FM 5-422

ENGINEER PRIME POWER OPERATIONS

HEADQUARTERS, DEPARTMENT OF THE ARMY

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PREFACE

This field manual (FM) provides a doctrinal basis for planning and employing engineer prime power assets in the theater of operations (TO). It describes the responsibilities, relationships, capabilities, constraints, planning considerations, and logistics requirements associated with engineer prime power operations.

The fundamental purpose of this manual is to integrate engineer prime power operations into the overall sustainment engineering structure. The doctrine presented is applicable to operations across the entire continuum of military operations. The manual was designed for all commanders and planning staffs who require engineer prime power support or those who must provide engineer prime power support.

The proponent for this publication is the United States Army Engineer School (USAES). The Prime Power School, operated by the US Army Corps of Engineers (USACE), is responsible for technical content. Submit changes for improvement on Department of the Army (DA) Form 2028 (Recommended Changes to Publications and Blank Forms) to Commandant, US Army Engineer School, ATTN: ATSE-TDM-P, Fort Leonard Wood, Missouri 65473-6650.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

Chapter 1
OVERVIEW

ELECTRICAL POWER

Electrical power is an essential element of military operations. Without it, many crucial systems cease to operate. Command, control, communications, and intelligence (C^3I) functions are highly reliant on dependable electrical power. Administrative, health service support (HSS), and logistical support operations would be seriously jeopardized without it. Some weapons systems are dependent on electrical power for operation. The proliferation of automated data processing equipment that supports modern warfare further contributes to the Army's dependence on electricity. The result of this growing dependence on electricity is a continual increase in the quantity and quality of power required to support operations. The indispensable nature of electrical power compels commanders and planners to recognize their electrical power needs and to ensure that those needs are met.

THE ELECTRICAL POWER CONTINUUM

From the military perspective, electrical power encompasses the entire spectrum of power generation, distribution, and transmission systems that support military operations. It ranges from the power produced by the smallest tactical generators (TACGENS) through prime power to the power produced and distributed by the largest commercial power plants and their associated transmission and distribution networks.

TACGENS, which range from 0.5 kilowatt (kW) generators to 200 kW generators, are standard military portable generator sets. They provide a mobile source of power to units operating in the field. TACGENS are included in unit tables of organization and equipment (TOE) as required. Installation, operation, maintenance, and repair of TACGENS are unit responsibilities. TACGENS power may be supplemented with small commercial portable generators when they are available. Distribution systems for TACGENS power are usually very simple and often consist only of standard components such as general illumination kits or the electrical distribution and illumination system (Distribution Illumination Set, Electrical–DISE).

Prime power is reliable, commercial-grade utility power continuously generated by nontactical generators (NTGs). NTG power plants comprise the Army's family of portable generators larger than 200 kW. NTGs are portable, but

much less so than TACGENS. NTGs require site preparation for installation. They also require the use of transformers, distribution equipment, and switchgear for operation. Installation, operation, maintenance, and repair of prime power assets are the responsibility of engineer prime power units. Prime power may be supplemented with portable commercial generation equipment when it is available. Prime power may be employed as a stand-alone power source. It may also be installed in parallel with a commercial power source. When installed in parallel with commercial power, prime power can be used for either load sharing or standby. The use of prime power usually requires the construction of nonstandard distribution networks to take power to the users who need it.

Commercial power plants and their associated transmission and distribution networks are fixed nonstandard systems. Output capacity of commercial power plants may vary from a few megawatts (MW) to several thousand MW. These power systems are part of the infrastructure, as are other utility systems. Commercial power is provided in the theater by the host nation or nations.

PRIME POWER OPERATIONS

Prime power operations are conducted by engineer prime power units. They provide an essential continuity between power from TACGENS and commercial sources (see Figure l-l). Prime power units satisfy the critical electrical requirements above the capability of TACGENS and below the availability of commercial power. In addition, prime power can augment both sources. The portion of the continuum that is exclusively prime power represents power generation and distribution accomplished by prime power units with their organic equipment. The intersections of TACGENS and commercial power with prime power represent areas of shared responsibility.

One overlap between TACGENS power and prime power can occur when a prime power unit designs and installs a distribution network that is powered by either TACGENS or small, commercial portable generators. Responsibility for providing, operating, and maintaining the generators lies with the user. The overlap between prime power and commercial power may occur when a prime power unit repairs and maintains part of a distribution network on a commercial grid or when the unit taps into a commercial power source to provide power to a user. Chapter 4 provides detailed information on prime power missions and capabilities.

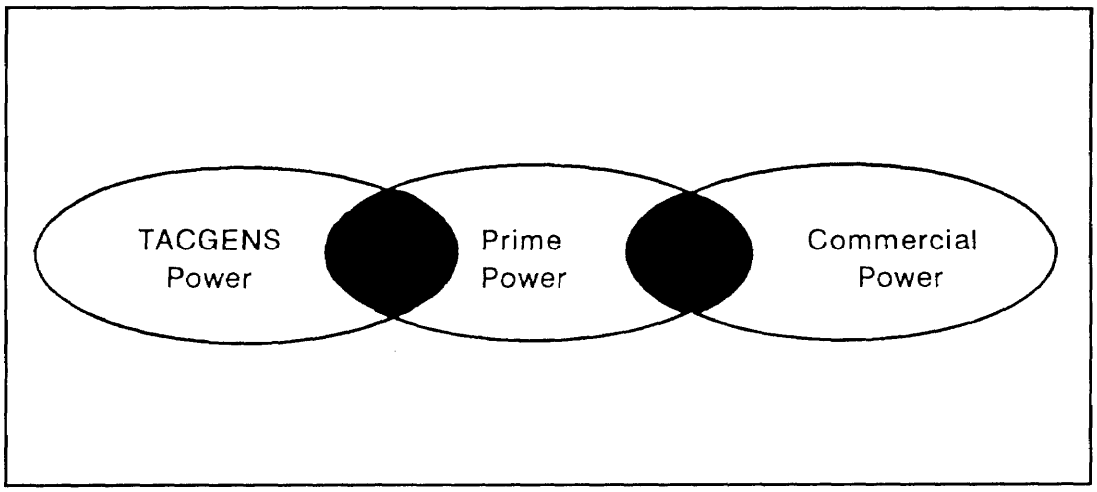

Figure 1-1. The power continuum

Engineer prime power units provide nontactical power generation and power-related technical expertise in support of operations across the continuum of military operations. During war, the primary objective of prime power operations is to support force sustainment in the communications zone (COMMZ), providing power generation and power-related technical support to rear-area units, facilities, and activities. Prime power support may extend forward into the corps area at the direction of the theater engineer. Prime power operations also support post-war operations including redeployment, emergency restoration of host-nation services, and humanitarian assistance.

During operations short of war, the primary objective of prime power operations is to provide prime power generation and power-related technical support to forward presence operations, contingency response, and disaster relief.

Chapter 2
ORGANIZATION

ENGINEER PRIME POWER UNITS

Active Component engineer prime power units are organized as an engineer battalion (prime power). This battalion is assigned to the USACE, which is a major Army command (MACOM). The battalion consists of a battalion headquarters (HQ), with a HQ and HQ detachment (HHD) and subordinate engineer companies (prime power). Each company consists of a company HQ detachment and two to five subordinate engineer teams (prime power). The battalion provides guidance, training support, and equipment to the reserve component teams during peacetime. Upon mobilization, reserve component engineer prime power teams are will normally be assigned to the prime power battalion.

Although configured as a battalion, the companies and their subordinate teams can be employed independently. Normally, a cell from the battalion HQ is deployed if more than one subordinate company is required to support a particular theater or contingency. When necessary, the battalion HQ will task organize a battalion HQ cell to accompany a deploying element. This cell usually includes logistics and liaison/coordination capabilities. The battalion HQ cell provides command and control of the companies as well as specialized maintenance support, administrative and logistical support, and liaison and coordination. A line company HQ is normally deployed to provide command, control, and specialized technical services if two to five teams are required. If only one team is required it normally deploys as a separate unit.

ENGINEER TEAM (PRIME POWER)

The engineer team (prime power) is an autonomous unit. It is the basic building block for the company and battalion (prime power). The team can be employed independently or as part of a prime power company, battalion, or task force. The 16-man team includes 14 noncommissioned officers (NCOs) with a military occupational specialty (MOS) of 52E. 52E is the Prime Power Production Specialist MOS. These NCOs have grades of sergeant (SGT) through sergeant first class (SFC). The team noncommissioned officer in charge (NCOIC) is a master sergeant (MSG) with MOS 51Z. The team commander is a warrant officer with a 210A5 specialty. The team is organized into two seven-man sections. Figure 2-1, page 2-2, further describes the team's organization and equipment.

The training and experience of prime power NCOs give them an in-depth working knowledge of electrical and electro-mechanical systems. Each 52E NCO possesses one or more of a variety of power-related specialty skills. The specialty skills found in each team include mechanical, electrical, instrumentation, and power distribution. The skills and knowledge of these NCOs enable them to perform electrical field engineering on a wide range of power-generation and distribution systems.

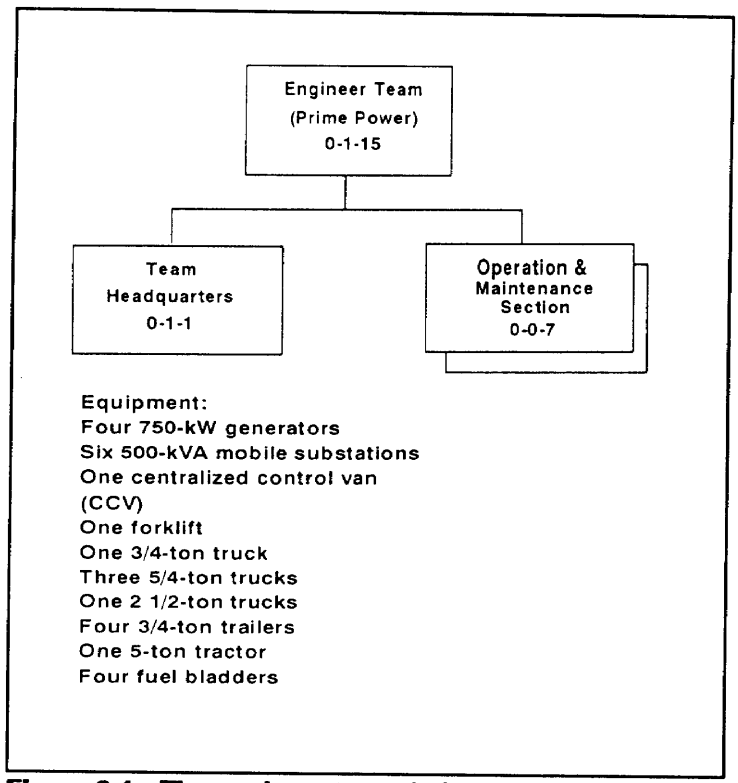

Figure 2-1. The engineer team (prime power)

A team has the equipment, manpower, and expertise to perform many highly technical power-related tasks, including the following:

1. Produce and distribute power.

2. Provide power-related technical expertise.

3. Advise commanders and staffs on technical power-related issues.

4. Maintain organic prime power equipment including limited direct support (DS).

5. Conduct load surveys to determine power requirements.

6. Design, construct, and maintain temporary nonstandard primary and secondary distribution systems. Make connections to commercial distribution networks.

7. Provide power-related techincal advice and assistance to contracting officers representatives (CORs).

8. Conduct damage assessment of power-generation and distribution systems. Perform minor repair of distribution systems and generation equipment.

9. Provide limited repair and maintenance of industrial electrical systems and controls.

10. Operate and maintain nonstandard power-generation equipment.

ENGINEER COMPANY (PRIME POWER)

The company consists of a company HQ detachment and two to five prime power teams. It is commanded by an engineer captain (CPT). The company HQ detachment includes a first sergeant, (lSG), an operations sergeant, a supply sergeant, a personnel services sergeant, a clerk typist, and an equipment records and parts specialist. The company's organization and equipment are further described in Figure 2-2. The engineer prime power company provides—

1. Command and control of assigned prime power teams.

2. Power-related staff assistance, technical advice, and coordination with higher HQ, supported units, supporting units, the host nation, and other engineer units.

3. Administrative and logistics support to subordinate prime power teams. This includes specialized Class IV, VII, and IX support.

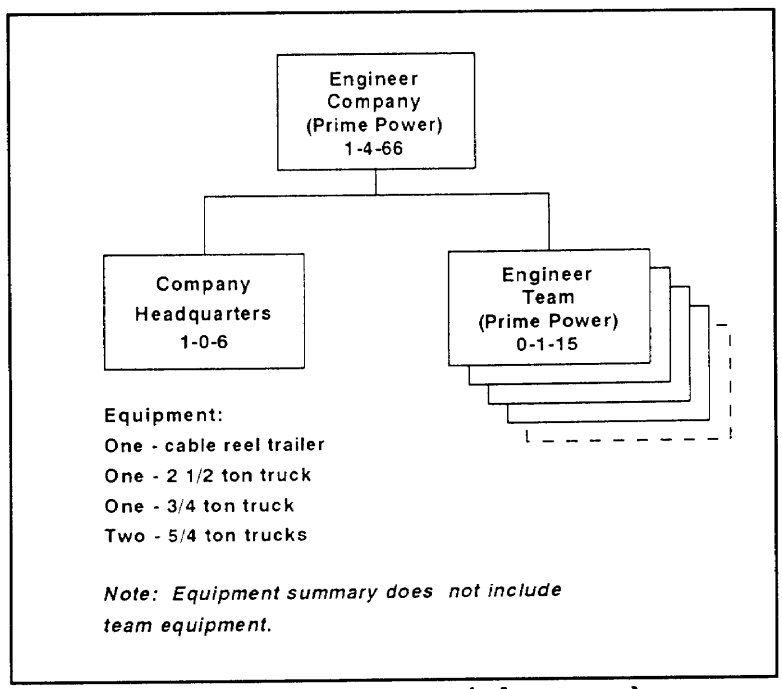

Figure 2-2. The engineer company (prime power)

ENGINEER BATTALION (PRIME POWER)

The battalion is commanded by an engineer lieutenant colonel (LTC). The battalion executive officer (XO) and operations/ security officer (S-3/S-2) are both engineer majors (MAJs). The battalion adjutant (S-1) and the logistics officer (S-4) are engineer CPTs. The adjutant also performs the duties of the HHD commander. The S-3 and S-4 officers are electrical engineers. Figure 2-3 further describes the battalion's organization and equipment.

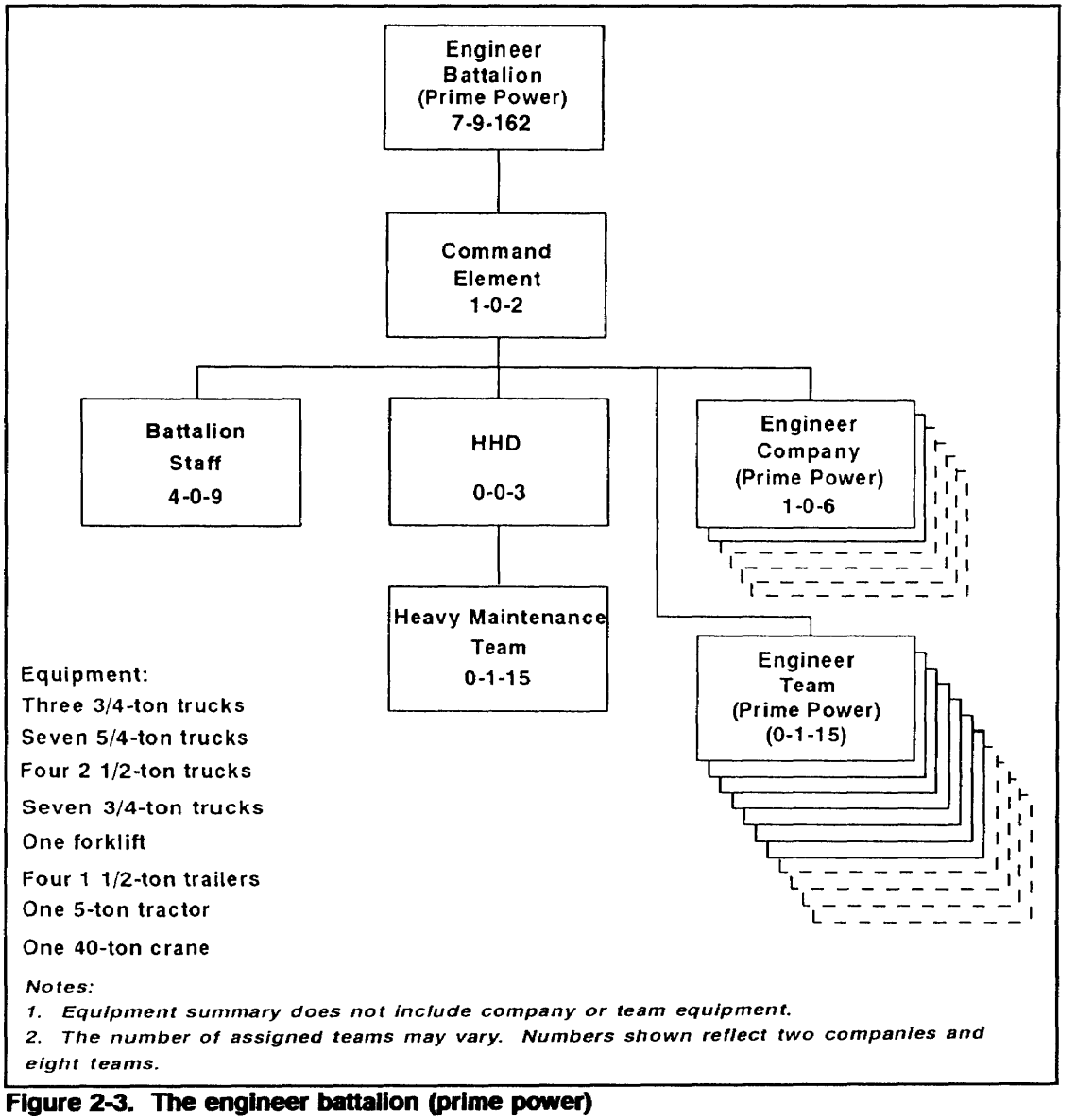

Figure 2-3. The engineer battalion (prime power)

Organic to the HHD is a heavy-maintenance prime power team capable of performing general support (GS) maintenance of prime power plants.

Elements of the battalion HQ may deploy to a theater of operations in the event that more than one subordinate company is deployed in support of the same theater. The battalion HQ will normally task organize a support cell to deploy with and support subordinate elements. When deployed to a theater during war or when supporting operations short of war, the key functions of the battalion HQ are to—

1. Provide power-related staff assistance. The battalion coordinates and manages prime power requirements. The battalion commander or his representative acts as a special staff officer to the theater engineer in a mature theater or to the supported headquarters or agency when a theater engineer is not available.

2. Provide command and control for subordinate units. The battalion can provide command and control for up to six subordinate companies and/or teams. This includes not only engineer prime power companies and teams but also engineer power-line detachments.

3. Provide administrative support to subordinate units.

4. Provide GS-level maintenance for prime power equipment.

5. Provide specialized Class IV, VII, and IX support to subordinate units.

6. Provide electrical engineering support. This includes a limited design and analysis capability.

The battalion also provides several additional functions relevant to operations short of war. These include—

1. Rapid worldwide deployment of engineer prime power teams in response to contingency missions or emergencies. This rapid response includes responding to natural and man-made disasters.

2. Staff liaison, coordination, and war planning with engineer commands (ENCOMs), USACE, US Army Forces Command (FORSCOM), and unified and specified commands.

3. Management and coordination of prime power requirements worldwide.

4. Management of the NTG war reserve. The battalion can also provide, on a reimbursable loan basis, power-generation equipment to support the Department of Defense (DOD) and other federal agency activities worldwide. The battalion can also provide training on power generation equipment for US and foreign personnel, both military and civilian.

Chapter 3
MISSION

MISSION STATEMENT

The mission of engineer prime power units is to generate electrical power and provide advice and technical assistance on all aspects of electrical power and distribution systems in support of military operations. This mission statement encompasses military operations across the entire continuum of military operations to include disaster relief, humanitarian assistance, and other operations short of war. Engineer prime power units support sustainment engineering efforts by providing reliable power generation and power-related technical expertise.

POWER GENERATION

Engineer prime power units can produce large quantities of reliable power with their organic 750-kW generators. They can also install, operate, and maintain nonstandard, portable power-generation equipment and operate and maintain some fixed commercial power plants. The units' power-generation capability allows them to—

1. Provide power to locations where another source is not available or is inadequate.

2. Replace existing power sources such as large concentrations of TACGENS.

3. Augment existing commercial power.

Organic Equipment

Each prime power team is equipped with four 750-kW generators, giving the team a 3-MW peak power-production capability. The team can configure its generators into one large power plant or two smaller plants. Table 3-1, page 3-2, shows the various possible configurations and the manpower requirements for continuous operation.

The team can install and operate these plants in any of three modes. Chapter 4 contains information on the three modes of power generation. Appendix A contains a discussion of power-generation concepts.

Table 3-1. Power plant configuration options

Number of Generators	Installed Capacity	Continuous Operating Capacity	Percent of Team Required to Operate Plant(s)
4	3 MW	2.25 MW	100
3	2.25 MW	1.5 MW	100
2	1.5 MW	0.75 MW	50
1	0.75 MW*	*	50
3 and 1	2.25 MW and 0.75 MW*	1.5 MW and *	100
2 and 2	1.5 MW and 1.5 MW	0.75 MW and 0.75 MW	100

* This configuration cannot provide continuous power.

Note: Manpower requirements are for continous operations. Manpower requirements may be reduced when plants are used in the standby mode, depending on frequency and duration of operation time.

Nonstandard Portable Equipment

The prime power team can install, operate, repair, and maintain nonstandard portable generators when they are available. Nonstandard generators are nonmilitary, commercial-type generators. Once installed and operational, these generators should be turned over to the supported unit to operate and maintain, thus freeing the prime power team for additional missions. The prime power unit can train the requesting unit personnel to operate and maintain this equipment. Supported units may use contracting channels to rent or lease these generators. In some cases, nonstandard generators may already be installed as backup. An important consideration when using nonstandard equipment is the availability of service and repair parts. The prime power team can perform damage assessment of nonstandard power-generation equipment and, subject to availability of repair and service parts, repair the equipment and return it to operation. Army Regulation (AR) 700-101 precludes the purchase of nonmilitary-standard generators without the express approval of the program manager-mobile electric power (PM-MEP).

Fixed Power Plants

Prime power units have a limited capability to operate, maintain, and perform damage assessment of some fixed commercial power plants, especially diesel-engine- and gas-turbine-driven plants. Continuous operation of large fixed plants exceeds the manpower capabilities of the team. In all cases, the prime power team should work with indigenous power-plant operators or contracted technicians who are familiar with the power plant. Prime power unit personnel cannot operate nuclear and fossil-fuel steam-powered plants or hydroelectric plants.

POWER-RELATED TECHNICAL ASSISTANCE

In addition to producing power, the prime power unit performs many other technical power-related tasks. These include—

1. Conducting load surveys.
2. Performing analyses and design of distribution systems.
3. Performing construction, maintenance, and repair of distribution systems.
4. Performing damage assessment of distribution system.
5. Operating and maintaining industrial power systems and controls.
6. Providing power-related staff assistance.
7. Providing power-related technical assistance to CORs.

Load Survey

A load survey is an analysis of power requirements. The load survey is a vital preliminary step in providing prime power support. The prime power team conducts a load survey to determine the amount of power a supported unit needs and what the distribution requirements are. The load survey also determines the level of reliability required and identifies any special power requirements or problems. The recommended power source is determined based on the load survey. A thorough load survey must be completed before work can begin on the installation of a power plant or the design of a distribution system.

Distribution-System Analysis and Design

The prime power team performs analyses of existing distribution networks to determine their capacity and charateristics. This is useful in determining how

much power is available on a system and whether the system is expandable or not. It is also useful in identifying potential electrical hazards that could result in damage to connected equipment, electrocution, or electrical fire. The prime power unit also designs temporary, ground-laid distribution systems. The design includes sizing of conductors, breakers, switches, transformers, load centers, and other devices. Design calculations include voltage drops as a result of line loss and grounding requirements. Systems are designed in compliance with current National Electric Code (NEC) standards. The completed design includes circuit diagram and site layout drawings or sketches, a complete bill of materials (BOM), estimated work requirements, and construction time. For more complex projects, a critical path method (CPM) diagram is also produced. The Army Facilities Components System (AFCS) construction plans contain standardized construction plans for power systems. Prime power units use these off-the-shelf designs where applicable. AFCS is discussed in Chapter 4.

Distribution-System Construction. Maintenance. and Repair

Prime power teams can construct and maintain temporary, ground-laid (or buried) primary and secondary distribution systems. All distribution systems are designed and constructed with approved material and methods and include appropriate devices. Prime power units have a limited capability to maintain overhead distribution systems. Construction and maintenance of extensive overhead distribution systems should be accomplished through use of contracts. Prime power personnel can make connections to existing distribution networks.

The manpower requirements for construction, maintenance, and repair of nonstandard distribution networks depend on a wide diversity of variables. Workload estimates for these tasks, which are provided below, are for planning and estimating purposes only and are highly dependent on controlling variables. For planning and estimating purposes, a team can—

1. Maintain 25 kilometers (km) of overhead or ground-laid primary distribution line. Maintain 10 km of buried primary distribution line. This is roughly equivalent to the distribution system of a small rural town.

2. Construct or repair 1,500 meters of ground-laid primary distribution line per day. This includes making in-line cable splices but does not include making connections to distribution transformers.

3. Make 12 connections per day to the primary side of pad-mounted distribution transformers. Make 4 connections per day to the primary side of pole-mounted transformers.

4. Maintain 25 km of overhead or ground-laid secondary distribution line. Maintain 10 km of buried secondary distribution line.

5. Construct or repair 800 meters of ground-laid secondary distribution line per day. This includes making in-line splices but does not include making connections to distribution transformers, load centers, or service equipment.

6. Make 20 connections per day to service equipment, load centers, and the secondary side of pad-mounted distribution transformers. Make 6 connections per day to the secondary side of pole-mounted transformers.

Prime power teams are not normally used to perform interior electrical work such as interior wiring. This function is performed by the vertical construction platoon of the combat-heavy, engineer-battalion line companies and by engineer utilities detachments. When installing secondary distribution, the prime power team's responsibilities end at the service entrance. The prime power team is responsible for making the connections to the service equipment. Service equipment, which is installed by interior electricians, is the main distribution panel or switched fuse box inside the structure. The prime power team does conduct a safety inspection of the interior branch circuits and connections before energizing the service equipment.

Industrial Power System Maintenance and Operation

Because the prime power teams have working knowledge of multiple power systems, they are able to repair, maintain, and operate industrial power systems and their associated controls. These power systems may be encountered in factories or other production plants where large quantities of power are required to operate heavy machinery. They may also be encountered in facilities such as ports, fuel-storage complexes, hospitals, refrigeration warehouses, and rail-switching centers. The team can also repair and maintain airfield lighting and other specialized illumination systems.

Technical Assistant to Staff

The prime power unit provides power-related technical advice to the appropriate engineer staffs. The prime power unit commander is the theater's subject-matter expert for electrical power. In this role, he acts as an electrical engineer staff officer to the theater engineer in a mature theater, or to the supported headquarters when a theater engineer is not available, providing information and recommendations on power-related issues.

Technical Assistance to CORs

The prime power unit provides power-related technical assistance to CORs. Prime power personnel can help develop specifications for electrical performance contracts and purchase contracts for electrical material. Performance contracts are needed when a power project exceeds the construction capabilities of the prime power unit or when contracted services are preferred over troop labor. In addition to developing specifications for contracts, prime power personnel also help perform the technical evaluation of the bids that are received. This assistance is available to both military engineer units and supporting USACE personnel.

Chapter 4
EMPLOYMENT

COMMAND AND CONTROL

The command and support relationships established for employment of engineer prime power units depend on the situation. Command and control during warfighting situations may differ significantly from that during operations short of war.

War

When employed in a TO during war, engineer prime power units are theater engineer asstes. They are normally assigned or attached to the senior engineer headquarters in the theater. As such, they will most likely be employed in a GS role throughout the theater. Based on the policies and priorities of the theater army (TA) commander, the theater engineer determines relative priorities and allocates prime power assets on a task basis. When appropriate, the theater engineer may allocate prime power assets on an area basis and place prime power companies or teams in a DS role to a theater army area command (TAACOM) or to an area support group (ASG).

Short of War

Prime power units can be employed in a variety of different roles in operations short of war. They can be employed to support units conducting operations, to be actual participants in the operations, or both. For example, a prime power unit can provide power to an American facility supporting a nation-assistance effort. On the other hand, it can participate in the operation by providing power or power-related technical assistance and training directly to the host nation. The command and support relationships established will be dependent on the role of prime power units in these operations.

The operational control (OPCON) command relationship is used extensively in the employment of engineer prime power units. Highly specialized Class IV, VII, and IX requirements require deployed companies and teams to maintain working supply channels with the prime power battalion. Companies and teams also depend on the battalion for electrical engineering support and personnel replacement. Regardless of the command and support relationships used, prime power units must rely on the supported unit to provide unit maintenance (less generators) as well as supply, food, health, religious, legal, finance, and personnel administration services. Chapter 5 contains detailed information about logistical requirements.

Nation Assistance

Prime power units can be employed in nation-assistance operations independently or as part of a larger assistance effort. A prime power unit participating in nation-assistance operations with other military units will normally be OPCON to the senior military commander or to the senior engineer commander as appropriate. When operating independently (such as in support of a State Department assistance effort) the prime power unit will normally be OPCON to the chief of the Security Assistance Organization (SAO) for the country being assisted. The chief of the SAO is one of the military representatives on the country team. The country team provides advice and assistance to the ambassador.

Disaster Relief

Disaster-relief operations are separated into two categories—disaster relief to foreign nations and disaster relief in the continental United States (CONUS), Alaska, Hawaii, and US Territories. Differentiation is made along these lines in accordance with federal law. Army Regulation 500-60 governs Army participation in disaster relief.

Military participation in foreign disaster relief falls into the category of contingency operations. DOD takes part in foreign disaster relief normally at the request for assistance and allocation of funds from the State Department. Prime power units participating in foreign disaster-relief operations are normally OPCON to the senior commander or the senior engineer commander as appropriate.

When supporting disaster-relief operations in CONUS, Alaska, Hawaii, or US Territories, a prime power unit will normally be OPCON to the Defense Coordinating Officer (DCO). For the 48 contiguous states, the DCO is appointed by the continental United States Army (CONUSA) commander. For Alaska, Hawaii, and US Territories, the commander in chief (CINC) of the regional unified command appoints the DCO.

Engineer prime power units also support other types of operations short of war such as contingency operations, peace-keeping operations (PKO), and support for insurgencies and counterinsurgencies. Prime power units supporting these operations will be part of a larger force such as a joint task force (JTF). As such, they will normally be OPCON to the senior US command participating.

PRIME POWER EMPLOYMENT FUNDAMENTALS

Effective employment of prime power units requires a basic understanding of the capabilities discussed in Chapter 3. Knowledge of some basic employment fundamentals is also essential.

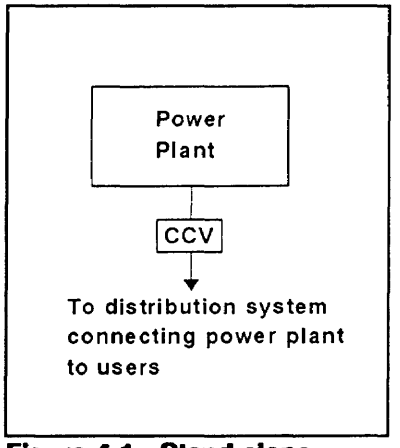

Figure 4-1. Stand-alone mode

Modes of Power Generation

Prime power plants can be used in stand-alone, standby, and load-sharing modes. The stand-alone mode, which is most commonly used, is employed when providing power to locations where commercial power is not available. The standby mode is employed to provide power to a section of the grid when commercial power fails. The load-sharing mode is used to supplement existing power and add capacity to the commercial source. In the standby and load-sharing modes, the plants are connected in parallel with the commercial grid. Figure 4-1 depicts a plant employed in the stand-alone mode. Figure 4-2, page 4-4, shows the standby and load sharing-modes.

Multigenerator plants in any of these three modes can be operated as prime or nonprime plants. Single-generator plants can only be operated as nonprime. By definition, prime power is electrical power that is continuously produced. Single-generator plants cannot be operated nonstop indefinitely; hence, they cannot produce continuous power. Appendix A provides an in-depth discussion of power generation.

Power Transformation and Distribution

The electricity produced by prime power plants must be distributed to the intended users and transformed to the required voltage before it can be used. Transformation can be accomplished by the team's organic equipment or by commercially available nonstandard transformers. When employed with a prime power plant, organic transformation equipment can provide 60-hertz (Hz) power at 480/277 volts or at 208/120 volts. 50-Hz power can be transformed to 380/220 volts.

The prime power team is equipped with enough medium-voltage distribution cable and accessories to allow connection from the power plant to the primary side terminals of its organic mobile substations and distribution transformers. Nonstandard, primary distribution material and all secondary distribution material

must be provided by the supported unit. Secondary distribution material includes the cable, splices, load-distribution centers, circuit breakers, distribution panels, ground rods, and so forth required to make the connections from the secondary side terminals of the transformers to the intended users.

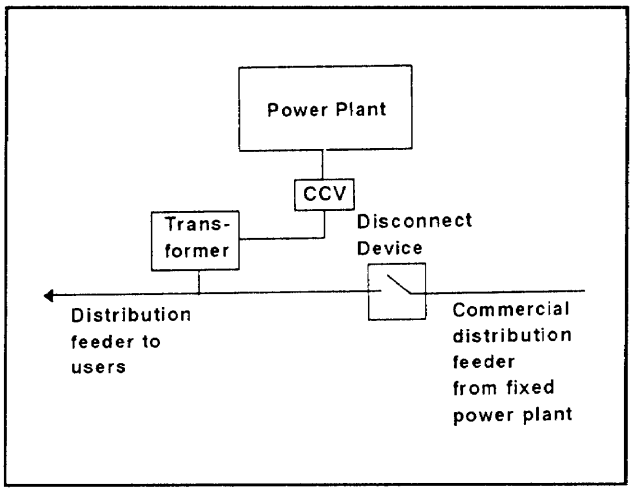

Figure 4-2. Standby and load-sharing modes

The prime power team identifies required materials as part of the design process and lists them on a BOM. These materials may be locally procured or obtained through supply channels (Class IV) by the supported unit. The standard DISE can readily be incorporated into the secondary distribution network. DISE is a Class VII item listed on some unit TOEs. Appendix A contains more information on power transformation and distribution.

Army Facilities Components System (AFCS)

Technical Manuals (TMs) 5-301, 5-302, 5-303, and 5-304 contain TO construction plans that incorporate prime power as an electrical power source. Electrical distribution plans are based on the availability of a 4,160-volt, 3-phase power source. This is the output voltage of prime power plants. The AFCS lists required materials, including distribution transformers, and the anticipated work requirements to install the initial standard (design life of up to six months) distribution system. Initial, standard electrical distribution systems are ground laid. Cable is marked with fences and signs and is buried at road and track crossings. Electrical safety-related construction standards are not relaxed for initial standard construction. Temporary standard (design life of up to 24 months) normally specifies buried or overhead cable installation.

Power System Upgrade

Units and activities that are in place for extended periods may need to upgrade their facilities. For power systems, this upgrade means improving system reliability. Power that is initially provided by TACGENS should be replaced by prime power or commercial power as soon as feasible. This replacement not only saves wear and tear on TACGENS but also improves reliability. Stand-alone

prime power plants should be replaced with commercial power as it becomes available. The desired end result is to use power from the highest level of the power continuum.

Employment Priorities

The priorities for employment of prime power support are the same as those for other engineer support in the theater of operations. FMs 100-16 and 5-116 list engineer support priorities in the TO.

Planning Guidelines

A few basic planning considerations apply to the employment of prime power teams and their assets. Consideration of these guidelines, listed below, will enhance the employment of prime power assets and will result in more reliable electrical service.

1. Consider power requirements as an integral part of the theater base-development planning process and the resultant plan. How much power is needed and where will it come from? Is there a plan to upgrade service after initial installation? Electrical-power planning should never be an afterthought.

2. Use commercial power when it is available. Commercial power is usually reliable in developed countries. Prime power teams can make connections to commercial distribution networks. Once connected, the system can provide continuous power service, virtually maintenance free. A major advantage of using commercial power over installing a plant is that the prime power team remains available to perform other electrical work. When a plant is installed, the team or part of the team is fully committed to operating and maintaining the plant.

3. Conduct preliminary power needs assessment before committing assets. The prime power team can determine what the power needs are and recommend the best way to fulfill them. The team conducts a load survey to determine how much power is required and where it is required, then designs systems to provide power based on the survey. They also recommend the best power source based on the level of reliability required and available assets. Many times, the power requirements are so complex that the supported unit is unable to communicate its power needs. A thorough preliminary assessment solves this problem.

4. Match the power source to load requirements. Resources that are ill suited for a particular application should not be committed. A common violation of this guideline occurs when a large prime power plant is installed to provide power to a relatively light load. This is a waste of scarce resources that could be better used elsewhere. Operating large prime power generators under light loads also

increases the wear and tear on the engine. Prolonged misuse will cause carbon fouling and buildup, reduced engine performance, and eventual engine failure.

5. Anticipate load increases and plan ahead to provide adequate power. If future plans indicate growth that will increase power demands, build the distribution system to handle the growth. This can be done either by overbuilding the system initially or by building it so that it can be readily expanded as needed. Systems that are not anticipating growth should still be designed and built to accommodate 150 percent of the estimated demand.

6. Plan for backup power to critical loads. Some critical facilities such as hospitals and C^3I sites may require backup power. Power outage at these facilities could otherwise mean loss of life or serious mission degradation. Therefore, these critical facilities and activities should have a standby power source even when connected to commercial power.

PRIME POWER SUPPORT REQUEST PROCEDURES

War

Request channels for obtaining prime power support during war are shown in Figure 4-3. In a smaller theater where the theater engineer brigade performs the ENCOM function, it assigns missions to the prime power unit.

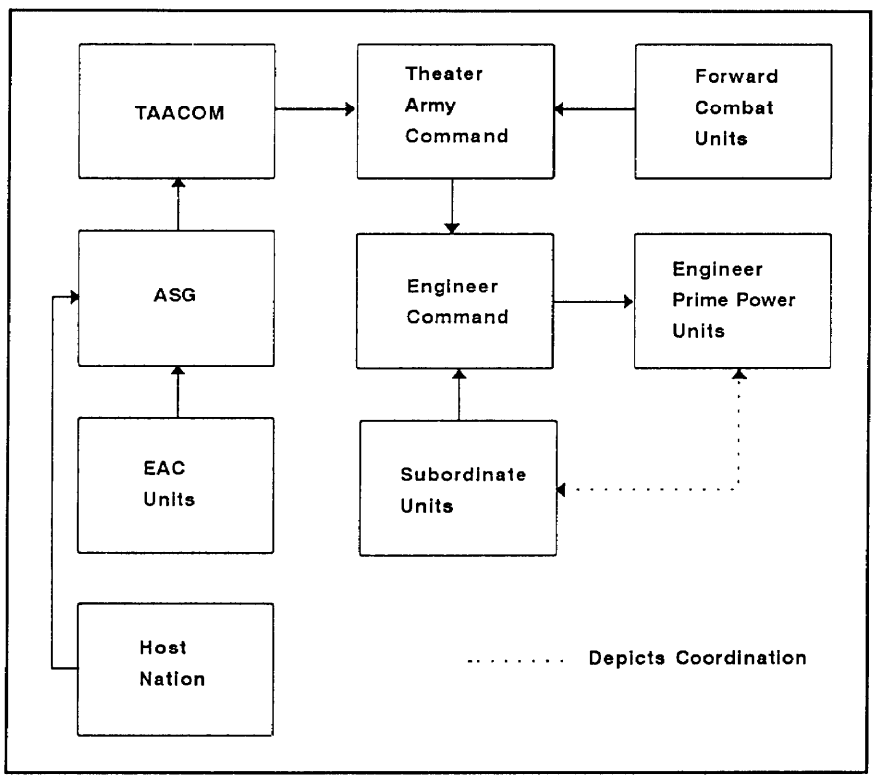

Figure 4-3. Prime power support request channels in war

COMMZ

Echelons above corps (EAC) units, located in the COMMZ, request support through the ASG. The requests are forwarded through the TAACOM to the theater army command. The theater army command approves requests, assigns their priority, and tasks the theater engineer to support them. The theater engineer assigns the missions to the supporting prime power unit. Support requests from the host nation are submitted to the ASG and are handled like all other requests.

Combat Zone (CZ)

Requests for prime power support in the CZ are submitted through command channels to the theater army command. Approved requests are assigned priority and tasked to the theater engineer, who assigns the mission to the supporting prime power unit.

All requests should include as much mission detail as possible and an estimated time for work completion. If available, information as outlined in Appendix B should also accompany requests.

Coordination with other theater engineer units is very important when working together on a construction mission. Close coordination before and during construction will preclude on-the-job confusion between units and will reduce safety hazards associated with electrical construction.

Short of War

Request procedures for prime support to operations short of war can occur under routine or emergency conditions. Figure 4-4, page 4-8, depicts request channels for routine requests. Typically, routine requests are a result of preliminary planning for a particular operation, exercise, or activity. These requests may originate from Army units or joint or sister-service units conducting operations or exercises. They may also originate from government agencies needing support for domestic or foreign activities. Joint and non-Army military requests are forwarded through the appropriate joint specified or unified command to the Joint Chiefs of Staff (JCS) for approval. Nonmilitary requests are forwarded to the Office of the Secretary of Defense (OSD) for approval. Once approved, support taskings are forwarded to the Director of Military Support (DOMS), who determines which service will support the taskings.

Taskings selected to be supported by Army assets are forwarded to the DA Deputy Chief of Staff for Operations (DCSOPS).

Requests from Army units are forwarded through the appropriate MACOM to DA DCSOPS for approval. All taskings are forwarded to USACE and finally to the engineer battalion (prime power). The battalion commander selects the company or team to support the requirement.

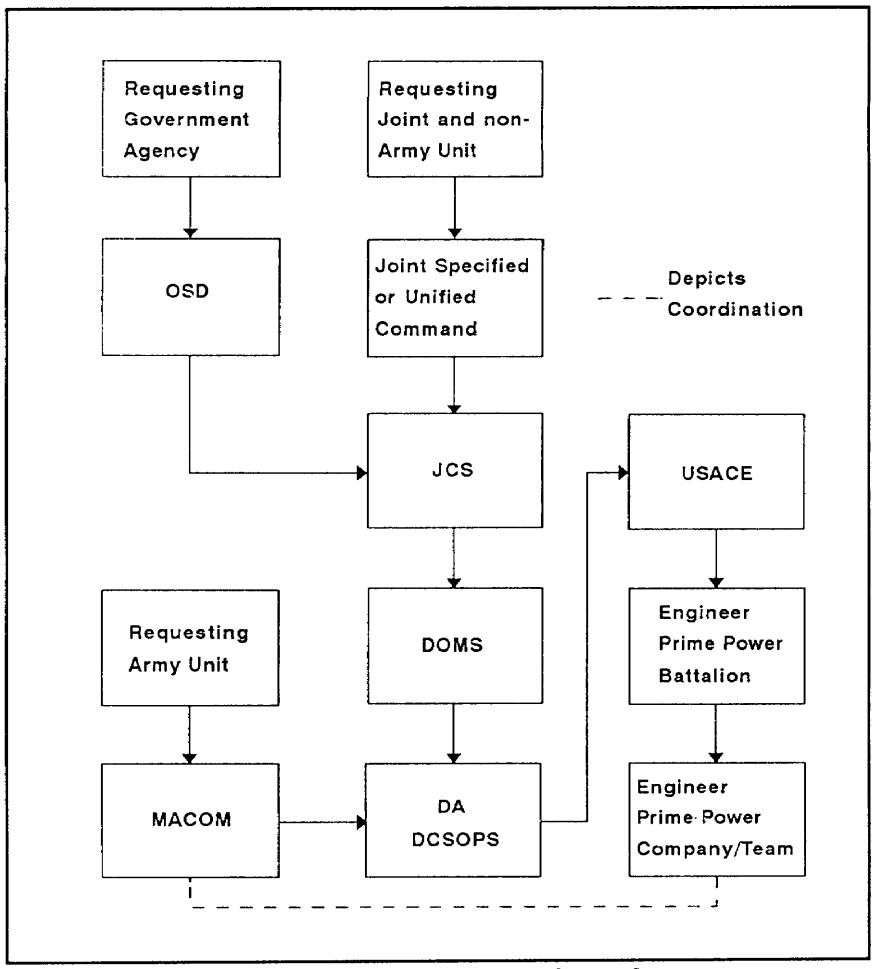

Figure 4-4. Routine prime power request channels

Figure 4-5 illustrates emergency request channels. Emergency request procedures are followed to obtain prime power support for emergencies. Requests for emergency prime power support are usually associated with disaster relief. They may originate from the State Department for overseas disasters or from the Federal Coordinating Officer (FCO) or the DCO for domestic disasters. State Department requests are routed through OSD to the JCS. FCO and DCO requests are routed through the CONUSA or regional CINC to the JCS. The JCS task DOMS, who determines which service will support the tasking. Taskings selected for Army support are forwarded through DA DCSOPS to USACE, who tasks the engineer battalion (prime power).

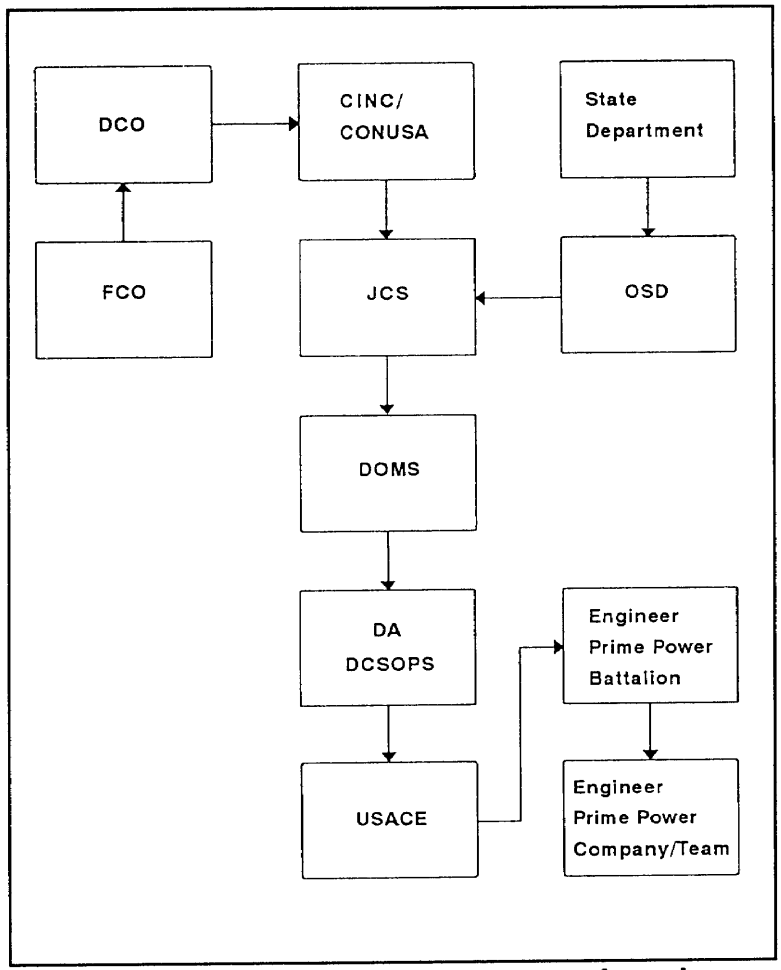

Figure 4-5. Emergency prime power request channels

Chapter 5
PLANNING CONSIDERATIONS

ENVIRONMENT

Prime power operations are affected by the environment in which they are conducted. The most important environmental factors to consider when planning for prime power support are climate, terrain and vegetation, and lighting.

Climate

Climatic conditions in some locations affect prime power operations. The low temperatures and short periods of daylight encountered during winter in polar regions will adversely affect manpower efficiency but will not degrade equipment performance. Under these conditions, expect significant work-rate slowdowns.

Operations in tropical and coastal regions require additional equipment maintenance to combat corrosion from humidity and salt spray. Generator performance is degraded by humidity and high temperatures in tropical regions. Under extreme conditions, power-plant output may have to be derated as much as 25 percent to compensate for this degradation.

Operations in desert regions require intense and frequent maintenance due to heat and dust. Grounding problems are often encountered in these arid climates due to extremely high soil resistivity. Units may have to construct grounding grids and use soil additives and water to overcome grounding problems.

In mountainous regions above 5,000 feet, the thin air degrades the performance of power-generation equipment. It also reduces manpower efficiency. To compensate, units should derate generators and anticipate slower work rates with frequent rest breaks.

Terrain and Vegetation

Rugged terrain and dense vegetation may affect plant siting and distribution system routing. Each generator and control van in a power plant requires a prepared level surface. Plant sites may need to be cleared and leveled before preparing generator-unit pads.

Rugged terrain and dense vegetation may restrict construction of distribution lines to cleared areas such as roadways. These restrictions can result in longer lengths of distribution line, increased conductor sizes, and additional manpower requirements. Equipment used in laying distribution cable is not suited for cross-country use in rugged terrain.

Lighting

Artificial lighting is necessary when constructing or repairing distribution systems at night. The hazards associated with electrical construction and repair are deadly. They are greatly compounded if work is attempted under blackout conditions.

THREAT

Power plants and transmission and distribution networks are likely targets for sabotoge. Large commercial power plants are likely targets for long-range, surface-to-surface missiles and aerial raids. Prime power plants, especially those powering critical facilities, and their associated distribution networks are also likely sabotage targets. Recognizing the vulnerability of these lucrative targets is important to their defense. Additionally, prime power plants and many commercial power plants have significant noise and heat signatures. This fact should be considered when threat capabilities include infrared or thermal-imagery surveillance and targeting.

TIME

Plant relocation and installation and distribution system construction take time. This is significant in that it precludes the rapid relocation and setup of power plants and their associated distribution networks. Generally, it is feasible to install a prime power plant for units or activities that plan to use it for 30 days or more. This time frame is subject to other factors such as availability of distribution materials and the level of reliability required. Units and activities that relocate often should use TACGENS or relocate to facilities powered by the commercial grid or an existing prime power plant. Expanding an existing prime power plant and its distribution network is usually more practical than relocating it.

THEATER INFRASTRUCTURE LEVEL

Planners should consider how developed the TO infrastructure is in terms of developed utilities, skilled labor work force, sustainable power sources, and so forth. Initially, theaters with less developed infrastructures will probably require more prime power support effort than those that are well developed. During war, however, developed infrastructures can be crippled in a short amount of time. Depending on the extent of damage, restoration of commercial power can take months or years. Loss of commercial power production will be detrimental to military operations and disastrous for civilian activities. It will also greatly increase the demand for electric power produced from TACGENS, nonstandard generators, and prime power plants.

When developing the Civil Engineer Support Plan (CESP) at the unified and specified command level, planners should consider the impact of extensive war-damaged electrical utilities. They should also determine the requirement for prime power support to provide electricity to critical facilities under these circumstances.

Logistics planners should consider the availability of sources for power-related materials in the theater. This includes generators, distribution cable and wire, connecting devices, switch boxes, transformers, protective devices, and so forth. Planners should also consider the availability and reliability of potential sources for power-related service and performance contracts. Materials and services not locally available have to be imported to the TO.

Planners should also consider distribution voltage and frequency. This is critical if plans call for using commercial power. When voltage and frequency are not compatible with intended use, they must be altered or power must be obtained from an alternate, compatible source. Appendix C lists frequency and voltage of worldwide power systems.

PERSONNEL

Prime power production specialists are highly skilled technicians. Their training and experience give them a strong background in electrical theory and practical application. This enables them to perform the power-related tasks discussed in chapters 2 and 3. Another facet not previously discussed is their ability to supervise and manage power-related projects using unskilled and semiskilled troops and indigenous workers. This function is especially useful when mission manpower requirements exceed prime power unit capabilities. Prime power team members can also train and supervise semiskilled troops and indigenous workers in power plant operations. Personnel with some electrical background, such as interior electricians or generator mechanics, are likely candidates. Once trained, these personnel can assist with power-plant operations, thereby freeing team members for additional missions.

CONSTRUCTION SUPPORT REQUIREMENTS

Establishment of a prime power plant normally requires construction effort beyond the capability of the team. Site preparation in a bare base theater includes basic earthwork (clearing, grubing, leveling, and compaction) that must be accomplished by an engineer construction unit or a local contractor. Distribution system installation may require ditch construction and/or pole erection. In addition, overhead-line installation and repairs normally require support from others. Planning for prime power plants must include these tasks, as a minimum.

LOGISTICAL SUPPORT REQUIREMENTS

Prime power operations require considerable logistical support. Power-plant operations and distribution construction account for most of the logistical requirements.

Supply

Large quantities of material are required in the construction of nonstandard distribution systems. Prime power units deploy with only a small, basic no-mission load of these items. However, the wide diversity of this material makes it impossible for a prime power unit to maintain a stockage level adequate to accomplish construction tasks. Therefore, prime power units rely on supported units to acquire construction materials. These materials are available through normal supply channels and, in some theaters, through contracting, local procurement, and host-nation supply.

Operation of a prime power plant requires a daily resupply of diesel. Fuel is normally delivered to the power plant by the supported unit. Consumption rate depends on plant size and electrical load and varies from 40 gallons per hour (GPH) to 220 GPH. The supported unit also provides the Class III packaged products required for generator services.

When deployed independently, prime power teams require support from their attached or OPCON higher HQ for all classes of supply. The team receives this support from the prime power engineer company when the team and company are deployed together. The prime power engineer company and the battalion HHD establish supply accounts and provide for their subordinate teams. The battalion provides highly specialized Class IV, VII, and IX items associated with prime power assets.

Transportation

Prime power units require transportation support to relocate power plants and associated equipment. All equipment, including generators, cable, control vans, and transformers, can be transported on flatbed or lowboy trailers. Mobile substations are trailer mounted and only require tractor support to move. Organic equipment can also be moved by air.

Materials Handling Equipment (MHE)

Prime power companies and teams require MHE support to upload and download equipment subsequent to relocation. Usually, a 40-ton crane or two 20-ton cranes and a 10,000 pound rough-terrain (RT) forklift can support this requirement. Forklift support beyond the teams' organic capability may also be required when constructing distribution networks. Units involved in repairing and

making connections to overhead distribution networks may require the use of a bucket truck.

Services

Mess, laundry and bath, chaplain, medical, and all other troop life support services must be provided. These services are normally obtained through either the higher HQ or the supported unit.

Maintenance

All levels of maintenance through GS can be performed on prime power equipment within the battalion. All levels of maintenance above operator level must be provided by another unit for their tactical vehicles and other common items.

Communications

Prime power units have very little organic tactical communications equipment. Each power plant is equipped with a field telephone, but all other communications requirements must be provided by another unit.

SAFETY

Working with and using electrical systems poses certain hazards. Mistakes and accidents can result in electrical fires as well as death by electrocution. For this reason, prime power units continually stress and practice safety and quality control in all work. Prime power personnel do not work on energized medium or services must be provided. They de-energize these circuits before performing work and keep them de-energized using caution and clearance (lockout/tagout) procedures. They also perform a safety inspection of circuits before energizing them. The current NEC is used as a quality standard for materials and methods where applicable. The National Electrical Safety Code (NESC), DA safety regulations, and Occupational Safety and Health Administration (OSHA) regulations are also followed very closely.

Appendix A
POWER SYSTEM CONCEPTS

GENERAL

This appendix discusses some of the technical concepts involved with prime power operations. Although knowledge of these concepts is not critical, it is useful for planners and commanders who employ engineer prime power units.

POWER GENERATION

Prime power is electrical power that is continuously produced. It is not necessarily uninterrupted power. Power is produced by generators. Generators are machines and as such are subject to mechanical or electrical failure. They require periodic maintenance and service to avoid breakdown. To obtain a source of continuous or prime power, multiple generators are installed in parallel. This arrangement allows the performance of maintenance on one or more generators while the others produce power. Simply having a backup generator that can be installed in the event of a generator failure does not constitute a prime power plant. The same multigenerator principle is used in the production of commercial power and can be used with some models of TACGENS.

Prime power plants can produce power at either 50 or 60 Hz. When operating at 60 Hz, the frequency common to most US systems, the generator output voltage is 4,160 volts, 3 phases. At 50 Hz, the output voltage is 3,800 volts, 3 phase. These output voltages are in the range called *medium voltage.*

Figure A-1 depicts a typical prime power plant. It shows that a generator may be isolated from the power bus by opening the air switch between the bus and the generator. With the air switch open, maintenance can safely be performed on the isolated generator while other generators continue to produce power. A four-generator plant has an installed output capacity of 2.25 MW, based on continuous operation of three generators. The peak capacity of the plant is 3 MW. This may be attained for limited periods of time.

POWER DISTRIBUTION AND TRANSFORMATION

Primary Distribution

Primary distribution networks carry medium-voltage power from the power plant to the transformers or mobile substations. Primary systems are constructed with extra-heavy-duty, multiconductor, shielded power cable that is

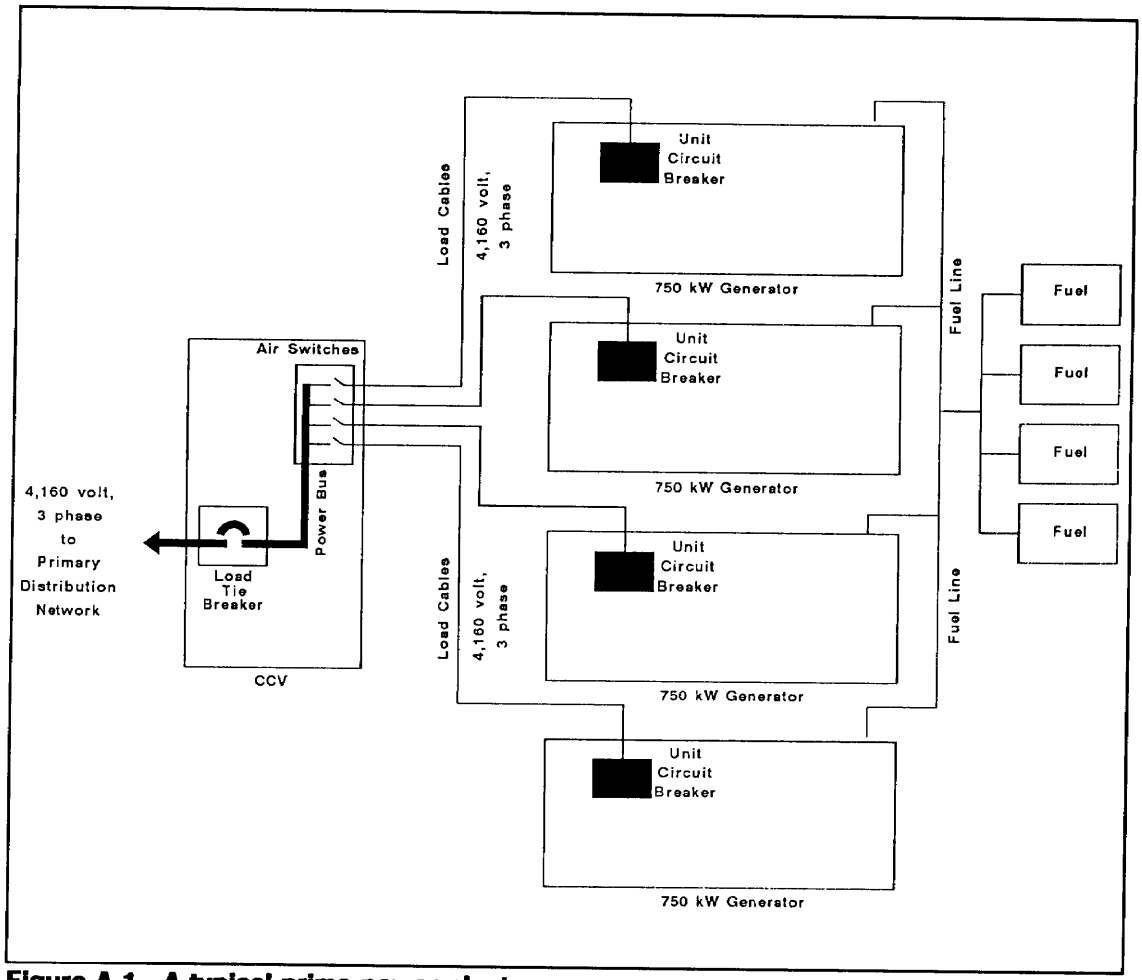

Figure A-1. A typical prime power plant

suitable for ground-laid or buried applications. These networks can be laid out in radial or loop patterns.

The radial layout has the advantage of being quicker and more economical to install. The loop layout is more reliable. Figures A-2 and A-3 depict stand-alone prime power plants powering loads over radial and loop primary distribution networks. These two figures show that a radial layout can be upgraded to a loop layout to increase reliability.

Transformation

The medium-voltage power distributed on the primary system is stepped down to user-voltage power by transformers. In the simplest terms, transformers are

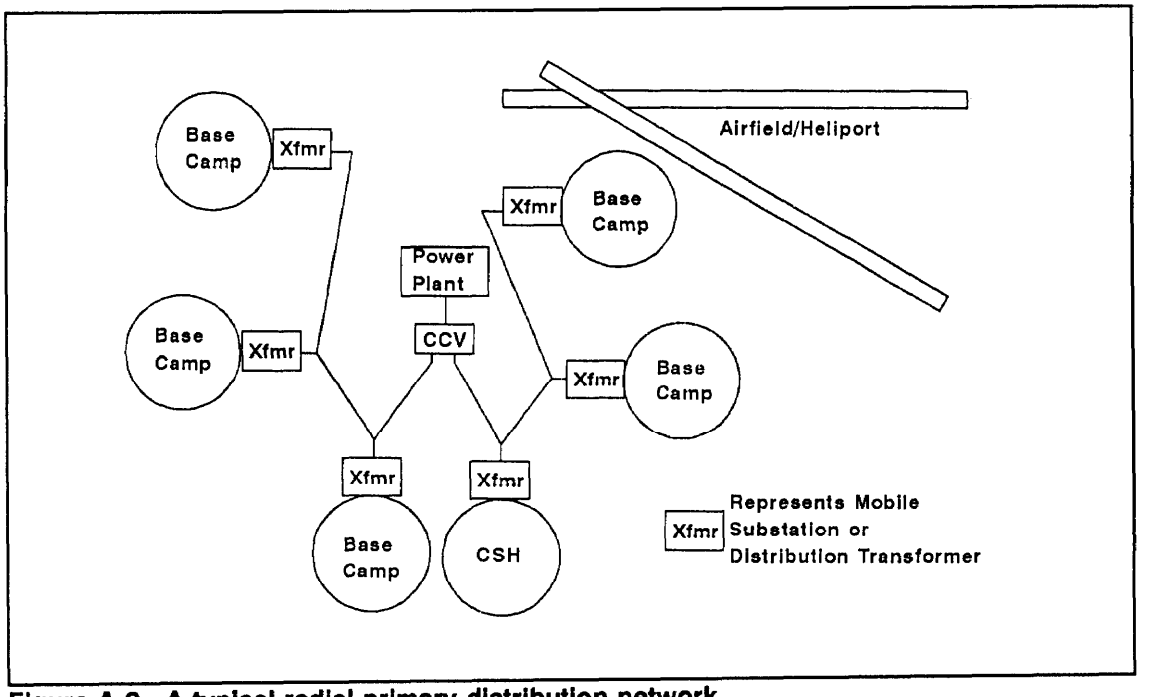

Figure A-2. A typical radial primary distribution network

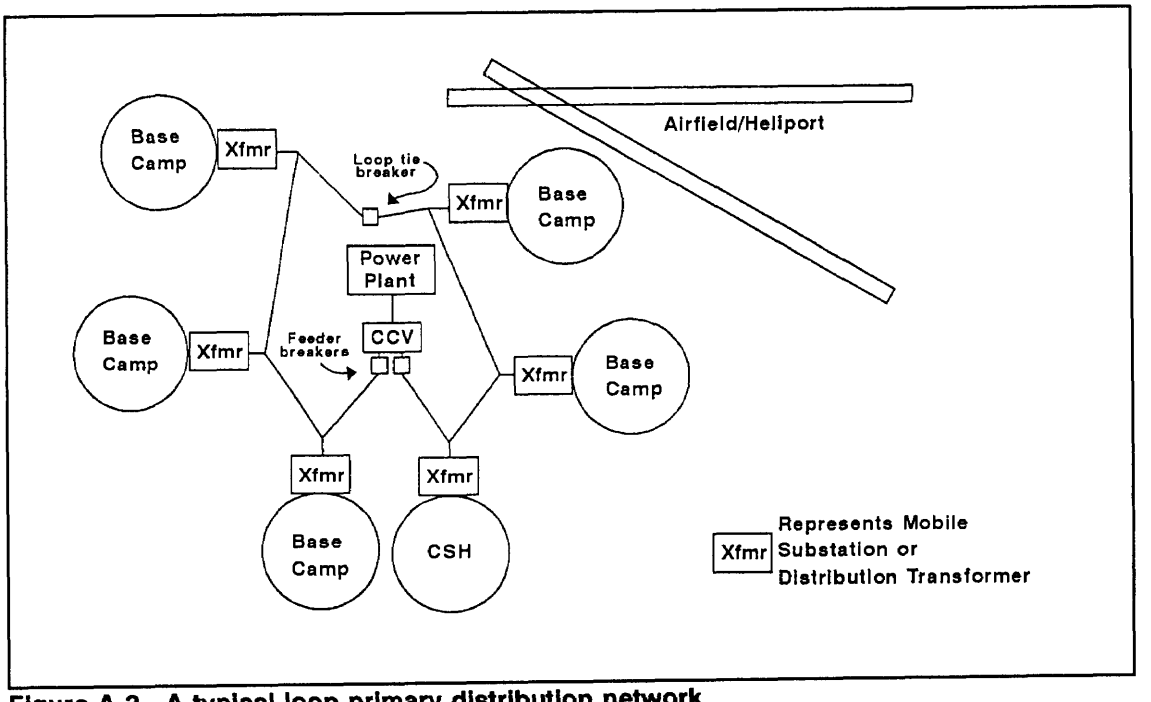

Figure A-3. A typical loop primary distribution network

electromagnetic devices that use mutual inductance to transfer energy from one circuit to another. Most transformers are more than 95 percent efficient. As a result, very little energy is lost in the transformation process. The power put into a transformer approximately equals the power coming out. In the case of stepdown distribution transformers, the high-voltage, low-current power going into a transformer approximately equals the low-voltage, high-current power coming out. When a transformer reduces voltage, it increases the current proportionally.

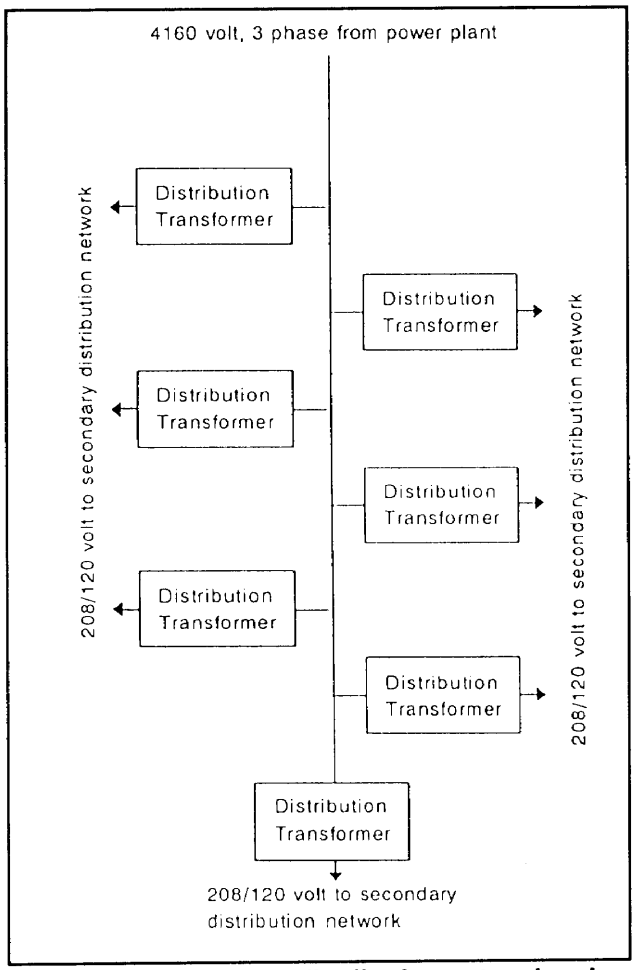

Figure A-4. A primary distribution network using distribution transformers

Primary distribution voltage (medium voltage) is stepped down to user voltage by distribution transformers or mobile substations. A primary distribution system may incorporate either or both of these items. The system can incorporate distribution transformers and switch gear that are organic to the prime power team or commercially obtained or both. Use of distribution transformers is advantageous when the electrical load consists of several small power requirements dispersed over a relatively wide area. Figure A-4 shows a typical primary distribution feeder using distribution transformers. Use of distribution transformers allows power to be distributed at a higher voltage on smaller conductors and helps to reduce voltage drop and line loss.

Mobile substations are simply large, trailer-mounted transformers with self-contained switching and protective devices. Use of mobile substations is advantageous when providing power to larger loads concentrated in a smaller area. Mobile substations are well suited for powering industrial areas and large facilities. Multiple mobile substations can be employed in parallel to increase capacity. Figure A-5 depicts a typical application of mobile substations.

Secondary Distribution Networks

Once the voltage is stepped down to user voltage at the transformer, the secondary distribution network carries the power from the transformer to the user. Secondary distribution systems are constructed with multiconductor cable when possible. Figure A-6 depicts a typical, simple secondary distribution network.

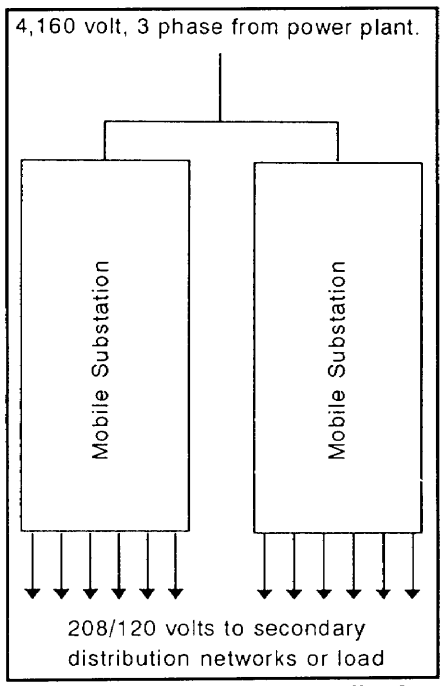

Figure A-5. A primary distribution

POWER SYSTEM CHARACTERISTICS

Consideration of power systems characteristics is important in determining power use for specific applications. Some power system characteristics can be altered to suit user needs.

Output Voltage

Output voltage is the measure of the voltage at the output terminals of the power system. Large output voltage alterations can be made by using transformers. Small output voltage changes can be made by adjusting generator controls on TACGENS and prime power generators. Devices such as voltage regulators can be used to make small voltage adjustments to commercial power.

Single-Phase or Three-Phase Power

Most alternating current (AC) power is generated as three-phase power. Single-phase power can easily be obtained from a three-phase source. Three-phase power is provided at three separate output terminals that share a common neutral terminal. The voltage difference between phases is the result of each being ±120 degrees out of phase with the other two. For many applications where higher voltage single-phase power is required, two-phase power can be used to provide power at approximately the needed single-phase voltage. For example, a 120/208-volt system can provide single-phase 120-volt power. It can also provide 208-volt three-phase and/or 208-volt two-phase power.

Three-phase power systems should be designed so that each phase carries approximately the same amount of load as the other two. This concept is called *load balancing.* Badly unbalanced loads will result in frequent tripping of protective devices and may damage equipment.

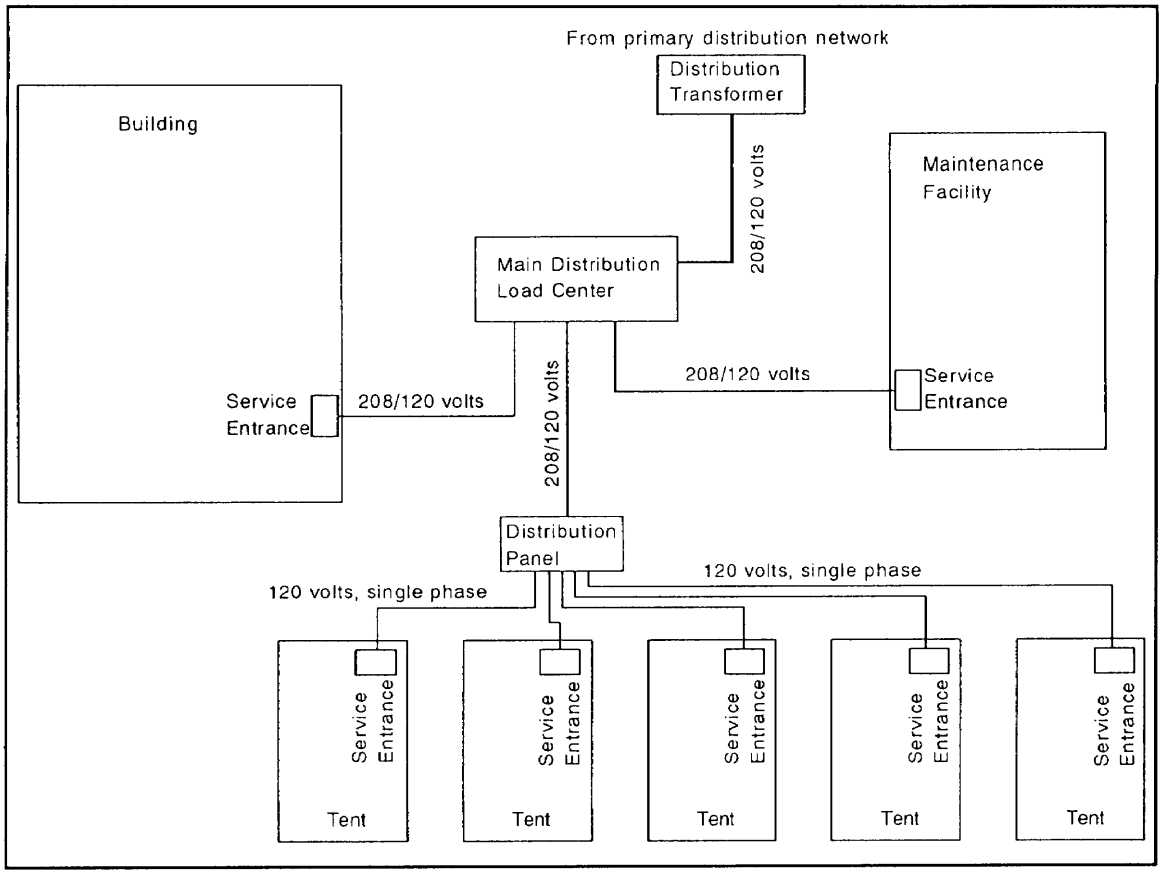

Figure A-6. A typical secondary distribution network

Output Capacity

Output capacity is the amount of power a system can deliver. It is usually measured either in kilovoltamperes (kVA) or in kW. Output capacity is limited not only by the size of the generation equipment but also by the rated capacity of the distribution system. Electrical conductors and devices such as transformers, breakers, and switches are designed and manufactured with specific limitations on current and voltage. When user power demand exceeds output capacity, the system is said to be *overloaded* and one of two things may occur. Either protective devices such as fuses, breakers, or relays are blown or tripped or else the system is damaged. The damage can occur in the form of melted conductors, burned connections, or blown transformers. Output capacity may be increased by upgrading distribution systems and by employing additional or larger generators.

Reliability

Reliability is the measure of a power system's ability to fulfill all user demands without failure for a long period of time. Systems that are susceptible to outages,

either scheduled or unscheduled, or that cannot provide all the power a user needs are not very reliable. Reliability can be improved by the employing standby and load-sharing generators. It can also be improved by using redundant distribution systems and enhanced by maintaining existing distribution systems and generation equipment.

Portability

The ability to rapidly relocate a power system may be critical to certain operations. TACGENS are the most portable systems available. Since commercial power is tied to fixed facilities, it is the least portable. Prime power systems are portable but require more effort and time to move and install than TACGENS. Prime power plant installation may be feasible if the plant remains in operation (stationary) for 30 days or longer.

Frequency

AC power frequency is given in cycles per second, or Hz. The most common worldwide systems are 50 and 60 Hz. The accepted US standard is 60 Hz. Most countries establish one or the other as a national standard. They build their commercial power systems accordingly. In a few countries, both systems may be encountered. Appendix C lists the commercial power-grid frequencies and user voltages for various countries.

Some equipment is sensitive to AC frequency and will not operate properly when powered by a source with a different frequency than the equipment is designed for. Units should ensure frequency compatibility for this equipment to avoid damaging it. Most transformers designed for 50-Hz operation can be used for 60-Hz application. Most 60-Hz transformers cannot be used for 50-Hz application unless they are significantly derated.

Prime power generation equipment can operate at 60 Hz or 50 Hz. Most TACGENS operate at 60 Hz. Some specialized TACGENS operate at 400 Hz. 400-Hz frequency power is used extensively for aircraft systems, missile and avionics systems, signal systems, and some shipboard systems. Frequency alterations are possible with the use of frequency converters.

Line Loss and Voltage Drop

Electrical conductors have some resistance. The amount of resistance depends on the type of metal, cross-sectional area and length, and temperature of the conductor. Copper is less resistive than aluminum. Conductors with larger cross sections and shorter lengths are less resistive than those with smaller cross sections and longer lengths. Conductors are less resistive at lower temperatures than at higher temperatures.

When electrical current flows through a resistive material, some of the energy is converted to heat, causing a drop in voltage. The energy converted to heat is called line loss and the drop in voltage is called voltage drop. Distribution systems must be designed to safely carry the required amount of current while maintaining output voltage within the operating parameters of the devices being powered.

Appendix B

SUPPORT REQUEST INFORMATION

This appendix addresses the key elements of information that should accompany a request for prime power support. The prime power unit uses this information in formulating a preliminary assessment and support plan. The requestor speeds the support process by providing detailed, accurate information regarding power needs. The requester should provide–

1. General information:

a. Unit. The requesting unit designation or activity.

b. Location. The location of the requesting unit and the exact location where support is needed.

c. Point of contact (POC). This should be a responsible individual who is knowledgeable of the requested support requirements. Also provide telephone numbers or other means of contacting the POC.

2. Description of support required:

a. Nature of support. Describe the nature of support needed and the general situation prompting the request.

b. Special conditions. Describe any special conditions that may affect the support request. Special conditions may include potential hazards; unusual voltage, current, or frequency requirements; or special grounding or protection requirements. Also, state any special considerations that affect the level of reliability required.

c. Site layout. Include a sketch or drawing showing the site layout for the requested support. If possible, the sketch should be to scale and should show linear distances between load connections.

d. Load estimate. Provide an estimate of load requirements for each separate load. If a load estimate cannot be given, state the type and quantity of devices being powered. If possible, state the voltage requirements.

3. Required time frame: State any time factor pertinent to the support request such as the earliest start time, the latest completion time, and the expected period of duration support is required.

4. Availability and accessibility of commercial power, TACGENS, and nonstandard generators: State the location of the nearest commercial distribution feeder. Provide information on the availability of TACGENS and nonstandard generators.

Figure B-l depicts a sample information enclosure.

Enclosure to request for prime power support.

1. General information:

a. Requesting unit: 952nd ASG

b. Location: Unit location—group HQ is near the intersection of Fester Cletus Freeway and Homer Buford Boulevard, on Royal Air Force Base (grid coordinates AM463988). Support location—adjacent to group HQ.

c. POC is MAJ Kirk, commercial 123-456-7890.

2. Description of support required:

a. Nature of support. The Camp Carla Belle base camp is to be expanded. Expansion will include addition of 80 GP medium tents for living quarters, 6 portable shower units, 10 commercial-type trailers for offices and dental clinic, a PX trailer, and a host-nation-operated fast-food stand. Needed support includes expanding the existing secondary distribution network and connecting to existing commercial power to accommodate this new growth.

b. Special conditions: The dental clinic will have an X-ray machine. The operating voltage of this machine is, at present, unknown.

c. A sketch of the planned site layout is attached.

d. Load estimate. Each tent will have 6 incandescent lights and 6 duplex outlets. Outlets will operate fans and personal devices. Each office trailer has 8 fluorescent light fixtures, 6 duplex outlets, and 2 small window air conditioners. The outlets will be used primarily for office equipment and machines. The shower units each have 10 incandescent light fixtures, 8 duplex outlets, and an electric 100-gallon water heater. These duplex outlets have ground fault current interrupt (GFCI) protection and will be used for shavers, hair dryers, and the like. The dental clinic has 8 fluorescent light fixtures, 1 X-ray machine, 6 duplex

Figure B-1. A sample enclosure to a prime power support request

outlets, and 2 small window air conditioners. The PX trailer has 8 fluorescent light fixtures, 4 large refrigerators, 10 duplex outlets, 3 small window air conditioners, and 10 exterior floodlights. The outlets are used for cash registers. The only known data about the host-nation fast-food stand is that it will have refrigerators, freezers, ovens, deep fryers, and a grill—all electric. The only known data about voltage requirements is that the lights and outlets are 120 volts.

3. Time frame. The group commander has mandated that the base camp be habitable NLT 15 July. Construction is scheduled to begin on 18 June.

4. Availabile power sources. Camp Carla Belle is currently powered off the commercial grid. The distribution feeder comes in from a buried system along Fester Cletus Freeway to four distribution transformers in Camp Carla Belle. Total and unused capacity of these transformers is not known. The group HQ has a 75-kW generator for use in the event of power failure.

Figure B-1 (cont.). A sample enclosure to a prime power support request

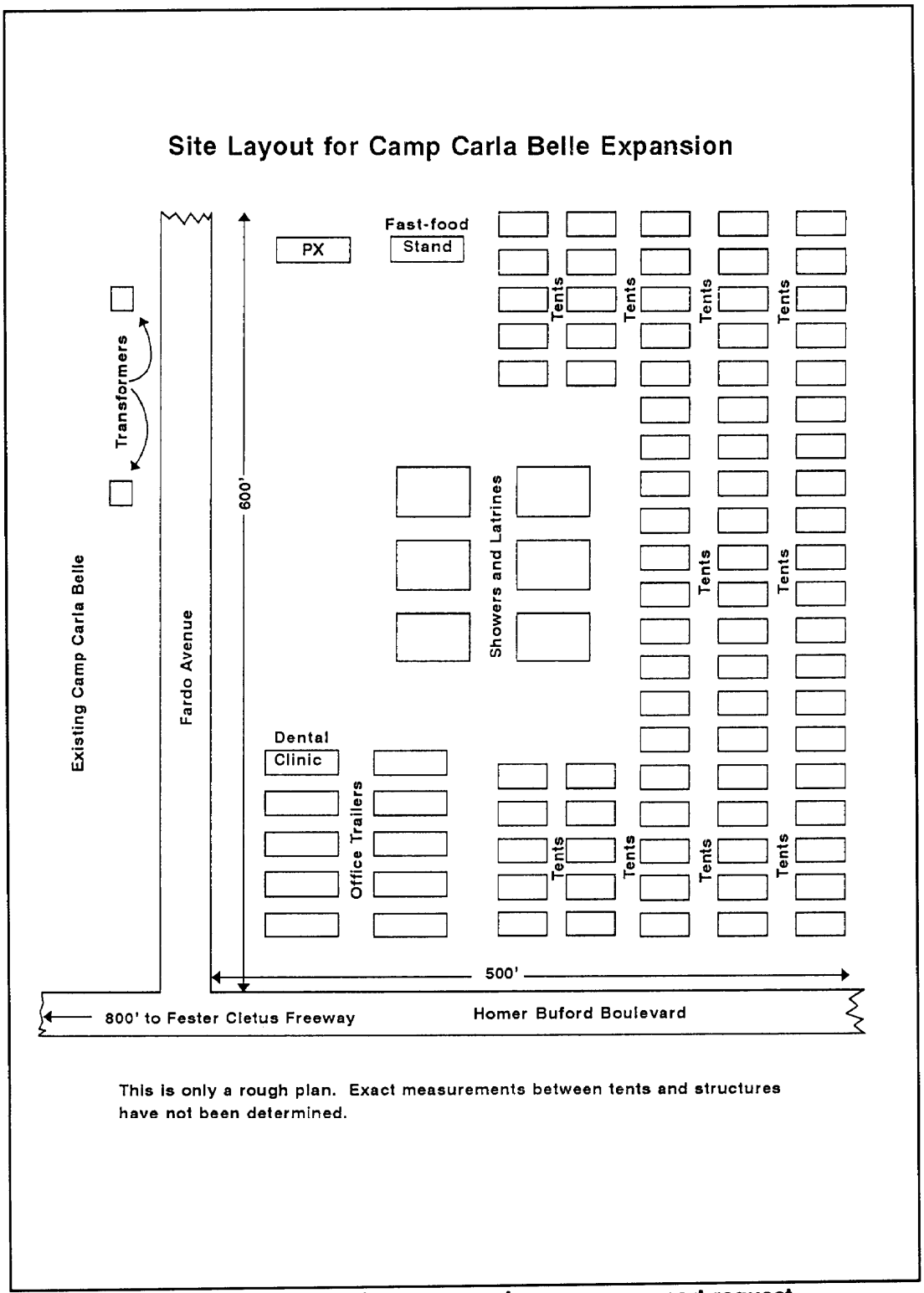

Figure B-1 (cont.). A sample enclosure to a prime power support request

Appendix C
FREQUENCY AND VOLTAGE DATA

Different power frequencies and voltages are used in different parts of the world. In the US, 60 Hz is the most common frequency. Secondary distribution volt ages of 120/208, 120/240, and 277/480 are common. Table C-1 provides an extensive but not exhaustive list of the frequencies and secondary voltages for commercial power systems in many foreign lands and US territories. This data is subject to change, so planners should verify it before use.

Table C-1. Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
North America, Central America, and the Caribbean			
Bahamas	AC	60	115, 120, 110/220, 120/208
Barbados	AC	60	110
Belize	DC		110/220
Bermuda	AC	60	110/220
Canada	AC	60	115/230, 110/220, 110/220/550, 155/230/575
Costa Rica	AC	60	110/220
Cuba	AC	60	115, 110/220, 110/220/440
Dominican Republic	AC	60	110/220/440, 120/240
Dutch West Indies	AC	60	110/220
El Salvador	AC	60	110/220
	DC		110
French West Indies	AC	50	110, 110/220
Greenland	AC	50	220
Guatemala	AC	60	220, 110/220, 230/400
	AC	50	220
Honduras	AC	60	110, 110/220
Jamaica	AC	50	110/220

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Leeward Islands	DC		220
Mexico	AC	60	110/220, 125/220
	AC	50	110/125
Nicaragua	AC	60	110, 110/220
	AC	50	220, 125, 127/220
	DC		110
Panama	AC	60	110, 110/220
St. Kitts and Nevis	AC	60	110
St. Lucia	AC	50	230
St. Pierre and Miquelon	AC	50	110
Trinidad	AC	60	110/230
South America			
Argentina	AC	50	225/390, 220/380, 220/440
	DC		235, 220, 200
Bolivia	AC	50	230, 220, 240, 110/220, 127/220
	AC	60	220
	DC		220, 110
Brazil	AC	40	220
	AC	50	120/220, 230, 110/220, 125/220, 127/220, 115/220, 220/440, 125/216
	AC	60	110, 120/220, 220, 127/220, 110/220, 210
	DC		220
Chile	AC	50	220, 220/380
	AC	60	110, 220, 220/380
	DC		220

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Colombia	AC	60	110/220, 220/380, 115/230, 150/260
	AC	50	230/380, 110/220
Ecuador	AC	60	220/380, 110/220
	AC	50	220
	DC		220
French Guiana	AC	50	110
	DC		120, 220
			110, 125
Guyana	AC	50	115/230
	AC	60	110/220
Paraguay	AC	50	220
	DC		220
Peru	AC	50	110/220, 380/500, 110/220, 220, 240
	AC	60	110/220, 220, 230, 240
	DC		220, 110/220
Suriname	AC	60	220, 440
	AC	50	125
Uruguay	AC	50	220
Venezuela	AC	50	110/220, 120/240
	AC	60	110
Europe			
Aegean Islands	AC	50	127/220
	DC		220
Albania	AC	50	230, 220/380, 125/220, 220,125
	DC		125/150

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Austria	AC	50	220/380, 125/220, 120, 110,220
	DC		110/220
Azores Islands	AC	50	220/380, 110, 220
	AC	60	220
	DC		220
Belgium	AC	50	220, 115/220, 220/380, 110/190, 220/390/500, 127/220, 120/220, 130/220
	DC		110, 220, 220/440, 110/220
Bulgaria	AC	50	220/380, 150/220, 120/220
	DC		440
Canary Islands	AC	50	115/190, 110/220
Channel Islands	AC	50	230, 230/400, 240
	DC		210
Corsica	AC	50	127/220, 120/200
Crete	AC	50	127/220
	DC		220
Cyprus	AC	50	110, 220
	DC		220
Czechoslovakia	AC	50	200, 110/220, 110/220/380
Denmark	AC	50	220, 220/380, 110/220, 127/220
	DC		220, 240, 110/220, 220/440
England	AC	50	240/415, 230, 230/400, 210/365, 200/400, 230/415, 230/400, 100/200, 230/460, 210/250, 210/420, 227/380

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
England (cont.)	DC		240/480, 230, 230/460, 250/500, 500, 460, 220/440, 200/400, 200, 210/420
Estonia	AC	50	220/380, 110, 200/380
	DC		110, 200
Finland	AC	50	110/127, 220/230, 127/220, 120/208, 220/380, 115/220
	DC		110
France	AC	50	115/200, 110/115, 120/190, 120/210, 110, 110/190, 120/280, 110/190/240, 125/215,115/208
	AC	25	110, 115/200
	DC		110, 120, 110/220
Germany	AC	50	220, 220/380, 120/210, 110/220, 125/220, 127/220
	DC		220, 110, 220/440, 160/320, 600
Gibraltar	AC	50	110/240
	AC	76	110/240
	DC		440
Greece	AC	50	220, 220/380, 127/220
	DC		220
Hungary	AC	50	238/380, 110/220, 115/220/380, 110/190, 150/260, 120/210
	AC	42	105
	DC		150/300
Iceland	AC	50	220

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Ionian Islands	AC	50	127/220
	DC		220
Ireland	AC	50	220/380, 220/250, 200/220
Isle of Man	AC	50	230
	DC		230
Italy	AC	50	160/280, 150/260, 145/250, 127/220, 120/120, 160/220/280
	AC	42	127/220, 125,220
	AC	45	125/220
	DC		150/300
Latvia	AC	50	220/380
	DC		220
Lithuania	AC	50	220/380
	DC		110/220, 200/440
Luxembourg	AC	50	110/220
	AC	60	110/220
	DC		110/220
Madeira Islands	AC	50	220/380
	DC		110, 220
Mallorca Islands	AC	50	220/380
Malta	AC	50	100
	AC	100	100/200
Menorca Island	AC	50	110/125/220
Monaco	AC	42	110/115
Netherlands	AC	50	220/380, 127/220, 127/216, 127/200, 125/216, 150/260, 120,208
	DC		220
Northern Ireland	AC	50	220

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Norway	AC	50	220, 230, 130/220, 150
	AC	45	220
	DC		220
Poland	AC	50	220/380, 110/220, 115/200, 220, 127/220, 120, 300, 135/240, 120/220
	DC		110/220
Portugal	AC	50	127/220, 110/190, 110/220, 220/380
	AC	60	110/220
	DC		220
Romania	AC	50	220/380, 120/208, 220/220, 125/125
	AC	42	150/150, 110/110, 185/320
	DC		220/440
Scotland	AC	50	230/400, 240/415, 230/250, 230/400, 200/346, 230, 250, 230/400/460, 220/250, 200/400
	DC		220/440, 240/480, 230, 400
Spain	AC	50	125, 115, 125/215, 127/220, 120/210, 110/220, 210/220, 125/220, 110/125/220, 110, 150, 150/260
	DC		110, 150, 125, 110/220, 130/260, 150/300
Sweden	AC	50	127/220, 220, 220/380, 110/190, 110/220
	AC	60	110

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Sweden (cont.)	AC	25	220
	DC		127, 220, 120
Switzerland	AC	50	220, 220/380, 125/220, 110/190, 145/250, 250/435, 250/325
	DC		160, 220/440
Trieste	AC	50	127/220
Wales	AC	50	230/400, 200/230, 220
	DC		230/460, 230
Yugoslavia	AC	50	220, 220/380
Asia			
Afghanistan	AC	50	220, 115/200
	AC	60	230
Bahrain	AC	50	230/400
Burma	AC	50	420, 220
	AC	60	220
Cambodia	AC	50	110/190, 220
China	AC	60	110/220, 110/190, 220/380, 200/350
	AC	50	220/380, 110/220, 135/234, 220, 230/380, 110, 200/350, 110/190, 120/200, 200/346, 230/400, 250/440, 220, 230, 220/440
	DC		220/440, 230/460, 220, 225/450, 250/500, 230
Iran	AC	50	220/380, 220
	AC	60	110
	DC		110

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Iraq (Power systems in Iraq were extensively damaged in 1991. New systems may have different voltage and frequency.)	AC	50	200, 220, 230/440, 230/400
Israel	AC	50	220, 220/380
Japan	AC	50	105/210, 100/110, 100, 100/200, 110/210
	AC	60	110/200, 100, 110/220, 100/200
	AC	40	110/200
Jordan	AC	50	220/380
Korea	AC	60	220, 110, 110/220
Kuwait	AC	50	240/415
Laos	AC	50	115
Lebanon	AC	50	110, 110/190, 220, 220/380
Nepal	AC	60	120/220, 380/440
Okinawa	AC	60	110
Pakistan	AC	50	230/400, 220, 220/380, 230/400
	DC		220
Russia	AC	50	120/210, 220/380, 220, 110, 120, 110/220, 127/220, 217/380, 125/215, 120/220, 110/220
	DC		110/220, 250/500, 220/440
Saudi Arabia	AC	60	110, 127/220, 120/208, 110/220
Singapore	AC	50	220
Sri Lanka	AC	50	230/400, 220/230, 230/416, 240/416
Syria	AC	50	110, 110/190
	AC	60	110

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Taiwan	AC	60	110, 200
Thailand	AC	50	220, 110/220, 110
	DC		220, 110
Turkey	AC	50	220/380, 220, 110/190
Vietnam	AC	50	120/210, 120/208, 115, 120/200
Yemen Arab Republic	AC	50	127/220
Africa			
Algeria	AC	50	110, 127/220, 220/380
Angola	AC	50	220
Benin	AC	50	230/400
	DC		220
Burkina Faso	AC	50	230/400
Cape Verde	DC		220, 230, 240, 280
Djibouti	DC		220
Egypt	AC	50	200/6000, 110, 110/3000, 220, 200/3000, 110/200, 220/6000, 110/220, 200/3300, 110/3000
	AC	40	110, 220
	DC		220/440
Ethopia	AC	50	110/220, 110/125, 220/240, 127/220
Ghana	AC	50	230/400, 220/380
	DC		220, 220/440
Guinea	AC	50	230, 230/400, 115/200
Ivory Coast	AC	50	230
	DC		220
Kenya	AC	50	240/415, 220/440

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Liberia	AC	60	13,000, 110/220
	AC	50	200
Libya	AC	50	125/220
Madagascar	AC	50	220, 115/200, 120/208, 110/220
Malawi	AC	50	230/400
Mali	AC	50	115/200, 230/400
Mauritania	AC	50	115/200
Mauritius	AC	50	230
Morocco	AC	50	110/220, 127/220, 115/220, 115/200
Mozambique	AC	50	200, 240
	DC		240
Niger	AC	50	230/400
Nigeria	AC	50	230/400, 230
Reunion Island	AC	50	220/310
Senegal	AC	50	127/220, 115/200
Seychelles	DC		220
Sierra Leone	AC	50	230/400
Somalia	DC		110
Tanzania	AC	50	240, 230/400, 220/380
	DC		230
Tunisia	AC	50	110/190, 220/380, 115/200, 127/220
Uganda	AC	50	240/415
South Africa	AC	50	220/380, 200/400, 200/347, 220, 200/220, 120/200, 240/416, 250
	DC		230/460
Zaire	AC	50	220, 220/380
Zambia	AC	50	230/400, 220/380

Table C-1 (continued). Frequency and voltage in foreign lands and US territories

Country	Type of Current (AC or DC)	Frequency (Hz)	Voltage
Zanzibar	DC		220
Zimbabwe	AC	50	230/400, 200/380
Australia and Oceania			
Australia	AC	50	240, 240/415, 230/400, 240/480
	AC	40	250/440, 110/200/550, 250
	DC		600, 240/480, 480, 220
Fiji	AC	50	240/415
	DC		240/480
Guam	AC	60	110/220
Indonesia	AC	50	127/220, 127/190, 125/200, 125, 110/125, 115/200
Kirabati	DC		240/480, 500
New Caledonia	AC	60	125/220
	AC	50	110/120
New Guinea	AC	50	110/220, 240/415
New Zealand	AC	50	230, 230/400, 220/240
Philippines	AC	60	110/220, 220
Tuamotu and The Society Islands	AC	60	110
Samoa	AC	50	110/220
Sarawak	AC	50	230/400

GLOSSARY

1SG
first sergeant

AC
alternating current

AFCS
Army Facilities Components System

air switch
a no-load disconnecting device

ampacity
the current-carrying capacity of a conductor

amperage
current

AR
Army regulation

ASG
area support group

ATTN
attention

BOM
bill of materials

breaker
circuit breaker

C^3I
command, control, communications, and intelligence

cable
a multistrand conductor used in power transmission and distribution systems

CCV
centralized control van

CESP
Civil Engineer Support Plan

CINC
commander in chief

circuit breaker
a device that can be used to open and close an electrical circuit and that will open automatically to protect the circuit without damage to itself

CO
contingency operations

commercial power
power produced by a commercial power plant

COMMZ
communications zone

continuous output capacity
a power plant's rated capacity to produce continuous power for a long period of time

CONUS
continental US

CONUSA
continental US Army

COR
contracting officer's representative

CPM
critical path method

CPT
captain

current
the time rate of flow of electrical charge through a conductor; the basic unit of current is the ampere or amp

CZ
combat zone

DA
Department of the Army

DC
direct current

DCO
defense coordinating officer

DCSOPS
Deputy Chief of Staff for Operations

derate
to reduce output capacity due to uncontrollable circumstances such as elevation, humidity, or ambient temperature

DISE
distribution illumination set, electrical

distribution network
also called distribution system; an electric system or portion thereof that delivers electric energy from transmission substations or the bulk power system to the users

distribution panel
a collection of overload protective devices connected to buses where a power supply is subdivided into feeders and/or branch circuits.

distribution transformer
a transformer for transfering power from a primary distribution circuit to a secondary distribution circuit or a user's service circuit

DOD
Department of Defense

DOMS
Director of Military Support

DS
direct support

EAC
echelons above corps

electrocution
death caused by electric shock

ENCOM
engineer command

FCO
federal coordinating officer

FM
field manual

FORSCOM
Forces Command

frequency
the number of complete oscillations per second of alternating current

generator
an electromechanical device that converts mechanical energy into electrical energy

GFCI
ground fault current interrupt

GP
general purpose

GPH
gallons per hour

grid
a power transmission and distribution system

GS
general support

hertz
cycles per second

HHD
headquarters and headquarters detachment

HQ
headquarters

HSS
health service support

Hz
Hertz

JCS
Joint Chiefs of Staff

JTF
joint task force

kilowatt
1,000 watts

km
kilometers

kva
kilovoltamperes

kW
kilowatts

load
electrical power received by a device or devices on a circuit

load center
a distribution panel located at the assumed center of the load

load survey
a preliminary study conducted to determine type, quantity, and quality of power required for a particular application or system

LTC
lieutenant colonel

MACOM
major Army command

MAJ
major

medium voltage
voltage between 600 and 5,000 volts

megawatt
1,000,000 watts

MHE
materials handling equipment

MOS
military occupational speciality

MSG
master sergeant

MW
megawatt

NCO
noncommissioned officer

NCOIC
noncommissioned officer in charge

NEC
National Electrical Code

NESC
Nation Electrical Safety Code

NLT
no later than

NTG
nontactical generator

OPCON
operational control

OSD
Office of the Secretary of Defense

OSHA
Occupational Safety and Health Administration

peak capacity
the maximum output capacity of a power plant

PKO
peace-keeping operations

PM-MEP
Program Manager - Mobile Electric Power

POC
point of contact

power
the time rate of doing work; electrical power is measured in watts

power bus
one or more conductors that serve as a common connection for two or more circuits in a switchgear assembly

primary terminals
the connecting terminals on the high voltage side of a distribution transformer

prime power
power that is continuously generated

protective devices
devices such as breakers and fuses which serve to protect a circuit from overload

resistivity
the tendency to resist the flow of electricity

RT
rough terrain

S-1
personnel/administrative staff section

S-2/S-3
security and operations staff section

S-4
logistics staff section

SAO
Security Assistance Organization

secondary terminals
the connecting terminals on the low voltage side of a distribution transformer

service entrance
all components between the termination point of the overhead service drop or the underground service lateral and the building main disconnecting device with the exception of the utility company's metering equipment

service entrance equipment
equipment located at the service entrance that provides overcurrent protection for the feeder and service conductors and provides a means of disconnecting the feeders from energized service conductors

SFC
sergeant first class

SGT
sergeant

switchgear
switching or interrupting devices and their associated control, instrumentation, metering, protective, and regulating devices; also refers to assemblies of these with associated interconnections, supporting structures, enclosures, and accessories

TA
theater army

TAACOM
theater army area command

TACGENS
tactical generators

TM
technical manual

TO
theater of operations

TOE
table of organization and equipment

USACE
US Army Corps of Engineers

USAES
US Army Engineer School

voltage
electrical potential or electromotive force; basic unit of voltage is the volt

watt
the basic unit of electrical power; power (in watts) equals voltage (volts) multiplied by current (amperes)

XO
executive officer

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