. One limitation of this source is the probability that it was damaged or destroyed during actions that prompted the need for force bed down. In continental United States (CONUS) locations, commercial power sources normally are restored relatively quickly following a disaster. However, the needs of the surrounding civilian community may be such that excess power is unavailable for use by the incoming forces.

High-voltage generator

In terms of contingency bed down operations, you may be operating with different high-voltage generators. You may be working with one of the legacy systems or a BPU. We'll look at both but focus on the BPU.

Legacy systems

For many years, the MEP–12 served the high-voltage generator used in contingency power plants around the globe. 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 to meet multiple operations in the Middle East. Over the years, a few other generation systems were developed and deployed, but they proved ineffective in the harsh deployment environments. The extreme heat and dusty conditions of the Middle East required high operation standards for such systems.

The MEP–12 generator set was a trailer-mounted diesel engine-driven, prime power unit that produced 750 kW at 60 Hz and 625 kW at 50 Hz. It provided 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. They were capable of operating as a stand-alone unit; for greater load requirements, four units could be paralleled together.

BPU

In most cases, primary power is supplied by BPU, a high-voltage generator that is shipped with the BEAR electrical system (fig. 4–3). The BPU is the replacement for the MEP–12 Generator. It is a state of the art generator with digital controls for both engine systems and power generation. Over time, these will become the standard for power supply in deployed areas. You will increasingly see these and it is important that you are familiar with them and how they work. Like the MEP–12, the BPU is a fully enclosed, trailer mounted, mobile generator that is diesel-driven and capable of providing 4,160 VAC using a three-phase four-wire system. For instructional purposes, our discussion will use the BPU for power source installation and operation.

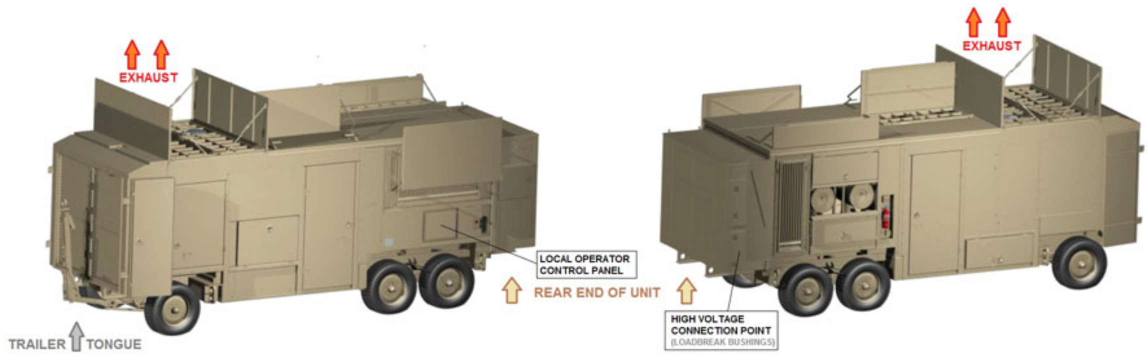


Figure 4–3. BPU, 800-KW generator

The BPU is able to produce 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 4,000 feet and temperatures from –25 to 122 °F. 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.

The Digital Control System (DCS) is the brain of the BPU. It allows for configuration and operation; annunciation (fig. 4–4a), fault and warning reporting, and emergency stop control. When connected to suitable laptop, the remote operator panel (ROP) software allows for full operation from a remote location.

All local control of the BPU is done through the DCS (fig. 4–4b). 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 pushbutton.

There are three connectors located on the right side of the DCS; the USB connector, the service connector, and the remote parallel connector. The USB connector allows for download of the ROP software, InPower BPU software, and the digital technical order. The service connector is available to connect a computer to utilize InPower BPU software for diagnostics. Lastly, the remote parallel connector allows for remote operations using the ROP software.

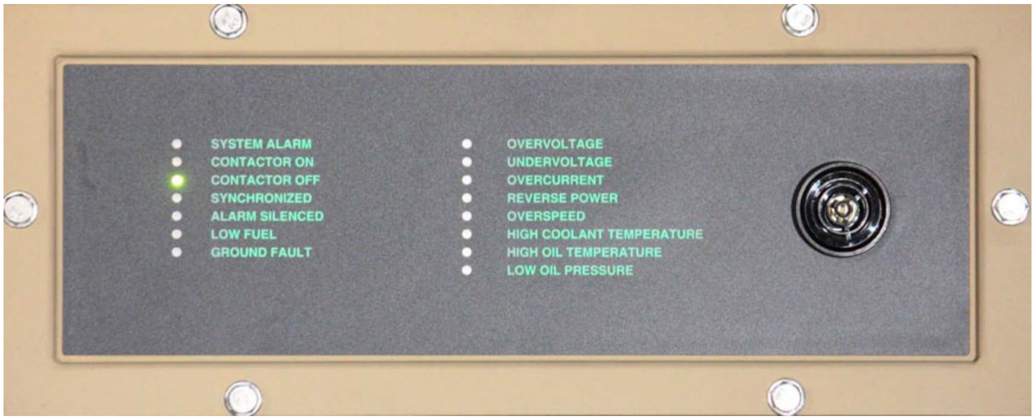


Figure 4–4a. Fault annunciator.

Figure 4–4b. DCS.

Generator installation

There are a few steps to setting up a contingency power plant. First, you will need to place all of the equipment then connect all of the systems together.

Equipment placement

Before positioning the generator make sure to consult the most recent technical order for the correct procedures. Locate generator sets as far apart as feasible, while maintaining consistency with other requirements. In addition to the preceding considerations, you also need to:

- Ensure the decompression doors—located at the bottom of the generator—are closed.
- Select a smooth, level surface capable of support the BPU’s weight.
- Position the BPU so there is a *minimum* of 15 feet of clearance all around for maintenance and that there are *no overhead obstructions*.
- If using multiple generators, place them close enough so that the paralleling cable can be connected to the DCS of each BPU (fig. 4–5).
- Engage the parking brakes, check the wheels, and then disengage the parking brakes.

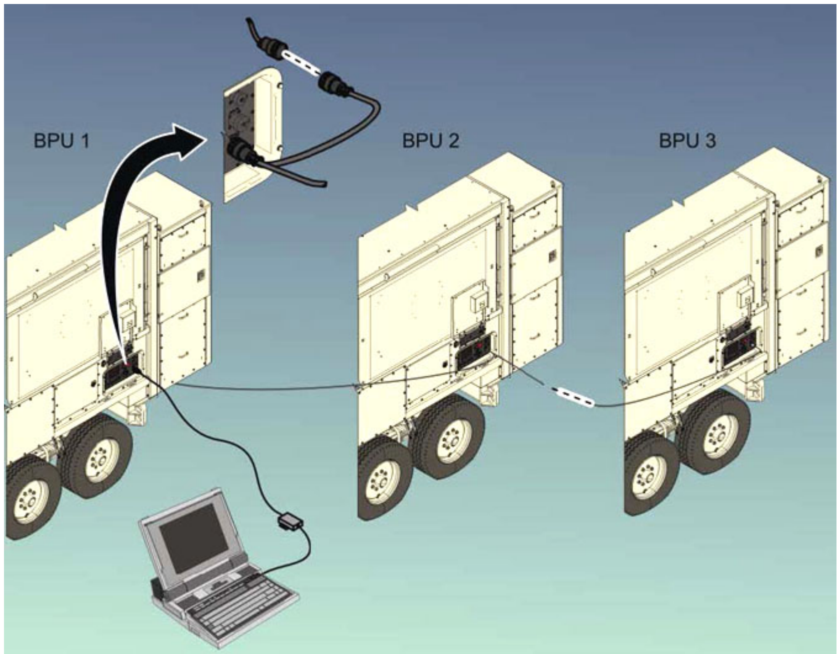


Figure 4–5. Remote operating platform cable setup.

One 10,000-gallon fuel bladder (fig. 4–6) is provided for every two BPUs or MEP–12 generators. The objective is to have approximately a 7-day fuel supply at each generating plant. Construct berms around the fuel bladders that are 3½ feet higher than the bottom of the bladders. A berm provides for containment of fuel should it leak from the bladders. They also provide a small degree of protection from threats, such as small arms fire or rocket and mortar shrapnel.

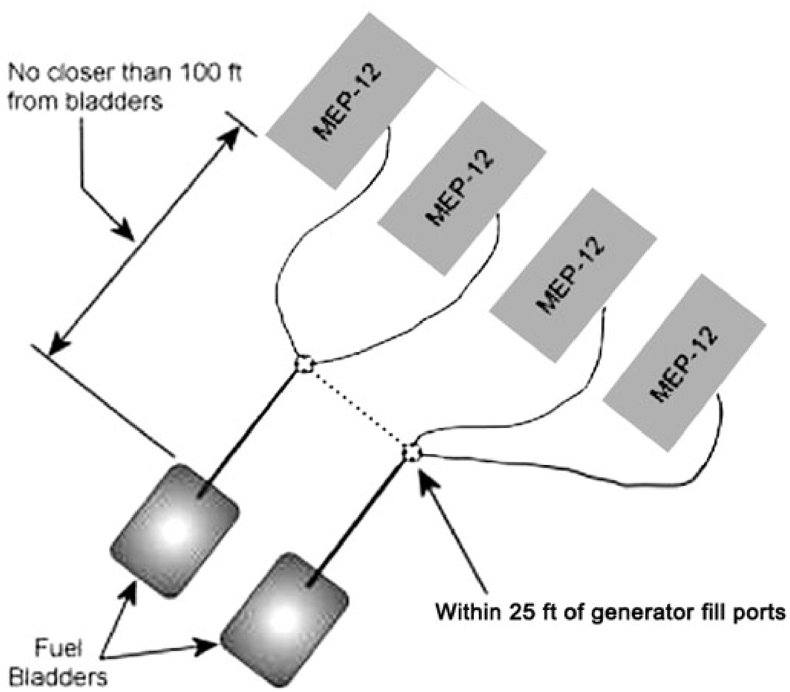


Figure 4–6. 10,000-gallon fuel storage bladder setup.

Final connections

Like any electrical component, you will need to ensure that all equipment is grounded properly. This protects personnel and valuable equipment, both are important resources in a deployed environment.

<table>
<tr><th colspan="2">Generator Installation Final Connections</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td>Grounding</td><td>Each BPU contains 3 3-foot sections, use these to ground the generators.

Drive the ground rod 8 feet or more into earth within 6 feet of the BPU, leaving a minimum of 6 inches above ground.

When using more than on BPU, create a central ground grid by connecting all BPUs ground rods together with #2 AWG copper conductor ground grid cable.

Connect the ground cable between the slotted chassis ground stud on the rear of the BPU and the ground rod.</td></tr>
<tr><td>External fuel supply</td><td>Make fuel connections using quick disconnects at the fuel bladders and at the BPU manifold.</td></tr>
<tr><td>High-voltage connections</td><td>The load break elbow connectors are compatible with current expeditionary power systems.

The three phase connections are accomplished by “landing” the applicable load break elbows on L1, L2, and L3.

The L0 bushing will not be used since the BEAR primary distribution system does not utilize the neutral even though it is a Wye configuration (fig. 4–7).

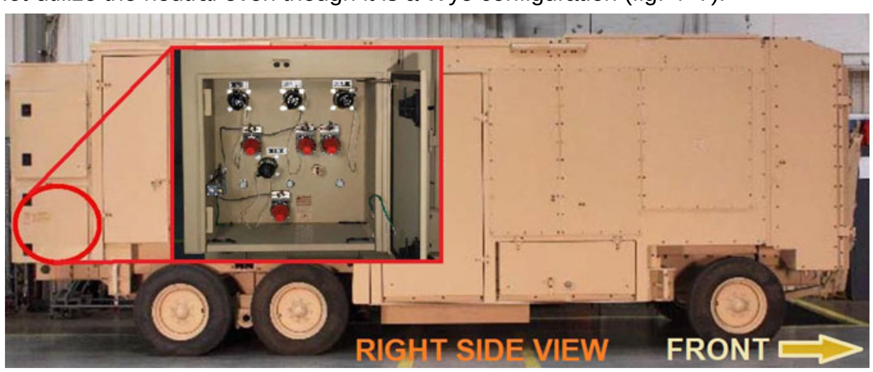


Figure 4–7. Load break trailer location.</td></tr>
</table>

Local generator operation

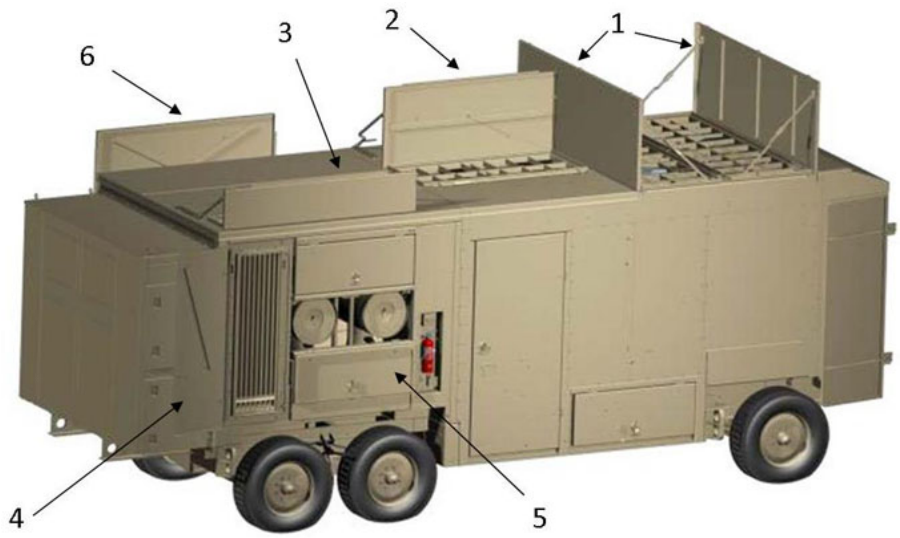
The BPU was specifically designed to work with current BEAR base assets. However, there are several updated areas that make this unit a huge advancement over the MEP–12. These new features allow for the BPU to be used in a multiple number of scenarios.

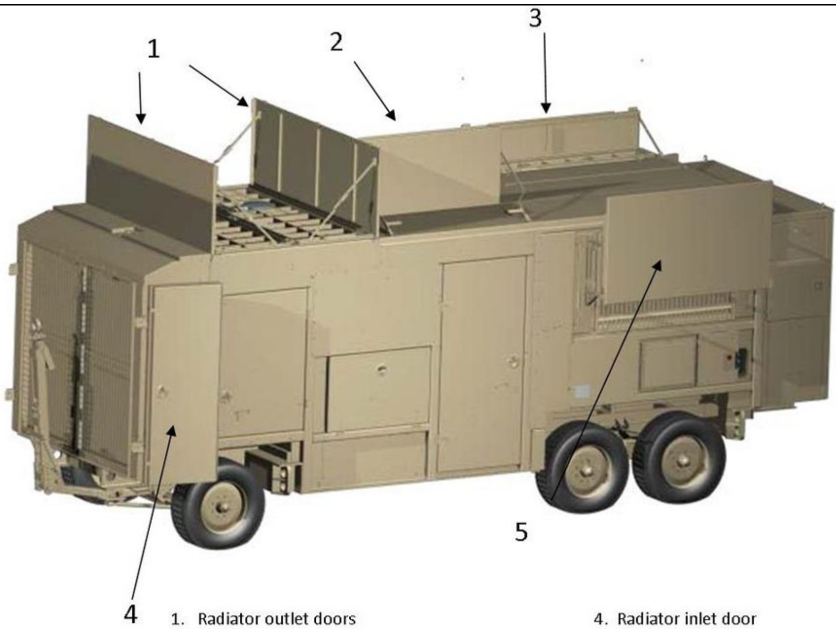
The BPU has several operating modes: standalone (single unit) and three different paralleling modes.

BPU Paralleling Modes	
Isochronous	The *Isochronous* mode provides constant voltage and frequency and is used when paralleling with other BPUs.
Droop	*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	*Utility* Mode allows parallel operation with a utility power grid (Commercial power grid).

Pre-operational inspection

Before starting the generator you must do a preoperational inspections. As always consult the T.O. before performing this inspection. The following table covers a few of the steps involved in preparing the BPU for operation.

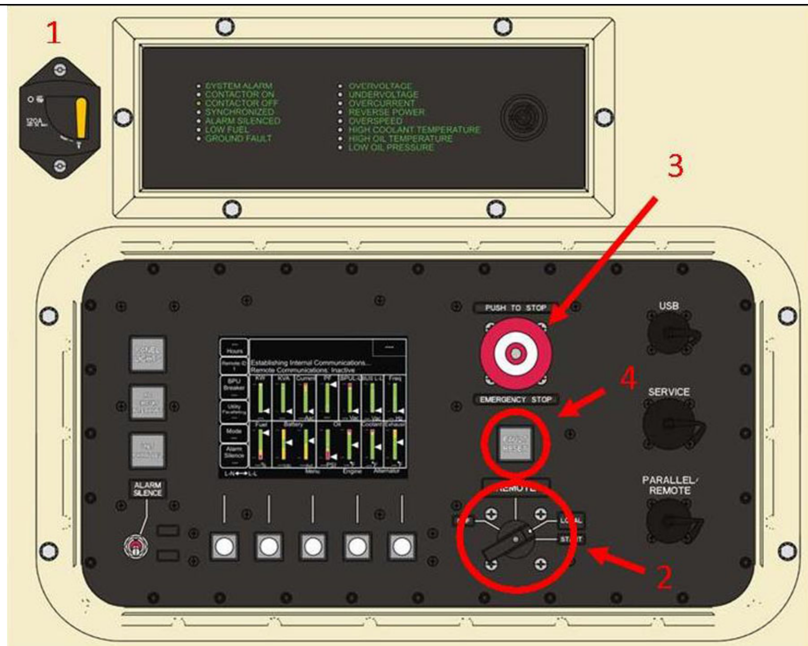
Local Generator Pre-operational Inspection	
Step	**Action**
1	Ensure the correct grade of oil and coolant is being used.
2	Open and lock air inlet and exhaust doors. See figures 4–8 and 4–9 for exact locations.  1. Radiator outlet door 2. Engine outlet door 3. AC alternator outlet door 4. Alternator inlet door 5. Air cleaner inlet door 6. Cooling air inlet door **Figure 4–8. Inlet doors.**

Local Generator Pre-operational Inspection	
Step	**Action**
	 **Figure 4–9. 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

Starting procedures for the local generator are described in the table below.

Local Generator Starting Procedures	
Step	**Action**
1	Use figure 4–10 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.

Local Generator Starting Procedures	
Step	**Action**
	 **Figure 4–10. 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 the area is clear, push the AC circuit interrupt key on the operator's control panel. The main control screen will display [BPU Contactor Closed] and the values of current bus loading.

Continuing operation

While operating the BPU, continue to monitor for fault or warning conditions, monitor your fuel levels; additionally, ensure that proper documentation is completed for power plant operations. If any unsafe or damaging conditions occur, activate the *emergency stop switch*.

Shutdown procedures

Once the BPU is no longer needed you will need to shut down the unit. Shutdown procedures are described below.

BPU Shut Down Procedures	
Step	**Action**
1	Turn off the supplied load.
2	Push the *AC circuit interrupt* on the control panel and 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. To setup for parallel operations you need to ensure the parallel/remote cables are attached to all of the BPUs that are going to be paralleled. The two paralleling modes—manual and automatic—are described in the following table.

BPU Parallel Operations	
Type	**Description**
Manual	To manually parallel the BPUs navigate to the adjustments screen and change parallel mode to manual (fig. 4–11).

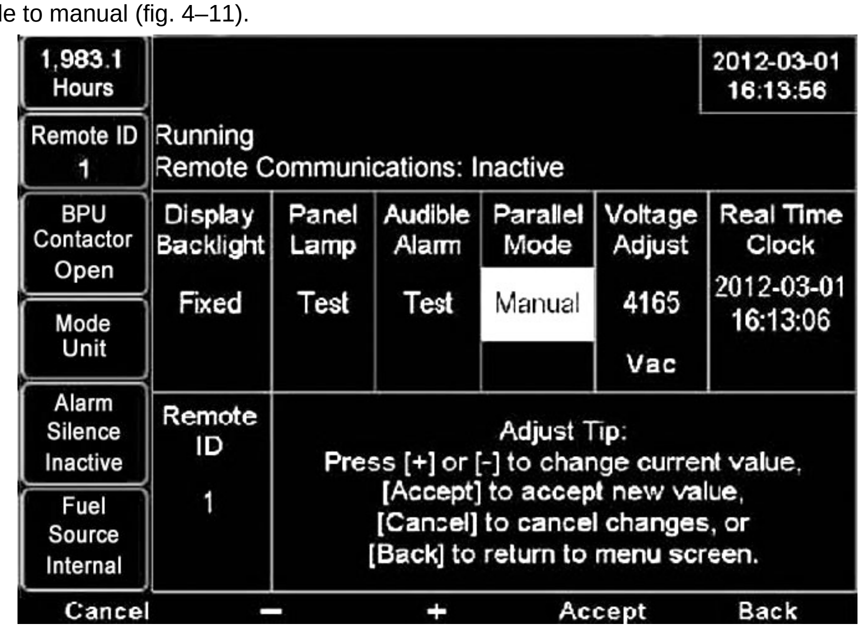


Figure 4–11. Manual parallel mode.

<table>
<tr><th colspan="2">BPU Parallel Operations</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td></td><td>
Once switched, navigate to the synchroscope screen.

Push the AC circuit interrupt button to close the contactor once the generator is synchronized (fig. 4–12).

The speed is automatically adjusted by the DCS and once in phase it will stay in phase.

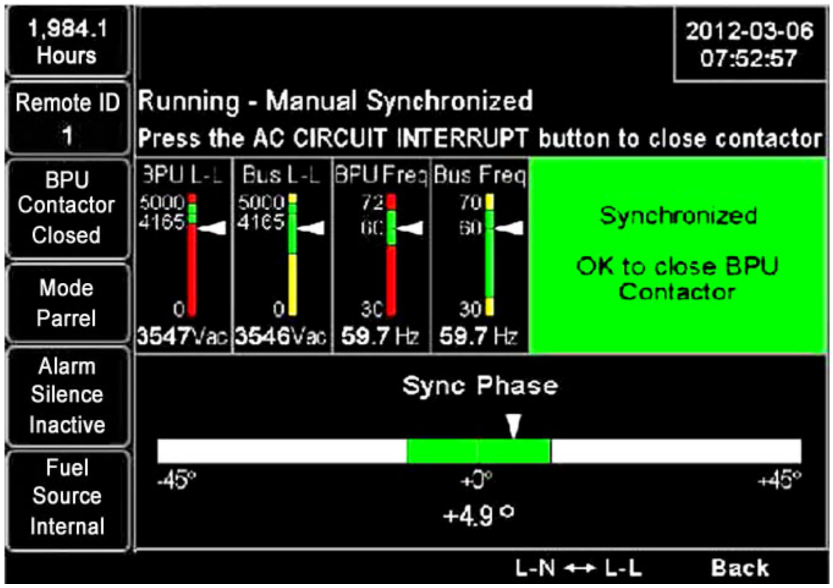


Figure 4–12. Synchroscope screen.
</td></tr>
<tr><td>Automatic</td><td>
Automatic paralleling is exactly how it sounds.

Simply go to adjustments screen and make sure parallel mode is in auto (fig. 4–13).

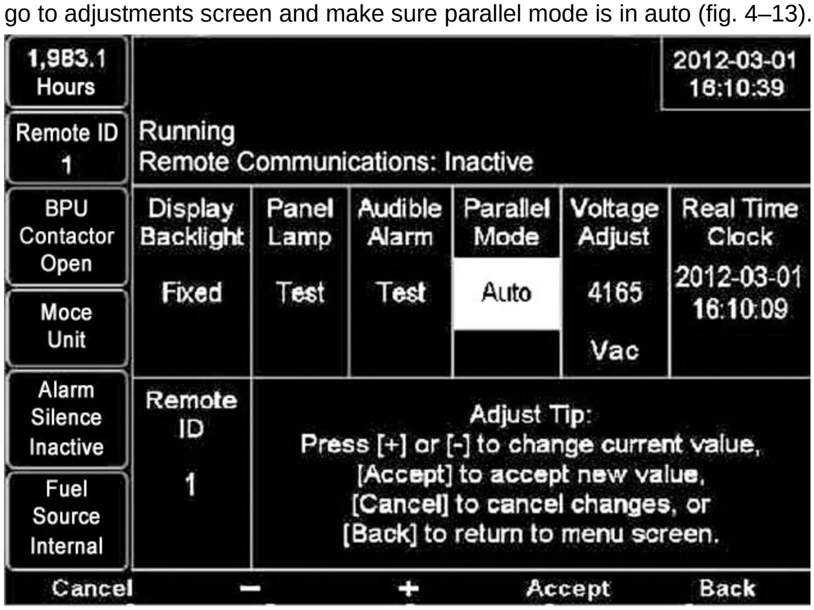


Figure 4–13. Auto parallel mode.

Once you have set the paralleling mode to auto, navigate back to the main screen.

Once there, simply push the auto/parallel mode button.

This allows the synchronization of the unit and closes the contactor.
</td></tr>
</table>

Remote generator operation

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 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).

In the remote mode you can operate up to 12 BPUs with the ROP software.

Operating using the ROP

When operating BPUs with the ROP, there is 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. 4–14).

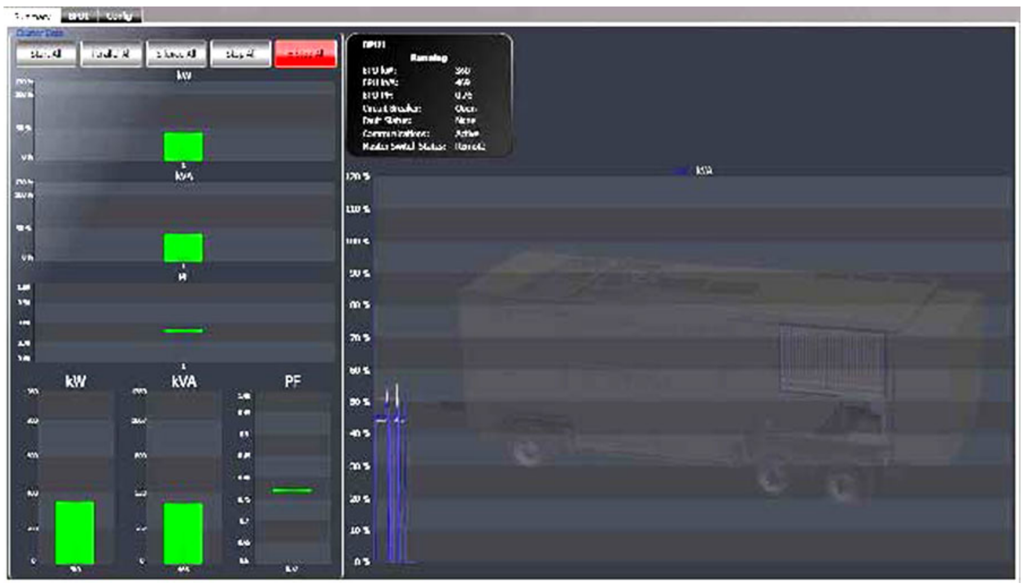


Figure 4–14. ROP master screen.

The configuration screen provides communication information for each BPU (fig. 4–15). Configuration screen displays are color coded as follows:

- 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 and is operated using a mouse (fig. 4–16).

Figure 4–15. ROP configuration screen.

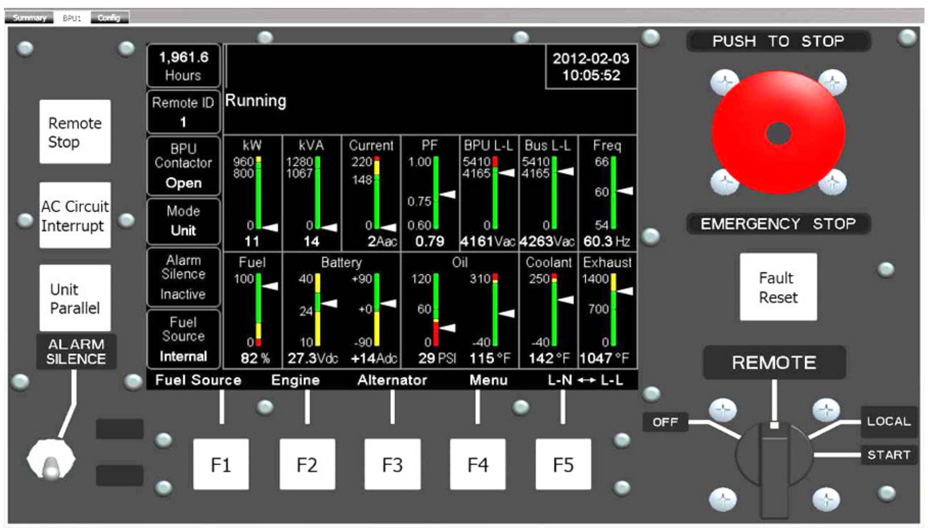


Figure 4–16. ROP individual BPU screen.

Extracting capture files

The BPU is programmed from the factory 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—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.

614. Basic Expeditionary Airfield Resources primary distribution system, part 2

This lesson continues our discussion of the BEAR primary distribution system. We'll cover the PSC, the SDC, and operating procedures. Then, we'll finish by discussing maintenance requirements and troubleshooting.

PSC

The PSC is a high-voltage switching station, serving as a connection point between the power plant generators the primary distribution circuits (fig. 4–17). The internal switch is manufactured by S&C Electric and is commercially designed for underground use. The PSC takes this reliable switch and puts it into a deployable unit (fig. 4–18).

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

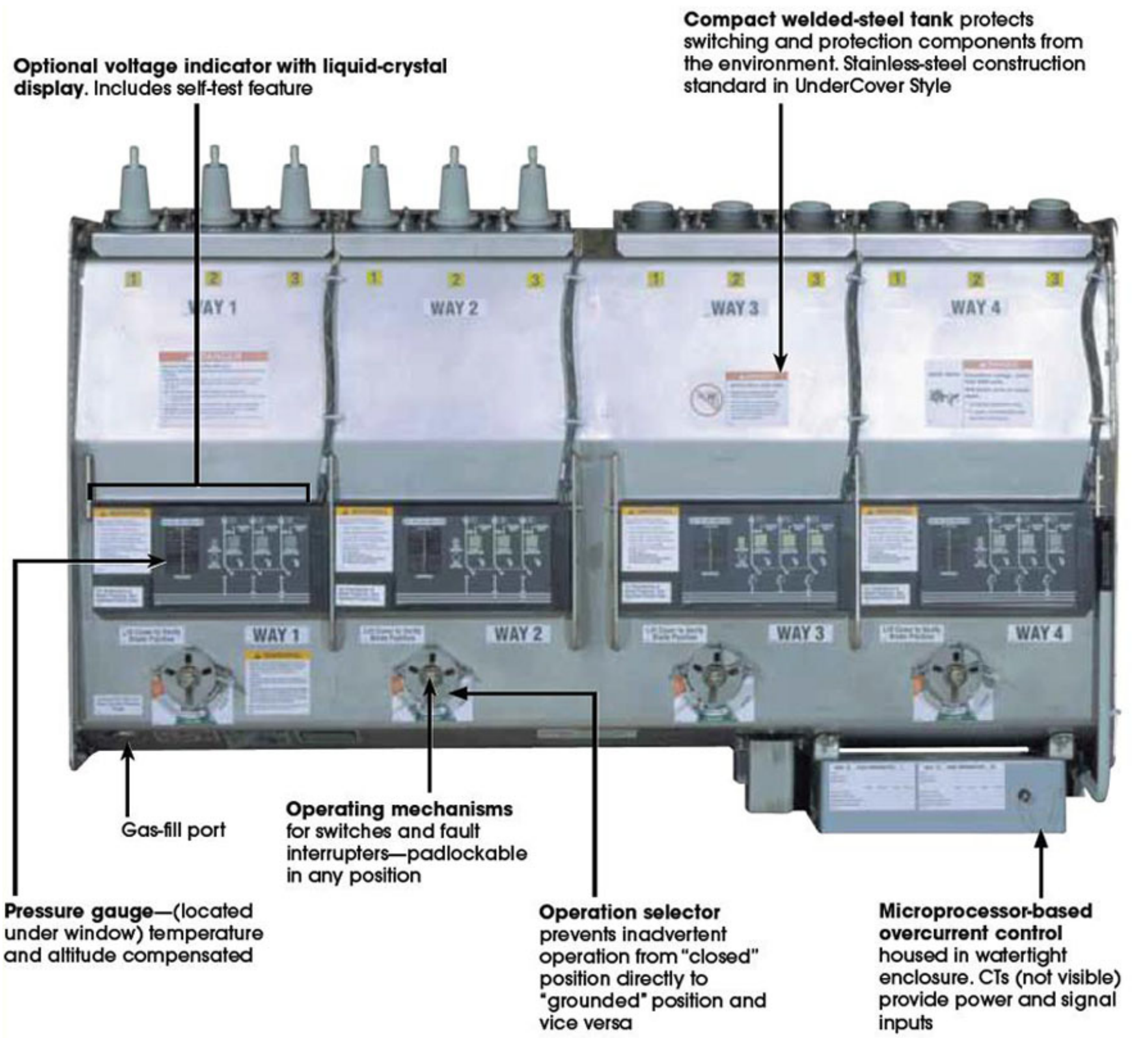
Electrical configuration

The PSC features switches for switching 600-ampere main feeders, and microprocessor controlled re-settable, vacuum fault interrupters for switching and protection of 600-ampere main feeders. These elbow-connected components are enclosed in an SF6-insulated, welded steel tank. The three position (closed-open-grounded) switches are manually operated and provide three-pole live switching of 600-ampere three phase circuits. These circuits also provide a visible gap when open and internal grounding for all three phases. The 600-ampere fault interrupters feature re-settable vacuum interrupters in series with manually operated three-positions. The PSC has six connections called ways (fig. 4–19a & fig. 4–19b). The connections for each way may be either a switch or a combination of a switch and a circuit breaker.

Load interrupters

A load interrupter switch is comprised of **only** a manually operated three-position (closed-open-grounded) disconnect switch. Only two ways have load interrupter switches while the other four have fault interrupter capabilities. Ways 1 and 2 have only the load interrupter switches, so these are used as inputs from the generators. Ways 1 or 2 could be used as outputs, but without the circuit protection capability.

Figure 4–17. PSC.



Operating panel of Vista UDS gear. Viewing windows, for confirming open gap and grounded position on load-interrupter switches and fault interrupters, are located under hinged covers of voltage indicators.

Figure 4–18. PSC internal components.
(Photo courtesy of S&C Electric Company.)

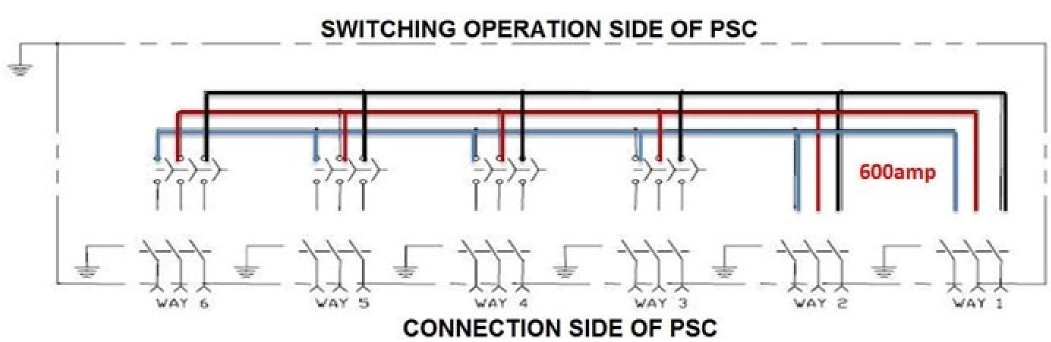


Figure 4–19a. PSC internal electrical diagram.

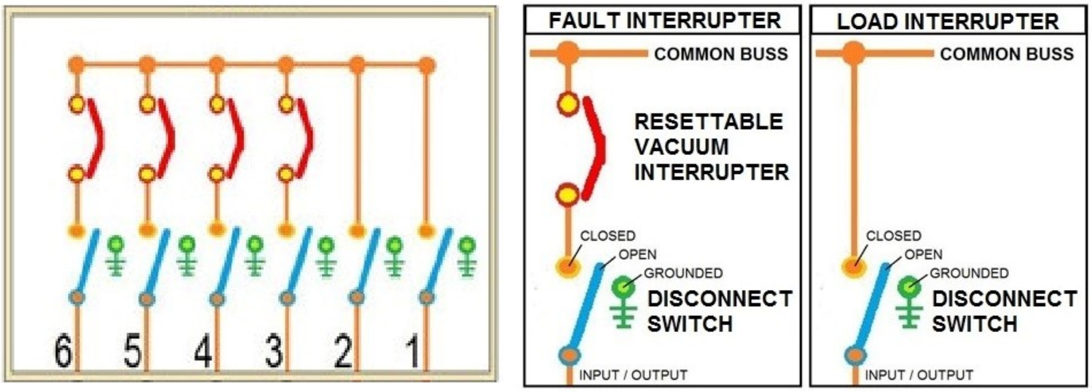


Figure 4–19b. PSC internal electrical diagram.

Fault interrupters

The PSC fault interrupters feature a resettable vacuum interrupter in series with manually operated three-position (closed-open-grounded) disconnect switch for isolation and internal grounding of each phase. Ways 3, 4, 5, and 6 are fault interrupter switches, therefore they have a circuit breaker in series with the (closed-open-grounded) switch. These ways are normally used as output feeders. Fault interrupters provide single-pole (standard) or three-pole (optional) live switching of load circuits. Fault interruption is initiated by a programmable overcurrent control.

The fault interrupter settings and trip points can be set on Ways 3 thru 6 by connecting a computer to the applicable overcurrent control unit. Since either a 200-Ampere loadbreak or a 600-Ampere deadbreak termination can be used, ensure that your fault interrupter settings correspond with the appropriate ampacity. The fault interrupter settings for Ways 3 and 4 use one overcurrent control unit, and Ways 5 and 6 use the other. The factory setting for Ways 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 340 amps, based on using Way 6 to *parallel 2 primary switches together* to support 4 BPUs or MEP–12 generators. A 500 MCM copper cable can also be used as a tie; in this instance, the settings would be increased to 590 Amps to match the amperage rating of the cable. This setup would create a 600 ampere bus across all of the PSCs, allowing more flexibility in the system. Due to the increased amperage, 600 amp deadbreak cable terminations would be required.

Sulfur hexafluoride

As you learned in the previous volumes of this course, the electrical insulation value provided by sulfur hexafluoride (SF_6) is second to none. This allows the switching components to be in close proximity with one another without the risk of arcing or flashing over. If the switch tank is punctured or has a leak, the SF_6 gas would escape, therefore losing the insulation factor that the SF_6 provides. If this happens in a deployed location, identify the damage to the unit and make preparations to have the PSC replaced. It isn't an ideal situation, but the PSC could still be used if the mission required. It is extremely important to remember that any of the Ways should *not* be operated *without first de-energizing the unit*. Without the SF_6 inside to insulate, the internal switch contacts will pull an arc and flash over, causing damage to the operator and bystanders. For this reason, it is important to check the level of the SF_6 gas inside of the tank to ensure that the gas level is in the "green" zone. This can be done by opening the viewing window of Way 1 (fig. 4–20).

Electrical connections

The PSC has two sides: the connection side and the operation side. As the names implies, the *connection side* is where all of the high voltage electrical connections are made (fig. 4–21). As you view the PSC from this side, please be aware that Way 1 is on the right end and that the phasing is also reversed. So from left to right, the connection bushings are Way 6 C-phase, Way 6 B-phase, Way 6 A-phase, Way 5 C-phase, and ending with Way 1 A-phase. Since the switch is rated for 600 Amps, it is designed with 600 amp Deadbreak bushings. For situations where you have a 4/0 or 500 MCM conductor, a 600 amp Deadbreak elbow will be installed. On the ways where a 1/0 cable is used, a 200 amp Loadbreak will be installed using the 600 amp – 200 amp adapter hardware that is provided with the PSC.

Figure 4–20. SF_6 Gauge.

Figure 4–21. PSC connection side.

Switching operations

The normal switching operations are accomplished from the *operation side* of the unit, identified by an “Operation Compartment” label on the door (fig. 4–22). As you view the switch from this side of the unit, all of the ways and phases are in the normal left to right manner (fig. 4–22). Each way has a voltage indicator at the top that is charged by either sunlight or a bright flashlight.

The PSC provides the capability of grounding a circuit for maintenance purposes to protect personnel and equipment. Therefore, each way has three switch positions: Grounded, Open, and Closed. The switch is operated by placing the switch handle into the Operation Selector for the Way that you want to operate. Notice that the switch handle has an “L” shaped indicator that indicates the current switch position (fig. 4–23).

If you flip up the voltage indicator up, you can see the viewing window where you can see inside to the switch. The viewing window allows you to visually verify the connection of the Way (fig. 4–24).

It is important to look for the orange colored metal that is part of the movable switch blade. The *grounded switch position is towards the operation side* of the PSC and the *closed position blades are on the connection side*.

Multiple PSC connections

As the previous lessons on BPUs indicated, 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. The twelve units can be spaced out in a three plant configuration as long as the paralleling cables are able to be connected between all 12 BPUs. The standard parallel cable for the BPU is roughly 80 feet long.

Connecting two BPUs together is simple using one PSC (fig. 4–25); Ways 1& 2 are used as the generator inputs. Then adding additional another PSC is simply done by adding a tie conductor using Way 6 on both pieces of equipment (fig. 4–26). Since there is more than one tie conductor when connecting more than two PSCs together, use Ways 5 & 6 for tie connections when a PSC has an input and output tie cable. Use Way 6 for the first or last PSC that only requires one tie cable (fig. 4–27). A 6 PSC setup is very similar, just add another two PSCs in the middle (fig. 4–28). It is important to change the amperage settings for the fault interrupter for each way that is used for a tie connection. The amperage setting depends on the *maximum rating* for the tie conductor that is used. If you use a 4/0 AWG aluminum or 500 MCM copper cable as the TO recommends, it will be either 340 amp or 590 amp respectively.

Figure 4–22. PSC operation side.

Figure 4–23. PSC operation.

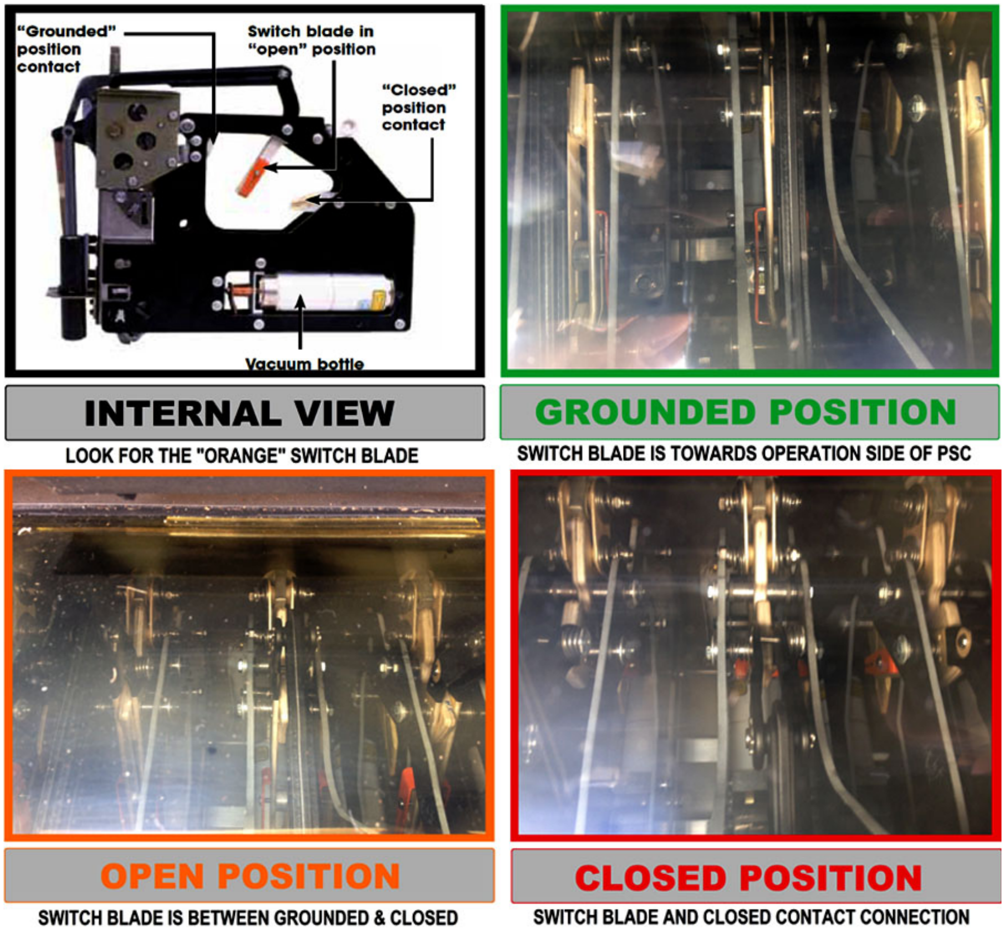


Figure 4–24. PSC Switch Positions.

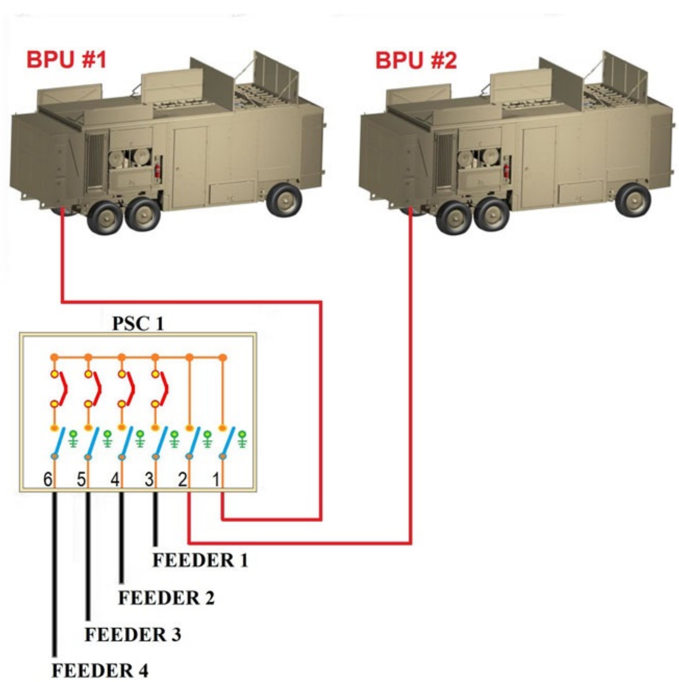


Figure 4–25. Single PSC connections.

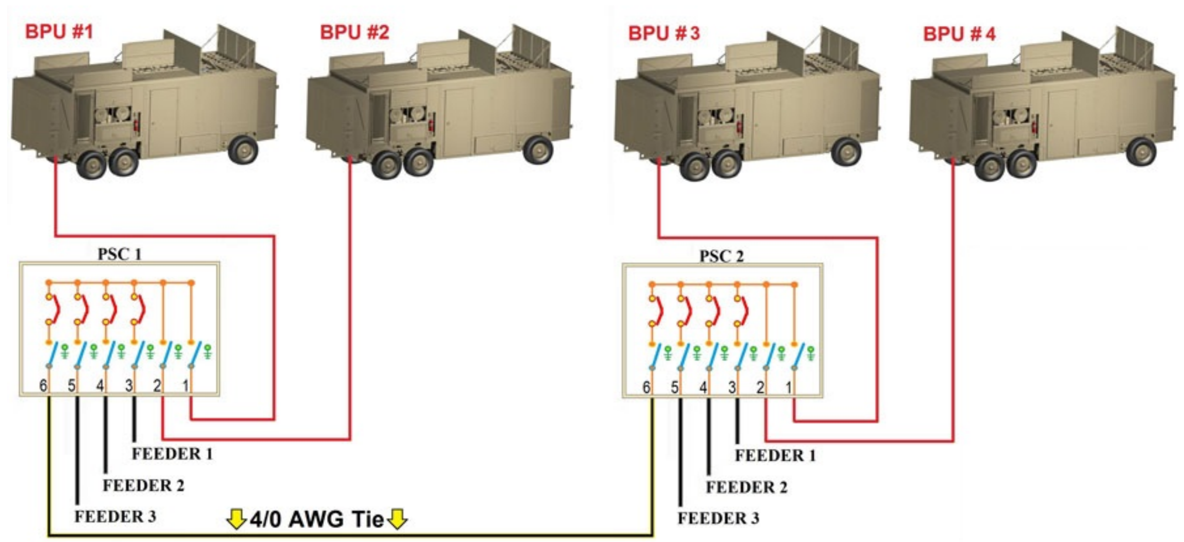


Figure 4–26. Connecting 2 PSCs together.

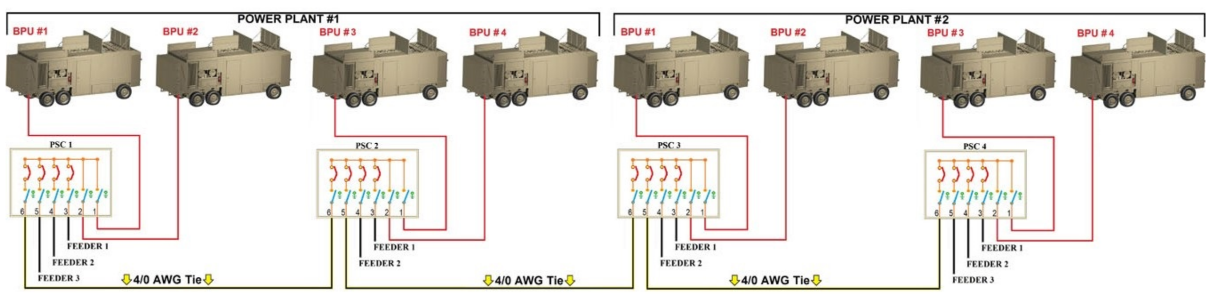


Figure 4–27. Connecting 4 PSCs together.

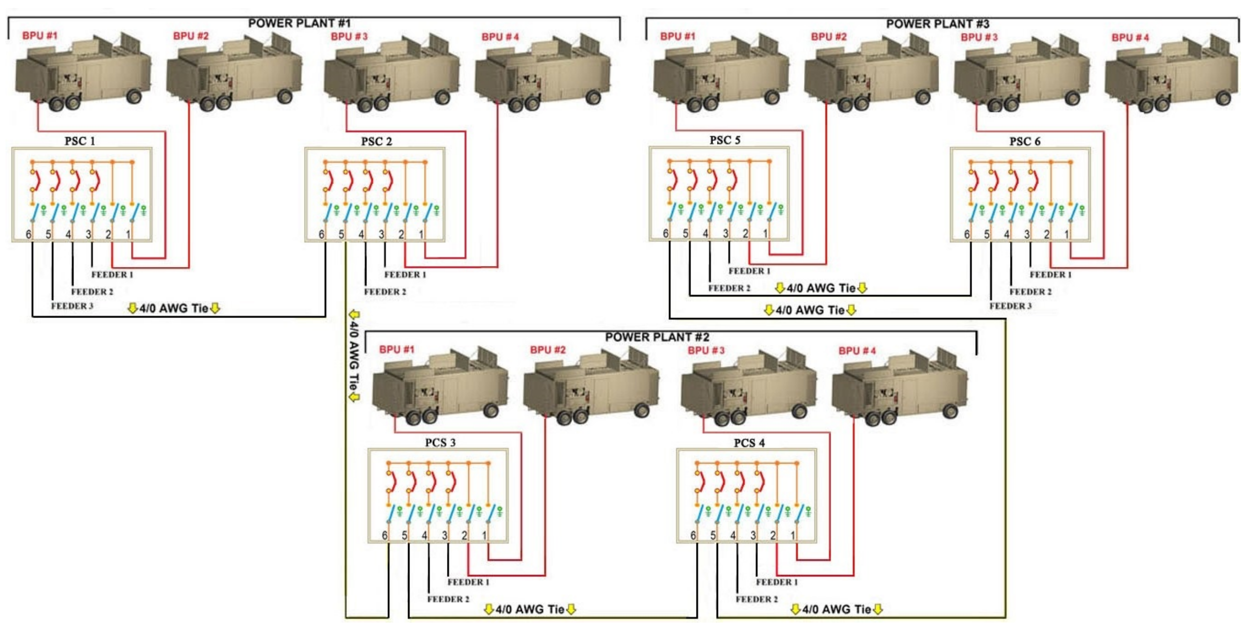


Figure 4–28. Connecting 6 PSCs together.

Figure 4–29. SDC.

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 BPU, a PSC, 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. Figure 4–29 shows an SDC.

The number of SDCs on each circuit depends on the situation. If you are feeding directly from a high-voltage generator, then connect a *maximum* of 5 SDCs. If you are using the standard PSC distribution, then connect from 6 to 10 SDCs per feeder/circuit.

Secondary connections

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, *never* 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 (fig. 4–30). The secondary feeder cables are five-wire, #6 AWG copper wires with 600-volt THW insulation with a rating of 60 amps. The older generations of SDCs had a cable storage compartment that was eliminated on the newer generation of SDCs to conserve space and reduce the overall size.

High-voltage connections

Place SDCs as close to the load as possible. The feeder circuits from the PSC output are attached to the SDC terminations that are located in the high-voltage compartment. These terminations use the same load-break elbows used with the PSC connections. Take special care to secure the high-voltage section of the SDC to prevent access by unauthorized personnel. Figure 4–31 shows the SDC high-voltage compartment.

There are three sets of switches known as electric fusible disconnect (EFD) which control the high-voltage power to the transformer and feed-through bushings. Notice in figure 4–32 that the three EFDs on the left are all for A-phase, the three in the middle are for B-phase, and the three on the right are for C-phase. As you view each group of three, the first is for Output 1 and the third is for output 2. Each middle EFD controls the primary side of the internal 150 KVA dry-type transformer; it also includes a fuse to protect the transformer from overcurrent. Figure 4–33 illustrates some of the connections inside of the high-voltage compartment; ensure that the SDC is de-energized and grounded prior to opening this section of the SDC. All of the high-voltage cables MUST be parked on parking stands to ensure that dangerous voltages are *not* present when personnel are working on the transformer.

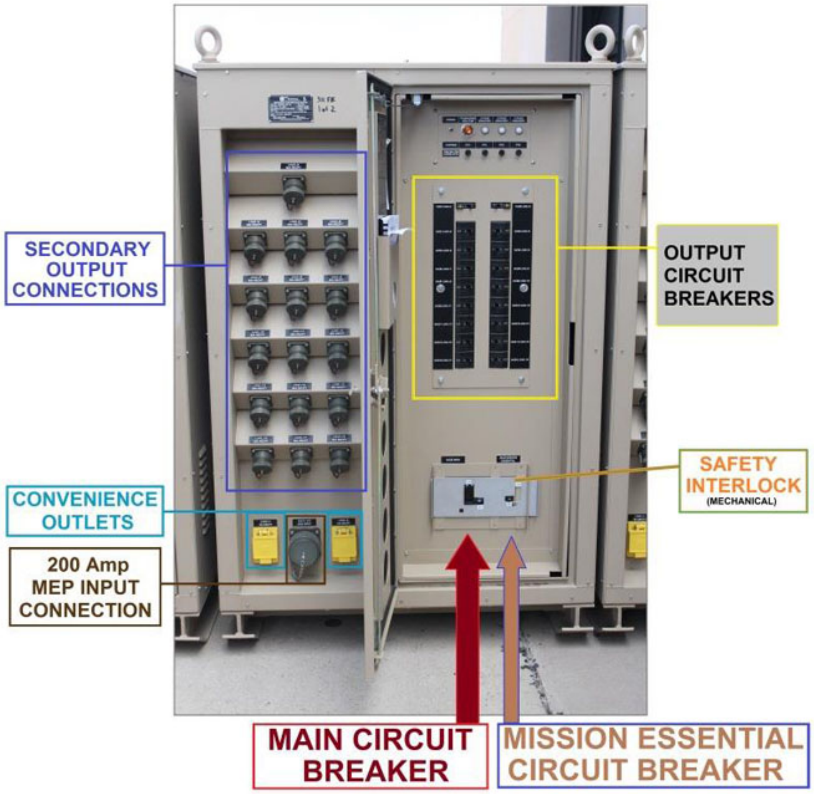


Figure 4–30. Secondary side of SDC.

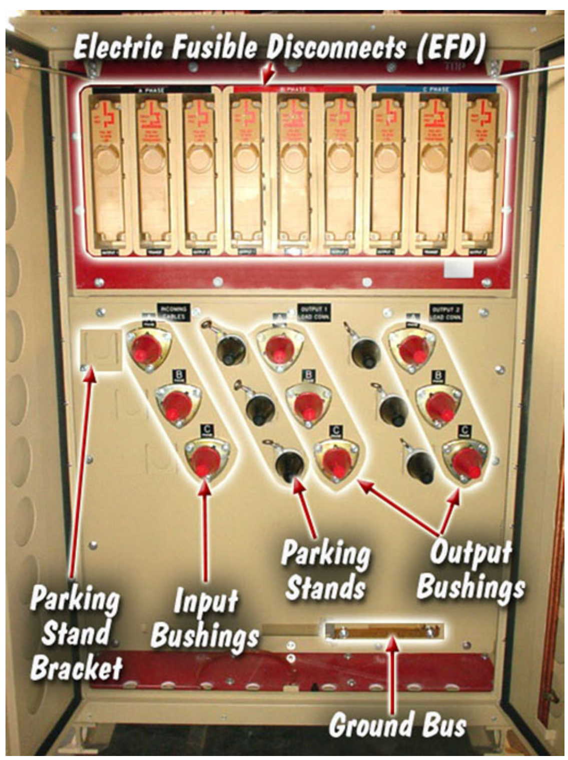


Figure 4–31. SDC high voltage compartment.

Figure 4–32. SDC high voltage compartment.

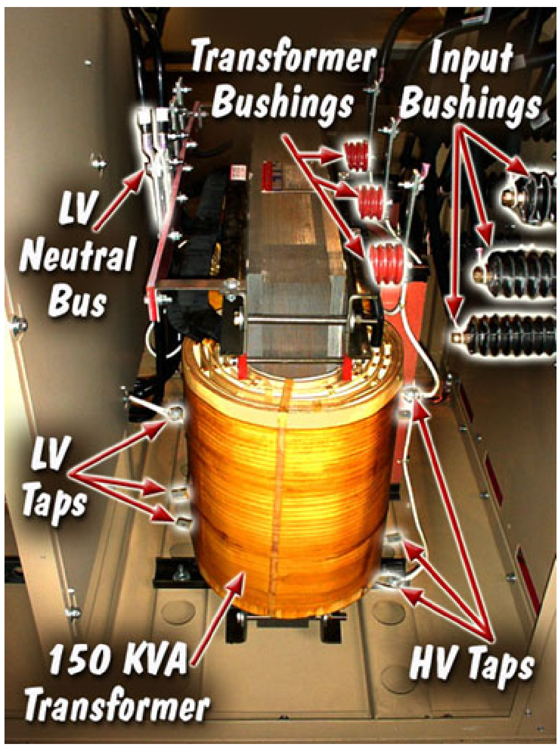


Figure 4–33. SDC high voltage transformer.

When SDC installation requires that they be placed at ½-mile intervals or more, you must consider voltage drop at the primary windings. The SDC primary windings have seven tap connections; two steps above and four steps below 4,160. The table below indicates proper tap connections to compensate for voltage drop.

Incoming Voltage	Tap Connections (Each Phase)
4372	1 - 2
4266	2 - 3

Incoming Voltage	Tap Connections (Each Phase)
4160	1 - 4
4054	3 - 4
3948	3 - 6
3849	4 - 5
3743	5 - 6

NOTE: Tap changes can *compensate* for up to a 629-volt loss and still provide the proper voltage on the secondary side of the SDC.)

High-voltage cable installation

Number 1/0 AWG, 5-kV, aluminum, cross-linked polyethylene (XLP) high-voltage cables distribute power from the generators to the PSC and finally to the SDC high-voltage compartment. This cabling is made up of a single conductor with a concentric ground, and comes supplied on cable pallets. Each pallet contains three reels of cable with 3,000 feet of cable on each reel (fig. 4–34). The jacket of each cable is usually labeled for a specific phase (A, B, or C). This labeling aids in maintaining proper phase relationships during installation.

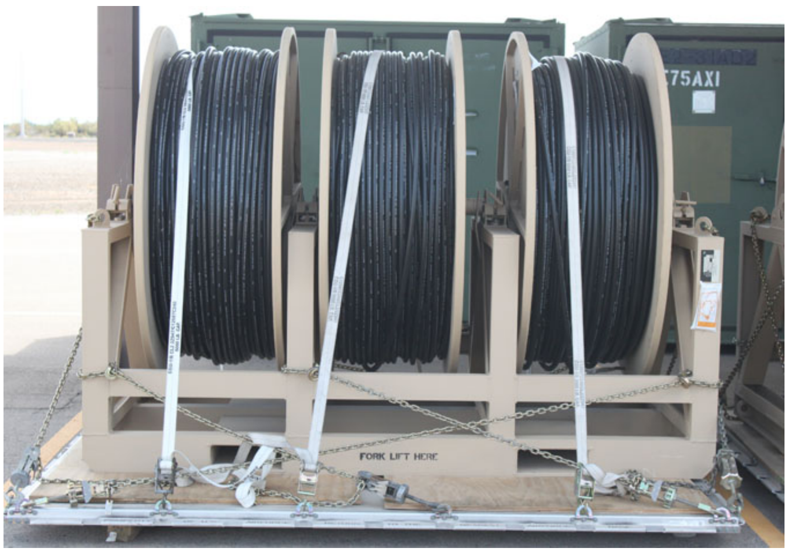


Figure 4–34. Cable pallet.

Effects of environment

High ambient temperatures influence the maximum allowable current a cable can handle. Heat buildup within current-carrying conductors does not dissipate rapidly in high-temperature environments. Hence, the current-carrying ability of conductors must be reduced when such conductors are installed in areas of high ambient temperature, since an excessive increase in cable temperatures causes insulation failure.

These high ambient temperatures also affect protective devices, such as fuses, circuit breakers, and motor control contactors. Additionally, sand and dust tend to build up in these electrical components and cause operational problems.

Cable protection

Bury primary distribution cables to a depth of at *least* 18 inches when possible. Cables may be placed in common trenches with raw water or sanitary lines. When circuits are routed under roadways, direct bury them *at least* 3 feet deep, or place the cables in buried conduit. Electrical wiring, if properly installed, requires minimum maintenance.

Testing

After the circuits and equipment are installed, test them to ensure proper installation. Only by close inspection can hazards be detected and incorrect installations discovered.

Safety

Safety during installation and continued safety for personnel using the equipment are a primary concern. The work crews responsible for installing the electrical system at the bed down location must be qualified electrical craftsmen, and they must have the proper tools to accomplish the job. This is not an area where inexperienced volunteers can augment the workforce. For further guidance on installation, refer to USAF TO 35F14–1–1, *Commercial Technical Manual – Primary Switching Center.*

Operating procedures

The electrical distribution system is designed to accept 4,160-VAC, three-phase, 60-Hz primary power from a generator or commercial power source and to step the voltage down through transformers in the SDC to 120/208 VAC. The SDC is the primary distribution point for the secondary circuits that power various loads such as shelters, hangars, remote area lighting, and other systems requiring low-voltage power.

Energizing circuits

We will specifically discuss energizing procedures for the PSC, but since it is a part of a larger system, we also may mention steps that involve other components. To energize the PSC, follow the steps listed below.

- Ensure SF_6 gas pressure gauge (way viewing window) is in the green or green/yellow zone.
- Ensure all cable terminations are seated properly on the bushing well inserts.
- Ensure all circuit breakers at the SDCs are in either the OFF or OPEN position.
- Ensure all three position (closed-open-grounded) switches are in the OPEN position.
- Ensure all unused input bushing well inserts are covered with a high-voltage terminal cap.
- Instruct generator operations personnel to apply power to the PSC.
- Close the three position (closed-open-grounded) switch on the first output circuit.

When the three position (closed-open-grounded) switches are in the closed position, high voltage is fed through the cables to the high-voltage bushings on the SDC. When the SDC electric fusible disconnect (EFD) switches are in place, the feed-through bushings, along with the transformer windings, are energized. *If sizzling or crackling sounds come from the PSC during load application or under full load, remove loads and de-energize the unit immediately!* Then perform troubleshooting procedures.

> **WARNING:** Wear rubber gloves and the appropriate Arc-Flash (40 cal) during *all* PSC operation phases.

Maintenance requirements

Once the entire system is operating properly, you can concentrate on keeping the electrical system functional. You perform maintenance on the bare base electrical equipment in much the same way as you do at home station. You perform maintenance tasks to keep the base operating in a day-to-day mode and prevent long down times of the electrical system.

Preventive maintenance can be broken down into two basic categories: mechanical and electrical. The dividing line may not always be crystal clear.

Mechanical

The technical order for the PSC (USAF TO 35F14–1–1) outlines the necessary inspection and preventive maintenance actions. These items represent the *minimum* requirements and should *not* be used to limit the amount or frequency of preventive maintenance done. Different environmental and usage conditions may require that inspections occur more often.

Electrical

Only qualified persons should inspect and maintain PSCs. This is true with all other types of electrical distribution equipment as well. Only electrical workers who are familiar with the construction and operation of medium-voltage switchgear should be permitted to inspect or work on the PSC or SDC. There are many things to look for when inspecting switchgear and some require very close scrutiny. Often discrepancies that are small in appearance can cause failures that are tremendous in proportion, and these discrepancies could impact the mission. There are some inspections that can be done with the PSC or SDC energized, while other inspections require the equipment to be de-energized.

Inspection of energized equipment

The amount of inspection that can be done with the equipment energized is somewhat limited; you can only look, listen, and smell. Be sure to read and understand all warnings and cautions listed in the TO.

> **WARNING:** When inspecting *energized* electrical equipment, do *not* remove any panel, barrier, or partition. Covers that are bolted in place are *not* intended to be removed for *routine* maintenance inspections, and they provide *protection* for maintenance personnel from *lethal* voltages of the energized bus. Removing any bolted panel or partition while the PSC or SDC is energized could result in *serious injury or death* to operating personnel.

Immediately after energizing the equipment, inspect for the problem indications described in the table below.

Energized Equipment Inspection Items	
Item	**Description**
Sounds	Listen for popping or crackling sounds produced by electrical discharges or sparking, and for humming noises of vibration caused by electrical resonance.
Visuals	With lights out, look for blue or purple corona halos. Intermittent sparking creates orange or red sputter arcs.
Odors	Ozone, produced by corona or overheating of organic materials can be detected by smell.
Tracking	Tracking is an electrical discharge caused by bridging insulators phase-to-phase, or phase-to-ground. Usually a surface phenomenon, it can occur internally in some materials. It is the nature of epoxy cast insulators used in the PSC, to melt to a non-conducting surface extinguishing the arc when tracking occurs. Although there appears to be a “self-healing” of the insulation, damage has occurred and the insulator should be replaced as soon as possible. Usually, when carbon lines or erosion craters become visible in the epoxy insulators, the insulator has already been damaged beyond repair by extensive bombardment of electrical discharges.

PSC maintenance

Requirements and procedures for Maintenance are contained in USAF TO 35F14–1–1 Attachment 2, S&C Instruction Sheet 681–510, Instructions for Operation, pages 18-19. The primary switch is a self-contained unit that is not repairable in the field. If a failure occurs, the switch is repairable at the depot level.

SDC maintenance

The SDC requires periodic maintenance to maintain proper system operation. The table below lists SDC maintenance requirements. It shows items to be inspected, how often to inspect, what to look for, and what action to take.

SDC Maintenance			
Item	***Frequency***	***Condition***	***Action***
SDC structure	Semiannually	Free of structural damage; free of corrosion; paint in good condition; storage compartments clean.	Repair structural damage as required; remove corrosion; repaint as necessary. Clean storage compartments.
Access doors	Quarterly	Free of damage; free of corrosion, paint in good condition. Hinge in good condition and properly lubricated. Latch assembly and friction stay in good condition. Door seal firmly attached and in good condition.	Repair damage as required. Remove corrosion; repaint as necessary. Lubricate hinge, friction stay and latch assembly as required.
Access panels	Quarterly	Free of damage; free of corrosion, paint in good condition. All fastening hardware in place.	Repair damage as required. Remove corrosion; repaint as necessary. Replace missing or damaged hardware.
High-voltage section	Quarterly	Load break connectors or terminal lugs, bushing wells, and parking stands in good condition. EFD switches and fuses in good condition. Ground connections secure and in good condition.	With a hot stick, remove EFD switch poles. Using a wire brush, remove dirt and corrosion from all terminal and conductors. Tighten loose connectors and grounds. Replace damaged broken terminal and connectors. Replace damaged pins in load break connectors. Replace blown or damaged fuses.
Transformer section	Semiannually	Transformer compartment clean. Tap connections secure and in good condition.	Remove transformer access panel. Remove dirt and corrosion from terminals. Tighten connections. Clean compartment as necessary. Reinstall access panel.

WARNING: Ensure that *all* power is *removed* and the SDC is *isolated* from *all* power sources and loads *before* performing preventive maintenance on the unit.

Troubleshooting procedures

When it comes right down to it, the circuits found in the Harvest Falcon electrical system are no different than the electrical circuits mentioned in previous volumes of this course. The same techniques and testing equipment are used during troubleshooting procedures. Of course you remember that one key element to troubleshooting any electrical system is isolation.

Isolation

The isolation technique takes some thought on the part of the electrician. You must analyze the situation and find solutions to the problems. Look at figure 4–35. Assume that there is no power to the last three SDCs on circuit #2. With that knowledge, you can now speculate that the problem is located in either SDC 7 or 8, or somewhere in the cable between the two. You know that SDC 8 has no power; however, SDC 7 feeds 8, therefore, you can assume that a problem could exist there. You have isolated the problem to SDC 7, SDC 8, or the cable simply by analyzing the situation and saving perhaps several hours of troubleshooting. Now that you have isolated the problem, you can take your tools and testing equipment to specifically locate and fix the problem.

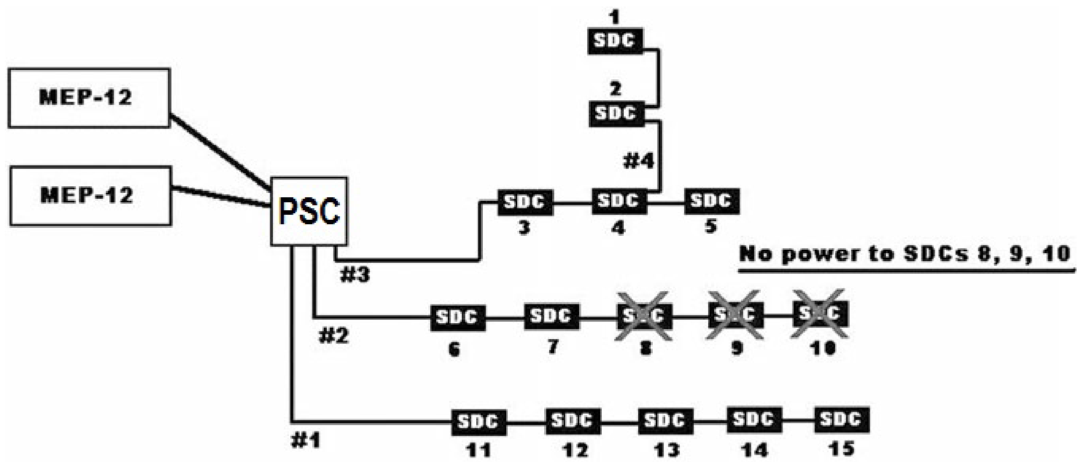


Figure 4–35. Circuit isolation.

Troubleshooting SDC high voltage section

Troubleshooting the SDC isn't much different than the PSC. The table below lists the trouble, a probable cause, and corrective action to take for the SDC.

SDC Troubleshooting		
Trouble	***Probable Cause***	***Corrective Action***
No primary 4,160 VAC power to SDC transformer	1. Source failure of generator, PSC, or cable. 2. Primary cable connections. 3. EFD switch transformer fuse *not* in place or blown.	1. Check source. If power is being supplied from source, check primary cables. Repair or replace broken cables. 2. Check that high voltage load break connectors are securely mounted in bushing wells. 3. With input power OFF, use a hot stick to remove center poles of EFD switch and check that fuses are in place and in good condition. 4. Replace missing or blown fuses.

615. Basic Expeditionary Airfield Resources secondary distribution system

During the initial phases of bed down, critical facilities require power immediately. Those facilities can't wait weeks for the high voltage system to be established. For this reason the secondary distribution is installed. The power needed for those facilities is provided by SDCs, powered by low voltage MEP generators. You can anticipate that MEP generators will power SDCs for up to 15 days *before* the high voltage grid is installed. The secondary distribution includes the SDC, PDP, and the low voltage cable.

Installation

The layout of each facility is based on obtaining maximum dispersal compatible with the electrical distribution system assets that are available in the bare-base equipment package. In the event your deployment is to a low-threat area where maximum dispersal is not required, you 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.

SDC

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 PSC, a loop feed from another SDC, or through a low voltage generator. The SDC's components are described in TO 35CA2–2–10–1, *Opn And Maint Instr With Overhaul Proc And IPB—Secondary Distribution Center 150kva, Pn 8335844 (John Hollingsworth Co)*.

The secondary side of the SDC consists of the panel board bus, circuit breakers, and 60-amp cannon plug connectors (fig. 4–36). 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 mission essential power (MEP) generator or from the secondary transformer windings. This means that the SDC can accept power from a MEP generator that is connected through the mission essential receptacle in the case of a primary power failure or maintenance actions.

> **CAUTION:** During normal operations, this MEP generator may remain connected while the SDC is energized with primary 4,160-volt power. However, you *never* transfer power from MAIN to MISSION ESSENTIAL *while under load*.

Each SDC has sixteen 120/208-output circuits capable of supplying 60 amps per phase (fig. 4–36). The secondary feeder cables are five-wire, #6 AWG copper wires with 600-volt THW insulation with a rating of 60 amps. Storage space is provided for four 100-foot and two 50-foot lengths of secondary cable, all of which come with the SDC.

PDP

The PDPs are circuit breaker panels that receive 120/208-volt power from the SDC and divide it into separate circuits to run a given facility's HVAC, lighting, and utility outlet systems. PDPs are placed wherever they are needed, and then cables are attached to them.

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 sub-distribution centers to other PDPs and major loads (fig. 4–37). Smaller PDPs usually serve a single facility and come with the facility being served.

The 25 kW and the 15 kW PDPs normally support a single facility and its associated environmental control unit.

- The 25 kW PDP is associated with the small shelter system. 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, some models may have to be hard-wired through the bottom of the unit, or they may have the larger 200-amp cannon plug connection.

Each tent receives a lightweight distribution box to power 6 lights and 12 duplex outlets. The layout of BEAR tents provides the maximum dispersal of assets under the limitations and constraints of a low-voltage system. If the deployment is to a low-threat area where maximum dispersal is not required, you can reduce the spacing distances between tents and modules accordingly. For *dispersed conditions*, however, secondary cables are simply plugged together much like household extension cords to gain the desired lengths. Total cable distances from the generator to the point of use should *not exceed* 800 feet

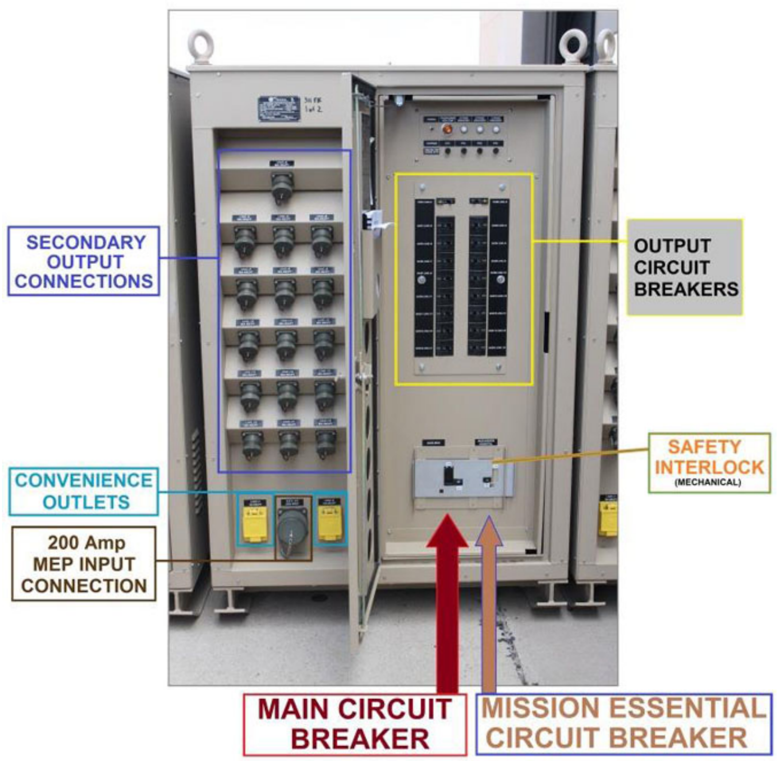


Figure 4–36. Secondary side of SDC.

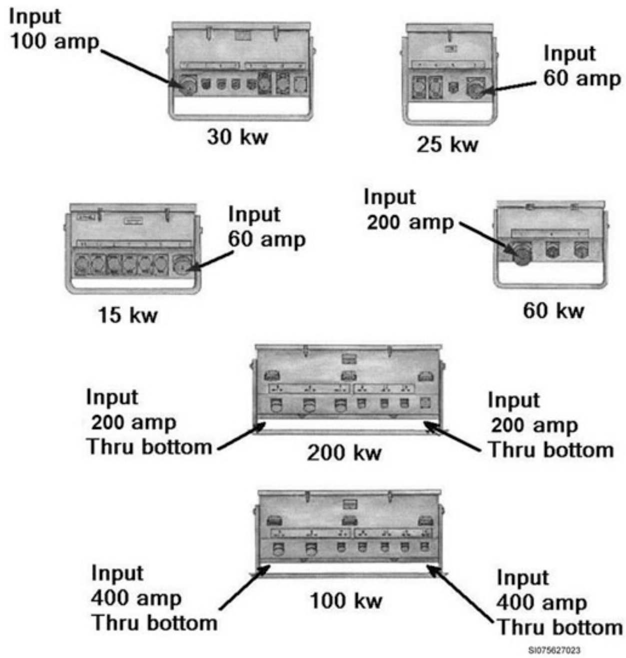


Figure 4–37. PDPs.

Secondary cable assemblies

Bare-base secondary cable assemblies come in 200-amp and 60-amp sizes. The 200-amp cable is 25 feet long and is used to connect the low-voltage MEP generator to the SDC. One 200-amp cable comes with each 60- and 100-kW MEP generator. The 60-amp cables come in lengths of 25, 50, and 100 feet (fig. 4–38). These cables are used to connect shelters and electrical equipment to the SDCs or PDPs. Some 60-amp cables are stored with the using shelters or equipment (fig. 4–39). When installing these assemblies, pay close attention to these *safety* factors:

- Bury electrical cables or place them so they do *not* present a tripping hazard.
- Install cables inside a tent or other expedient structure so they do *not* present an electrical hazard.
- Place lights in an expedient structure low enough for all occupants to reach them, but high enough that no one walks into them.

Figure 4–38. Secondary cable.

Figure 4–39. Secondary cable connections.

Operation

The three sets of EFD switches located in the high-voltage compartment control the application of 4,160 VAC to the SDC transformer primary windings and the feed-through bushings. The center pole EFD of each set is fused at 30-amps and controls the transformer, while the other two EFD switches are non-fused and control the feed-through bushings. This provides the ability to isolate the SDC transformer by removing the center EFD of each set, and still maintain service to remaining SDCs in the circuit. The main circuit breaker applies the 120/208 VAC power to the panel board bus. The mission essential circuit breaker applies power from the low-voltage MEP generator to the panel board bus. A mechanical safety interlock prevents both breakers from being ON at the same time. Bus-energized indicator lights for each phase are located at the top-center of the circuit breaker panel. A transformer high-temperature indicator light is also located near the bus-energized lights, and it illuminates during excessively high transformer temperatures.

The steps to energize and operate the secondary side of the SDC are described in the following table.

Energizing and Operating SDC Secondary Side	
Step	**Action**
1	Set the SDC transformer CKT BKR MAIN to ON. The A, B, and C BUS ENERGIZED lights come on. If one or more of the phase indicator lights does *not* come on, return the XFMR CKT BKR MAIN to OFF and check the fuse(s) and lamps for the phase that indicator(s) did not light.
2	With the XFMR CKT BKR MAIN in the ON position and the BUS ENERGIZED lights lit, the SDC is ready to deliver power to any or all loads. Connect each load to the SDC through the FEEDER receptacles. To apply power to the loads, set the appropriate FEEDER RECEPTACLE circuit breaker(s) to ON. The SDC is now fully operational and requires no further attention unless some trouble develops in a load, a feeder line, the SDC transformer, or the primary power line.
3	Apply load gradually to the circuit by *closing remaining circuit breakers one at a time*.
4	PDP operation consists of simply switching on the circuit breakers. After application of power from the SDC and secondary connections made, switch on the PDP main breaker then *turn on each branch circuit breaker one at time*.

Maintenance

There are certain requirements needed for maintenance of the bare base equipment. This information is in the respective TO. Performing the required maintenance on this equipment will ensure the reliability of the electrical system. The table below lists the maintenance requirements for the SDC low-voltage system.

SDC Low-Voltage Maintenance			
Item	**Frequency**	**Condition**	**Action**
Receptacles	Quarterly	Pins in good condition and not corroded or bent. Caps in good condition. Caps screwed on tight on unused receptacles.	Repair or replace missing, damaged, or badly corroded receptacles and caps. Screw caps down securely on unused receptacles.
Circuit breakers	Quarterly	Breakers in good condition and operate properly.	Exercise breakers to remove any accumulated dirt from latch mechanism. Replace broken or inoperable circuit breakers.
Indicator lamps, lenses, and fuses	Quarterly	All indicator lamps and lenses in good condition. All fuses intact and fuse holders in good condition.	Replace broken lamps. Replace cracked, broken, or missing lenses. Replace blown fuses. Replace damaged, broken, or corroded lamp sockets and fuse holders.

One important SDC function is the high-temperature override circuit. Should the transformer primary windings overheat, the main circuit breaker will trip preventing damage to the SDC. The main circuit breaker is a shunt-trip design and is incorporated into the override circuit. You will find a transformer high temperature override lamp and switch located on the SDC secondary section (fig. 4–40). Using this switch allows the technician to *bypass* the shunt trip mechanism applying power to the secondary bus during maintenance and troubleshooting procedures. This override switch is used *only during maintenance and troubleshooting* procedures and *never during normal operations*.

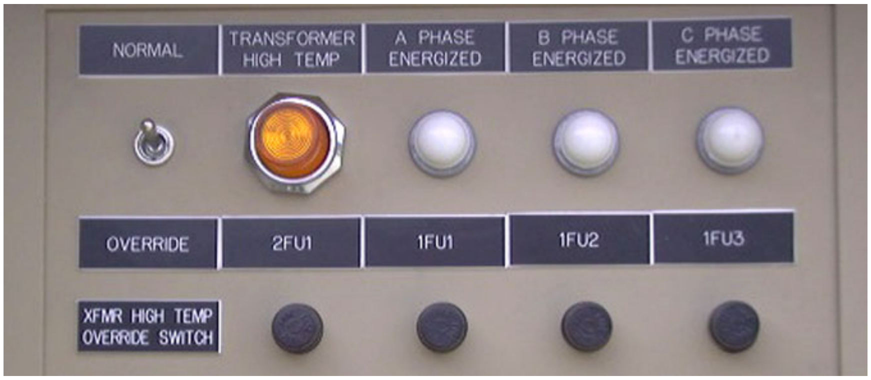


Figure 4–40. SDC transformer override switch and lamp.

Troubleshooting

Troubleshooting bare base electrical equipment is practically the same as you perform at home station. You will find troubleshooting procedures in the respective TOs for the bare base electrical equipment. The SDC troubleshooting chart is in the table below. Notice that the chart provides you with the trouble, probable cause, and corrective actions to take.

SDC Secondary Section Troubleshooting		
Trouble	**Probable Cause**	**Corrective Action**
No 208 VAC secondary power available and XFMR high temp light illuminated.	Transformer overheating and XFMR CKT BKR main tripped.	Allow transformer to cool. Check for and remove overload. Reset main breaker.
A, B, and/or C bus energized indicators not lit.	Fuses blown. Lamps broken or burned out.	Check for and replace blown fuses. If lamps still do not light, check lamps and replace broken or burned out bulbs. If lamps still do not light, check transformer output.
No secondary 208 VAC power received at loads.	Feeder circuit breakers are off or tripped.	Set or reset appropriate breaker to ON. If breaker trips, check and remove fault; then reset breaker. If power still not delivered to load, check receptacles, connectors, and secondary cables. Check for faulty circuit breakers and replace as necessary.
No 120 VAC power at convenience receptacles.	Breaker off or tripped.	Set or reset breaker to ON. If breaker trips, check for and remove overload. Reset breaker.

616. Grounding methods

In any electric power generation and distribution system, appropriate electrical grounding of equipment such as generator sets, transformers, junction boxes, and bus bars is generally very important to ensure safe and reliable operation of the system. Traditional guidance requires *no more than* 25 ohms resistance to ground at all *normally grounded* locations.

However, the nature of the soils in many locations does not permit this level of assured grounding with traditional ground rods or expedient techniques. In especially dry, rocky, or sandy regions, 25 ohms or less grounding to earth can only be obtained by using more involved and equipment-intensive methods that may not be available to bare-base engineers. Therefore, this lesson outlines grounding methods that are available to you and your field engineers to provide “adequate by expediency” grounding levels that are consistent with both time phasing of base camp construction and the distribution system used.

Grounding objectives

The basic objectives of grounding are to:

- Minimize damage and service interruptions due to all possible electrical faults, including lightning discharge.
- Reduce over voltages and resultant insulation damage due to both normal operations such as switching, static buildup, and abnormal occurrences such as lightning faults.
- Minimize injuries to persons near electrical equipment by providing a low-resistance path to the earth.
- Minimize noise in communication and control circuits by establishing a solid electrical reference.

The key words in these objectives are “minimize” and “reduce.” It is not possible to produce a system in which each of these quantities of risk and performance degradation is zero. Nevertheless, the objectives must be satisfied by any grounding technique known to be good engineering practices.

Levels of adequate grounding have been identified for bare-base operations where personnel expertise, materials, time, and special equipment may be limited or not available. These levels are identified in the table below.

Bare-Base Operation Grounding	
Level	**Description**
LVST	*Low-voltage short-term* distribution system (generation at 600 volts or less) deployed only for a short period of time; usually up to 4 weeks.
LVLT	*Low-voltage long-term* distribution system constructed for online use over longer periods of time; usually from 4 weeks up to 2 years.
HVST	*High-voltage short-term* distribution systems (generation at greater than 600 volts) deployed for short-term operation.
HVLT	*High-voltage long-term* distribution constructed for online, long-term operation.

Grounding techniques

The recommended grounding techniques to be used within each of these levels are discussed below. They apply to bases constructed in arid, sandy, or rocky areas where local water tables are very low and to areas where ample water supplies are not readily available.

In coastal regions and other locations where water tables are high and soils are relatively moist, traditional grounding methods normally provide excellent grounding because of the high mineral and salt content of the soil. In coastal regions, corrosion of ground connections is a significant maintenance problem because corroded terminals and connections develop their own high resistance. This corrosion can be reduced by frequent inspections, maintenance, and treatment of ground connections.

Unless specified otherwise, equipment should be grounded with a #2 or #4 AWG copper wire. See figure 4–41 for traditional ground rod technique.

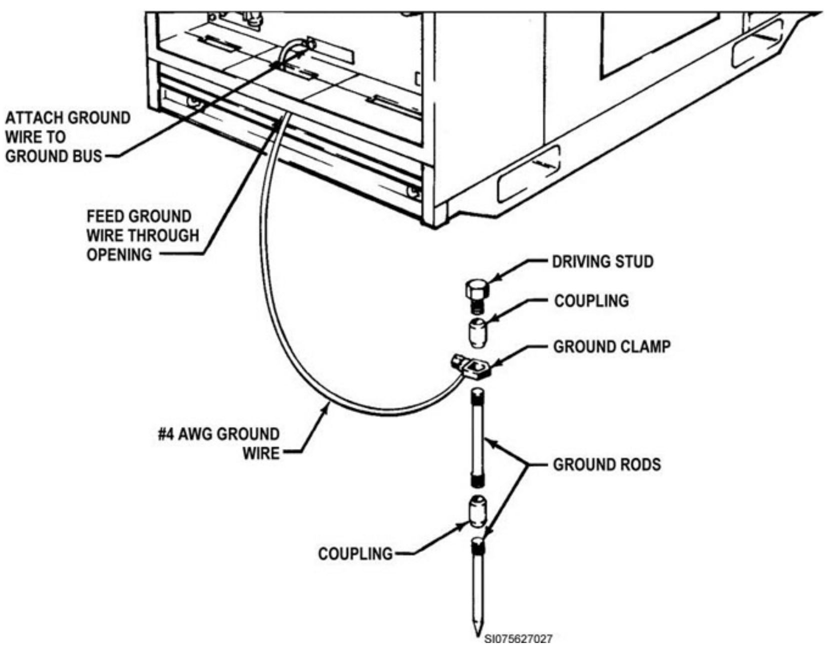


Figure 4–41. Ground rod.

The following table describes the grounding techniques used with the different levels of bare base grounding.

<table>
<tr><th colspan="2">Grounding Techniques</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td>LVST</td><td>
Generators are grounded with a standard ground rod driven next to the generator.
Where rods cannot be driven, lay them horizontally in a trench 18 inches deep and cover them with soil; not rocks.
Connect the distribution system neutral conductor from the generator to this ground.
As long as this three-phase system has a grounded neutral, further deliberate grounding at other locations is not required.
</td></tr>
<tr><td>LVLT</td><td>
This situation is probably most typical for a small bare-base operation.
Place the generators on an electrical grid platform (fig. 4–42) of either concrete or sandbags that are tied to a standard ground rod that has been driven a few feet away from the platform.
The platform must be large enough to permit the generator operator to stand on it while that person attends the generator. Also, connect the generator and the distribution system neutral wire to this ground grid and ground rod.
Other distribution equipment, such as transformers, junction boxes, pedestals, and distribution panels, must also be locally grounded by standard ground rods.
As water availability permits, treat the generator and other local ground rods with salt solutions that you pour directly on or around the rod to saturate the soil. Repeat this treatment as necessary to keep the soil that is in contact with the rod as moist as possible.

Normally, 3 pounds of salt per gallon of water gives a good saturated solution for this application.
ROWPU brine water also serves well for this purpose.

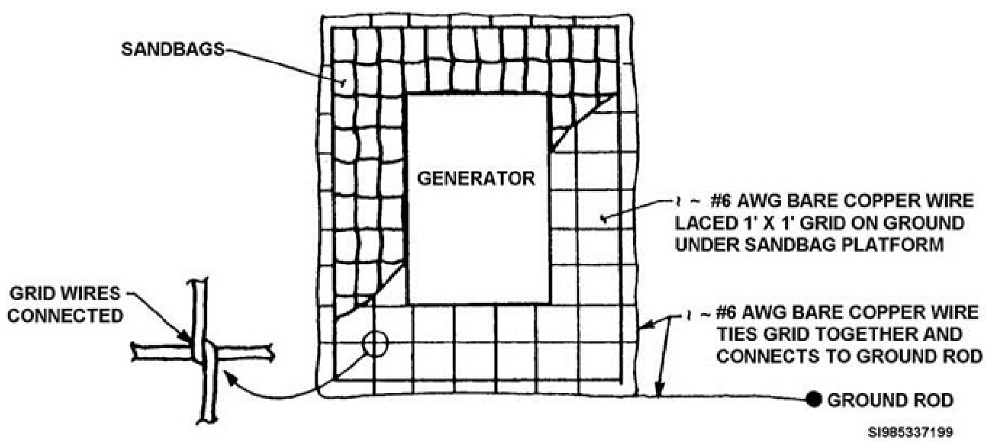


Figure 4–42. Expedient generator grounding grid.
</td></tr>
<tr><td>HVST</td><td>
Use of high voltages in bare base operations may be necessary when the bare base receives power from large Air Force electrical distribution complexes, host nation power plants, or high-voltage 750-kW generators. Along with traditional grounding of generators, transformers, and junction boxes for short-term use, it is essential to have a grounded neutral distribution, using the standard driven ground rod or trench buried rod in rocky areas.
In addition to this initial grounding, a dedicated ground wire must be run from the generator-grounding rod to all grounded locations on the base.
This extra wire, or cable, can be laid in existing trenches or in separate trenching, or it can be formed using the concentric ground wires of high-voltage cables. Whichever is the case, it provides a common ground plane that is normally provided by the soils.
</td></tr>
</table>

Grounding Techniques	
Type	**Description**
	This grounding wire is necessary to provide adequate safety for personnel operating electrical equipment.
HVLT	For system reliability and personnel safety, this longer-term scenario requires that the HVST grounding system described above be augmented with grid ground planes for generators and surface-mounted transformers and with direct contact of the grounding system with a known permanent water source, such as the local water table. It is anticipated that some form of water well will be present at the bare base where HVLT applies. In this case, the grounding plane and dedicated ground wires should be connected to the metal well casing or a separate copper conductor can be lowered into the well to make contact with the water. If a water well is not available, other drilling operations will be necessary to establish positive electric contact with the local water table. Also, of prime importance in this grounding system is the continuous and frequent inspection of grounding connections and dedicated ground wires for electrical continuity and low resistance of connections. Cleaning of corrosion from these connections and protection are critical to maintaining good system reliability and safety.

Assumptions

The preceding outline of “adequate” grounding levels was developed based on assumptions of construction in very dry, sandy, and rocky terrain. Such soils form a relatively high-resistance electrical path to ground, as do driven ground rods. Therefore, use a dedicated ground wire for high-voltage systems. In effect, this extra wire serves the same purpose as the soil in normal moist environments. It ensures that faulting currents are driven back to the generator, thus tripping appropriate circuit protection devices.

Existing water

Existing water sources such as oasis, river beds, or underground streams often indicate that local water tables are high enough to be contacted with driven ground rods. Deep wells can be used as described earlier to easily tie the entire grounding system to earth potential using dedicated grounding cables and grids. These water sources can also be used to dampen the soil around local ground rods. If a bare base is developed in an area that is already built up, electrical contact with existing water piping systems can provide excellent ground conditions. The rebar in reinforced concrete serves the same purpose as horizontal ground rods.

Concentric ground cables

Concentric ground wires of high voltage cables in distribution systems can be used to provide a dedicated grounding conductor. The following outlines other site selection factors that should be considered before placing the generation and distribution system to improve the system’s grounding effectiveness. As noted earlier, highly arid and sandy-base sites with low water tables do *not* allow ideal solutions for grounding electric distribution systems with traditionally available Air Force grounding equipment. However, other regions may provide at least reasonable opportunities for good electrical grounding when sites are selected carefully.

Another location for grounding

Another good location for grounding would be an existing metal sewage system. Finally, existing metal fencing can be used to construct electrical grids for generators and SDCs. In locations where such structures or water sources are not available, distribution grounding can be improved by driving ground rods near or into operational waste water dumps or sinks. For instance, dining halls and latrines may use evaporation ponds or cesspools. Sewage liquids are normally very conductive.

However, exercise care to ensure that this ground connection does *not* endanger personnel should a fault occur.

Wastewater drainage

Figure 4–43 shows grounding using wastewater drainage. The drain pipe *must not* be constructed with metal materials. Plastic or PVC is recommended if the sewage drain is used for ground. This prevents the possible injection of current into the water systems of a latrine or dining hall.

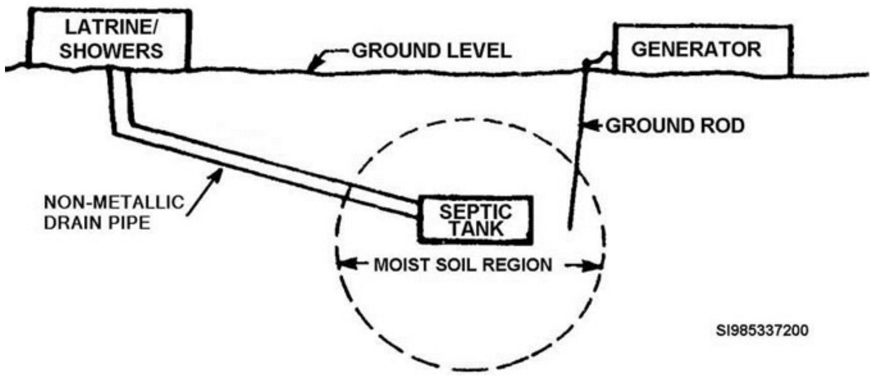


Figure 4–43. Sewage system grounding.

Two expedient techniques

Two expedient techniques for local grounding are particularly applicable to field applications. These techniques are the *expedient ground pipe* and *expedient ground trench* methods.

Expedient Local Grounding Techniques	
Type	**Description**
Expedient Ground Pipe	This can be easily used in deep, loose, dry sand where a “quick fix” ground is needed. Figure 4–44 shows how an 8-foot section of galvanized steel or copper pipe can be modified to aid immediate introduction of salt solution to the rod and sand interface. • After you drive it into the ground, fill the perforated pipe with a solution of, 15 pounds of salt per 5 gallons of water. • Introduce that mixture into the pipe through a funnel. • The salt solution percolates into the sand and provides a conductive soil for current flow. This ground remains effective until the solution either evaporates or drains away from the rod, usually in several hours or a few days. A major *disadvantage* to this procedure is that it tends to corrode the pipe very quickly; frequent replacement of the pipe is necessary. Also, keep the grounding clamp and wire connection clean and corrosion-free for good results. **Figure 4–44. Expedient grounding pipe.**
Expedient Ground Trench	This technique is most useful in rocky terrain where rods are difficult to drive, has been loosely called a “ground ring.” Lay bare copper wire in a horizontal trench and cover it with soil and salt solution treatment, if available. More wire in the trench, usually 18 inches deep, provides a better ground. A “ground ring” of this type is shown in figure 4–45.

<table>
<tr><th colspan="2">Expedient Local Grounding Techniques</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td></td><td>

With this technique, the wire becomes unrecoverable after several salt solution treatments.

Note that some field users have successfully employed this type of grounding method without the salt solution treatment.

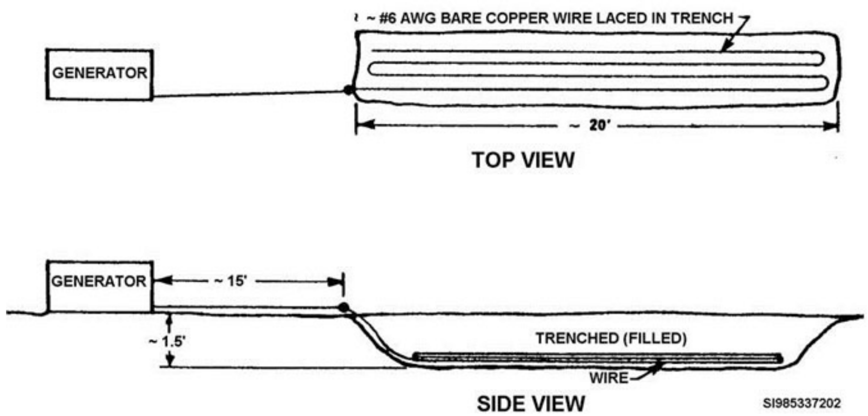


Figure 4–45. Expedient grounding trench.

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617. Basic Expeditionary Airfield Resources tent lighting

The small shelter system (SSS) is a series of expeditionary modular soft shelters that are supported by an aluminum frame structure. The fabric is made of a synthetic material and comes with roll-up windows. The nominal tent size is 32 by 20 feet. An electrical wiring kit provides lights and duplex outlets.

BEAR tent lighting installation

Installation of lighting and convenience outlets to service deployed personnel is one of your primary contingency tasks. The interior tent lighting and power distribution system consists of *three* major components: a distribution box, two convenience outlet assemblies, and an incandescent light streamer assembly. *Each* tent receives one light streamer (with six lights spaced along streamer) and two convenience outlet assemblies (one assembly for each side of the tent).

The lightweight, molded distribution box is feed from a PDP by a 50 fool long 20 amp with a twist-lock connection at the PDP. The distribution panel (fig. 4–46) has a single-pole toggle switch mounted to the side, protected by a 20-amp circuit breaker, to control the lights. Two GFCI 20-amp circuit breakers protect an outlet streamer for each side within the tent. Both the light streamer and the outlet streamers connect to the molded distribution panel with a twist-lock connection (fig. 4–47). Velcro straps are used to connect the streamer cables to the frame of the tent.

Figure 4–46. Distribution panel.

Figure 4–47. Lighting streamer.

BEAR tent lighting removal

When the need for the power to the tents no longer exists, then obviously it is time to disassemble the lighting assets and store them away. Because of the ease of the assembly (plugging in cords), it is just as easy to disassemble. The design of the power kits is such that anyone can remove the kits once you disconnect the *primary* power. It is *very* important that once all the components have been disconnected you make certain you put back all the cords and various components (panels, light fixtures, outlets, etc.) into their proper storage containers. This ensures that when the kit is needed again, all parts are accounted for, and the system can be installed in a *rapid* manner, as designed.

BEAR electrical distribution maintenance and troubleshooting

The maintenance portion of bare base employment is where civil engineer personnel function much as they do at home station, performing the tasks required to keep the base operating in a day-to-day mode. However, it is almost impossible to see a distinction between the ending of the erection and construction portion and starting the maintenance portion. Often there is considerable overlap. For example, once you connect the stand-by generators to their facilities, they start receiving operational and maintenance checks, even though the electrical distribution system is still being installed in other areas of the base.

Self-Test Questions

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

613. Basic Expeditionary Airfield Resources primary distribution system, part 1

1. What are the two major components that make up the BEAR primary electrical system?

2. What *primary voltage* is needed for the BEAR electrical system?

3. What two power sources can you use to obtain *primary power* for the distribution system?

4. In most cases, what equipment supplies *primary power* for the electrical distribution system?

5. Name the two distribution system layouts.

6. What is the major *disadvantage* of the *radial* layout?

7. How many feet should you allow *between generator sets* during installation?

8. What piece of electrical equipment serves as a *high voltage switching station*?

9. What must you do *before* you close the arc strangler switch?

614. Basic Expeditionary Airfield Resources primary distribution system, part 2

1. Where in the SDC do the PSC *feeder circuit cables* attach?

2. When you bury high voltage cables, how deep must you bury them?

3. What is *first step* prior to *energizing* the BEAR electrical equipment?

4. What do you inspect for *immediately after energizing* the BEAR electrical equipment?

5. What Way on the PSC is *used* when *paralleling multiple primary switches together?*

6. What action do you take when inspecting the SDC *transformer section*?

7. What symptom would be present if an SDC EFD switch has a *blown fuse*?

615. Basic Expeditionary Airfield Resources secondary distribution system

1. As a general practice, the length of branch circuits should be *no more than* how many feet?

2. What item in the SDC changes the 4,160 VAC to 120/208 VAC?

3. From what two sources does the *secondary bus* on the SDC receive its power?

4. List the PDP kilowatt sizes.

5. Which PDP is associated with the Small Shelter System installation?

6. List the 60-amp secondary cable lengths.

7. What happens when the *primary windings* of the SDC *overheat*?

8. What is a probable cause when *no secondary 208 VAC power* is received at the PDP?

616. Grounding methods

1. Name two grounding objectives for the electrical distribution system.

2. Which grounding technique only requires ground rods to be driven at the generator?

3. What can be used as a *dedicated grounding conductor* in the electrical distribution system?

4. Name the two expedient grounding techniques.

617. Basic Expeditionary Airfield Resources tent lighting

1. What does the interior tent lighting and power distribution system consists of?

2. How many light streamers are installed in each tent?

3. What is used to control the lighting streamers?

Answers to Self-Test Questions

613

1. Power generation and high-voltage primary distribution.
2. 4,160 VAC.
3. High-voltage generators or commercial power sources.
4. MEP–12, high voltage generators.
5. Loop and radial.
6. Susceptibility to damage from disasters or enemy attacks.
7. At least 20 feet.
8. Primary Switching Center.
9. You must place it in the cocked position.

614

1. To the SDC terminations that are located in the high-voltage section.
2. At least 18 inches deep. (At least 3 feet deep if routed under roadways).
3. Ensure all cable terminations are seated properly on the bushing well inserts.
4. Sounds, visuals, odors, and tracking.
5. Way 6.
6. Remove transformer access panel, remove dirt and corrosion from terminals, tighten connections, and reinstall panel.
7. No primary power to SDC transformer.

615

1. 800.

2. Dry-type transformer.
3. MEP generator or secondary transformer windings.
4. 15, 25, 30, 60, 100, and 200.
5. 25 kW.
6. 25, 50, and 100 feet.
7. The main circuit breaker trips preventing damage to the SDC.
8. Feeder circuit breakers are off or tripped.

616

1. Any two of the following:
   (1) Minimize damage and service interruptions due to all possible electrical faults, including lightning discharge.
   (2) Reduce over voltages and resultant insulation damage due to both normal operations such as switching, static buildup and abnormal occurrences such as lightning faults.
   (3) Minimize injuries to persons near electrical equipment by providing a low-resistance path to the earth.
   (4) Minimize noise in communication and control circuits by establishing a solid electrical reference.
2. Low-voltage, short-term.
3. The concentric ground wires of the high-voltage cable.
4. Expedient ground pipe and expedient ground trench.

617

1. A distribution box, two convenience outlet assemblies, and an incandescent light streamer assembly.
2. One.
3. A single-pole toggle switch mounted to the side of the distribution panel.

Complete 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 the Field-Scoring Answer Sheet.

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

35. (613) What is the *primary distribution voltage* of the basic expeditionary airfield resources (BEAR) electrical system?
    a. 12,470 volts alternating current (VAC).
    b. 4,160 VAC.
    c. 2,400 VAC.
    d. 240 VAC.

36. (613) What is the output of the 750-kW, mission essential power (MEP)–12 generator in a basic expeditionary airfield resources (BEAR) package?
    a. Three-phase, 4,160 volts.
    b. Three-phase, 2,400 volts.
    c. Single-phase, 4,160 volts.
    d. Single-phase, 2,400 volts.

37. (614) What type of cable *termination* is used for the primary switching center (PSC) connections?
    a. Joy splices.
    b. Load-break elbows.
    c. Tape termination kits.
    d. Heat-shrink molded terminations.

38. (614) Which way point is used to tie two primary switching centers (PSC) together?
    a. 3.
    b. 4.
    c. 5.
    d. 6.

39. (614) When connecting two primary switching centers (PCS) together using 500 MCM copper cable, what is required to make the connection?
    a. 200 amp loadbreak.
    b. 600 amp loadbreak.
    c. 200 amp deadbreak.
    d. 600 amp deadbreak.

40. (614) What is used to *compensate for voltage drop* in a secondary distribution center (SDC)?
    a. Larger cable.
    b. Tap changes.
    c. Copper conductors.
    d. 200-kVA transformer.

41. (614) What is the conductor size and insulation value of the basic expeditionary airfield resources (BEAR) *high-voltage electrical cable*?
    a. #6, 15 kilovolts (kV).
    b. #1/0, 5 kV.
    c. #6, 5 kV.
    d. #1/0, 15 kV.

42. (614) You should bury primary cables to a depth of at *least*
    a. 8 inches.
    b. 12 inches.
    c. 18 inches.
    d. 24 inches.

43. (614) How many ways on the primary switching center (PSC) have load interrupter switches?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

44. (614) Before performing maintenance on the secondary distribution center (SDC) you
    a. shut down the primary switching center (PSC).
    b. close the mission essential power breaker.
    c. contact the disaster control center.
    d. ensure all power is removed.

45. (614) What is the *mostly likely* problem when there is *no* power to *any* of the outbound primary distribution center feeders?
    a. Defective load-break elbow.
    b. High-voltage cable failure.
    c. 200-amp fuse blown.
    d. Power source failure.

46. (615) The recommended distance for secondary runs from the secondary distribution center (SDC) is *not to exceed*
    a. 400 feet.
    b. 600 feet.
    c. 800 feet.
    d. 1,000 feet.

47. (615) What basic expeditionary airfield resources (BEAR) asset is used as the *main distribution point for secondary circuits*?
    a. Contractor control cubicles.
    b. Primary switching center (PSC).
    c. Remote airfield lighting set (RALS).
    d. Secondary distribution center (SDC).

48. (615) How many 120/208 volts alternating current output circuits can the secondary distribution center (SDC) provide?
    a. 2.
    b. 6.
    c. 12.
    d. 16.

49. (615) Which *power distribution panel* is associated with the tent extendible modular personnel (TEMPER) tent?
    a. 15 kilowatt (kW).
    b. 25 kW.
    c. 100 kW.
    d. 200 kW.

50. (615) What cable size is used to connect the low-voltage mission essential power generator to the secondary distribution center (SDC)?
    a. 100-foot, 60-amp.
    b. 50-foot, 150-amp.
    c. 25-foot, 200-amp.
    d. 25-foot, 100-amp.

51. (615) How do you deenergize the transformer windings of one secondary distribution center (SDC) *without* deenergizing any of the interconnected SDCs?
    a. Turn off the main circuit breaker.
    b. Pull the three fused disconnects in the high-voltage compartment.
    c. Deenergize the main feeder at the primary switching center (PSC).
    d. Disconnect the load-break elbows in the high-voltage compartment.

52. (616) What can you do to ground the system if the ground rod *cannot* be driven into the earth during deployments to locations where low voltage will be used for a short time?
    a. Connect generator ground to system neutral.
    b. Bury the ground rod in a horizontal trench that is 18 inches deep.
    c. No grounds are required for low-voltage short-time deployments.
    d. Drive the ground rod in as far as it will go, and cut off the excess.

53. (616) What mixture of salt and water *normally* increases the conductivity of the soil that is in contact with a ground rod?
    a. 1 pound of salt per 1 gallon of water.
    b. 1 pound salt per 3 gallons of water.
    c. 3 pounds of salt per 1 gallon of water.
    d. 3 pounds of salt per 5 gallons of water.

54. (617) How many light streamers are installed in each tent?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

55. (617) When dissembling the tent lighting assets, where do you store the components?
    a. In the proper storage containers.
    b. In an approved cargo container.
    c. In the middle of the tent.
    d. In a convenient location.

Glossary

Abbreviations and Acronyms

Ω	ohms
AC	alternating current
ACS	agile combat support
AEF	expeditionary air force
AETF	Air and Space Expeditionary Task Force
BEAR	Basic Expeditionary Airfield Resources
BOB	Basic Expeditionary Airfield Resources Order of Battle
BPU	Basic Expeditionary Airfield Resources power unit
CB	circuit breaker
CONUS	continental United States
COTS	commercial off-the-shelf
DCS	Digital Control System
DTG	distance-to-go
EALS	emergency airfield lighting system
ESPEK	Electric Single Pallet Expeditionary Kitchen
FDECU	field deployable environmental control unit
GFCI	ground fault circuit interrupter
GPH	gallons per hour
hp	horsepower
HPS	high pressure sodium
Hz	hertz
I/O	inputs and output
IL	isolation transformer
kVA	kilo volt amps
kW	kilowatts
MEP	mission essential power
MOS	minimum operating strip
NEC	National Electrical Code
PAPI	precision approach path indicator
PDP	power distribution panel
PLC	programmable logic controller
ppm	parts per million
PSC	primary switching center

RALS	remote area lighting system
RHW	rubber insulated
ROP	remote operator panel
ROWPU	reverse osmosis water purification unit
RPM	rotations per minute
SCA	series circuit adapter
SDC	secondary distribution center
SF_6	sulfur hexafluoride
SSS	small shelter system
TB2	terminal board 2
TDS	total dissolved solids
TQG	tactical quiet generators
UGR-H&S	UGR-heat and serve
UTC	unit type codes
VAC	volts alternating current
VD	voltage drop
WRM	war reserve materiel
XLP	cross-linked polyethylene

Student Notes

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