Administrative Changes to AFTTP 3-32.34V5, *Contingency Electrical Power Production and Distribution Systems.*

OPR: AF/A4CX

Changes OPR from “AFCEC/CXX” to “AF/A4CX” 25 March 2025

References throughout to “AFI 32-1064, *Electrical Safe Practices,*” are hereby changed to “AFMAN 32-1065, *Grounding and Electrical Systems.*” 25 March 2025

References throughout to “AFI 32-1065*, Grounding Systems,*” are hereby changed to “AFMAN 32-1065, *Grounding and Electrical Systems.*” 25 March 2025

References throughout to “AFMAN 91-201, *Explosive Safety Standards,*” are hereby changed to “DESR6055.09_DAFMAN91-201, *Explosives Safety Standards.*” 25 March 2025

References throughout to “AFI 91-203, *Air Force Consolidated Occupational Safety Instruction,*” are hereby changed to “DAFMAN 91-203, *Air Force Occupational Safety, Fire, and Health Standards.*” 25 March 2025

BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-32.34V5

28 February 2017

Certified Current, 6 May 2025

Tactical Doctrine

CONTINGENCY ELECTRICAL POWER PRODUCTION AND DISTRIBUTION SYSTEMS

ACCESSIBILITY: Publications and forms are available on the e-Publishing website at **www.e-publishing.af.mil** for downloading or ordering.

RELEASABILITY: No releasability restrictions on this publication.

OPR: AFCEC/CXX

Certified By: AF/A4C (Maj Gen Timothy S. Green)

Supersedes: AFH 10-222V5, 1 July 2008

Pages: 61

PURPOSE: This publication supports Air Force Instruction (AFI) 10-209, *Red Horse Program* and AFI 10-210, *Prime Base Engineer Emergency Force (BEEF) Program.* It provides tactics, techniques, and procedures (TTP) that address actions helpful when installing Basic Expeditionary Airfield Resources (BEAR) contingency electrical generation and distribution systems.

APPLICATION: This publication applies to active duty Air Force, Air National Guard (ANG), and Air Force Reserve Command (AFRC) Civil Engineer personnel. The electrical and power production technicians using this TTP should have a basic knowledge of electrical components of the contingency systems. This TTP provides additional guidance by augmenting applicable electrical power production distribution systems technical orders (TOs); TOs remain the final authority. Refer to the applicable system TO for detailed installation, operation, maintenance, and removal procedures. Readiness and deployment planners and base level mobility team chiefs responsible for contingency planning may also find this information helpful regarding bare base electrical generation and distribution planning. This publication may also be used in support of peacetime contingencies. Other users of this TTP should be familiar with basic contingency electrical components.

SCOPE: This TTP applies to Electrical Systems and Electrical Power Production technicians charged with providing electrical distribution and power generation for contingency beddowns.

RECORDS MANAGEMENT: Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with (IAW) Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of IAW the Air Force Records Disposition Schedule (RDS) in the Air Force Records Information Management System. Refer recommended changes and questions about this publication to the Office of Primary Responsibility (OPR) using the AF Form 847, *Recommendation for Change of Publication*; route AF Forms 847 from the field through the appropriate functional chain of command.

Chapter 1

INTRODUCTION

1.1. Contingency Electrical Systems Overview. The contingency electrical system is composed of three major subsystems: power generation, primary (2,400/4,160-volt) distribution, and secondary (120/208-volt) distribution. The equipment described in this TTP must be installed, operated, and maintained by persons knowledgeable in contingency electrical power generation and distribution equipment and their associated hazards as described in UFC 3-560-01, *Electrical Safety, O & M*.

WARNING

Working on energized electrical equipment is prohibited except in rare circumstances, and then only when justified and approved by the Base Civil Engineer (BCE) or equivalent IAW AFI 32-1064, *Electrical Safe Practices*.

Note: Maintenance personnel shall wear appropriate personal protective equipment (PPE), to include arc thermal performance value (ATPV) rated PPE, IAW AFI 32-1064 and UFC 3-560-01 when working on or near energized electrical equipment or circuits.

1.1.1. Within the major subsystems are components such as generators, primary cable reels and pallets, secondary distribution centers (SDCs), primary switching centers (PSC), remote area lighting system (RALS), secondary cable assemblies, power distribution panels, and mission-critical cable assemblies.

1.1.2. Contingency electrical systems arrive at the beddown site in air transportable and or surface deployment packages. These deployment packages are Force Module Enablers necessary to open and operate any austere airbase across the spectrum of Air Expeditionary Force operations. These packages may also be used in other contingencies such as humanitarian operations.

1.2. Deployment Packages. BEAR provides vital equipment, facilities and supplies necessary to beddown and support combat forces at austere airbases with limited infrastructure and support facilities. It is assumed that the beddown location has a runway, taxiways and aircraft parking areas suitable for the type of aircraft deployed, and a source of water that can be made potable. BEAR provides the electrical equipment listed in **Table 1.1** in support of the Establish the Base Force Module.

Table 1.1. BEAR Electrical Equipment by Unit Type Code (UTC).

	XFA16 / XFS16 (Low Pwr Ind)	XFAPL / XFSPL (Low Pwr Hskpg)	XFABP / XFSBP (High Pwr)	XFASD / XFSSD (SDC)	XFAEG / XFSEG (Pwr Dist)	XFAZC / XFSZC (RALS)
BPU			2			
MEP-806	2	5				
MEP-805		3				
PSC			1			
SDC				2		
PDP - 60	2	8				
CRPA (w/o wire)					2	
Primary Wire (reel)					6	
10K Fuel Bladder			2			
ORT (laptop)			1			
Cable, 25ft, 200A	2	8				
Cable, 50ft, 60A				4		
Cable, 100ft, 60A				8		
RALS						2

Note: Items and quantities are subject to change without notice.

Chapter 2

MAJOR SYSTEMS COMPONENTS

2.1. Contingency Electrical Power Generation and Distribution Systems Components. This system provides electrical power generation and distribution equipment designed to support austere base power requirements. The design is modular to support a broad range of contingency operations requiring electrical power. Contingency operations ranging in size from relatively small deployments requiring power generation and distribution at the hundreds of kilowatt level to very large operations requiring power generation at the multi-megawatt level can be supported. A brief description of the major components follows.

2.1.1. BEAR Power Unit (BPU). The BPU (**Figure 2.1**) is a fully enclosed, trailer-mounted, mobile generator set with a prime power output of 800 kW at 60 hertz (Hz) and 435 kW at 50 Hz, both at 0.75 lagging PF. The BPU is a 3-phase, 4-wire system that can operate at 60 Hz or 50 Hz. It delivers a nominal voltage of 4160/2400 VAC at 60 Hz and a nominal voltage of 3800/2200 VAC at 50 Hz. The BPU can achieve this performance at altitudes from sea level up to 4,000 feet and in ambient air temperatures from -25 ºF up to 122 ºF without derating. See **Table 2.1** and **Table 2.2** for altitude and ambient temperature derating information. The BPU utilizes JP-8 fuel, but can also operate on alternate fuels that include JP-5, 1-D S15, 1-D S500, 1-D S5000, 2-D S15, 2-D S500, 2-D S5000, TS-1 with JP-8 additives, Jet A, and Jet A1. It can operate as a standalone generator, in parallel with other BPUs, or in parallel with a commercial power grid. The BPU consists of a diesel engine, an AC system, cooling system, fuel system, air intake system, exhaust system, Digital Control System (DCS), enclosure, trailer, and DC electrical system.

Figure 2.1. BEAR Power Unit (BPU).

Table 2.1. Generator Set Capability as a Function of Altitude & Ambient Temperature kW at 60 Hz.

Altitude	-25 F	80 F	90 F	100 F	110 F	120 F	130 F	140 F
10,000 ft	800	800	800	792	620	515.2	440.8	384
9,000 ft	800	800	800	800	784	584	489.6	472
8,000 ft	800	800	800	800	800	680.8	526.8	560
7,000 ft	800	800	800	800	800	779.6	547.04	656
6,000 ft	800	800	800	800	800	800	768	736
5,000 ft	800	800	800	800	800	800	796	792
4,000 ft	800	800	800	800	800	800	800	800

Table 2.2. Generator Set Capability as a Function of Altitude & Ambient Temperature kW at 50 Hz.

Altitude	-25 F	80 F	90 F	100 F	110 F	120 F	130 F	140 F
10,000 ft	800	800	800	792	620	515.2	440.8	384
9,000 ft	800	800	800	800	784	584	489.6	472
8,000 ft	800	800	800	800	800	680.8	526.8	560
7,000 ft	800	800	800	800	800	779.6	547.04	656
6,000 ft	800	800	800	800	800	800	768	736
5,000 ft	800	800	800	800	800	800	796	792
4,000 ft	800	800	800	800	800	800	800	800

2.1.1.1. The BPU Digital Control System (DCS) performs automatic voltage regulator functions, engine governing, system fault annunciation, paralleling functions, and operator and servicing control panel functions. The BPU also has a software component that can be installed on a suitable PC that emulates the Operator Control Panel functions of the DCS for remote operations. Remote operation can be provided up to 250 feet from the generator set. This computer is not furnished with the BPU, but is included in the High Power UTC. The DCS display is a Video Graphics Adapter (640x480) full color, sunlight readable display. The display switches and labels are backlit green for viewing under dark conditions.

2.1.1.2. BPU tow vehicles must meet the following requirements: 6X4 tractor, with a pintal hook height between 22 inches and 30 inches, and minimum 80,000 pounds gross combined weight rating. Do not use tow vehicles that do not meet all requirements. Tow vehicle NSN 2320-00-721-1432 meets all these requirements. Do not exceed 15 MPH on level paved road, 10 MPH on graded gravel, 8 MPH on Belgian Block or equivalent. Failure to comply may result in damage to equipment.

2.1.2. MEP-12A. This generator set (**Figure 2.2**) is a trailer-mounted diesel engine driven, prime power (Type II), utility (class 2A), mode I unit that produces 750 kW at 60 Hz and 625 kW at 50 Hz with 0.8 power factor, lagging. It provides 2400/4160 volts, 3 phase, 4-wire, wye (2400 volts line-to-neutral; 4160 volts line-to-line) for 60 Hz operation; and 2200-3800 volts, 3 phase, 4-wire, wye (2200 volts line-to-neutral; 3800 volts line-to-line) for 50 Hz operation.

Figure 2.2. MEP-12A Generator.

2.1.2.1. The main control panel assembly allows local and remote start, stop, monitor, and control of the generator set in operation. Operation can be achieved up to 150 feet (45 meters) from the generator set.

2.1.2.2. The MEP-12A is designed to operate on a variety of fuels, which include DF-2, JP-4, JP-8 DFA (Arctic Grade Diesel), and commercial jet A-1. One MEP-12A consumes 55 gallons of fuel per hour at full load under normal environmental conditions, which equates to a consumption of about 1,320 gallons during daily operation. To ensure an adequate continuous fuel supply, connections are provided to accept fuel from two external fuel sources, such as a fuel trailer or a fuel bladder.

Note: There are very few MEP-12As currently in inventory. The MEP-12A is being replaced by the BPU through attrition. Any mention of generators concerning power plant operations in this TTP past step 2.1.2.2 will be in reference to the BPU, unless otherwise specified.

2.1.2.3. MEP-12A tow vehicles must have a 25,000 pound towing capacity with a pintal-hook connection. Do not exceed a speed of 20 MPH on a paved road or 5 MPH on an unpaved road.

2.1.4. The PSC provides for interconnection and safe isolation of primary generators and the connection of loads to the system (**Figure 2.3**). The basic electrical component of the PSC is the S&C Vista™ Switchgear. The switchgear is housed in an enclosure that provides both environmental protection as well as a stacking capability for transportation. The housed switchgear is referred to as a PSC.

Figure 2.3. Primary Switch Center (PSC).

2.1.4.1. General Description. The PSC features load-interrupter switches for switching 600-ampere main feeders and micro-processor-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) load-interrupter 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-position (closed-open-grounded) disconnects for isolation and internal grounding of each phase. Fault interrupters provide three-pole live switching of load circuits. Fault interruption is initiated by a programmable over current control. The TO includes instructions on programming the control.

CAUTION

All routine operating tasks, switching, voltage testing, and grounding must be accomplished by a two-person team due to potential exposure of high-voltage IAW AFI 32-1064.

The PSC allows for insulation testing without physically isolating the high voltage cable to within the high voltage compartment by switching the Way to open position. Then go to the nearest SDC and isolate and test from there. **Note:** PSCs have 600-amp deadbreak bushing connections. Install 600-amp to 200A adapters on bushings before connecting 200 amp load break elbows.

2.1.4.2. PSC Connections. The Primary Switch features six Way Switches and provides for 3 phase inputs from a primary power generator. Primary power (4160VAC, 60Hz, or 3800VAC, 50Hz, 3-phase, 3 wire) is supplied to the PSC via three primary cables. A primary power connection is accomplished by connecting three loadbreak elbows to the 600-amp-to-200-amp adapters that are connected to the PSCs bushing wells. The bushing wells are connected to the Way Switches, or "Ways." The function of each way is either a switch or a combination of a switch and a circuit breaker. A Load Interrupter Switch is comprised of only a switch. A Fault Interrupter Switch is comprised of a switch and a circuit breaker. Way 1 and Way 2 are Load Interrupter Switches; Way 3, 4, 5 and 6 are Fault Interrupter Switches. Depending on the configuration of a specific application, the Way Switches can either be inputs from a primary power generator, or outputs (feeders) to a load such as an SDC or to another PSC.

2.1.4.3. Overcurrent Relay Settings. An operator's remote terminal and overcurrent control adapter cable is furnished with the PSC to input settings, review settings, and interrogate the event recorder. However, the software for programming the overcurrent control is contained within the control, allowing any computer meeting minimum system requirements to input settings as long as the adapter cable is available. Two data ports are provided, one port is for programming ways 3 & 4 and the other is for programming ways 5 & 6. Procedures for programming overcurrent controls are presented in TO 35F14-1-1, Attachment

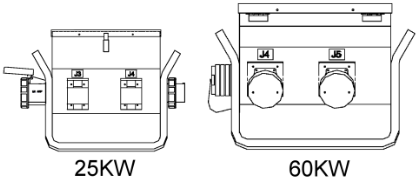
3, Instruction Sheet 681-515, *Instructions for Programming S&C Overcurrent Control*.

2.1.5. Secondary Distribution Center. The SDC features a 150-KVA three-phase 2400/4160 VAC primary 120/208 VAC secondary utility transformer and a low-voltage secondary distribution panel. The SDC has 16 secondary outputs, 60 amps each (**Figure 2.4**), which are fed by 100 amp, 208 VAC output circuit breakers (16 each). The primary power connections are configured for a feed through configuration. The high-voltage power is connected using 200 amp load break quick disconnects, to a common high-voltage bus. The high-voltage bus is designed to accept one input and two outputs and is equipped with three sets of high-voltage disconnects. Two sets of disconnects are used to provide feed through capability. The third set are fused disconnects (30 Amps) and provide overcurrent protection to the high-voltage side of the transformer. The low-voltage power distribution portion of the SDC provides 120/208 VAC, 60 Hz, 3-phase, wye connected with ground (5 wire system) from a 3-Phase 800 Amp distribution bus panel through a 600 amp, 208 VAC Main circuit breaker. **Note**: The SDCs are available with both the "Commercial Connector" and the "Class-L Connectors/cannon plugs." AF SDCs only come with Class-L connectors and will be the only ones discussed in this TTP.

Figure 2.4. Secondary Distribution Center (SDC), Low Voltage Side.

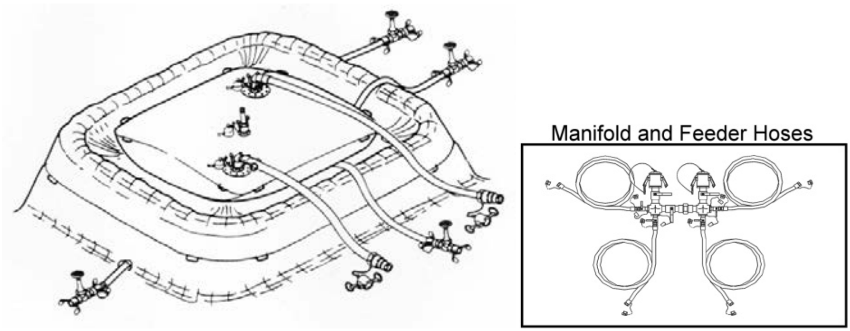
2.1.6. Power Distribution Panel (PDP). PDPs receive power from SDCs and distribute it directly to both single and three phase loads. BEAR features a 25kW and 60kW PDP (**Figure 2.5**). The PDPs receive 120/208V, 3-phase, 60Hz, wye-connected 4-wire with ground power through a Class L (MIL-C-22992) connector and distributes to 3-phase Class L outputs, single-phase military standard outputs, and single-phase NEMA L5-20R outputs. All outputs are circuit breaker protected.

Figure 2.5. Power Distribution Panels (PDP).



2.1.7. External Fuel System. Major components of the External Fuel System are the manifolds, fuel lines, the 10,000 gallon fuel bladder and the Berm Liner (**Figure 2.6**).

Figure 2.6. External Fuel System.



2.1.8. Advanced Mobile Medium Power System (AMMPS). Mission critical loads are supported with 30kW and 60kW AMMPS generators (**Figure 2.7**).

2.1.8.1. MEP-1060. This is a diesel or JP-8 powered, mobile unit that provides 3-phase, 60-cycle, 120/208 or 240/416-volt power to support loads up to 30 kW. The AMMPS series is light weight, electronically controlled, skid mounted and EPA compliant. This generator may also be operated at 50 cycles, but will be de-rated to 25 kW. **Note:** For altitude and temperature deratings see applicable TO.

2.1.8.2. MEP-1070. This is a diesel or JP-8 powered, mobile unit that provides 3-phase, 60-cycle, 120/208- or 240/416-volt power to support loads up to 60 kW. The AMMPS series is light weight, electronically controlled, skid mounted and EPA compliant. This generator may also be operated at 50 cycles, but will be de-rated to 50 kW. **Note:** For altitude and temperature deratings see applicable TO.

Figure 2.7. Advanced Mobile Medium Power System (AMMPS).

2.1.9. Tactical Quiet Generators (TQG). Mission critical loads are supported with 30kW and 60kW TQG sets (**Figure 2.8**). Wheel kits are included to allow ease of transport. **Note:** TQGs will be phased out through attrition.

Figure 2.8. Tactical Quiet Generators (TQG).

2.1.9.1. MEP-805B. This is a diesel or JP-8 powered, mobile unit that provides 3-phase, 60-cycle, 120/208 or 240/416-volt power to support loads up to 30 kW. This generator may also be operated at 50 cycles, but will be de-rated to 25 kW. The MEP-805B model is provided with digital controls and instruments. **Note:** For altitude and temperature deratings see applicable TO.

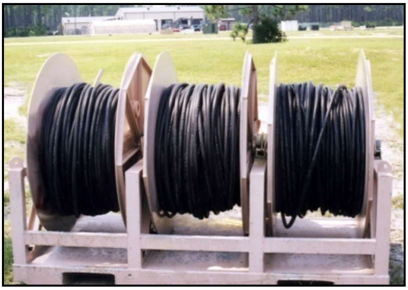
2.1.9.2. MEP-806B. This is a diesel or JP-8 powered, mobile unit that provides 3-phase, 60-cycle, 120/208- or 240/416-volt power to support loads up to 60 kW. This generator may also be operated at 50 cycles, but will be de-rated to 50 kW. **Note:** For altitude and temperature deratings see applicable TO. The MEP-806B model is provided with digital controls and instruments.

2.1.10. Primary Power Cable. The 1/0, 5kV cable provides the tie connections between the BPU generator, PSC, and SDCs. The cable is also used for power distribution. The primary cable uses load break elbows (**Figure 2.9**) as primary connectors.

Figure 2.9. Load Break Elbow (secured with Grip-All Stick).

2.1.11. Cable Reel Pallet Assembly. Primary cables are provided on three cable reels housed within a cable reel pallet assembly (**Figure 2.10**).

Figure 2.10. Cable Reel Pallet Assembly (CRPA) with Cable Installed.



2.1.12. Secondary Power Cable. Secondary Power Cables have Class L connectors and are keyed for voltage, frequency, and current. Covers, cable grips, and glands for both ends of the cable are supplied and properly secured to each connector. There are three different secondary power cables: a 25 foot 200 amp cable that distributes power from TQGs to the SDC or 60kW PDP, two 60 amp cables, 50 foot and 100 foot, that distributes power from the SDCs to PDPs, and in some cases from the PDPs to Environmental Control Units (ECUs).

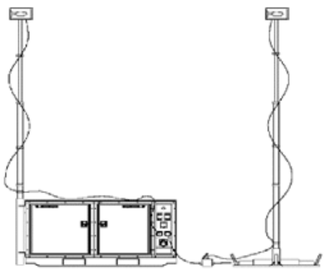
2.1.12.1. In lieu of a PDP, some BEAR facilities have power distribution panels incorporated into the facility and therefore will be connected directly from the SDC via secondary power cables.

2.1.12.2. When connecting cables to the SDC, start with the bottom row of connectors and work your way up. This will keep connected cables from interfering when connecting additional cables (**Figure 2.11**).

Figure 2.11. Secondary Power Cables Connected to SDC.

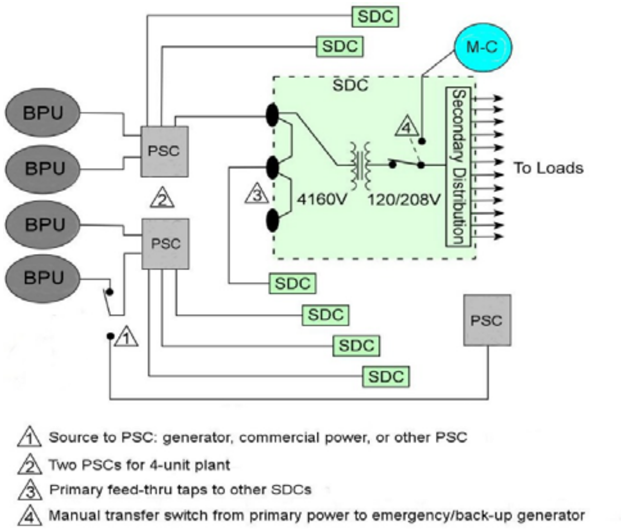
2.1.13. Remote Area Lighting System (RALS). The RALS provides a flexible solution to support illumination requirements. The RALS features 13 telescoping poles, twelve of which are positional through the use of "left-side" and "right-side" cable loop assemblies originating from the RALS container. The RALS is required to be fed by a 60 amp secondary power cable. The thirteenth pole is mounted on the RALS container. Each RALS pole uses a single 150 watt, 16,000 lumen, high-pressure sodium lamp. The manual telescoping aluminum poles have locking collars. Each cable loop assembly is comprised of two (2) RALS loop cord sections of 375 feet each, thereby providing 750-foot of lighting string in each direction, for a total of 1,500 feet. The RALS container and a representative pole are illustrated in (**Figure 2.12**).

Figure 2.12. RALS Container and Light Poles.



2.2. System Composition. A typical contingency electrical distribution system is depicted in (**Figure 2.13**). **Note:** If host nation commercial power is available and compatible with BEAR system, plan to use it to supplement BEAR generation capability; this will vastly reduce fuel consumption.

Figure 2.13. Basic Electrical Distribution System Schematic.



2.2.1. When all system components are placed together, they create an electrical system with three subsystems: power generation, primary power (high-voltage) distribution, and secondary power (low-voltage) distribution.

2.2.2. Primary system components are tied together with high-voltage cable, using load break elbows, from the prime generator through the PSC, and onto the SDC.

CAUTION

If a commercial power source is used, ensure the maximum voltage does not exceed the ratings of the SDC.

2.2.3. The secondary system starts at the SDC and is provided to the user's PDP, or service panel, through secondary voltage cables using cannon plug connectors. The input can be made from either a prime generator, the output side feeders of another PSC, or from a commercial power source.

Chapter 3

SITE PLANNING AND LAYOUT

3.1. Site Planning. When most power production and electrical personnel begin arriving to set up the power plant and electrical distribution system, basic beddown planning will have likely already been accomplished, including designating and siting facility groupings.

3.1.1. There are three main facility groupings: Flight-line Operations and Maintenance, Industrial Operations and Base Support, and the Cantonment Area (living and services facilities). In addition, Munitions, LOX and POL functions should be located separately from these three main groupings.

3.1.2. If an austere base is being established with a view toward expansion, growth should be addressed during all stages of planning. Therefore, siting of individual facilities during initial stages of planning should also take the growth of the utility systems into account.

3.1.2.1. Planners should recognize that the increase in physical size and number of facilities for each facility group is not usually directly proportional to the increase in base population. Most functional groups will not double, triple, etc. in facilities, area size, or utility support if the population doubles, triples, etc. Supply, Transportation, and Civil Engineering functions will increase marginally, while Billeting, Maintenance, Squadron Operations, and Wing Operations may increase between two to three times.

3.1.2.2. During initial planning, consider the possibility of the base growing in population and identify locations for additional kitchens, laundries, power plants, water plants, and sanitary waste facilities; each of which may require large support areas and new electrical utility and backup generator support.

3.1.2.3. Preplanning for facilities layout should also take into account the base may be expandable in only one or two directions without creating conflict with previously sited roads, facilities, and utilities.

3.1.3. A major consideration when developing a base layout plan is the location and spacing of key facilities and essential areas. Force protection measures help minimize the vulnerability of facilities and reduce the risk to personnel from a variety of threats. Structure separation, standoff, and dispersal force protection measures affect facility siting decisions. Information on minimum standoff distances and separation standards for new and existing facilities as well as expeditionary and temporary structures can be found in AFPAM 10-219, Volume 5, *Bare Base Conceptual Planning*.

3.1.4. Deployment packages are standardized for the types of facility structures that serve each functional grouping. For planning purposes, functional groupings vary little and carry a common designation. **Table 3.1** identifies basic designations for facility groups and types of structures supplied to house major functions. **Note:** The specific type and quantity of UTCs will determine the specific type and quantity of structures. The BEAR Power Planning and Distribution Tool (PPDT) helps plan the expeditionary beddown requirement by calculating the type and number of BEAR UTCs required based on a series of questions presented to the user. Additionally, the BEAR UTC Planning Factors within the tool can be viewed. The BEAR Expeditionary UTC planning tool is available at the BEAR Global Management Office SharePoint website at <https://org1.eis.af.mil/sites/635scow/WM/Requirements%20Determination/Forms/AllItems.aspx> **Note:** If you receive an error message when you click on the hyperlink, click on "Request access." It will be at the bottom of the error message in fine print. The PPDT software will download as a zip file from the SharePoint. Once downloaded, your information technology support personnel should install the software (requires admin rights). The software certificate for net worthiness is located on the SharePoint with the PPDT.

Table 3.1. Bare Base Facility List.

Facility	Facility Group	Structure Type			
		SSS	MSS	LAMS	4K/8K Dome
A	Avionics	X	X		
B1 B2	Lodging & Services Admin	X			
C	Chapel	X			
D	Dining Facility	X			
E	Engineer	X	X		
F	Maintenance	X	X	X	X
G	Squadron Operations	X	X		
H	Support Group	X	X		
I	Emergency Services	X			
J	Aerial Port	X			
L	Laundry	X			
M	Munitions	X	X		

Facility	Facility Group	Structure Type			
		SSS	MSS	LAMS	4K/8K Dome
P	POL	X			
R	Alert	X			
S	Supply	X			X
T	Transportation	X			X
W	Wing Operations	X			
EW1, EW2	Water Plant(s)	X			
Note: The following facility groups provide their own structures: Hospital (X), Communications (Y), and Airfield Facilities (Z)					

3.1.5. Which facilities go where varies from location to location. In most cases, physical size and topographic conditions may constrain or dictate the basic base layout (e.g., a linear or conventional layout). The functional interrelation of flight-line operations, maintenance, and command structures may also dictate that some facilities and functions be collocated differently, especially if the base supports other US or allied military services.

3.1.6. Gather the following facts to determine the type of power system required.

3.1.6.1. Threat level of the deployed area.

3.1.6.1.1. If the threat is low and population of the base is not too large, one centralized power plant may be all that is needed.

3.1.6.1.2. If the threat dictates facility dispersal, two power plants may be required to increase survivability and to cover the extended area. Ensure enough PSCs are available if two power plants are required.

3.1.6.2. Determine if plants can be located to allow connection between them.

3.1.6.3. Determine availability of primary cable to connect between power plants.

3.1.6.4. Determine if SDCs from separate plants can be located in close proximity to quickly lay and park cable between critical SDCs for redundancy.

3.1.7. The issues above may be easily addressed after rechecking facility groupings, loads, and layout plans. However, the situation can become increasingly complicated when considering additional transient aircraft, personnel support, and/or beddown expansions, especially if dispersed. The larger the size of the area to be served, the more resources required for setup, support, and security.

3.1.8. Determine the system power factors and how they may affect power plant operations and the distribution system. Consider the following basic limiting factors when planning the layout of the electrical system. These system limitations are based on transmission and distribution distances from the prime power source to the PSC, the PSC to the SDCs, and the SDCs to the PDPs.

3.1.8.1. Keep the primary power cable runs between generators and PSCs to the shortest distance possible (less than 100 feet). The primary reason for this is to minimize the overall footprint of the power plant.

3.1.8.2. Limit the primary power cable runs from the PSC to the SDCs to one mile where the SDCs are grouped at the end of the run. A one mile run may still experience excessive voltage drop, but can be partially compensated for by adjusting the tap settings of the SDC. To avoid changing tap settings, limit the length of a run from the PSC to the SDCs to 4,000 feet.

3.1.8.3. Primary runs between the PSC and SDCs should not exceed two miles where the SDCs are equally distributed along the run. Again, a two mile run may experience excessive voltage drop that requires SDC tap adjustments. To help avoid changing tap settings when SDCs are distributed equally along the run, limit the length of a run to 1.5 miles.

3.1.8.4. Limit secondary runs from SDCs to PDPs and facility distribution panels to 800 feet when it is necessary to keep the voltage drop below 10% for the supported facility. Longer runs may be made for emergency use and use with resistance type equipment less vulnerable to voltage drops.

3.1.9. An electrical distribution schematic should be developed during beddown planning. Planners should calculate, determine, and/or identify load factors, demand, maximum draw, and diversified load as related to individual facility groups. The specific information is used to develop a detailed secondary distribution schedule, placement of mission essential generators, and develop individual feeder schedules used for installation. Given time and expertise, going into this amount of detail during the initial beddown planning will significantly limit the need to relocate SDCs, re-site/relocate facilities, and relocate cable runs. During initial planning, basic planning factors can be followed to help minimize duplication of work. Detailed schedules should be accomplished prior to installing the electrical distribution system.

3.1.10. Initial billeting planning is essential. **Figure 3.1** shows billeting in the initial stages of low voltage (LV) set-up, with and without Field Deployable

Environmental Control Units (FDECUs), and eventually transitioning to high voltage (HV).

3.1.10.1. Due to time and manpower required to set up and remove HV equipment for billeting, it may not be practical to transition from LV to HV (**Figure 3.2**) for short term contingencies.

Figure 3.1. Initial Billeting Planning with Low and High Voltage

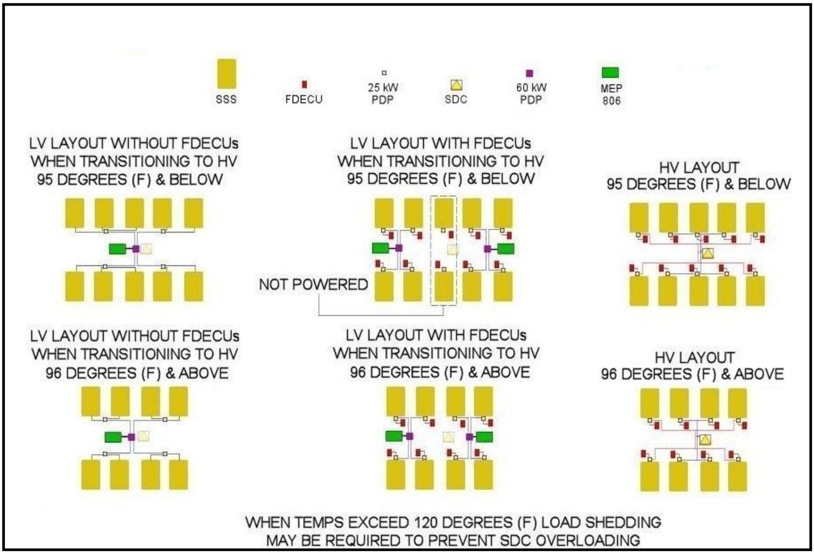


Figure 3.2. Low Voltage Billeting Planning with no Transition to High Voltage

3.1.11. Basic electrical planning factors. System design should take into consideration the minimum number of generators required to support the maximum load at each power plant. This does not imply that each generator will be online at all times, but ensures sufficient capacity is available to meet peak demand.

3.1.11.1. Where FDECUs sustain their continuous maximum amperage draw, consider the maximum load that one generator can support through the PSC and SDCs. The total load on each SDC should not exceed 150 kVA and the load on each SDC circuit should not exceed 21.6 kVA.

3.1.11.2. One BPU, 800 kW generator (operating at 80% of its maximum capacity) will support no more than 5 SDCs per one 200-amp PSC output circuit when facilities are operating at maximum loads with FDECUs.

3.1.11.3. Under normal operating loads, a power plant with at least two generators operating will support 6 to 10 SDCs per PSC circuit when facilities have FDECUs, and 10 to 15 SDCs per circuit when facilities do not have FDECUs.

3.1.11.4. Each SDC has two high voltage output circuits with loadbreak elbow connections for feed through capabilities. A maximum of five SDCs can be supported from these connections. Only 10 shelters per SDC can be connected when the FDECU is used in each shelter. By properly balancing the number of SDCs per plant, the number of SDCs per PSC should not exceed this maximum number (maximum number depends on how many BPUs are connected).

WARNING

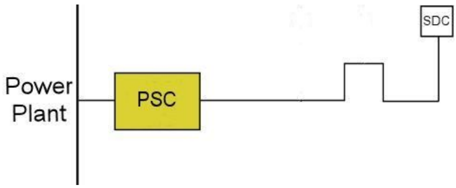
At full load, the FDECU draws 41 amps. For ambient temperatures over 125°F, do not operate SDCs at more than 60% load (i.e., no more than 8 of 16 output connections used).

3.2. Layout. All CE units with deployable UTCs should conduct bare-base layout table-top exercises during home station training. Layouts should focus on which facilities require close proximity to each other, both within and between facility groups, in order to function effectively and efficiently (see AFPAM 10-219V5, *Bare Base Conceptual Planning*). Site planners will need this information during the "Open the Airbase" phase of the deployment. This exercise will also provide opportunity for power production and electrical systems personnel to practice layout of the electrical generation and distribution system and calculate secondary distribution requirements and feeder schedules. Layout decisions need to consider the threat, future growth of the base, and type of primary distribution system to be installed.

3.2.1. Bare base primary distribution systems can either be a radial or network (loop or tie) system.

3.2.1.1. A radial system has a single simultaneous path of power flow to the load. A radial feeder connects between a source and a load point, and it may supply one or more additional load points between the two (**Figure 3.3**). Each load point can be supplied from one direction only. Radial systems are easier and faster to construct, but do not provide redundancy.

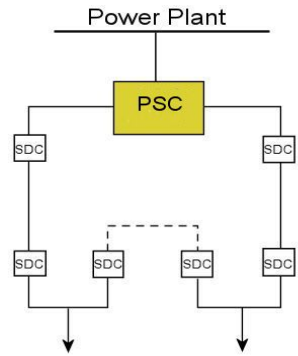
Figure 3.3. Radial System.



3.2.1.2. A network system has more than one simultaneous path and can have two feeder arrangements, loop and tie. This system is more advantageous than the radial system because they provide redundancy by feeding loads from more than one direction.

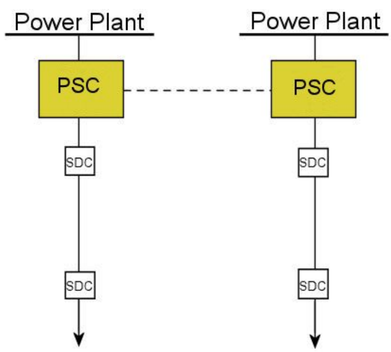
3.2.1.2.1. A loop feeder has its ends connected to a source (usually a single source), but its main function is to supply two or more load points in between (**Figure 3.4**). Each load point can be supplied from either direction; so it is possible to remove any section of the loop from service without causing an outage at other load points. One section of the loop feeder cables are normally parked at one SDC ready to be connected in case of an outage somewhere in the loop.

Figure 3.4. Loop Feeder.



3.2.1.2.2. The main function of a tie feeder is to connect two sources. It provides a connection between two PSCs to provide service continuity for the load supplied from each bus (**Figure 3.5**). Make sure that correct phasing is maintained and concentric grounds are properly connected. **Note:** Use way point 6 as the tie feeder in each PSC and ensure the trip rating of the PSC tie Way and the tie cable are sized IAW Technical Order. 35F14-1-1.

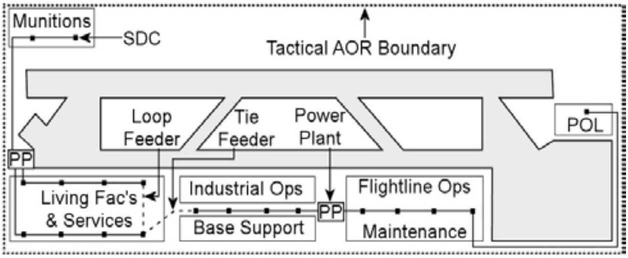
Figure 3.5. Tie Feeder.



3.2.2. For expeditionary bases in a medium to high threat area, planners should consider the base structure from an air base defense point-of-view, combined with normal base operating requirements. In many cases, the boundary of the tactical area of responsibility (AOR) for base defense may dictate the initial installation pattern for the electrical system.

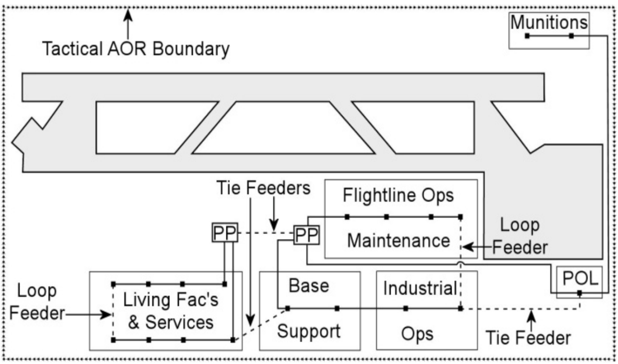
3.2.2.1. For some locations, the tactical AOR may dictate a linear base structure (**Figure 3.6**) designed along a flight-line where the base is long and narrow. In this case, a radial electrical distribution system may be necessary with loop and tie feeders installed where possible.

Figure 3.6. Linear Base Layout.



3.2.2.2. When defense boundaries allow a more conventional layout to be considered, support facilities, billeting, and services functions can be progressively moved away from the flight-line operations and industrial support functions (**Figure 3.7**). For this layout, a tie feeder may be achievable between two power plants, even during the initial installation. A looped system for each power plant may also be possible.

Figure 3.7. Conventional Base Layout.



3.2.2.3. For critical facilities, especially those that require emergency or backup generators, SDCs can be connected with tie feeders parked on one end. This will allow SDCs to be quickly connected in case one feeder circuit is disrupted. Additionally, SDCs connected to critical facilities can be connected to an emergency back-up 30Kw or 60Kw via the low-voltage mission input connector of the SDC.

3.2.2.4. Cables provided with electrical generation and distribution systems are adequate for initial installation based on non-dispersed facility separation guidelines. However, if high-threat conditions require facility dispersal at the maximum distances, some non-critical facilities may require portable generator support, and/or additional primary and secondary cable and connectors. Be aware that required separation criteria for some facilities (such as Munitions, POL, and LOX) can be varied based on terrain, protection of assets, and mission/weapons systems and should be determined for each individual base. This could have a major impact on the layout of power plants, SDCs, and mission-critical generators.

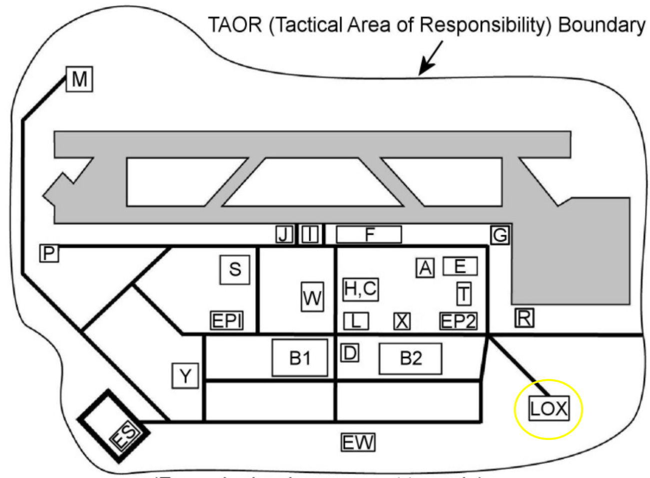
3.2.3. Assets. If the population increases to accommodate two additional squadrons, or other missions, most assets needed for expansion usually does not triple with the population. When laying out the base, be aware that some functions require additional planning, either due to large size (i.e., an aircraft hangar, 4K/8K dome shelter, a 9-2 kitchen, or a medical facility) or minimum separation requirements (i.e., a power or sewage plant).

3.2.3.1. An effective way to manage and delineate where facility groups will be placed is to locate and line up the facility groups within a network of travel and emergency response routes consisting of flight-line pavement, roadways, and utility corridors (**Figure 3.8**).

3.2.3.2. If the base does not have a basic roadway system established, fire, security, and base planners should make this a priority during the layout process. Roadways should be created and fit easily between the groups (within the group separation distances), while utility corridors and utility right-of-ways would run along and between the groups and roadways.

3.2.3.3. Facility group grids should then be established within the “blocks” created by roadways. Plan ahead; orient the tents/shelters and maintain adequate distances between each tent/shelter to allow room for FDECUs and other utilities. Otherwise, utility corridors can become cluttered with equipment, which make repairs, maintenance, emergency response, and removal of equipment more difficult.

Figure 3.8. Typical Layout.



A	Avionics	**F**	Maintenance	**R**	Alert
B1,2	Billeting	**G1,2**	Squadron Ops	**S**	Supply
C	Chaplain	**H**	Support Group	**T**	Transportation
D1,2	Dining Hall	**I**	Emergency Svcs	**W**	Wing HQ
E	Engineering	**J**	Aerial Port	**X**	Medical Fac.
EP1,2	Power Plant(s)	**L**	Laundry	**Y**	Comm Plant(s)
ES1	Sewage Treatment	**M**	Munitions		
EW1	Water Plant(s)	**P**	POL		

3.2.3.4. With expansion, facilities grow within the roadway system blocks. Flight-line facilities (such as Maintenance and Squadron Operations) normally grow along the flight-line. Industrial operations and base support functions (such as Civil Engineering, Wing Operations, and Support Group) normally expand outward and away from each other. Billeting functions normally expand away from the industrial operations, while additional key personnel services support functions (i.e., mobile kitchen trailer, latrines, 9-2 kitchens, and laundry) are located in areas where personnel are massed. Areas should be reserved to allow growth of existing power and sewage plants and placement of new power plants.

3.2.4**. Power Plant Layout.** There are many ways to lay out a power plant as long as available resources are not exceeded, systems operate safely, and the system is installed in a secure environment. Layout power plants using planning factors stated previously in this chapter and adhere to safety requirements in **Chapter 4**. **Figure 3.9** provides an example for a power plant layout. Key concerns for laying out the plants are topography, noise prevention, and vehicle and equipment accessibility.

3.2.4.1. Topography. The general location of the primary power plant is determined by facility planners (primarily engineer officers and engineering personnel) with input from electrical and power production personnel. If a dispersed plant operation is called for, all plant locations need to be identified. With general locations decided, specific sites can then be picked out by on-site physical inspection. Consider the following when determining specific sites:

3.2.4.1.1. Ensure the area is large enough to accommodate all power plant assets (e.g., generators, fuel bladders, berms, PSC, operator’s shelter, etc.).

3.2.4.1.2. Plan for a secure boundary around plant perimeter (e.g., concertina wire, soil-filled wire fabric container).

3.2.4.1.3. Look for relatively level ground to minimize site preparation.

3.2.4.1.4. Plan to level ground for fuel bladders and PSC locations. Ensure the base under the bladder is free of sharp objects (large rocks, etc.) Consider using sand or small gravel under the base of the fuel bladder.

3.2.4.1.5. Check area for potential flooding and reasonable drainage patterns.

3.2.4.1.6. Ensure drainage ditches, swales, or irregular terrain does not inhibit access to site.

3.2.4.1.7. If possible, leave trees on site to provide shade and some camouflage, but do not allow to block airflow.

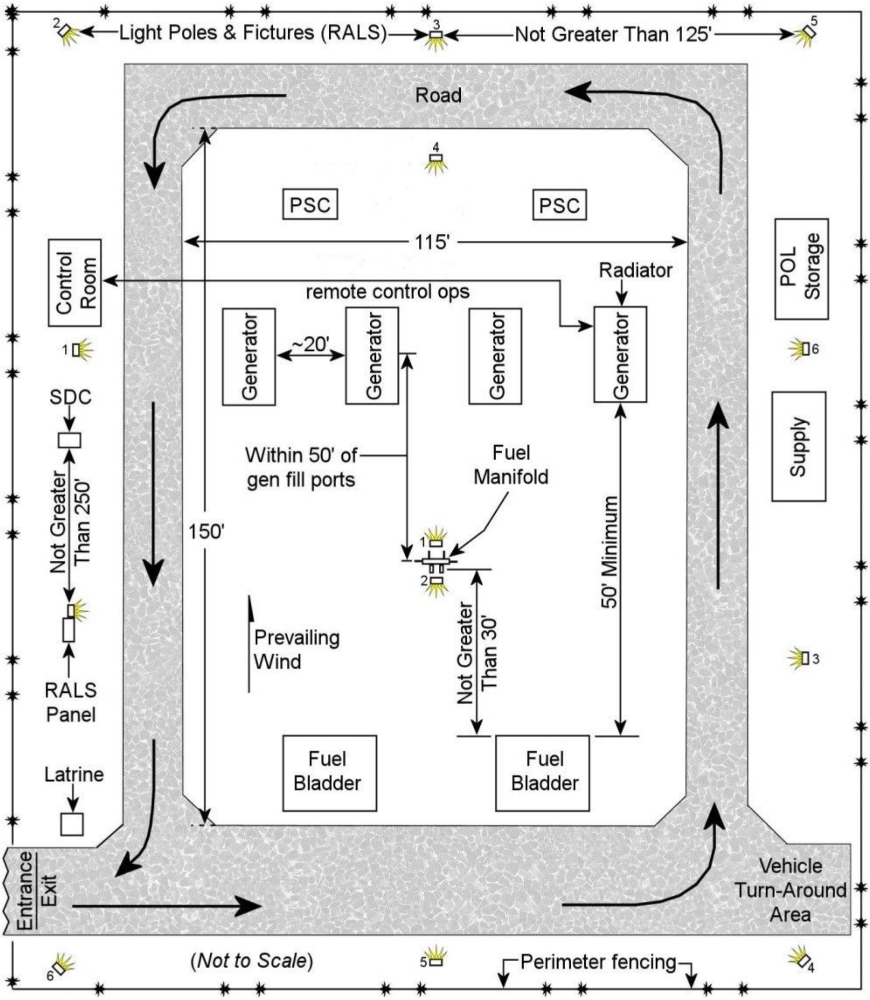
3.2.4.1.8. To minimize blowing dust and dirt, leave ground cover undisturbed to the greatest extent possible.

3.2.4.2. Noise Considerations. When selecting the site, consider noise generated by power plants. Planners normally take this into account by distancing power plants as far as possible from cantonment and administrative type areas.

3.2.4.2.1. In addition to distance, the use of tree lines and natural ground contours between power plants and highly populated areas can reduce noise intrusion.

3.2.4.2.2. In barren regions, man-made revetments and baffles may also be used as noise barriers.

Figure 3.9. Power Plant Layout Example.



3.2.4.2.3. When practical, locate power plants downwind of high-use areas to allow prevailing winds to carry noise and exhaust fumes away from cantonment and administrative areas.

3.2.4.3. Vehicle access is of critical importance to power plant operation, particularly for larger trucks and heavy equipment. Once the plant is constructed, large vehicles require access for delivery of operating supplies, repair parts, and fuel.

3.2.4.3.1. Sufficient space should be allowed to enable removal of an entire generator unit for depot level repair without removing other plant equipment or moving assets around.

3.2.4.3.2. Burial of electrical cables may be desired at a later time. Leave space for trenching equipment when future trenching in plant area is anticipated. At locations where cables cross roadways and in high-traffic areas, the lines should be buried even in the initial phases of the operation. See section **4.4** through **4.4.6** for more detail concerning trenching and cable burial.

3.2.4.3.3. If an extended contingency operation appears probable, it is advisable to build hard surface vehicle access ways, at least to the refueling points. If blacktop roads are not possible, use soil-cement mixture or compacted gravel.

3.2.4.3.4. Be sure to consider fire-fighting access. Coordinate with the base fire chief to determine realistic space requirements; different bases have different fire fighting vehicle sets. As a minimum, plan your plant layout to allow complete accessibility to its entire perimeter.

3.2.4.4. Power Asset Configurations. Although the same basic equipment is used in all Air Force contingency power plants, there are many possible equipment layout configurations. These configurations are influenced by two basic factors—the size of the base population (determines quantities of assets received) and whether dispersed or non-dispersed operations are required (dictates number of plants).

3.2.4.4.1. Layout with PSCs. One, two, and three generator plants are typically configured with one PSC as shown in **Figure 3.10**. For a one and two generator plant, remove generators starting with "Unit 3" as necessary. If using Way 3 as a generator input, the PSC must be reprogramed to remove fault isolation on Way 3. If not reprogramed, any fault will open Way 3. A four generator plant (**Figure 3.11**) requires the use of two PSCs for safe isolation. See TO 35F14-1-1 for proper power plant set-up when using PSCs.

Figure 3.10. Three-Unit Plant with PSC Configuration.

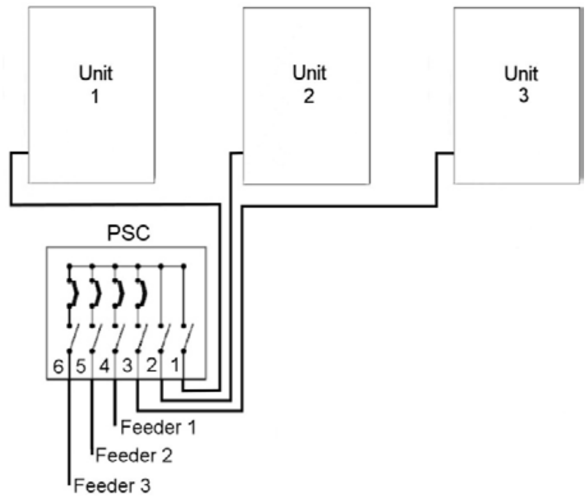
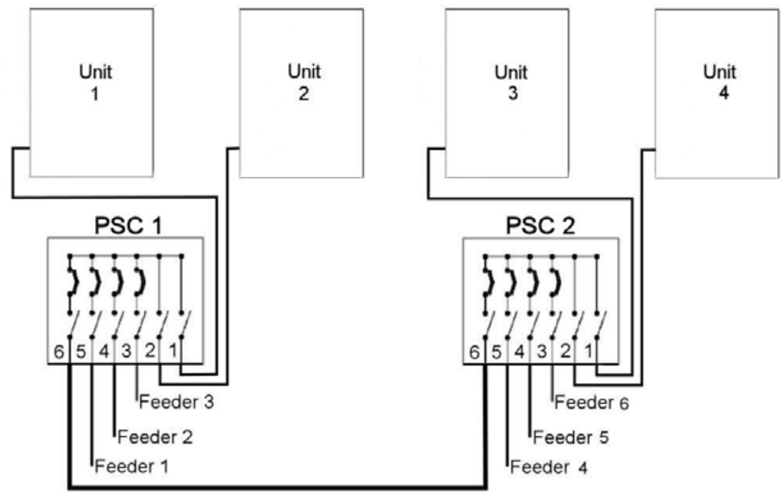
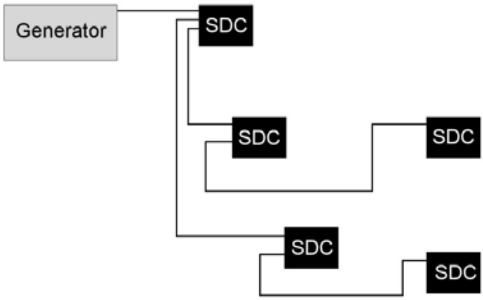


Figure 3.11. Four-Unit Plant with PSC Configuration.



3.2.4.4.2. When only one prime generator is required for a limited area and in unusual cases when a PSC is unavailable, an SDC can accept power directly from a prime generator or from a commercial source of 4160VAC, 3-phase, 50/60Hz power. Then, SDCs may be branch-connected (**Figure 3.12**) to sufficiently distribute power. Theoretically, five SDCs can be connected in this manner to distribute high-voltage power; however, such an installation will provide a lower degree of safety for the generator than will be provided with the use of a PSC.

Figure 3.12. Branch Connected SDCs.



CAUTION

Standard SDC configuration with electric fusible disconnects only in center pole position does not provide over-current protection back to the generator.

3.2.4.4.2.1. Managing loads coming from an SDC branched distribution system must only be accomplished by experienced personnel who are qualified to make primary electrical connections and disconnects IAW UFC 3-560-01; as the overall branched system will be functioning as a PSC. Always communicate with power production personnel before shedding sufficient loads from primary distribution. Also, shed loads slowly at SDCs on the secondary side before isolating the high voltage compartment of the SDC.

WARNING

Verify the secondary (load) system is de-energized before pulling outer poles with a hot stick.

3.2.4.4.2.2. Unlike the PSC, which has load interrupter switches, the SDC has only outer switch poles that may be removed. However, there is no recommended procedure to allow emergency energized disconnects for the SDC.

3.2.4.4.3. Generator Siting. Typically, power plant generators are lined up in parallel with one another. Position and ground the generators according to TOs or manufacturers recommendations. While the minimum clearance between the four sides of the generator and any obstructions is 15 feet, generators are usually positioned up to 20 feet apart to provide plenty of room for maintenance access and to ensure adequate air supply. Also, spacing of 20 feet allows for additional cooling when prevailing winds have a range of directions.

3.2.4.4.3.1. For enduring deployments in hot regions, consider building sunshades over the generators to reduce solar heat buildup. The BPU is 116 inches tall (almost 10 feet) and 152 inches tall (almost 13 feet) when the radiator outlet doors are opened in order to operate the unit. It is recommended that the covering roof height for generator sunshades be at least 240 inches (20 feet) to avoid re-circulation of the air being drawn in and pushed out of the unit.

3.2.4.4.4. Locate Fuel Storage Area. When setting up a power plant, normally one bladder is provided for every two generators. **Figure 3.13** depicts the common placement of the fuel bladder with respect to the generators.

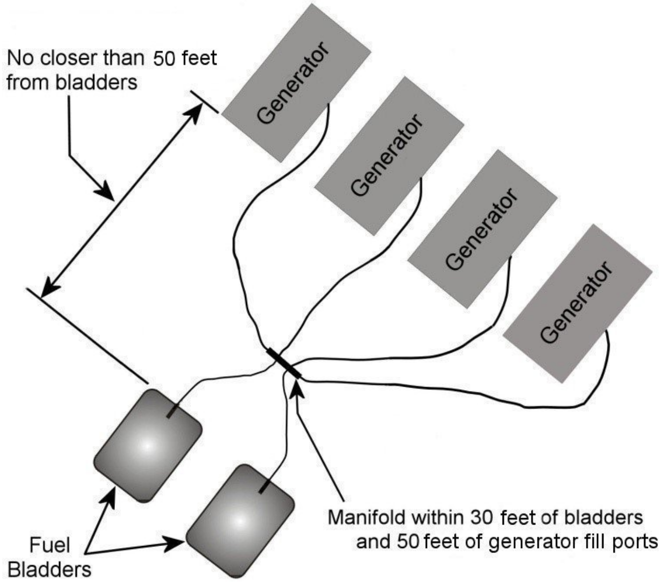
3.2.4.4.4.1. Do not locate generators any closer than 50 feet to fuel bladders due to flammability and fire protection purposes. **Note:** The BPU generator must not be more than 100-ft from the fuel source IAW TO35C2-3-474-11.

3.2.4.4.4.2. Two 25 feet long by one inch diameter fuel lines are provided with each generator; therefore, manifolds should be within 50 feet of the generator fill ports, but should have enough slack to be moved and connected.

3.2.4.4.4.3. Three, three inch by 10 foot long discharge hoses are provided with each bladder; therefore, the fuel manifold has to be within 30 feet of the bladders.

3.2.4.4.4.4. Carefully consider where you place fuel bladders. Do not place them in a location that would permit fuel from a ruptured bladder and berm to flow downhill into other base areas or waterways. Lastly, be sure you have developed a plan for fuel containment in case a bladder and berm rupture or refueling operations result in major spillage.

Figure 3.13. Typical Fuel Bladder Placement.



3.2.4.4.5. PSC Siting. The installation site should be in close proximity to the generators and should be relatively level and capable of bearing the weight of the PSC. Clear the site of brush, large rocks, and other items that might interfere with the operation, maintenance, access to, or stability of the unit. Ensure area is free from potential floods or potential washout from rains. Ensure adequate access to all removable outside panels and door openings. Provide at least six feet of overhead clearance for proper ventilation and ten feet for cable access and a safe clearance zone. If possible, make use of terrain features to minimize the heat loads on the PSC by placing the unit in a shady area.

3.2.4.4.6. The RALS is another item designated for the power plant area. It provides overall general lighting for safety and security.

3.2.4.4.6.1. The RALS includes a panel box and receptacle container, 13 light poles and fixture assemblies, cables to connect the lights to the panel box, and cables to connect the panel box to an SDC. The panel box also serves as the storage and shipping container for the cables and lights.

3.2.4.4.6.2. The lights are controlled with photocells; however, the panel box should be placed within the power plant perimeter for security purposes and in case manual operation is ever desired.

3.2.4.4.6.3. The RALS receives power from an SDC. The cable provided for connection to the SDC is 250 feet long; therefore you'll have to ensure an SDC is nearby. The same SDC should also provide service to the power plant shelter and air conditioner.

3.2.4.4.6.4. Twelve of the 13 lights are connected to four 375-foot cable sections. Normally two strings of six lights are set up, each string 750 feet long. Each string is plugged into the panel box. The thirteenth light fixture is mounted on the panel box itself.

3.2.4.4.7. Remote Generator Operation. This function is for long term operation, or plant operation where several generators are in use simultaneously.

3.2.4.4.7.1. BPU Remote Operations. Establish a power plant control room and set-up the Remote Operator Panel (ROP) for the BPU. Remote operations are accomplished via the ROP laptop and the 250 foot remoting cable.

3.2.4.4.8. Other Facilities. Plan for a parts supply facility and POL storage area near the generators for maintenance purposes. Finally, place a portable toilet and hand washing station in the plant area for convenience.

3.3. Electrical Planning. Contingency electrical systems are pre-engineered; however, they need be tailored to each beddown location. Determine the electrical load on each SDC and then determine the electrical load on each primary feeder. To do this, you need to know the power that will be required for each facility. The information contained in this section will assist you in this task.

3.3.1. After determining what facilities will be erected in the base, the next step is to identify total electrical demand loads from these facilities. Each type of facility and function has a connected load, which is theoretically the maximum facility load if all equipment was operating at the same time. This will not be the case in most instances; therefore, a demand power load is more realistic. The demand load is the load that a facility would draw during normal operations. Expressed as a ratio, demand load over connected load provides a demand factor, which is normally less than 1.0. **Table 3.2** provides a list of typical demand factors by facility type and function. Actual demands may vary by mission and deployed equipment. Changes may be required for distribution and generation systems, including mission-critical generators; adjust demand factors and requirements as needed.

Table 3.2. Typical BEAR Demand Factors.

Type Facility	Function	Demand Factor	Type Facility	Function	Demand Factor
Small Shelter System	Wing Admin/ Command	0.9	LAMS	Hangar	0.9
	Billets	1.0	SSS	Engr Power Plant	1.0
	9-2 Kitchen	0.9		Avionics Shop	0.7
	Shower-Shave	0.9		Pneudraulics Shop	0.7
	Latrine	0.8		NDI Shop	0.7
	Laundry	0.9		Elect Shop	0.7
	Engr Utility Shop	0.6		Bearing Shop	0.7
	Engr Structures	0.6		Parachute Shop	0.8
	Engr Electrical	0.6		Wheel/Tire Shop	0.7
	Engr Fuels	0.6		Gen. Maint Shop	0.7
	Squadron Ops	0.9		Life Support Shop	0.8
	Base Admin	0.9		BX	0.8
	Post Office	0.9		Communications	0.7
	Legal Office	0.9		Armory	0.9
	BX	0.9		SRC	0.9
	Chapel	0.9		POL Lab	0.7
	MWRS	0.8		Sup Processing	0.8
	Fire Operations	0.7	Medium Shelter System	Wing Intelligence	0.8
	Fire Tech Srvs	0.8		Warehouse	0.6
	EOD	0.7		Avionics Shop	0.7
	Base Operations	0.7		Engr Pow Pro	0.6
	Engr Readiness	0.7		Engr Eqpt Shop	0.6
	Mortuary	0.8		Propulsion Shop	0.7
	Aerial Port	0.8		AGE Shop	0.7
	Alert Facility	0.9		Gen. Maint Shop	0.8
	Vehicle Ops	0.7		Sqd Ops Support	0.7
	TMO	0.7		Gen. Support	0.7
	Wing Briefing	0.9		Aerial Port	0.8
	Wing Ops/Plans	0.8	4K/8K Dome Shelter	Munitions Maint	0.7
	Wing Intelligence	0.8		Propulsion Shop	0.8
	Maint/Job Control	0.8		Supply Storage	0.9
	Maint Mat Control	0.7		Vehicle Maint	0.7
	Maint QC	0.8		Packing/Crating	0.7

3.3.2. **Table 3.3** details the power requirements for all base facilities by facility groups, functions, and types of structures used to house the function, and typical electrical planning factors in columns four and five. A diversity factor is applied to the connected and air conditioning (AC) loads since all equipment is not likely to be on at the same time. The diversity factors are usually 0.7 for connected power and 1.0 for AC power. Based on values determined either in the field, or taken from **Table 3.3**, total diversified power requirement is placed in the sixth column. This figure is obtained by multiplying the respective diversity factors with the respective connected power and adding that product to the AC power requirement. If total diversified load in column 6 is greater than the maximum allowable load on a single SDC circuit (i.e., 21.6 kVA at 100% load and 17.3 kVA at 80% load), then diversified load should be broken up between two circuits as shown in the last two columns. The seventh column is the requirement for mission-critical load; standard values are provided in the table, but use the specific, mission essential equipment loads if known.

Table 3.3. Typical BEAR Electrical Planning Factors.

Facility Group	Function	Shelter Type	Power Requirement (Kilovolt-Ampere [kVA])				kVA per Circuit	
			Max Load	AC Load	Div.	M-C Load	#1	#2
A Avionics	Avionics 15 kVA	SSS	15.0	10	20.5	11	20.5	
	General Avionics	MSS	15.0	20	30.5		20.5	10
	Latrine	SSS	6.0		4.2		4.2	
	RALS		7.2		5.0		5.0	
B Billeting	Billets	SSS	4.5	10	13.5		13.5	
	Latrine	SSS	6.0		4.2		4.2	
	Shower/shave	SSS	6.0		4.2		4.2	
	RALS		7.2		5.0		5.0	
C Chaplain	Chapel	SSS	7.8	10	5.5		15.5	
D Services	9-2 Kitchen/Dining	SSS	Up to 150[1]	70	150 ± 25[1]	60 to 100 [2]		150 ± 25[2]
	RALS		7.2		5.0		5.0	
E Engineer	Eng Command	SSS	5.2	10	13.6		13.6	
	Eng Mngmt	SSS	4.9	10	13.4		13.4	
	Mat. Control	SSS	7.0	10	14.9		14.9	
	Eng Operations	SSS	4.6	10	13.2	3	13.2	
	Utilities	SSS	5.8	10	14.1		14.1	
	Structures	SSS	11.6	10	18.1		18.1	
	HVAC	SSS	7.8	10	15.5		15.5	
	Fuels	SSS	7.2	10	15.0		15.0	
	Electrical	SSS	7.3	10	15.1		15.1	
	Entomology	SSS	5.8	10	14.1		14.1	
	Power Pro	MSS	9.7	20	26.8		16.8	10
	Equipment	MSS	6.9	20	14.8		14.8	10
	Power Pro	SSS	5.8	10	14.1		14.1	
	Water Plant	SSS	5.0	10	13.5		13.5	
	Latrine	SSS	6.0		4.2		4.2	
	Eng Support	MSS	6.9	20	24.8		14.8	10
	RALS		7.0		5.0		5.0	

Facility Group	Function	Shelter Type	Power Requirement (Kilovolt-Ampere [kVA])				kVA per Circuit	
			Max Load	AC Load	Div.	M-C Load	#1	#2
F	Pneudraulics	SSS	28.1	10	29.7	20	19.7	10
Mainte-	NDI	SSS	7.7	10	15.4		15.4	
nance	Propulsion	4K/8K	36.0		25.2	21	15.2	10
	Propulsion	MSS	15.0	20	30.5	10	20.5	10
	Electrical	SSS	15.6	10	20.9	11	20.9	
	Bearing Clean	SSS	5.8	10	14.1		14.1	
	AGE	MSS	8.2	20	25.7	6	15.7	10
	Command/Adm.	SSS	6.2	10	14.3	4	14.3	
	Parachute	SSS	6.6	10	14.6	5	14.6	
	Hangar	LAMS	36.0		25.2	25	15.2	10
	Wheel/Tire	SSS	6.0	10	14.2		14.2	
	Latrine	SSS	6.0		4.2		4.2	
	Gen Maint Sup.	MSS	10.0	20	27.0		17.0	10
	Gen Maint Sup.	SSS	8.0	10	15.6		15.6	
	RALS		7.2		5.0		5.0	
G Squad	Squadron Ops.	SSS	5.9	10	14.1	4	14.1	
Ops	Life Support	SSS	5.7	10	14.0	4	14.0	
	Latrine	SSS	6.0		4.2		4.2	
	Squad Ops. Sup.	MSS	6.5	20	24.6		14.6	10
	RALS		7.2		5.0		5.0	
H	Reproduction	SSS	5.6	10	13.9		13.9	
Support	Post Office	SSS	3.9	10	12.7		12.7	
Group	BITS	SSS	5.2	10	13.6		13.6	
	Legal/Contract.	SSS	4.9	10	13.4		13.4	
	Personnel	SSS	4.6	10	13.2		13.2	
	Administration	SSS	5.0	10	13.5		13.5	
	Latrine	SSS	6.0		4.2		4.2	
	Exchange	SSS	6.0	10	14.2		14.2	
	Exchange	SSS	8.0	10	15.6		15.6	
	Gen Support	MSS	7.0	20	24.9		14.9	10
	Communications	SSS	9.0	10	16.3	6	16.3	
	MWRS	SSS	4.6	10	13.2		13.2	
	Armory	SSS	4.5	10	13.2		13.2	
	Command/SRC	SSS	4.5	10	13.2	4	13.2	
	RALS		7.2		5.0		5.0	
I	Fire Tech Svs.	SSS	5.0	10	13.5	4	13.5	
Emergen	Fire Operations	SSS	4.5	10	13.2	3	13.2	
cy	Security Police	SSS	4.5	10	13.2	3	13.2	
Services	Disaster Prep.	SSS	4.5	10	13.2		13.2	
	EOD	SSS	6.2	10	14.3	4	14.3	
	Base Operations	SSS	4.5	10	13.2		13.2	
	RALS		7.2		5.0		5.0	
J	Mortuary	SSS	6.3	10	14.4	4	14.4	
Aerial	Aerial Port	SSS	4.5	10	13.2	3	13.2	
Port	Port Support	MSS	6.5	20	24.6		14.6	10
	RALS		7.2		5.0		5.0	
L Laundry	Laundry	SSS	10	10	17.0		17.0	

Facility Group	Function	Shelter Type	Power Requirement (Kilovolt-Ampere [kVA])				kVA per Circuit	
			Max Load	AC Load	Div.	M-C Load	#1	#2
M	Command/Adm.	SSS	6.5	10	14.6	5	14.6	
Muni-	Tool Crib	SSS	5.0	10	13.5	4	13.5	
tions	Munitions Maint.	MSS	8.2	20	25.7	6	15.7	10
	RALS		7.2		5.0		5.0	
P	Administration	SS	5.4	10	13,8		13.8	
POL	Laboratory	SSS	4.5	10	13.2		13.2	
	RALS		7.2		5.0		5.0	
R	Alert Facility	SSS	5.4	10	13.8	4	13.8	
Alert	RALS		7.2		5.0		5.0	
S	Command/Adm.	SSS	5.1	10	13.6		13.6	
Supply	Demand Proc.	SSS	5.1	10	13.6		13.6	
	Latrine	SSS	6.0		4.2		4.2	
	Storage	4K/8K	10.0		7.0		7.0	
	RALS		7.2		5.0		5.0	
T	Vehicle Ops.	SSS	4.5	10	13.2		13.2	
Transpor	TMO	SSS	4.5	10	13.2		13.2	
tation	Latrine	SSS	6.0		4.2		4.2	
	Vehicle Maint.	4K/8K	18.5		13.0		13.0	
	Packing/Crating	4K/8K	12.0		8.4		8.4	
W	Administration	SSS	5.7	10	14.0		14.0	
Wing	Briefing	SSS	7.0	10	14.9	5	14.9	
Ops	Plans	SSS	4.5	10	13.2		13.2	
	Operations	SSS	4.6	10	13.2		13.2	
	Targets	SSS	4.5	10	13.2	3	13.2	
	Intelligence	SSS	5.6	10	13.9	4	13.9	
	Intelligence	SSS	5.6	10	13.9	4	13.9	
	Maint Command	SSS	4.5	10	13.2		13.2	
	Job Control	SSS	4.8	10	13.4	4	13.4	
	Material Control	SSS	6.3	10	14.4	4	14.4	
	Quality Control	SSS	6.3	10	14.4	4	14.4	
	Maint Analysis	SSS	4.5	10	13.2		13.2	
	Maint Records	SSS	4.5	10	13.2		13.2	
	Maint Plans	SSS	6.3	10	14.4		14.4	
	Latrine	SSS	6.0		4.2		4.2	
	Finance	SSS	4.5	10	13.2		13.2	
	Command Post	SSS	7.0	10	14.9	4	14.9	
	Command/Adm.	SSS	5.7	10	14.0		14.0	
	RALS		7.2		5.0		5.0	
X Medical Facility	See Specific Type of Facility Requirements		*	*		*	*	
Y Commu-nications	See Specific Type of Facility Requirements		*	*		*	*	
Z Airfield Facilities	See Specific Type of Facility Requirements		*	*		*	*	
EW Water Plants	Per Specific Requirements		*	*		*	*	

Facility Group	Function	Shelter Type	Power Requirement (Kilovolt-Ampere [kVA])				kVA per Circuit	
			Max Load	AC Load	Div.	M-C Load	#1	#2
Notes: [1] Loads vary for deployed freezer units. [2] Loads vary and may increase as new equipment comes into the inventory. To prevent generator overload, two generators may be required even when level of service is reduced and some equipment is isolated.								

3.3.3. Keep in mind that electrical loads shown for the various facilities are estimated in many cases. Often, users bring additional or differing equipment that could alter these figures. If time permits, determine what equipment is actually being supported, particularly in areas related to flight-line maintenance operations. Do not be surprised to see containerized facilities arrive. Some organizations, such as the medical unit, have these types of facilities for specialized functions. During your planning efforts it would be wise to save a couple of circuits from the SDCs for these specialized facilities, at least in the medical and aircraft maintenance facility groups.

3.3.4. Pre-deployment discussions with aircraft maintenance, munitions, and medical personnel prior to deployment may reveal unit-unique power requirements greater than those normally supported by contingency electrical distribution systems. The facility diversity factor for each plant should be evaluated during operations by checking the average daily peak demand versus the total facility demand. A major difference from planned versus actual loads may justify rerouting electrical service to achieve greater efficiencies.

3.3.5. After the diversified loads are identified and excessive loads split between circuits, the next step is to identify how many of each facility type will be included in each of the facility groups. This will enable you to develop a secondary distribution schedule for each group.

3.3.6. Based on the number of facilities and their function, a secondary distribution schedule can be developed (**Table 3.4**) as a preliminary worksheet for determining the specific number of functions and facilities to be served within a group. The secondary distribution schedule can be used to brief commanders and control centers in order to determine if specific changes will be required before actually hard wiring the base. Using the suggested format in **Table 3.4** and the information from the previous tables, the third column beneath the headings shows the number of facilities of the same type that will be included within a specific group. The fourth and fifth columns beneath the headings shows the specific diversified loads per circuit required to service each facility. The sixth column under the headings shows the estimated basic mission-critical power required. The final line at the bottom of this worksheet provides a preliminary total power demand, which is determined by multiplying the number of facilities for each function by the kVA load for each function, and then adding all the products together. By dividing the results by the size of the SDC to be used, such as a 150 kVA SDC, you can determine the preliminary number of SDCs that may be required to support the group.

Table 3.4. Example Wing Ops Group Secondary Distribution Schedule.

Wing Operations Function	Facility Type	#	kVA Circuit #1	kVA Circuit #2	M-C kW
Administration	SSS	2	14.0		
Briefing	SSS	6	14.9		4
Plans	SSS	1	13.2		
Operations	SSS	3	13.2		
Targets	SSS	2	13.2		2.4
Intelligence	SSS	2	13.9		3.2
Maint Supervision	SSS	2	13.2		
Job Control	SSS	1	13.4		3.2
Materiel Control	SSS	1	14.4		3.2
Quality Control	SSS	1	14.4		3.2
Maint Analysis	SSS	1	13.2		
Maint Records	SSS	1	13.2		
Maint Plans	SSS	1	14.4		
Finance	SSS	1	13.2		
Latrine	SSS	1	4.2		
Command Post	SSS	1	14.0		3.2
Admin/Command	SSS	1	14.0		
Total Loads			379.2		25.6

3.3.7. The FDECU is a heat-pump-type air conditioner and heater that is widely used with most shelters and tents. When a beddown requires the use of FDECUs, load planning factors for generators and the distribution system are greatly increased. The result is that a significant number of fewer facilities can be supported by each SDC when providing power to each facility's FDECU.

3.3.8. After development of each group's secondary distribution schedule, group functional facilities by SDC as much as possible and arrange facilities to minimize the number of required emergency/back-up generators. Doing this will help ensure that emergency generators are properly loaded and decreases the manpower required for maintenance and operations. If possible, complete this before site planners finalize facility locations in each group.

3.3.9. **Table 3.5** is an example of an SDC Feeder Schedule. It is based on the secondary distribution schedule for a Wing Operations Group at a 3,300-person base. The schedule expands on information from **Table 3.4** and identifies circuit designations for each SDC.

Table 3.5. Example Wing Operations Group SDC Feeder Schedule.

Group	Circuit	Designator	Function	KVA	M-C kW
SDC-W1: Wing Operations	1	W1	Briefing Facility	14.9	4
	2	W2	Briefing Facility	14.9	4
	3	W3	Briefing Facility	14.9	4
	4	W4	Briefing Facility	14.9	4
	5	W5	Briefing Facility	14.9	4
	6	W6	Briefing Facility	14.9	4
	7	W7	Targets	13.2	2.4
	8	W8	Targets	13.2	2.4
	9	W9	Intel	13.9	3.2
	10	W10	Intel	13.9	3.2
TOTAL kVA (Use 60-kW generator) TOTAL M-C kW				**143.6**	**35.2**
SDC-W2: Wing Operations	1	W11	Job Control	13.4	3.2
	2	W12	Material Control	14.4	3.2
	3	W13	Quality Control	14.4	3.2
	4	W14	Command Post	14.0	3.2
	5	W15	Maint Supervision	13.2	
	6	W16	Maint Supervision	13.2	
	7	W17	Maint Analysis	13.2	
	8	W18	Maint Records	13.2	
	9	W19	Maint Plans	14.4	
TOTAL kVA (Use 30-kW gen. or group w/another SDC) TOTAL M-C kW				**123.4**	**12.8**
SDC-W3: Wing Operations	1	W20	Administration	14.0	
	2	W21	Operations	13.2	
	3	W22	Plans	13.2	
	4	W23	Plans	13.2	
	5	W24	Plans	13.2	
	6	W25	Admin/Command	14.0	
	7	W26	Finance	13.2	
	8	W27	Administration	14.0	
	9	W28	Latrine	4.2	

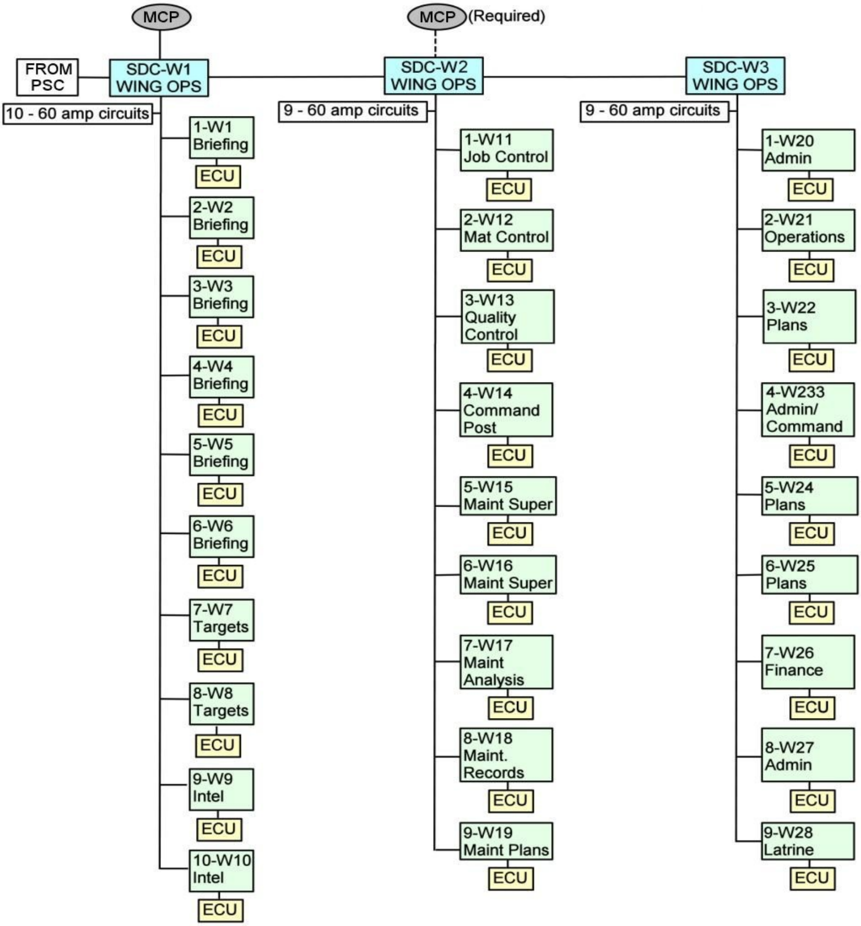
TOTAL kVA **Total M-C kW**	**112.2**	 **0**
TOTAL WING OPERATIONS GROUP kVA **Total M-C kW**	**379.2**	 **48**

3.3.9.1. This specific example shows that all circuits were kept within the capacity of a 150 kVA SDC and similar facilities/functions with mission-critical power requirements grouped together on two SDCs.

3.3.9.2. The 35.2 kW mission-critical load for SDC-W1 could be supported with a 60-kW emergency/back-up generator. The 12.8 kW on SDC-W2 could be supported with a 30-kW emergency/back-up generator, or the facilities and SDC could be sited near another group so that both groups could be fed from the same SDC and 60 kW emergency/back-up generator.

3.3.10. The feeder schedule for each group should be used to develop a circuit schematic to list the required connections. While the surveyors are determining the rough layout of major facility groups, the circuit schematics can be annotated to show concerns for a specific layout. Identify basic distances and locations for placement of SDCs next to major facilities and circuits requiring emergency/back-up generators for initial operation of the base. Critical base facilities may operate from emergency/back-up generators, linked by SDCs, for up to two weeks while assets arrive and the main electrical distribution system is installed. The schematics can be used to show and explain how facilities are located in proximity to SDCs and emergency/back-up generators. They can also be used to flag the need for an emergency/back-up generator at critical facilities where a load on the generator would be so low that it should be shared with critical facilities in another group; thus affecting the siting within two groups. **Figure 3.14** depicts an example of an SDC circuit.

Figure 3.14. Example SDC Circuit for Wing Operations Group.



3.3.11. Phase Balancing. To operate a power plant or generator efficiently, the load on all three phases of the system have to be nearly equal. The difference between phases should not exceed 10 percent; otherwise, generators will be out of balance and not provide full output. Also, voltage regulation will be poor, which can damage both generating equipment and equipment being powered. Even after all load factors are known and system schematics developed, the system might require further balancing (smaller generators are especially vulnerable to this condition when connected to critical or isolated facilities). When laying out loads other than three-phase, take into account the total loading on each phase. Equally distribute the facility loads on an SDC by alternating which phase each facility is connected to on the PDP (e.g., facility W1 connected to 25-kW PDP connector J5 [phase C], W2 connected to J6 [phase B], W3 connected to J7 [phase A], etc.).

3.3.12. Radial versus Loop. Radial systems are normally used during initial stages of a deployment or for smaller austere bases in a low threat environment. Otherwise, plan to use a loop system, as they provide more reliable power, better system grounding, and greater flexibility for handling everyday type power demands and maintenance outages. The #1/0 aluminum, 5,000-volt primary cable, and associated load break elbow connectors, are used to interconnect the power plants and provide both adequate insulation and mechanical integrity when buried to the proper depth.

3.3.13. Power Plant Dispersal. Plan to construct multiple power plants in a high-threat environment (where facility dispersal is required) and for larger deployments. Power plant dispersal does not require greater separation of equipment and controls within the plant. Protection of resources is provided through the use of revetments, barriers, concertina wire, camouflage concealment deception, and berms. Plants should have the capability to be electrically interconnected to ensure some degree of electrical generation capability is retained after an attack. For threat dispersal purposes, plants should be separated between 1,500 and 3,000 feet from each other as part of a loop electrical distribution network. The primary method of looping is by interconnecting some PSCs between plants.

WARNING

Ensure interconnecting cables are marked properly and maps are updated to show interconnecting cables to ensure future rotations are aware of these cables.

3.3.13.1. To establish a looped system, a physical connection is made from the Way Switches of one PSC to the Way Switches of another.

3.3.13.1.1. Larger beddowns may have two or three plants with more than one PSC. There are greater opportunities to loop between each plant and interconnect several PSCs to form a complete “parked” ring between plants.

3.3.13.2. When rerouting PSC feeder circuits to power additional SDCs, care should be taken to not overload the circuit.

3.3.13.3. Always ensure correct phase to phase relationship and the concentric grounds are properly connected on rerouted circuits.

Chapter 4

SAFETY

4.1. Safety Summary. As noted in **paragraph 1.1**, electricians and maintenance personnel shall wear appropriate ATPV rated uniforms, as well as other appropriate personal protective equipment IAW AFI 32-1064 and UFC 3-560-01 prior to working on or near energized electrical equipment or circuits. BCE or equivalent approval is required prior to working on any energized circuits. The following paragraphs are recommended safety precautions to apply during many phases of operation and maintenance of contingency electrical generation and distribution systems.

WARNING

High voltage may cause severe shock or death upon contact. Use caution and avoid contact with energized components. Use a hot stick when handling loadbreak elbows.

WARNING

Ensure loadbreak elbows are installed on parking stands at the generator when performing maintenance to prevent possibility of utility power being fed back into equipment. Failure to comply may result in death by electrocution.

WARNING

Ensure all high voltage switching and isolation operations with grip-all switch sticks are performed by trained and qualified 3E0X1 Electrical System Specialist.

4.1.1. Ensure only qualified individuals install, operate, and maintain the equipment described in this TTP IAW applicable TOs. A qualified person is one who is trained and competent in:

4.1.1.1. The skills and techniques necessary to distinguish energized parts from non-energized parts of electronic and electrical equipment.

4.1.1.2. The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed.

4.1.1.3. The proper use of the special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electronic or electrical equipment.

4.1.2. Keep away from live circuits. Operators must at all times observe all safety instructions IAW UFC 3-560-01. Do not replace components or make adjustments inside the generator set with the high-voltage supply energized. Under certain conditions, dangerous potentials may exist when the generator is not operating and disconnected from the circuit due to charges retained by capacitors. To avoid casualties, always remove power, test, and ground to assure it's discharged before touching.

4.1.3. High-Voltage Cable Connections and Disconnects. Always operate and connect generators, PSCs, and SDCs IAW the applicable TOs. Only properly trained and qualified 3E0X1 Electrical Systems personnel should connect and disconnect this equipment.

4.1.3.1. Disconnects should be made in an de-energized state, which is normally achieved by shutting down the power source and opening the load-interrupter switches on a PSC, or turning off circuit breakers on an SDC. De-energized cables and transformers should be grounded to prevent a shocking hazard from residual voltages.

4.1.3.2. During placement of the units (i.e., PSCs, SDCs, and PDPs) and cable laying prior to bringing generators on line, always use proper PPE and safety practices. Use of a grip-all shot gun for placing the load break elbows on bushings is always a good safety practice to ensure proper seating of the load break elbows.

4.1.3.3. PPE and electrical equipment must be used when connecting and disconnecting energized load break elbows, opening PSC load-interrupter switches, and fusible switches IAW UFC 3-560-01.

4.1.4. Resuscitation. Personnel working with or near high voltages will be trained and certified on cardiopulmonary resuscitation IAW AFI 91-203.

4.2. Personnel Responsibilities. Multi-skilling of power production and electrical personnel is critical for installation and operation of contingency power generation and distribution systems. Neither power nor electrical specialties have sufficient numbers of personnel on standard mobility teams to accomplish all beddown and recovery tasks following traditional skill breakouts. Contingency training programs direct several training activities meant to enable engineer personnel to perform beyond traditional peacetime-related skill requirements.

4.3. Grounding. Proper grounding of the electrical system is crucial for the safety of electrical power production and electrical system personnel. Procedures for grounding the deployable systems differ little from those used in standard electrical system installations. The grounding system for the contingency electrical generation and deployable system equipment consists of equipment grounds with ground rods at major components and the (grounded) concentric neutral wires throughout the high-voltage distribution portion of the system.

WARNING

Do not energize equipment unless properly grounded IAW applicable TO. Electrical faults in generator set, load lines, or load equipment can cause injury or electrocution from contact with an ungrounded system.

4.3.1. All equipment shall have a grounding resistance that does not exceed 25 ohms. Test grounds IAW AFI 32-1065, *Grounding Systems*.

4.3.2. Soil characteristics play a large part in the suitability of the grounding network. The type of soil, its chemical content, and the moisture level surrounding the ground rod will determine the resistance. Clay and loam soils with no rocks or stones will have a much lower resistance than clay or loam soils with many rocks or stones. Moisture content also affects resistance readings dramatically. As moisture content increases, soil resistivity decreases. This is especially true at the lower moisture content levels. Therefore, much of the dry, rocky, or sandy soils in southwest Asia cannot provide the required soil resistivity of 25 ohms or less using just the driven ground rods provided with each unit.

4.3.3. For proper grounding, you need to have a ground rod that will be in contact with moist soil. Use as many ground rods as required to obtain adequate resistance readings. If deployed to a location where a ground rod cannot be driven deep enough to reach low resistance soil, or if ground rods are in short supply, then alternate-grounding methods may be used. A horizontal ground rod installation, buried metal well pipes, metal plate electrodes, or a laced wire grounding installation can be used to obtain the adequate resistance reading. Dig a trench as deep as feasible to reach wet soil or soil that can be moistened with water or brine. Lace a copper wire up and down the bottom of the trench. To keep resistance readings low under extremely adverse soil conditions, you may have to continuously keep the grounding area damp using water or salt water/Reverse Osmosis Water Purification Unit brine solutions. Thoroughly compact the soil when backfilling the trench to maximize soil contact with the wire or rods.

4.3.4. For longer deployments, installation of a grounding grid under each equipment item (i.e., generator, PSC, SDC, etc.) should be considered both for additional safety and reliability. Each equipment item should have its own equipment ground.

4.3.5. If deployed to a location in a climatic zone where the ground freezes, be sure to lay the horizontal grounding system below the frost line, as resistivity readings can increase substantially for frozen ground. Also, frost heaves that occur in soil with different moisture contents may cause equipment to tilt or move if the buried horizontal rod or wire system is located too close to the equipment. Keep the disturbed, moistened soil of the buried grounding system at least 10 feet from the supported equipment. The grounding system should normally be within 15 feet of the supported equipment; this is not a hard and fast rule and is dictated more so by the available area, materials, and the ability to obtain and maintain adequate resistance readings. For driven ground rods, recheck the resistance readings regularly throughout the deployment. **Note:** If 25 ohms is not able to be reached for grounding systems, contact the Electronics Engineer SME (Grounding SME) through the AFCEC Reachback Center at 888-232-3721 (toll free), Defense Switched Network (DSN) 523-6995, or via email at afcec.rbc@us.af.mil.

WARNING

Prior to conducting trenching operations on previous battlefields or in areas suspected of unexploded ordnance consult Explosive Ordnance Disposal.

4.4. Trenching. During the initial layout and early operation, the electrical distribution network is an above ground system. When time permits, bury the primary distribution electrical lines in trenches about 18-inches deep. Trenching may be accomplished using a tractor with backhoe and blade (**Figure 4.1**).

Figure 4.1. Tractor with Backhoe, Blade, and Trenching Wheel.

CAUTION

To prevent damage to cables, do not lay them directly on sharp rocks or in very rocky soil.

4.4.1. When burying primary cables where rocks are present, place a layer of sand or other soil (free of rocks) on the bottom and top of cables to ensure they are protected. Trenches should be wide enough to provide a 6-inch separation between cables.

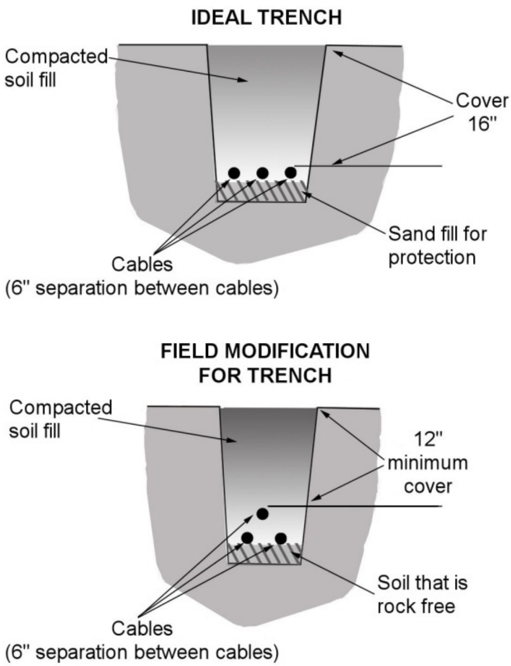
4.4.2. At locations where cables cross roadways and in high-traffic areas, the lines should be buried even in the initial phases of the operation. Consideration should be given to running the lines in conduit under roadways and burying the cables deeper to allow improving roads over these cables with gravel or hard surface. Secondary distribution lines for service from SDCs should also be buried (when time permits) in shallower trenches. Under most climactic conditions, secondary distribution lines require only eight inches of cover, except for the following conditions:

4.4.2.1. In areas subject to ground freezing, bury cables below the frost line.

4.4.2.2. In locations which may experience numerous freeze-thaw cycles throughout the winter (where there is intermittent flooding and ground movement), buried cannon plug cable connections may require some waterproofing protection (i.e., wrap in plastic sheeting and tape) or be surrounded with free draining sandy gravel. If winterizing procedures are required for the deployment, marking or otherwise identifying buried cannon plug connections at critical facilities will allow them to be checked if freeze-thaw cycles cause problems with electrical connections.

4.4.3. It is especially critical to maintain the six inch separation (**Figure 4.2**) for primary power cables and to keep the cable from bundling together in the trench for facilities that require more reliable power and for interconnecting power plants. If a rotary-trencher is used, maintaining adequate separation will be difficult due to the narrow width of the trench. Field conditions may dictate various installation choices, which can be used to maintain a six inch separation and also meet required cover and protection, such as multiple trenches with a wheel cutter trencher, wider trenches, and/or deeper trenches and cable laid with horizontal and a vertical separation between cables.

Figure 4.2. Trench and Cable Detail.



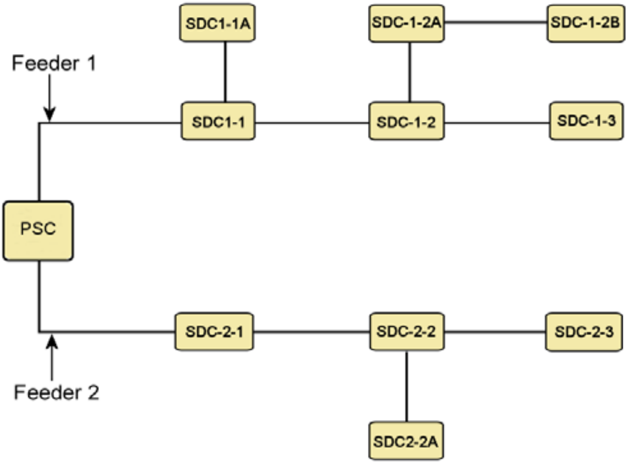
4.4.4. In the immediate power plant area, make sure the trenches are clearly marked to ensure that future additional trenching operations will not hit buried power cables. Plan ahead, especially when multiple power plants are used, to provide access for routing of cables between plants. In some cases it may be feasible to bury several sets of power lines in wider and deeper trenches (**Figure 4.3**) to accommodate base growth and/or expansion of the power plant.

Figure 4.3. Multiple Cable Runs in Common Trench.

4.4.5. Keep accurate, up-to-date records on the location of power lines and when possible, mark the cable routes. **Note:** Contact the Engineering Assistant office to ensure the continuity of records and the update of Geobase. Cable routes between plants can be relatively long, traversing much of the camp area. During long-term deployments, trenches can become overgrown or covered by blowing sand. If they do not have accurate records, follow-on units can easily disrupt electrical and other utilities when trenching to expand or repair/replace systems.

4.4.6. When burying cable, be sure to label SDCs with feeder and SDC numbers. These numbers should accurately match the as-built drawings for troubleshooting and safety purposes. When time permits, label the cable to show where it feeds and from where it is fed (**Figure 4.4**).

Figure 4.4. Feeder Circuits Labeled.



JOHN B. COOPER, Lieutenant General, USAF
DCS/Logistics, Engineering and Force Protection

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFI 32-1064, *Electrical Safe Practices*, 7 January 2015

AFI 32-1065, *Grounding Systems*, 12 January 2015

AFMAN 33-363, *Management of Records*, 1 March 2008

AFMAN 91-201, *Explosive Safety Standards*, 12 January 2011

AFPAM 10-219 Volume 5, *Bare Base Conceptual Planning*, 30 March 2012

AFPAM 91-216, *USAF Safety Deployment and Contingency Pamphlet*, 9 August 2001

AF Handbook 10-222 Volume 1, *Guide To Bare Base Development*, 23 January 2012

AF Handbook 10-222 Volume 2, *Guide To Bare Base Assets*, 6 February 2012

AF Handbook 31-109, *Integrated Defense in Expeditionary Environments*, 1 May 2013

AFI 91-203, *Air Force Consolidated Occupational Safety Instruction*, 15 June 2012

UFC 3-560-01, *Electrical Safety, O&M*, 14 April 2015

T.O. 31-1-141-5, *Basic Electronics Technology and Testing Practices Mathematics for Electrical and Electronics Technicians*, 7 April 2015

T.O. 35F14-1-1, *Commercial Technical Manual, Primary Switch (PS)*, 15 June 2007

T.O. 35CA2-2-10-1, *Operation and Maintenance Manual, Secondary Distribution Center (JEU-191/E)*, 15 Aug 1984

T.O. 35CA2-2-17-1, *Commercial Technical Manual, Secondary Distribution Center (SDC)*, 13 Dec 2006

T.O. 35CA3-18-1, *Commercial Technical Manual, Cable Reel Pallet Assembly (CRPA)*, 02 January 2003

T.O. 35CA6-1-101, *Operation, Maintenance and Overhaul Instructions with IPB – Power Distribution Panel*, 9 December 2013

T.O. 35CA6-1-211, *Commercial Technical Manual, Power Distribution Panel (PDP) 25 KW,* 12 November 2003

T.O. 35CA6-1-231, *Commercial Technical Manual, Power Distribution Panel (PDP) 60 KW,* 14 November 2003

T.O. 35C2-3-474-1, *MEP-012A Generator Set, Operator and Organizational Maintenance Manual*, 24 Jun 1999

T.O. 35C2-3-474-11, *Basic Expeditionary Airfield Resource (BEAR) Power Unit (BPU), Operation, Maintenance, and Overhaul Manua*l, 30 June 2014

T.O. 35C2–3-444–11-32, *Operator's Manual, Tactical Quiet Generator (TQG) 60 KW,* 31 December 2012

T.O. 35C2-3-446-32, *Operator and Maintenance Manual, Tactical Quiet Generator, 30 KW,* 11 April 2016

T.O. 35C2-3-534-1, *Operator's Manual for Generator Set, Skid Mounted 30KW Advanced Medium Mobile Power Sources (AMMPS),* 15 March 2011

TO 35C2-3-535-1, *Operator's Manual for Generator Set, Skid Mounted 60KW Advanced Medium Mobile Power Sources (AMMPS),* 15 February 2011

T.O. 37A12-15-1, *DPGDS External Fuel Supply (EFS)*, 28 June 2010

Prescribed Forms

No prescribed forms are implemented in this publication.

Adopted Forms

AF Form 847, *Recommendation for Change of Publication*, 22 September 2009

Abbreviations and Acronyms

AC—Air Conditioning

AEF—Air and Space Expeditionary Force

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFRC—Air Force Reserve Command

AOR—Area of Responsibility

ATPV—Arc Thermal Performance Value

BEAR—Basic Expeditionary Airfield Resources

BPU—BEAR Power Unit

CRPA—Cable Reel Pallet Assembly

DCS—Digital Control System

FDECU—Field Deployable Environmental Control Unit

Hz—Hertz

IAW—In Accordance With

KVA—Kilo-volt Ampere

LAMS—Large Area Maintenance Shelter

LOX—Liquid Oxygen

MSS—Medium Shelter System

OPR—Office of Primary Responsibility

PDP—Power Distribution Panel

PPDT— Power Planning and Distribution Tool

POL—Petroleum, Oil, and Lubricants

PPE—Personal Protective Equipment

PS—Primary Switch

PSC—Primary Switching Center

RALS—Remote Area lighting System

RDS—Records Disposition Schedule

ROP—Remote Operator Panel

SDC—Secondary Distribution Center

SSS—Small Shelter System

TQG—Tactical Quiet Generator

TO—Technical Order

TTP—Tactics, Techniques, and Procedures

UTC—Unit Type Code

Attachment 2

CONTINGENCY ELECTRICAL POWER SYSTEM INSTALLATION CHECKLIST

Note: After the electrical system and power plants have been installed, and before energizing the system, use the checklist to ensure the system is ready.

__	1. Has a holding area for temporary storage of incoming electrical system components been established?
__	2. Have mission essential facilities been identified and coordinated with the appropriate command?
__	3. Have the locations of mission essential facilities been identified?
__	4. Has a requirement for sustained operations at the contingency location been confirmed?
__	5. Has an initial estimate of the electrical loads of mission essential facilities been made to aid in sizing generators to the requirements?
__	6. Has vehicle/equipment support for moving electrical equipment to site locations been arranged?
__	7. Do all electrical installation crews have an individual capable of operating materials handling equipment?
__	8. Have SDCs been placed at locations where emergency/back-up generators can serve multiple mission essential facilities?
__	9. Have emergency/back-up generators been connected to mission essential facilities?
__	10. Have light carts been operationally checked and allocated to critical flight-line functional areas?
__	11. Have personnel been identified to perform routine maintenance and refueling operations on emergency/back-up generators?
__	12. Have electrical feeder schedules been developed based on the layout of the various base facility groups?
__	13. Have SDC circuits been sized to handle future AC loads (if applicable)?
__	14. Has a plan showing the layout of the electrical distribution system been developed?
__	15. Have locations for power plants been determined?
__	16. Have prime generators been positioned at power plant locations?
__	17. Have fuel bladders been installed at power plant locations?

__	18. Have fuel bladders been properly bermed?
__	19. Have control panels been correctly connected to prime generators?
__	20. Have PSCs been placed and connected at power plants?
__	21. Have adequate grounding systems been installed at power plants?
__	22. Have SDCs been allocated to and placed in the various facility groups in such a way that portions of the groups can be brought on line as facilities are erected?
__	23. Have SDCs been placed in areas accessible to vehicles, yet not adjacent to heavy traffic or personnel flow?
__	24. Have SDCs been grounded?
__	25. Have the cables connecting facilities, panel boxes, SDCs, PSCs initially been installed along the surface of the ground?
__	26. Have cables that cross roadways been adequately protected from damage by vehicle traffic?
__	27. Have facilities been brought onto the base electrical grid as soon as reasonably possible once electrical connections have been completed?
__	28. Have emergency/back-up generators serving mission essential facilities been placed in backup power mode once power plant electrical service was available?
__	29. Have personnel been specifically designated to provide around-the-clock power plant operation?
__	30. Have RALS units been installed at locations requiring large-scale area lighting?
__	31. If sustained operations are planned and electrical system is fully functional in an above ground mode, have efforts been started to bury electrical cables?
__	32. Have accurate records/drawings been made of buried electrical cables?
__	33. Have power plant operators been informed of what plant operation records to maintain?
__	34. Have arrangements been made for power plant refueling?