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MILITARY HANDBOOK

POWER AND ENVIRONMENTAL CONTROL FOR THE PHYSICAL PLANT OF DOD LONG HAUL COMMUNICATIONS

VOLUME I OF 2 VOLUMES

POWER

NO DELIVERABLE DATA REQUIRED
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SLHC

DEPARTMENT OF DEFENSE
Washington, DC 20301

MIL-HDBK-411A
Power and Environmental Control
for the Physical Plant of
DoD Long Haul Communications
VOLUME I, POWER

1. This standardization handbook has been developed by the Defense Communications Engineering Center (DCEC) of the Defense Communications Agency (DCA), in accordance with the Defense Standardization and Specification Program (DSSP).

2. This publication was approved on 8 July 1982 for printing and inclusion in the military standardization handbook series.

3. This volume provides information and technical guidance on the special requirements and considerations for the design and construction of power systems for Defense Communications System (DCS) facilities.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, Defense Communications Agency, ATTN: Code J110, 1860 Wiehle Avenue, Reston, VA 22090, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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FOREWORD

1. Volumes I and II of this handbook supersede MIL-HDBK-411, dated 21 May 1971. Volume I replaces those portions of the superseded handbook which deal with power systems for Defense Communications System (DCS) facilities. Volume II of this handbook replaces the remaining portions of the outdated handbook which are concerned with environmental control systems for DCA communications facilities.

2. As defined in Department of Defense Directive 5105.19, "The DCS is a composite of DoD-owned and leased telecommunications subsystems and networks comprised of facilities, personnel, and material under the management control and operational direction of the DCA. It provides the long haul, point-to-point, and switched network telecommunications needed to satisfy the requirements of DoD and certain other government agencies."

3. This part of the handbook provides technical guidance for use in the initial design, installation, upgrade and acceptance of power systems for Department of Defense (DoD) communications facilities.

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1. SCOPE

1.1 Purpose. This handbook is to provide technical guidance for the design and upgrade of power facilities within the physical plant of the Defense Communications System (DCS). This handbook is intended for use in the engineering design and installation of new power systems and equipment and also in the upgrading of existing systems and equipment.

1.2 Application. This handbook applies to government-owned and operated power systems and equipment, government-owned and contractor-operated power systems and equipment, and other power facilities provided by DoD resources.

1.3 Objective. To provide guidance to the Military Departments and other supporting activities of the DCS by delineating the criteria and standards for electric power systems. This guidance is to assure DCS subsystems are supported by a reliable, efficient, and maintainable power system.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATION

FEDERAL

FED-SPEC-W-L-305D	Light Set, General Illumination (Emergency or Auxiliary).

STANDARDS

FEDERAL

FED-STD-1037	Glossary of Telecommunication Terms

MILITARY

MIL-STD-188-124	Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems
MIL-STD-461B	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-633E	Mobile Electric Power Engine Generator Standard Family Characteristics Data Sheet.

HANDBOOKS

MILITARY

MIL-HDBK-419	Grounding, Bonding and Shielding for Electronic Equipments and Facilities.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NFPA 70-78	National Electrical Code

(Application for copies should be addressed to Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120 or to the National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110).

DCAC 350-195-2	Exercise of Auxiliary Electric Power Systems.
DoD 4270.1-M	Construction Criteria

(Copies of DCA Circulars and DoD Manuals should be obtained from the procuring activity or as directed by the contracting officer).

3. DEFINITIONS

3.1 Definition of Terms. Definition of terms used in this handbook shall be as specified in FED-STD-1037.

4. SYSTEM DESIGN AND ENGINEERING REQUIREMENTS

4.1 Physical plant systems. Physical plants should be designed to provide dependable, high quality, electric power to assure continuity of communications. The quality of electric power supporting digital, synchronous, and automated switching equipment at major communications facilities should be free from power abnormalities, which cause loss of synchronization, discontinuity of the switching function, or physical damage to the electronic equipment. The power requirements of the communications and support equipment must be known and considered during all phases of the physical plant design. The four classes of electric power and station load hierarchy are depicted in Figure 1.

4.2 Power systems. Power systems should be designed to provide the specific power characteristics required by each Defense Communications System (DCS) facility. This involves judicious selection of the primary and auxiliary power sources, UPS or other power conditioning equipment, secondary substations, and the distribution system to attain the maximum overall system performance with the most cost effective design. Initiative and engineering judgment must be exercised, considering the assigned mission in each individual case. The information contained herein is for guidance, assistance, and to indicate acceptable engineering practices. The guidelines herein should be employed for new construction and modernization projects and radical departures from these guidelines will be the subject for discussion with the cognizant Military Department Engineering Office. There are a considerable number of voltage and phase arrangements in use in DCS facilities to fulfill currently-installed electronic equipment demands. Facilities required to use host country power having nonstandard frequency and voltage must be specially engineered to meet electronic equipment requirements. All designs and upgrade of DCS power systems which require auxiliary power generating sources, such as diesel generators, should consider and, if possible, use the DoD Standard Family of Mobile Electric Power Generating Sources defined in the current edition of MIL-STD-633. All power and lighting systems supporting the DCS should be designed to meet the requirements of the National Electrical Code.

4.2.1 System design considerations. In planning and engineering of Government-owned power systems, the following must be considered: simplicity, reliability, flexibility, operability, maintainability, quality, cost effectiveness, synchronization, location, protection and safety, contingency planning, status indicators, types of sources, power conditioning, UPS, electromagnetic compatibility, survivability, recoverability, and environment.

4.2.1.1 Simplicity. The power system should be of uncomplicated design, consistent with established requirements and assigned mission. Complex circuitry and switching schemes should be avoided. Distribution circuits and system components should be protected by positive-acting protective devices capable of selective coordination throughout the primary distribution and secondary power and lighting system.

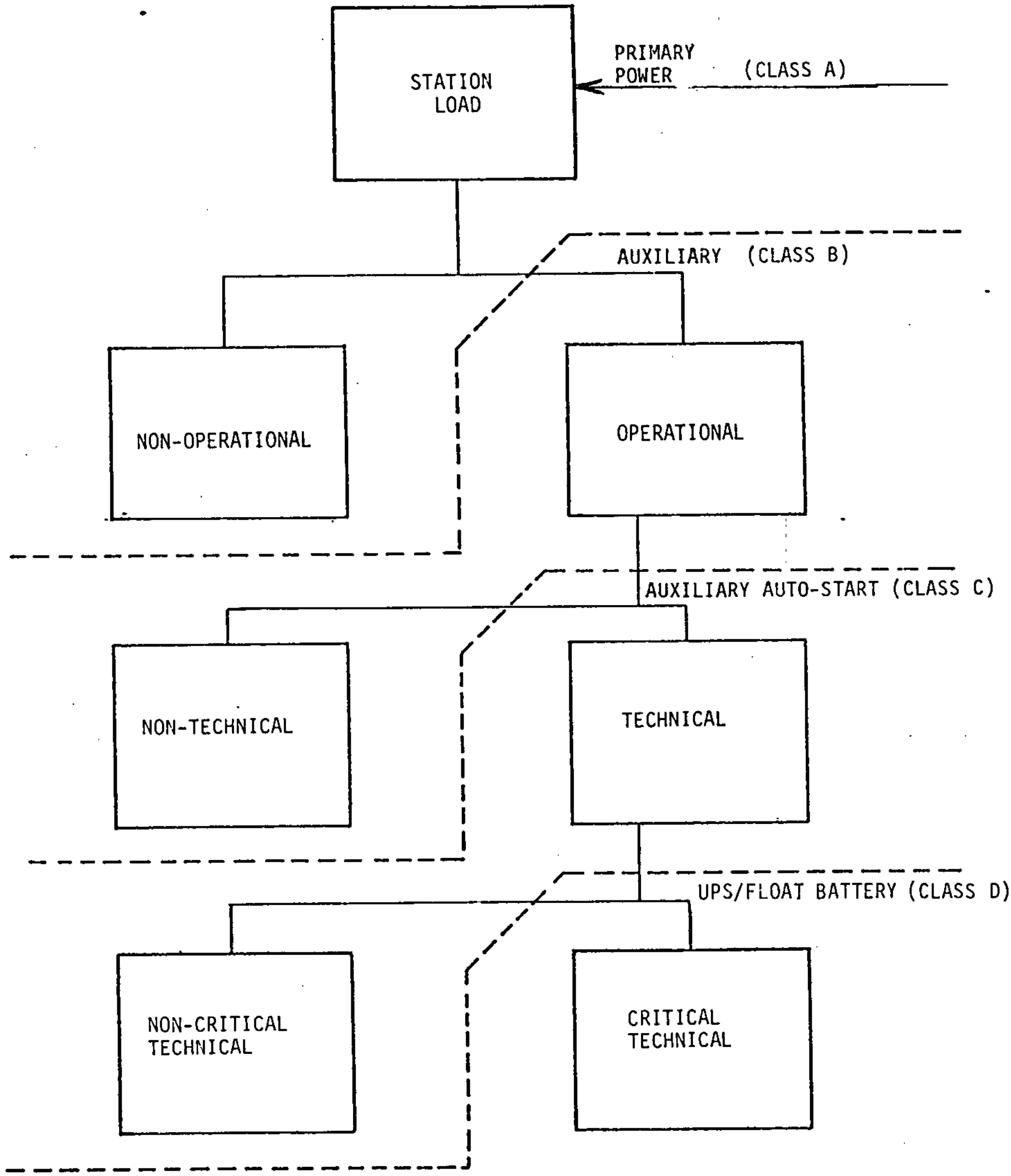

FIGURE 1. Station load hierarchy and classes of power.

4.2.1.2 Reliability. The primary power source and distribution system should be engineered and designed to provide optimum reliability at the lowest overall cost, considering initial installation, maintenance, and operation. Reliable power systems usually require auxiliary power supplies which will include emergency generators and UPS. The amount and class of auxiliary power required at facilities is determined by the degree of reliability dictated by strategic and operational considerations.

4.2.1.3 Flexibility. The system should be capable of providing and distributing the present load and be readily reconfigured to accommodate anticipated mission activity and improvements. Operational flexibility requires alternate sources, feeders, buses, switching arrangements, and testing arrangements.

4.2.1.4 Operability. Complex operating schemes should be avoided. Switching operations may be either manual or automatic, and be as simple as possible. Positive checks to reduce the possibility of error to a minimum should be included.

4.2.1.5 Maintainability. The power system and internal distribution systems should be designed to enable any facility to remain in service during de-energization of selected system components for maintenance, testing, and replacement of parts. Failure of any one major component (transformers, prime power source, auxiliary power source, or secondary switchgear) of the power system should not cause the facility to become non-operational. Strategically placed test points should be included to enhance troubleshooting and problem isolation.

4.2.1.6 Quality. The primary and secondary system delivering power to voltage and frequency sensitive electronic equipment should be engineered and designed to provide the quality of power required as indicated herein. Auxiliary equipment, such as air conditioning, ventilating systems, and pumps are inherent transient-creating sources, during starting conditions. These equipments should, therefore, be electrically isolated from electronic equipment to the degree required to prevent their operation from adversely affecting the communications-electronics (C-E) equipment operation. In no case should the transient producing motor driven equipment be served from the same distribution panel as sensitive C-E equipment. Current technological trends in C-E equipment requires an increase in the quality and decrease in quantity of electric power.

4.2.1.7 Cost effectiveness. Design factors should be applied so as to result in a power system of optimum cost and maximum operating efficiency.

4.2.1.8 Synchronization with primary power. Capability of synchronizing auxiliary power plants with primary power to permit assumption of technical load by an auxiliary power plant or to return from auxiliary power to primary power after a power failure, without interruption of power, is a requirement for DCS facilities. As a minimum, the synchronizing and transfer system should be manually activated, while the preferred method would operate automatically after a predetermined and adjustable time following the return

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of primary power. Where a synchronizing agreement cannot be obtained with a power company, special switching should be provided which will permit transfer from primary to auxiliary power or vice versa in the shortest practical time. Electrically operated circuit breakers may be required to permit synchronizing with commercial power.

4.2.1.9 Location. The general location of the various power sources should be as described in the following paragraphs:

a. The primary power plant, if required, should be located within the station boundary yet remote from the station boundary line to provide physical security and also sufficiently removed to ensure an acceptable noise level to administrative, communications and other work areas, and from any receiver site to minimize interference effects.

b. The primary substation should be located remote from the station boundary line a sufficient distance to provide physical security. The location should be convenient for accepting delivery of power from an off-station source and distribution of power to the on-station facilities.

c. The distribution substation should be contiguous to or a part of the operating building it serves, or the distribution feeders from the distribution substation to the communications facility should be underground.

d. The auto-start plant, Class C, and the uninterruptible power system, Class D, should be located in the immediate vicinity of, or adjacent to, the operating building they serve. Where Class C and D units are both provided, they may be installed in a common building. Consideration should be given to installing solid state UPS in an environmentally controlled room only for tropical locations and other adverse environmental conditions or when recommended by the UPS manufacturer. When power plants are placed contiguous with operating buildings, the generating units should be placed on isolated foundations to prevent transfer of engine vibrations to the building.

4.2.1.10 Protective devices and safety. Feeders and branch circuits should have circuit protective devices coordinated to ensure disconnection of the faulted circuit as close to the fault as practicable. Guards for live parts and protective devices should be installed and identified in accordance with the safety requirements of the National Electrical Code. Grounding must conform to the standards set forth in MIL-STD-188-124; grounding, bonding and shielding engineering and installation guidance for communications facilities is contained in MIL-HDBK-419. Transient Protectors, such as Metal Oxide Varistors (MOV), should be installed to provide transient-voltage protection for transient-sensitive equipment. The location for installation of protectors is shown in Figure 2. For low voltage power distribution, three basic ratings of MOV's (Series L, Series PA, and Series HE) are available and are designated in the order of increasing energy absorbing capability (in joules). Series PA is recommended for low voltage power distribution feeder and Series L for installation in branch circuit panelboards.

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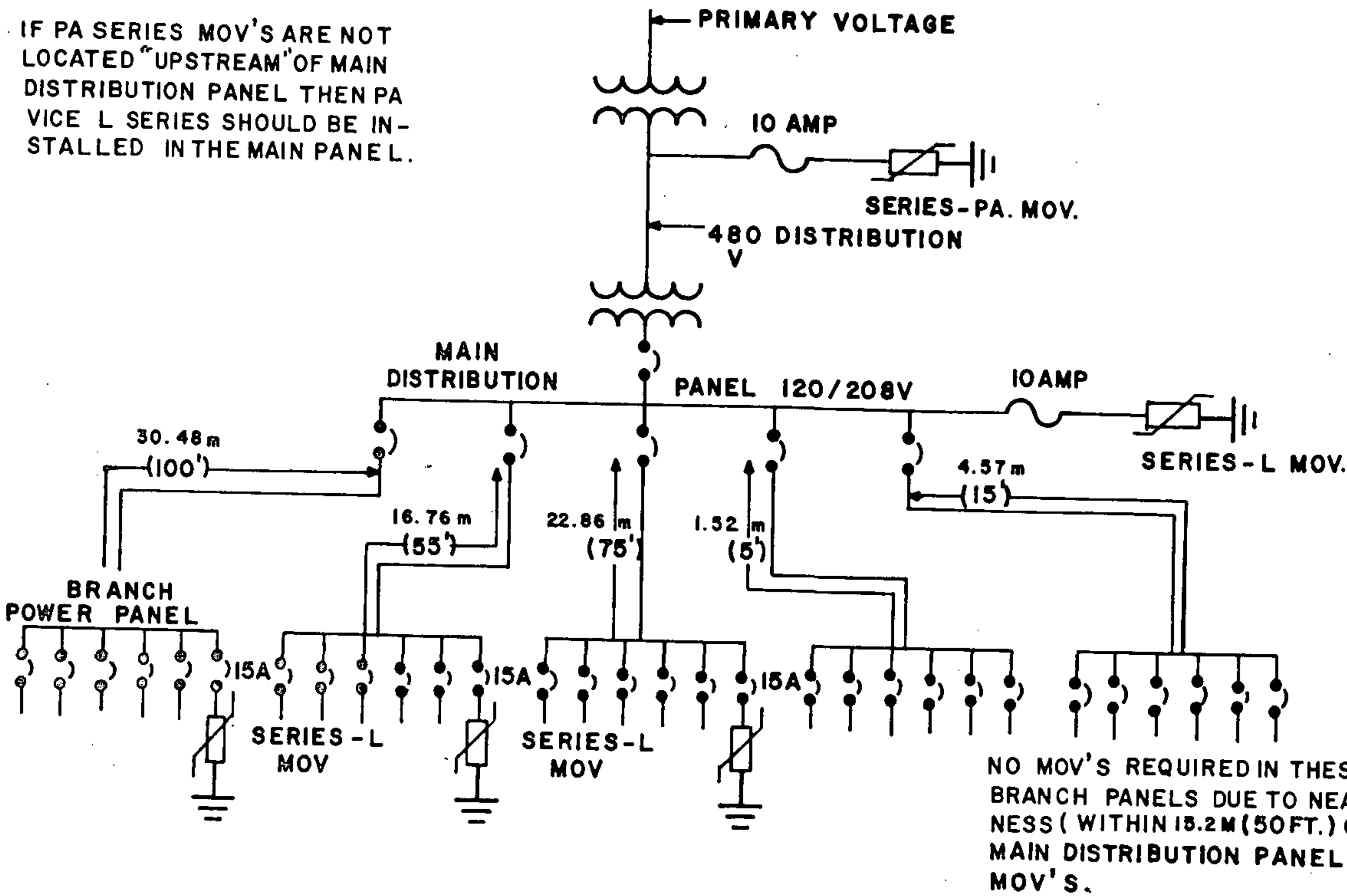


FIGURE 2. Metal oxide varistor (MOV) installation locations.

4.2.1.11 Load shed and restoration. A load shed and restoration plan should be developed and an operating procedure established for sequential load shedding and load restoration of power from Class A, B, C, and D power sources. This plan should cover load shedding, normal and bypass switching, where appropriate, and also include synchronizing requirements. Periodic scheduled testing of Class B, C, and D power sources under simulated or actual load conditions should be performed, in accordance with DCAC 350-195-2. These tests are performed to assure that the power systems are reliable and are in an operable condition. All operating aspects of Class D units should be fully automatic.

4.2.1.12 Power system status panel. A power status panel with appropriate meters and alarms should be provided in the control area of each operating building to indicate voltage and frequency delivered to the critical technical loads. Audible and visual alarms should be provided on the panel to indicate when controls have initiated starting of the auxiliary power units. Additional alarms should be provided to indicate the malfunction of unattended auxiliary power units. An alarm acknowledge capability, either automatic or manual, should be provided in order to inhibit the audio alarms once the operator knows an alarm condition exists.

4.2.1.13 Multiple primary sources. A primary power substation equipped with a dual supply, dual transformers, and sectionalized bus may be approved as an acceptable primary power source. An on-site power plant, consisting of an adequate number of generating units may, if cost-effective, be approved as a primary power source, subject to the provision of adequate operational and maintenance procedures. Bus segregation may be employed where an appreciable gain in reliability or an assurance of reduced power discontinuity may be attained by isolating the technical and nontechnical loads.

4.2.1.14 Uninterruptible power systems (UPS), Class D. An UPS, designed to provide continuous high quality power without transients, should be installed to serve only critical electronic equipment that cannot tolerate power outages.

4.2.1.15 Float battery systems. The float battery system is the most economical and reliable method to provide continuous dc power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide dc power, long-range communications plans call for an increased use of dc-powered electronics.

4.2.1.16 Power conditioners. A motor-generator set, solid-state frequency converters, isolation transformers, or line voltage regulators are used in the power system for the purpose of changing the primary frequency, attenuating transients and suppressing power line noise. The use of power conditioners in lieu of UPS will depend on the ability of the electronic equipment served to tolerate occasional power outages.

4.2.1.17 Electromagnetic compatibility. The power system should be designed to prevent electromagnetic interference to the communications system it serves. The power system must comply with applicable Class A3 and C2 requirements contained in MIL-STD-461B.

4.2.1.18 Survivability. Building construction, component selection, and system location can contribute to the survivability of an electrical power system. Operational requirements of particular DCS facilities will dictate specific survivability criteria, but many basic considerations can be made during the design of the power system which will enhance overall survivability without a major impact on cost.

4.2.1.19 Recoverability. Operation of the DCS in various political environments results in a number of unplanned facility closures and/or relocations. Major components of power facilities should be designed to be recoverable whenever possible, so that cost savings and operational flexibility can be attained when facility relocation is required.

4.2.1.20 Environment. Consideration of the climatic conditions of the system location must be included in the selection of auxiliary power sources. Operation at high altitudes, as well as at high ambient temperatures, degrades engine performance. Power sources housed in buildings must have sufficient ventilation to assure reliable operation by presenting overheating, as well as means to keep the generating source warm during extremely cold temperatures.

4.2.2 Primary power. Primary Class A power may be furnished by an off-station source (a commercial company or a Government-owned power system) or generated locally at the facility. The power source should be determined from an economical and technical analysis of all available power sources and the analysis should consider and include combinations of renewable energy sources.

4.2.2.1 Off-station source. Off-station power will usually be delivered to the facility by the utility company. An investigation should be made of the supplier's ability to serve the present load and the expected load projected over the next five years. A study should be made in which system outages over the last five years are evaluated. The voltage and frequency stability and other system characteristics should be determined. In addition, commercial plants connected to the primary feeder must be studied to determine what transients or any erratic regulation condition they may impress upon the distribution system.

4.2.2.2 On-station source. The primary power plant should be initially designed with a capacity adequate for peak electrical power demand of the station. The individual generating units should be so sized that the units are normally operated in excess of 50% of rated capacity under any station demand load. Figure 3 illustrates a typical on-station Class A power system. The following factors should be considered in selecting the number of units employed in a station generator plant.

a. Where the total station demand load is over 400 kW, the minimum size unit employed should be 200 kW, wherever practical.

b. A minimum of two spare generating units are recommended; one unit being available for replacement of a failed unit and the other for scheduled maintenance.

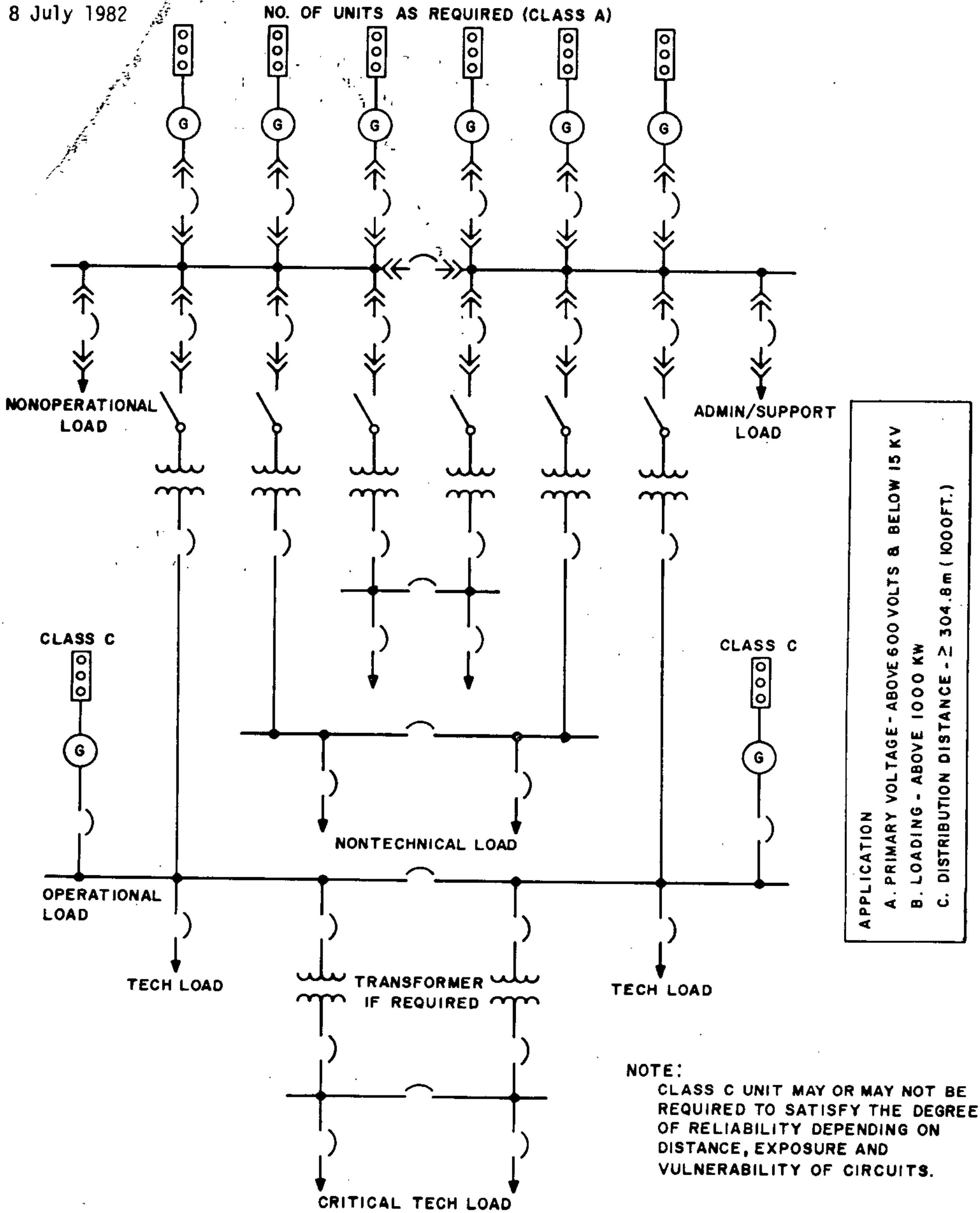


FIGURE 3. Typical power subsystem Class A plant (Split bus).

c. The total size of the fuel storage tank capacity should be determined by local replenishment conditions and should provide at least a 30-day supply. The storage tank(s) should be of fiberglass construction, when practical, installed underground on an incline for sediment accumulation. Provisions should be made for easy filling of the tank(s) and removal of water and other sediment.

d. Where transportable stations are included, Class C diesel units may be used as a primary power plant for a limited time period. These units should be replaced by Class A or B power sources, where long term operation is anticipated.

e. Utilization of waste heat from the water jacket and engine exhaust gas should be considered in the design of a primary on-station power plant.

f. Non-fossil fuel power sources should be used in facilities where the load and economical conditions permit or whenever mandated by mission requirements.

4.2.2.3 Power distribution. The primary power distribution system should be designed for the types of electrical loads shown in Figure 1. The loads should be segregated and duplex facilities such as transformers, feeders and circuit breakers, are considered necessary to provide the reliability and maintenance capability required for critical communications loads. Underground feeders should be used to enhance reliability and to avoid interference with the communications facility. The distribution system should include the standard protective relaying devices such as over-voltage relays, over-current relays and reverse power relays whenever the primary and auxiliary power systems are designed to operate in parallel. Aerial lines should not be installed within 61 meters (200 feet) of communications operation buildings, 366 meters (1200 feet) of receiver station antennas and 244 meters (800 feet) of other types of antennas. The distribution system of uninterruptible power systems should be designed to provide power only to critical loads. The requirements for UPS should be recognized at the inception of power project design. The distribution system for the administration area should be isolated from the technical load and provided by a separate feeder.

4.2.2.4 Equipment technical design considerations. Suggested minimum electrical performance parameters for DCS power subsystems.

4.2.2.4.1 Voltage. The most common voltages used by DCS equipment should be as follows:

Nominal System Voltage
(volts)
120 (single phase)
120/240 (three phase-three wire)
120/208 (three phase-four wire)
277/480 (three phase-four wire)

4.2.2.4.2 Frequency. The standard frequency is 60 Hz. Many types of electronic equipment and subsystems are designed to operate at 50 to 60 Hz. Where 50 Hz primary power is available, conversion to 60 Hz is required only for frequency sensitive electronic equipment. The steady state frequency tolerance should not exceed ±0.5% of system design frequency.

4.2.2.4.3 Power factor. The power generating source should be capable of providing service to a connected load with a power factor of 80 percent. Power factor should comply with DoD 4270.1-M and correction should be made if the power factor of the load is less than 85 percent at rated load.

4.2.2.4.4 Availability. The primary power supply, auxiliary power supply and distribution system should be engineered so as to provide 99.99% availability (exclusive of scheduled outages) to the technical load bus(es).

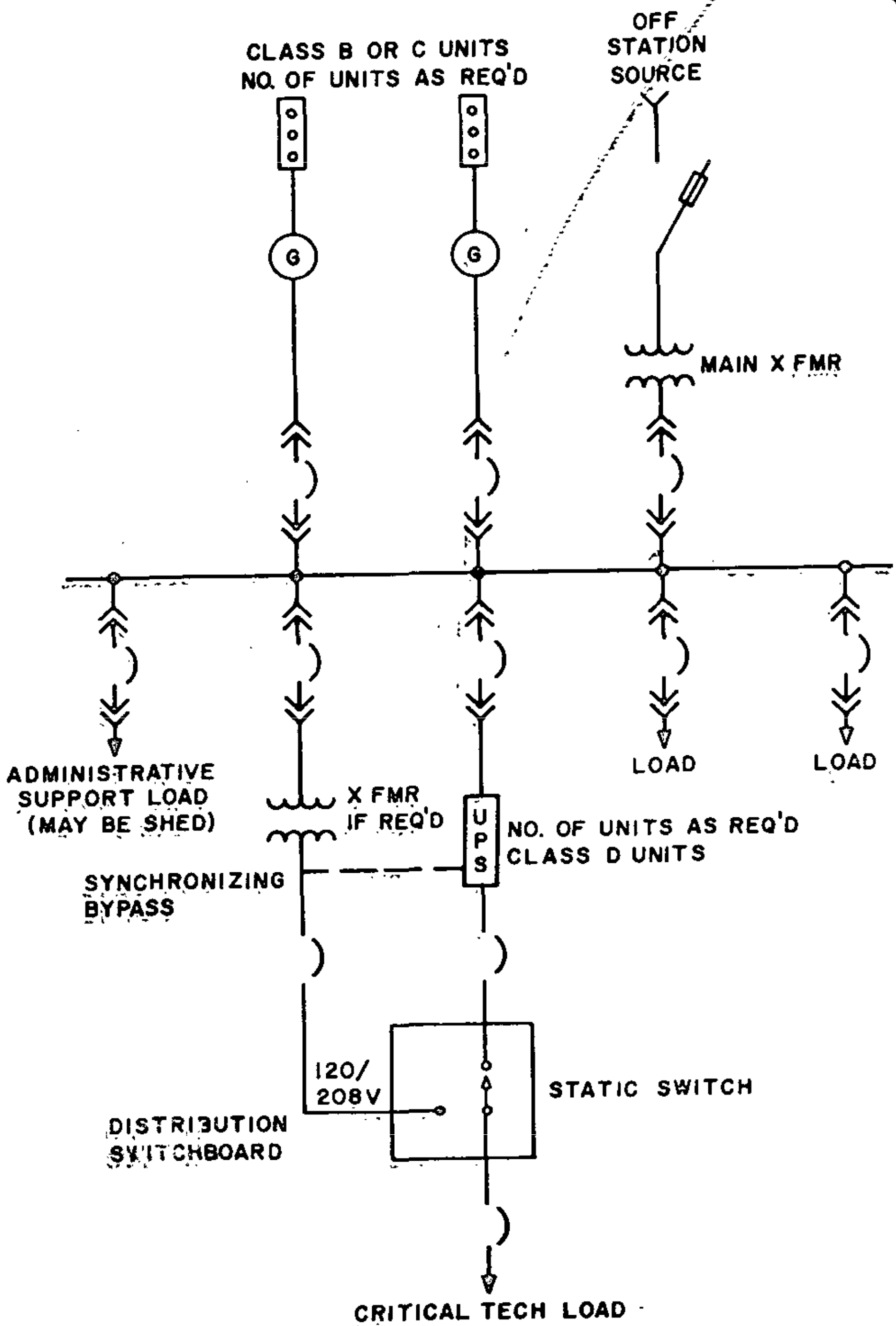
4.2.2.4.5 Mean time between failure (MTBF) and mean time between overhaul (MTBO). Realizing that the MTBF and MTBO varies with each type of equipment, the MTBF and MTBO should be specified individually for each power source. For DoD standard generator sets, the MTBF and MTBO are as specified in MIL-STD-633.

4.2.2.4.6 Steady state stability. Power systems should be designed to limit the steady state voltage stability to ±2.0% of the system design voltage and to ±0.5% of the system design frequency at any load from the maximum to the minimum steady state station load. In the case of commercial power, the steady state regulation should be evaluated in terms of operational impact and regulating devices provided, as required.

4.2.2.4.7 Dynamic or transient variation. Power systems should be designed to limit the dynamic or transient variation of power to the following limits: the maximum transient variation of the voltage delivered to the operational load bus should be within -20% and +10% of the system nominal voltage and the frequency within ±3.3% of the system nominal frequency. The duration of these transients should not exceed 500 milliseconds. In those cases where primary power interruptions or severe transients are appreciably worse than these limits, the primary power system should be investigated to determine corrective action required to meet the operational requirements of the system to be served.

4.2.3 Auxiliary power. The function of auxiliary power is to provide power for operation during interruption or extended degradation of primary power. All auxiliary generating power facilities should be designed for the existent load requirements. It is expected that the electronics and support loads requirements will continue to decrease as microelectronics influence the design of electronic and communications equipment. Therefore, to conserve energy and to maintain high operating efficiency, the auxiliary power source should be selected such that it will operate near rated capacity. Figure 4 illustrates Class B, C, and D systems.

4.2.3.1 Class B auxiliary power. A standby long term auxiliary power plant may be required where multiple commercial power feeders are not available or



APPLICATION
500 KW 120/208 V 152.4 m (500 FT.) MAX DISTRIBUTION DISTANCE
1000 KW 277/480 V 304.8 m (1000 FT.) MAX DISTRIBUTION DISTANCE

FIGURE 4. Typical power subsystem single off-station source with Class B, C, and D plants.

feasible to provide power, or where extended or frequent power outages may result from natural causes or sabotage. The criteria for a Class B plant are comparable to those of a primary power plant, except that only one spare generator set is required. It is expected that units in a Class B plant will operate between 1000 and 4000 hours annually. The size of the fuel storage should be determined by local replenishment conditions and should provide at least a 15 day supply. Since the cost of construction of Class B plant approaches that of a primary power plant (Class A) of equal size, the decision to provide a power installation requiring Class B service should be made only after a careful study. The Class B units should be capable of being started by an automatic control system. The autostart control system should be adjusted to start the prime mover when the primary power voltage varies more than ±10% or the frequency changes more than ±3.3%, after an adjustable time delay of approximately 5 seconds. The engines should be equipped with coolant preheaters to facilitate rapid start and load assumption. An alarm indicating such action should be sounded in the area where personnel responsible for manning the plant are stationed. The plant may be connected to the load automatically where practicable, and removed from the load manually by synchronizing and then paralleling with restored primary power, disconnecting electrically and shutting down.

4.2.3.2 Class C auxiliary power. The function of an autostart power plant is to provide rapid restoration of power to the technical load. It is expected that Class C units will operate less than 1000 hours per year. Where practicable, the nontechnical load should be served temporarily from the Class C plant. Spare Class C units should be provided for rotational maintenance and overhaul, where justified. The prime movers for these units should be equipped with ancillary equipment to assure that the load is assumed in the shortest practicable time (i.e., where liquid cooled diesel engines are used, they should be equipped with jacket water heaters and circulators and may use lube oil heaters to insure quick starting). The size of the fuel storage should be determined by local replenishment conditions, climate, geographical locations, and should provide at least a seven-day supply. The autostart control system should be adjusted to start the prime mover when the primary power voltage varies more than ±10% or the frequency changes more than ±3.3%, after an adjustable time delay of approximately 5 seconds or as otherwise dictated by operational requirements. Maximum use should be made of the established DoD Standard Family of Mobile Electric Power Generating Sources defined in the current editions of MIL-STD-633.

4.2.4 Uninterruptible power systems (UPS), Class D.

4.2.4.1 General. UPS are characterized by their ability to condition primary or auxiliary power to precise, high quality power, as required by the C-E equipment. UPS maintain continuous power even during periods of transfer from one power source to another or for a sufficient period to allow for an orderly shutdown. An UPS is required to maintain and provide continuous conditioned power to the critical C-E equipment and to provide protection from power line transients. To minimize power loss and to conserve energy, the UPS should be sized to support only the critical load and operate at a high efficiency. A solid state UPS consists of a rectifier/charger, batteries, inverter, synchronizing equipment, protective devices, static switches and other accessories. Continuity of power during emergency periods of power transfer is maintained by an energy storage battery. Solid state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single point failures are minimized by selection and proper configuration of solid state UPS. Reserve battery capacity of fifteen minutes is normally sufficient for UPS application, at which time the auxiliary power plant should be providing the input power.

4.2.4.2 <u>UPS configuration</u>. Several system configurations can be made which will provide continuous power to the critical bus. The advantages and disadvantages of the most common configurations are discussed below:

4.2.4.2.1 <u>Single UPS</u>. The single static UPS shown in Figure 5 has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices and an energy storage battery. This system also includes a static bypass circuit which automatically transfers the critical load to the alternate source of power without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. A failure of the UPS causes the static switch to transfer the load to the input source, thereby keeping the load on-line. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough so the load will not be disconnected; (b) the frequencies and voltages of the primary power and the inverter output must be the same.

4.2.4.2.2 <u>Parallel redundant system</u>. The system consists of at least two UPS operating in a load share mode. (See Figure 6). For protection, the output of each is normally connected to the bus through a static interrupter. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted, such as 50 Hz to 60 Hz, to serve the critical load.

4.2.4.2.3 <u>"Cold" standby independent UPS</u>. This configuration consists of two independent UPS with a common battery. One UPS is on-line and the other is in "cold" standby condition. Both UPS are equipped with static bypass circuits which will automatically transfer the critical load to the primary power or auxiliary power source without interruption, in the event that the operating UPS fails. The second UPS is then manually energized and placed in the bypass mode, and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the output of the UPS.

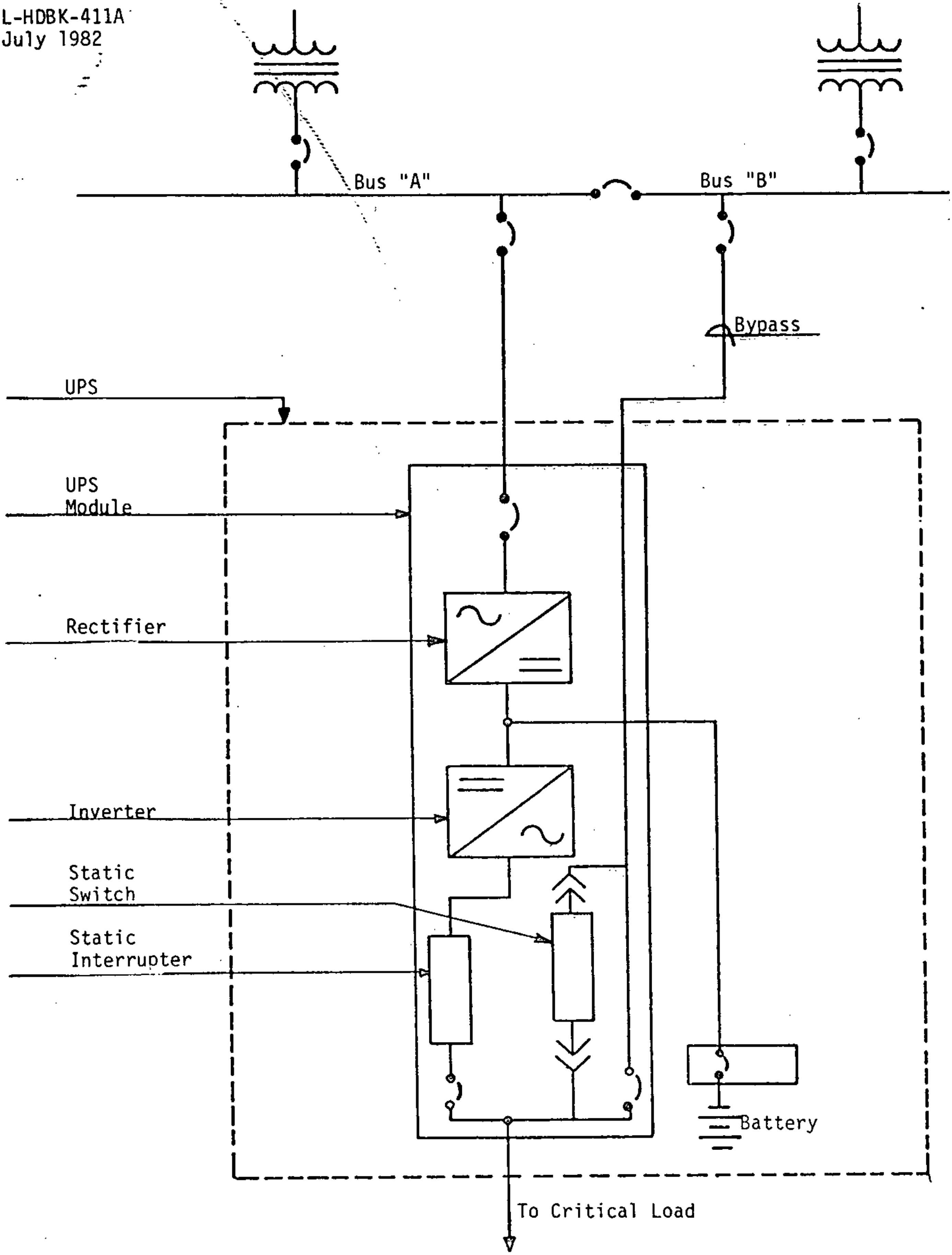


FIGURE 5. Single uninterruptible power system (UPS).

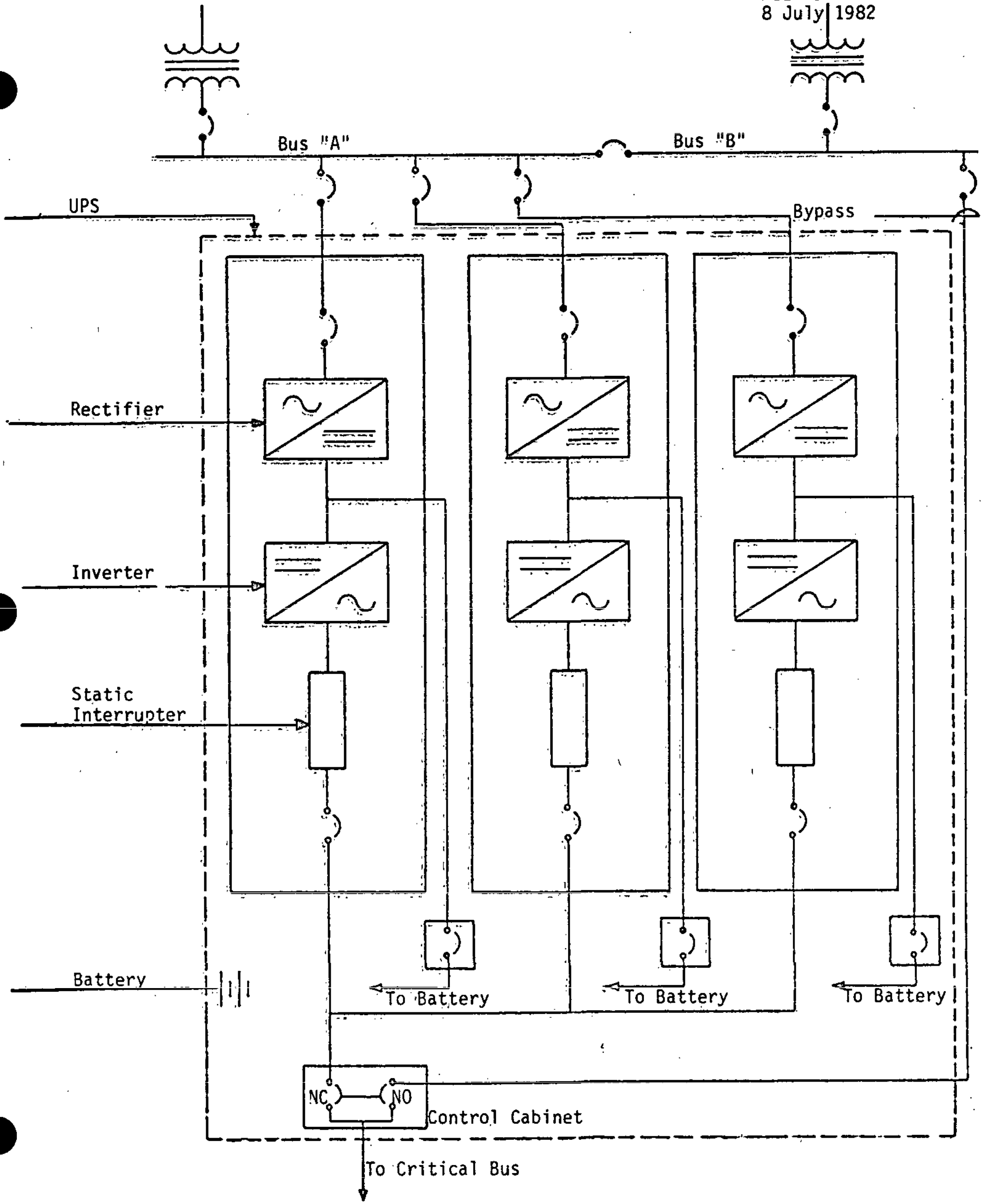


FIGURE 6. Parallel redundant uninterruptible power system (UPS).

4.2.4.3 Electric service and bypass connectors. Two separate electric services should be provided, one to the UPS rectifier circuit and the other to the UPS bypass circuit. Where possible, they should emanate from two separate buses with the UPS bypass connected to the technical (noncyclic) bus and the rectifier connected to the nontechnical (cyclic) bus. This connection provides isolation of sensitive technical loads from the effects of UPS rectifier harmonic distortion and motor start-up current inrush.

4.2.4.3.1 Electric service size. An UPS system is considered to be continuous type load, and service to both the rectifier and bypass circuits should be sized in accordance with the National Electrical Code Article 220. The required current for the rectifier circuit is calculated by using the UPS output rating divided by the UPS efficiency and multiplied by a load factor of 125 percent to take battery charging into account. The UPS bypass circuit may be rated for less current since both UPS losses and battery charging requirements need not be supplied.

4.2.4.3.2 Maintenance bypass provisions. Bypass provisions for maintenance of equipment are:

a. The single UPS has a built-in bypass circuit which can be manually activated to isolate the UPS module during emergency conditions or maintenance. This circuit is make-before-break and contains automatic synchronizing provisions.

b. Each module of the "cold" standby independent UPS has the same built-in bypass circuit provisions as the single UPS. Complete isolation of one UPS module (including its bypass) from the other module is inherent in the "cold" standby redundant configuration. (See Figure 7).

c. The parallel redundant UPS contains a built-in manual bypass circuit in the control cabinet which will serve to isolate the UPS modules during emergency conditions or maintenance. This manual bypass circuit provides make-before-break switching, and contains synchronizing provisions.

4.2.4.4 UPS distribution system. The UPS distribution should only serve the critical loads. Noncritical loads should not be connected to the UPS output. They should be served by separate distribution systems from either the technical or nontechnical bus, as appropriate. The critical load should be protected by installing fast-acting (microsecond) fuses in the load distribution panels to shorten the transient effects caused by load faults. Solid state transient suppressors, such as the metal-oxide type, should also be provided in the UPS distribution to suppress over-voltage transients caused by reactive load switching.

4.2.4.5 UPS and battery room. The UPS and associated battery should be installed in separate rooms. The construction should be of permanent type and the wall separating the UPS should be fire proof for a 1-hour rating. The battery room should be designed in accordance with Article 480 of the National Electrical Code and OSHA requirements. OSHA requires that facilities for quick drenching of the eyes and body be provided within 7.62 meters (25 feet)

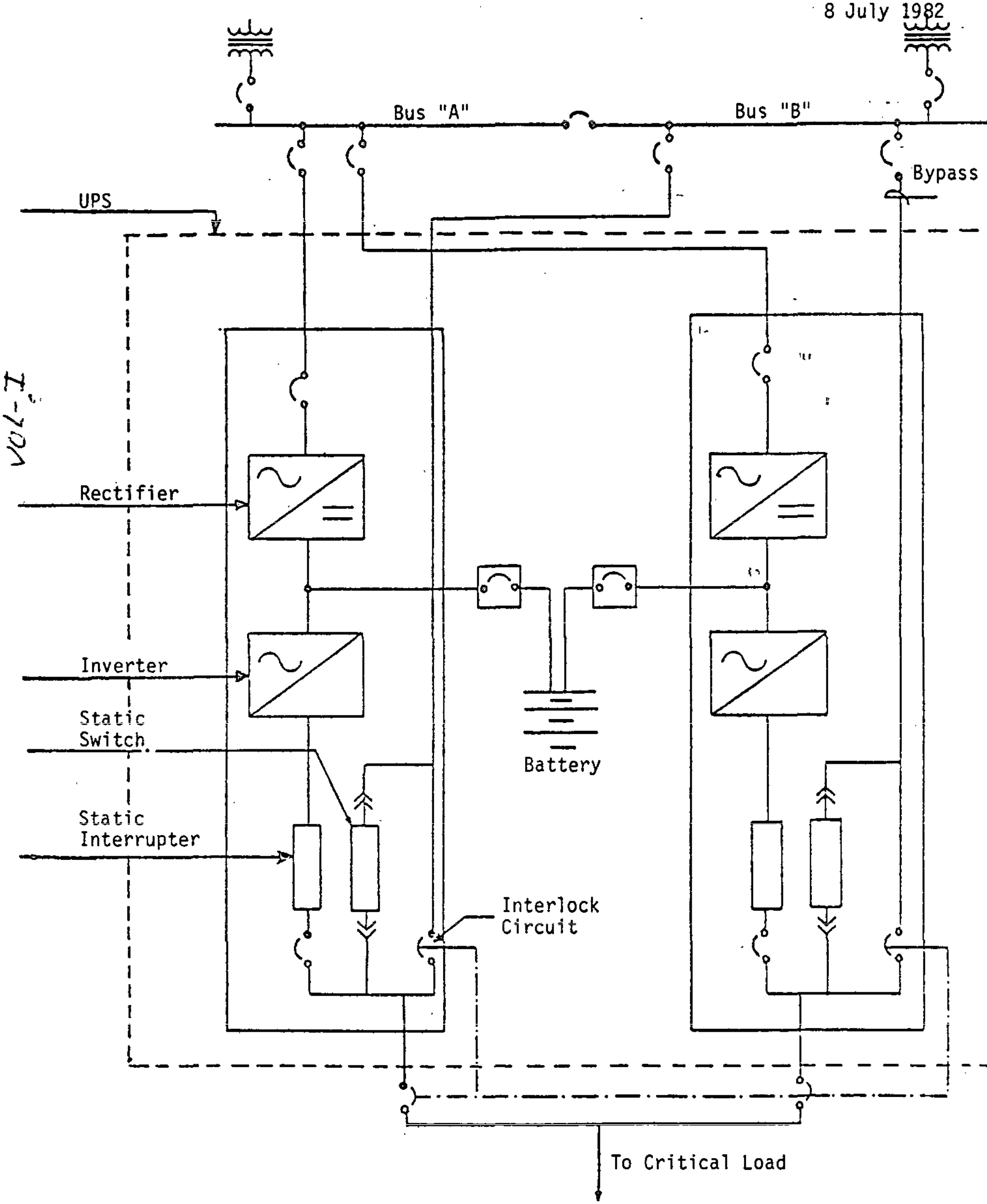


FIGURE 7. "Cold" standby independent uninterruptible power system (UPS).

of the work area for emergency use. Special attention should be given to floor loading for the battery room, entrance door dimensions for installation of UPS, and ceiling heights for clearance of exhaust fans and/or an environmental system. Emergency lighting units should be provided and conform to Federal Specification W-L-305.

4.2.5 DC UPS - Floating battery power. Floating battery power should be designed for optimum reliability and maximum independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period, consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid state UPS should be sized for 15 minutes, for most applications. For 48 volt applications, if specific battery operation requirements are not available, the batteries should be sized for 1-hour operation at attended sites and a minimum of 8-hours operation at unattended sites. A single float battery system should be designed for all float battery requirements within a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. Where static inverters are used, provisions should be made to transfer the load in a gradual manner from the battery to the primary or auxiliary power sources. This provision, normally part of the rectifier, will minimize the transient conditions on the primary or auxiliary power sources during the transfer period.

4.2.6 Seismic battery protection. Battery facilities in support of critical communications should be designed to provide the seismic protection compatible with the local seismic zone designation.

4.2.7 Power improvement planning.

a. When power improvements are required to provide expanded or new capacity in prime or auxiliary power for any site, a requirements survey of all C-E planning for that site should be conducted. Present and future requirements should be considered and programmed for, consistent with sound practice. Programming documents should show that the projects are responsive to site requirements and reflect consolidation planning.

b. Although primary and auxiliary power systems should be programmed to meet site requirements, power conditioning/UPS (including DC battery float systems) should be programmed on a C-E system basis and consolidation considered at time of implementation. Project programming documentation should identify projects for consolidation consideration. Consolidation should then be accomplished in light of funding and technical considerations.

c. When primary or auxiliary power (including UPS) are to be improved or reconfigured, a requirements survey should again be conducted and equipment ratings increased or decreased accordingly. Combinations of renewable energy sources should also be considered at this time.

4.2.8 Guidance for communications-electronics (C-E) equipment acquisition.

a. Acquisition managers should specify direct current powered equipment for high reliability C-E applications. The inversion process (where failure rates are the highest) and the rectification required in the communications equipment could thus be eliminated. Elimination of the inversion process would improve the efficiency and reliability of the power system.

b. To the maximum degree feasible, ac-powered equipment should be designed to tolerate the full range of voltage and frequency variations to be encountered. Suppliers should be required in their bidding to show costs of furnishing equipment with broader tolerance in increments over the range to be expected. Suppliers should also be required to determine and furnish an analysis of the effect on operation and failure rate when specified tolerances are exceeded. Communications equipment acquisition documentation should, to the maximum extent, encourage dc-powered equipment design.

c. Applicable to both a and b, above, would be procurement specifications requiring that those critical elements of the C-E system or equipment with the least tolerance be separately circuited to accommodate dc or ac UPS input without necessitating UPS for the entire system.

I-70

Custodians:
Army-SC
Navy-YD
Air Force-90

Preparing activity:
DCA-DC
(Project SLHC 4111)

Review activities:
Army-AD, CE, CR, ME
Navy-AS, EC, MC, OM, SH
Air Force-17

VOL - I

SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 22-R255

INSTRUCTIONS: This sheet is to be filled out by personnel, either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.

SPECIFICATION
MIL-HDBK-411A, Power and Evironmental Control For the Physical Plant of DOD Long Haul Communications
VOL I OF 2 VOLUMES

ORGANIZATION

CITY AND STATE	CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO *(If "yes", in what way?)*

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity - Optional)*	DATE

DD FORM 1 JAN 66 1426 REPLACES EDITION OF 1 OCT 64 WHICH MAY BE USED.

S/N-0102-014-1801 C-25251

MIL-HDBK-411A
8 JULY 1982

SUPERSEDING
MIL-HDBK-411
21 MAY 1971

MILITARY HANDBOOK

POWER AND ENVIRONMENTAL CONTROL FOR THE PHYSICAL PLANT OF DOD LONG HAUL COMMUNICATIONS

VOLUME II OF 2 VOLUMES

ENVIRONMENTAL CONTROL

NO DELIVERABLE DATA REQUIRED
BY THIS DOCUMENT

SLHC

DEPARTMENT OF DEFENSE
Washington, DC 20301

MIL-HDBK-411A
Power and Environmental Control
for the Physical Plant of
DoD Long Haul Communications
VOLUME II, ENVIRONMENTAL CONTROL

1. This standardization handbook has been developed by the Defense Communications Engineering Center (DCEC) of the Defense Communications Agency (DCA), in accordance with the Defense Standardization and Specification Program (DSSP).

2. This publication was approved on 8 July 1982 for printing and inclusion in the military standization handbook series.

3. This volume provides information and technical guidance on the special requirements and considerations for the design and construction of environmental control systems for the Defense Communications System (DCS) facilities.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, Defense Communications Agency, ATTN: Code J110, 1860 Wiehle Avenue, Reston, Virginia 22090, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. Volumes I and II of this handbook supersede MIL-HDBK-411, dated 21 May 1971. This volume replaces those portions of the superseded handbook which deal with environmental control systems for Defense Communications System (DCS) facilities. Volume I of this handbook replaces the remaining portions of the outdated handbook which are concerned with power generation and distribution systems for DCS facilities.

2. As defined in Department of Defense Directive 5105.19, "The DCS is a composite of DoD-owned and leased telecommunications subsystems and networks comprised of facilities, personnel, and material under the management control and operational direction of the DCA. It provides the long-haul, point-to-point, and switched network telecommunications needed to satisfy the requirements of DoD and certain other Government agencies."

3. This part of the handbook provides basic technical guidance for the design, installation, alteration, and acceptance of air conditioning systems for Department of Defense (DoD) long haul DCS facilities.

CONTENTS

1. SCOPE

1.1 Purpose. The purpose of this handbook is to provide technical guidance for environmental control systems supporting the Defense Communications System (DCS) facilities. This handbook is intended for use in the design, installation, and upgrading of air conditioning systems and equipment.

1.2 Application. This handbook applies to government-owned air conditioning systems for the Defense Communications System (DCS) facilities.

1.3 Objective. The objective of this handbook is to delineate the environmental control criteria needed to support the operational requirements of the Defense Communications System (DCS).

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

FED-SPEC-FF-300	Filter, Air Conditioning: Viscous Impingement and Dry Types, Cleanable

MILITARY

MIL-C-13724	Charcoal, Activated, Impregnated, ASC
MIL-F-51079	Filter Medium, Fire Resistant, High Efficiency

STANDARDS

MILITARY

MIL-STD-461B	Electromagnetic Emission and Susceptiblity Requirements for the Control of Electromagnetic Interference

HANDBOOKS

MILITARY

MIL-HDBK-232	RED/BLACK Engineering Installation Guidelines. (U)
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipments and Facilities.

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

Air Force, Army, and Navy Manual, Engineering Weather Data, AFM 88-29; TM-5-785; NAVFAC P-89 (Tri-Service manual).

American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Guide and Data Books, 4 volumes (Fundamentals, Applications, Systems and Equipment).

ASHRAE Standard 52-76, Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

(Application for copies should be addressed to American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 345 East 47 St., New York, NY 10017).

Associated Air Balance Council, National Standards for Field Measurements and Instrumentation.

(Application for copies should be addressed to Associated Air Balance Council, National Headquarters, 1000 Vermont Ave., N. W., Washington, DC 20005).

National Environmental Balancing Bureau (NEBB), Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

(Application for copies should be addressed to National Environmental Balancing Bureau, 8224 Old Courthouse Road, Vienna, VA 22180).

American National Standards Institute (ANSI) Standard S1.4, Specification for Sound Level Meters.

(Application for copies should be addressed to Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018).

Underwriters' Laboratories, Inc., UL Standard 900, Safety for Air Filter Units.

(Application for copies should be addressed to Underwriters' Laboratories Inc., 207 East Ohio St., Chicago, Illinois 60611).

3. DEFINITIONS

3.1 Air conditioning. As used in this handbook, the term air conditioning is synonymous with the term environmental control which is the process of simultaneously controlling the temperature, relative humidity, air cleanliness, and air motion in a space to meet the requirements of the occupants, a process, or equipment.

3.2 Critical areas. For purposes of this volume, critical areas or critical rooms are operational areas that contain communications equipment and require specific temperature and humidity operating conditions.

3.3 Technical area. For purposes of this volume, technical areas are those rooms or areas that contain communications equipment or other equipment that supports communications equipment and requires specific temperature limits.

3.4 Other definitions. Definitions of all other applicable terms are contained in the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals.

4. SYSTEM DESIGN CRITERIA

4.1 General. Air conditioning provides environmental control. Air conditioning includes heating, cooling, ventilation, humidification, dehumidification, circulation, filtration, pressurization, and distribution of air in areas occupied by communications equipment and in areas occupied by equipment that directly supports the communications equipment. This criteria does not apply to areas not directly engaged in supporting or operating the communications equipment or systems. This handbook provides the basis for air conditioning design and should be supplemented with the specific design criteria for the communications equipment or systems concerned. It is not the intent to dictate specific air conditioning system design. Each system design requires the initiative, imagination and expertise of the design engineer to meet all the requirements.

4.2 Design objective. The mission requirements of the Defense Communications System (DCS) dictate a 99.99% operational capability. In addition, the DCS should have the ability to withstand hostile actions or stresses and remain operational after the commencement of these actions or stresses. The air conditioning systems for DCS facilities should provide the environmental conditions necessary for the DCS to meet the mission requirements.

4.3 Design guidance. The air conditioning designer should consider the referenced documents listed in Section 2 and the following design guides:

a. The communications equipment environmental conditions specified by the manufacturer.

b. The applicable DoD construction criteria publications.

c. The applicable design agency publications.

d. The applicable user agency publications.

e. The construction criteria for the specific project.

4.4 Outdoor design conditions. The Departments of the Army, Navy and Air Force tri-service manual, Engineering Weather Data (AFM 88-29; TM 5-785; NAVFAC P-89), should be used for the selection of summer and winter outdoor design conditions. For locations not covered in the manual, the respective MILDEP should provide the summer and winter outdoor design conditions. The outdoor design conditions should be selected on the following basis:

4.4.1 Summer outdoor design conditions.

4.4.1.1 Critical areas. The 1% dry bulb and 1% wet bulb temperature conditions should be used for critical areas requiring close tolerance temperature and humidity control. The 2.5% dry bulb and 2.5% wet bulb temperature conditions should be used for critical areas requiring broad temperature control.

4.4.1.2 Technical areas. The 2.5% dry bulb and mean coincident wet bulb temperature conditions should be used for technical areas.

4.2.2 Winter outdoor design conditions.

4.4.2.1 Critical areas. The 99% dry bulb and average annual mean coincident wet bulb temperature conditions should be used for critical areas requiring humidity control.

4.4.2.2 Technical areas. The 97.5% dry bulb temperature condition should be used for technical areas.

4.4.3 Air cooled condensers.

4.4.3.1 Critical areas. The 1% dry bulb temperature plus 2.8 degrees C (5 degrees F) should be used for the summer outdoor design condition. The 99% dry bulb temperature less 2.8 degrees C (5 degrees F) should be used for the winter outdoor design condition for condenser winterization.

4.4.3.2 Technical areas. The 1% dry bulb temperature should be used for the summer outdoor design condition. The 99% dry bulb temperature less 2.8 degrees C (5 degrees F) should be used for the winter outdoor design condition for condenser winterization.

4.4.4 Cooling towers and evaporative condensers.

4.4.4.1 Critical areas. The 1% wet bulb temperature condition should be used.

4.4.4.2 Technical areas. The 2.5% wet bulb temperature condition should be used.

4.4.5 Water coolers and glycol coolers.

4.4.5.1 Critical areas. The 1% dry bulb temperature plus 2.8 degrees C (5 degrees F) should be used for the summer outdoor design condition.

4.4.5.2 Technical areas. The 1% dry bulb temperature should be used for the summer outdoor design condition.

4.5 Indoor design conditions. The selection of the indoor design conditions depends primarily on the environmental conditions specified by the manufacturer of the communications equipment. Communications equipment is sensitive to ambient dry bulb temperature, relative humidity, and dust. In some instances, certain components of the communications equipment or data processing systems may have conditioned air or chilled water supplied directly to them, in addition to conditioned room air.

4.5.1 Critical areas - rate of temperature change. Some manufacturers of electronic data processing equipment specify close limitations on the allowable rate of temperature change. For existing AUTODIN switching facilities and some other DCS facilities, the computer equipment manufacturer has specified that the maximum allowable rate of temperature change is 1.7 degrees C (3 degrees F) per hour. No stipulation is made as to the location or the time period for making the temperature change measurements. This requirement can be interpreted as meaning that a fluctuation of temperature (up and down) of more than 0.14 degrees C (0.25 degrees F) in five minutes, or 0.03 degrees C (0.05 degrees F) in one minute, or 0.0046 degrees C (0.008 degrees F) in ten seconds cannot be tolerated because computer operation would be adversely affected. Such small increments cannot be measured or recorded with available standard temperature recorders. Additionally, such small temperature changes can occur in any room during normal operation of the air conditioning system. Therefore, for all future installations, when a computer manufacturer specifies a maximum allowable rate of temperature change, the rate of change should be expressed for no less than the smallest time period during which the specified change can be measured and recorded by automatic temperature recorders presently available on the market. The time specified should be the smallest time duration of changing temperature which will adversely affect the computer. Also, the manufacturer must specify the exact location where the measurements are to be made.

4.5.2 Critical areas - close tolerance temperature and humidity control. Magnetic units are the communications system components which are most sensitive to temperature, humidity and dust. Usually, they can operate within a temperature range of 15.6 to 26.7 degrees C (60 to 80 degrees F) dry bulb and a relative humidity range between 40% and 65%. However, the conditions selected within the range must be kept relatively constant. Unless otherwise specified by the electronics equipment supplier, the operating room condition is taken as that temperature and humidity condition measured approximately 1.52 meters (five feet) over the floor adjacent to the communications system component which is the most sensitive to ambient conditions. One 24-hour temperature and humidity chart recorder should be installed in the same area. Others may be installed at other locations in the critical area. Presently, the critical areas of DCS installations utilizing electronic data processing equipment such as AUTODIN are generally held at 22.8 degrees C (73 degrees F) plus or minus 1.1 degrees C (2 degrees F) and a relative humidity of 50% plus or minus 5%. Usually, this is a safe operating ambient condition for computer rooms. Lower temperatures and humidities would result in increased operating costs and wasteful energy consumption. An operating temperature much above 22.8 degrees C (73 degrees F) might result in an unsafe differential between the operating temperature and the recommended computer shut-down temperature, usually 26.7 degrees C (80 degrees F). Because the temperature does vary a few degrees throughout the critical areas, if the air conditioning system fails when operating much above 22.8 degrees C (73 degrees F), there may be insufficient time to detect rising temperatures and to shut down the computer before damaging temperatures occur at some hot spots in the room. The recommended operating temperature and humidity conditions should be obtained from the manufacturers of the communications and data processing equipment and should be used for the design of the environmental control system.

4.5.3 Critical areas - broad tolerance temperature and humidity control. Operational environmental tolerances for installations not using magnetic memory devices or computer equipment are usually quite broad. Generally, AUTOVON equipment can operate within a dry bulb range of 7.2 to 40.6 degrees C (45 to 105 degrees F) and a relative humidity range of 20% to 90%. For system design purposes, in order to assure adequate reserve capacity for safe reliable operation of the communications equipment, the recommended indoor design conditions for communications facilities not employing data processing equipment is 23.9 degrees C (75 degrees F) dry bulb for summer and winter; 50% relative humidity for summer; and 20% relative humidity for winter. Winter humidification and summer dehumidification should be provided in locations where required. Generally, the air conditioning system can provide sufficient dehumidification during the cooling cycle to meet the relative humidity requirement and no supplementary dehumidification system is required. Very humid climates may require a dehumidification system. During operation of installations requiring year-round cooling, the thermostat should be set to that dry bulb temperature which is currently recommended for comfort cooling based on considerations involving energy conservation, economics and comfort, 25.6 to 26.7 degrees C (78 to 80 degrees F). For smaller installations where winter heating and summer cooling are required, the thermostat setting for summer should be the same, but the setting for winter should be 20 degrees C (68 degrees F). The humidifier should have the capacity to maintain the minimum relative humidity required during the operating conditions and weather conditions which require maximum moisture addition. The humidistat should be set above the minimum relative humidity required to ensure that the lower limit of relative humidity is met. At least one temperature and humidity recorder should be installed at a suitable location within the critical area. The recommended temperature and humidity conditions should be obtained from the equipment manufacturer and should be used for the design of the environmental control system.

4.5.4 Technical areas - temperature control. Generally, technical areas such as support rooms, uninterruptible power system (UPS) rooms, battery rooms, back-up power rooms, and equipment rooms do not require specific temperature and humidity operating conditions but have specific high and low temperature limits. Generally, the maximum allowable indoor air temperature is 40 degrees C (104 degrees F) and the minimum is 10 degrees C (50 degrees F), except for battery rooms where the minimum is 15.6 degrees C (60 degrees F). Mechanical ventilation should be employed for temperature control, as required. In some instances, certain components of technical equipment will require lower temperatures than mechanical ventilation can provide and mechanical cooling may be needed. In locations having extremely adverse atmospheric conditions, such as hot, humid tropical climates, salt laden marine atmospheres, atmospheres containing substantial quantities of corrosive, abrasive or irritating pollutants, consideration should be given to air conditioning solid state UPS and battery areas, rather than cooling by mechanical ventilation, which usually involves high rates of outdoor air circulation. The recommended temperature limits should be obtained from the equipment manufacturer and should be used for the design of the environmental control system.

4.5.5 Outdoor air ventilation rates and room pressurization. The supply rate of outdoor ventilation air should be sufficient to pressurize the critical areas to between 12.4 and 24.9 pascal (0.05 and 0.10 inches of water) gauge pressure above adjoining areas to prevent the infiltration of unconditioned outdoor air or inadequately conditioned air. The outdoor air supply rate should not be less than 2.36 x 10^{-3} m^3/s (5CFM) per person. Instrumentation should include an indoor-outdoor pressure differential inclined manometer or guage properly installed on an exterior wall inside the critical areas. Battery rooms should be ventilated with non-sparking exhaust fans to maintain a stable room pressure that is lower than that in adjoining rooms (to prevent the outflow of contaminated air to other rooms). The outdoor air ventilation rates for batteries and equipment should be obtained from the manufacturer and should be used for the design of the environmental control system.

4.5.6 Air cleanliness. The supply air for critical areas, technical areas, UPS rooms, and battery rooms should be filtered. Air filter performance values should be determined in accordance with ASHRAE Standard 52-76. All supply air (outdoor ventilation air and indoor recirculated air) should be filtered with filters having an atmospheric dust spot efficiency of not less than 20%, and should have a minimum average dust weight arrestance of 60%. Also, when computers are utilized, another bank of higher efficiency filters should be installed. For installations utilizing self-contained specialized Computer Room Air Conditioners, only one bank of the higher efficiency filters should be used for the recirculated room air passing through the units. The efficiency of the final filters should be as recommended by the computer manufacturer. Generally, efficiency requirements for the final filters depend on the type of magnetic memory units. At most existing AUTODIN switching facilities and some other DCS facilities utilizing computers, the final filters have a minimum initial efficiency of 60%. Generally, newer computer rooms require less efficient filters; around 45% average efficiency over the service life of the filter (between clean and dirty conditions).

4.5.6.1 Chemical, biological, radiological. The supply air for critical and technical areas should have the capability for Chemical, Biological, Radiological (CBR) filtering to provide operational capability for the DCS facilities during hostile actions or stresses. Smoke, dust, bacteria, radioactive particles, toxic warfare gases and antimaterial agents could render personnel and electronic equipment inoperable. These contaminants should be removed with filters and the critical areas, technical areas, and their entrances should be pressurized with this filtered air. The filters should remove 99.95% of 0.3 x 10^{-6} m (0.3 micron) average particle size of DOP test smoke and the flow rate of filtered air should be sufficient to maintain an overpressure of 74.7 pascal (0.3 inches of water) gauge pressure.

4.5.7 Room air velocity. Because of the cool temperatures prevalent in critical areas, air flow velocities should be kept to acceptable levels. Wherever possible in critical equipment rooms, the room air velocity should not exceed 0.254 m/s (50 ft/min) at a level of 0.76 to 1.52 meters (30 to 60 inches) above the floor where personnel are seated during normal working conditions and 0.356 m/s (70 ft/min) throughout the remainder of the occupied zones.

4.5.8 Sound level. The maximum allowable ambient sound level caused by the air conditioning system in the critical areas should be 50 dB(A). The ambient sound level is defined as the unoccupied space noise level with the air conditioning system operating and the communications equipment shut down. Measurements should be made on the A scale of a standard sound level meter which meets the American National Standards Institute (ANSI) Standard S1.4 and which is used in accordance with the manufacturer's instructions.

4.6 Energy conservation. Energy conservation measures should always be considered during the design of the air conditioning system. However, the operating environmental conditions specified by the communications equipment manufacturer should be the primary consideration governing the design of the air conditioning system. There are numerous publications available from various Federal agencies and military departments that provide substantial information on alternate energy sources and energy conservation methods, techniques and equipment. The air conditioning system designer should consider all applicable design parameters to provide the most reliable and energy efficient air conditioning system. Where feasible and cost effective, energy conservation measures should be incorporated in the air conditioning system design.

4.7 Air conditioning calculations. The air conditioning load estimate should be accomplished in accordance with the criteria of the ASHRAE Guide and Data Book. The use of other commercially recognized load estimating methods employing the criteria from the ASHRAE Guide and Data Book are acceptable. The use of computer energy programs is acceptable and encouraged. Computer programs provide heating and cooling load profiles for a typical year using a typical year's weather data. Heating and cooling load calculations are usually accomplished on an hourly , daily, weekly and monthly basis with summaries providing peak and annual loads with respective energy consumptions. Many programs can compare several different types of air conditioning systems and select the most energy efficient and cost effective one to meet the load estimate.

4.8 System selection considerations. The selection and design of an air conditioning system depends on many variables. Each air conditioning system should be designed to provide the specific conditions peculiar to each design requirement. The designer should consider the following:

a. The operating environmental conditions required by the communications equipment.

b. The site location and outdoor environmental conditions.

c. The capacity requirements for critical areas, technical areas, and all areas combined.

d. The availability of a central cooling source, a central heating source, and alternate energy sources.

e. The availability and quality of water.

f. The availability and quality of commercial utilities.

g. The availability of spare parts and maintenance items.

h. The availability of skilled maintenance personnel.

i The system installation costs and annual O&M costs including annual energy consumption and cost.

4.9 Electric-power compatibility. The air conditioning system should be designed so that it will not interfere with the communications systems that it serves. Operation of system components should not cause voltage fluctuations in the electric-power systems serving the communications equipment. Electric wiring to the air conditioning system should not cause electromagnetic interference to the communications system. Attention should be given to both radiated and conducted forms of interference, plant layout, and cable shielding and routing. Electromagnetic interference characteristics for air conditioning equipment and wiring should meet the applicable Class A3 requirements in MIL-STD-461B.

4.10 Vapor barriers. Vapor barriers are especially important for installations requiring humidity control. Effective vapor barriers should be installed on interior walls, floors, ceilings or roofs. Windows should not be installed in exterior walls of rooms requiring humidity control. Air ducts, utility conduits, cables and pipes penetrating humidity controlled areas should be vapor sealed. All doors and passages providing access to and egress from humidity controlled areas should be vapor sealed. Vestibules should be provided for entrance/exit areas to all humidity controlled areas.

4.11 "U" values. "U" values should be selected to provide the optimum effectiveness for the air conditioning system. The respective military departments should validate the "U" values to be used.

4.12 Reliability. The air conditioning system should be designed to provide the environmental conditions necessary for the DCS installation to maintain a 99.99% operational capability. To meet this requirement, a secondary or auxiliary air conditioning system, subsystem, equipment or components should be provided for areas containing communications equipment and systems that would not be operational if the primary air conditioning system failed. The secondary or auxiliary air conditioning system, subsystem, equipment or components should be able to provide the environmental conditions necessary for these critical areas to remain operational. Generally, these areas contain data processing equipment and may include AUTODIN switches. The air conditioning designer should determine the components, equipment or subsystem required for the secondary or auxiliary air conditioning system. Also, spare parts and service supplies recommended by the equipment manufacturers should be readily accessible for maintenance and repair work for both the primary and secondary air conditioning systems.

4.13 System types. There is no standard type of air conditioning system that is best for a communications facility. The design engineer must analyze all the conditions, criteria, and variables inherent for each design requirement and select the air conditioning system type that most fully meets all the requirements.

4.13.1 Heating systems. The heating system for the primary air conditioning system should provide the total installation heating load capacity. The heating system for the secondary air conditioning system should provide the heating load capacity for the critical areas to remain operational. Heating is generally required to provide heating for technical and office areas, winter humidification and reheat for summer dehumidification. Heating systems are normally hot water or steam type. Hot water or electric coils are normally used for reheat. Steam is normally used for humidification.

4.13.1.1 Central heating plants. At installations where a central heating plant supplying steam or high temperature hot water is available as a heat source, this source should be considered for the primary heating system. Heat exchangers and convertors should be used as required. For the secondary heating system, an individual steam or hot water boiler with required heat exchangers and convertors should be considered.

4.13.1.2 Individual heating plants. At installations where central heating plants are not available for a heat source, individual steam or hot water boilers with required heat exchangers and convertors should be considered for both the primary and secondary heating systems.

4.13.1.3 Heating fuels. Conventional heating fuels should be selected in accordance with the availability of supplies, logistics of fuel replenishment, efficiency of operation, availability of operations and maintenance personnel, cost of fuels, and vulnerability of fuels. Fuel storage should be based on the most stringent 30 day requirement.

4.13.1.4 Alternate heat sources. The use of alternate heat sources, such as waste heat recovery, thermal storage and active solar energy, should be considered for both the primary and secondary heating systems, where feasible. However, a conventional heat source should be provided for reliable back-up capability.

4.13.2 Refrigeration systems. The refrigeration system for the primary air conditioning system should provide the total installation cooling load capacity. The refrigeration system for the secondary air conditioning system should provide the cooling load capacity for the critical areas to remain operational.

4.13.2.1 Chilled water systems. For chilled water systems, a minimum of two water chillers should be provided for installations requiring both primary and secondary refrigeration systems. Each system should have a separate water chiller, condenser and chilled water pumping equipment. Refrigerant compressors and condensers should have sufficient capacity controls available for the size and type of units selected. Standby chilled water pumps should be provided. At installations where a central cooling plant supplying chilled water is available as a cooling source, this source should be considered for the primary cooling system.

4.13.2.2 Direct expansion systems. For direct expansion systems, a minimum of two refrigerant compressors and two condensers or two condensing units should be provided for installations requiring both primary and secondary refrigeration systems. Refrigerant compressors and condensers should have sufficient capacity controls available for the size and type of units selected.

4.13.2.3 Unitary packaged type air conditioning units. For those installations where unitary packaged self-contained type air conditioning units are selected, a minimum of two units should be provided where both primary and secondary refrigeration systems are required. The units should have sufficient capacity controls available for the size and type of units selected.

4.13.3 Air handling systems. The air handling system provides the conditioned air necessary for the installation to maintain the environmental conditions required. The system normally consists of air handling units to condition the air and an air distribution system to supply and distribute the conditioned air.

4.13.3.1 Air handling units. Air handling units normally heat, cool, ventilate, filter, humidify, dehumidify, and supply air to the installation to maintain the desired environmental conditions. They normally consist of a fan section for air delivery, a cooling section, a heating section, a filter section, outside air intake, and exhaust air outlet. A minimum of two air handling units should be provided for an installation requiring both primary and secondary air conditioning systems. One unit should provide the total installation air handling capacity and one unit should provide the critical area air handling capacity. Unitary packaged, self-contained type units should be considered for smaller systems. Multiple packaged type units or central built-up units providing multiple zone control should be considered for larger systems.

4.13.3.1.1 Outdoor air intakes. The outdoor air intakes should be located and installed to provide the cleanest source of outside air. Weatherized louvers with bird and or insect screens should be used.

4.13.3.1.2 Exhaust air outlets. The exhaust air outlets should be located and installed so that exhaust air will not be drawn into the outdoor air intake. Outlets should be weatherized types with backdraft dampers.

4.13.3.1.3 Air filters. Air filters should be installed in all air handling units to filter outdoor air and return air prior to conditioning by the air handling unit. The filters are normally installed in a filter section on the air inlet side of the air handling unit. The filter sections should have filter gauges installed to measure the pressure drop across the filters. The low efficiency type filters should be the viscous impringement type and may be either the throwaway or the cleanable type. The high efficiency types should be the dry disposable type. Automatic roll filters should be used whenever the filter bank exceeds 2.13 meters (seven feet) in height. All filters should conform to class 1 or 2 Underwriters Laboratory Standard UL-900.

Electronic air cleaners should not be used because of the danger of charged particles passing through the filter and being attracted to oppositely charged communications equipment. The use of electronic air cleaners should require the approval of the respective military department, based on the justification provided by the design agency.

4.13.3.1.3.1 CBR filters. A CBR filtering system should be provided to remove CBR contaminants from critical and technical areas. The filtering system should have the capability to be activated whenever a hostile action or stress has commenced and to be inactive otherwise. The filtering system should consist of:

a. Precleaner - dust filter, Federal Specification FF-300.

b. Particulate filter - Military Specification MIL-F-0051079, removes aerosols and particulate matter, 99.95% of DOP having an average particle size of 0.3 x 10^{-6}m (0.3 micron).

c. Gas filter - Military Specification MIL-C-0013724, removes toxic warfare gases.

d. Air supply blower/fan - provides required air flow through filtering medium.

The filtering system should provide a sufficient flow rate of filtered air to compensate for air leakage and outside air ventilation rates while maintaining a 74.7 pascal (0.3 inches of water) gauge overpressure. Entrance airlocks should be provided to filtered areas - vestibules provide a suitable means to accomplish this. The filtering system should either be coupled to the air handling systems for the critical and technical areas or installed separately. For either installation, the air handling systems for the critical and technical areas must have the capability to operate at 0% outside air upon activation of the CBR filtering system.

4.13.3.1.4 Cooling coils. Direct expansion evaporator coils should be used for packaged units and small systems. Chilled water cooling coils should be used with multiple units and large systems requiring multiple zone control.

4.13.3.1.5 Heating coils. Hot water or electric heating type coils should be used for packaged units and small systems. Hot water or steam type heating coils should be used with multiple units and large systems requiring multiple zone control. Hot water and electric type coils should be used for reheat for dehumidification control.

4.13.3.2 Air distribution systems. The conditioned air from the air handling units should be supplied and distributed to the various spaces or equipment and then returned to the air handling units using ductwork, diffusers, registers, grilles, ceiling plenums, and floor plenums. The air distribution system should be designed in accordance with the methods and procedures specified in the ASHRAE Guide and Data Book. The correct amount of conditioned air must be delivered to the space, zone, or equipment to ensure that the communications equipment will operate within its prescribed environmental conditions. Generally, a single duct, low velocity, constant volume system with terminal reheat is used for critical areas. For technical areas, a constant volume variable temperature system or a variable volume constant temperature system should be considered. The communications equipment operating environmental conditions will normally dictate the type of air distribution system required.

4.13.3.2.1 Overhead distribution system. An overhead air distribution system should be considered where communications equipment needs negate the requirement for a raised floor. Generally, supply air ductwork should be installed above a dropped acoustical ceiling with the space above this ceiling used as a return air plenum. A ducted return could be used in lieu of a plenum return. Diffusers, registers and grilles should be installed at the ceiling or sidewalls. For some types of communications equipment, a ducted supply and return can be connected to the equipment.

4.13.3.2.2 Underfloor distribution system. An underfloor air distribution system should be considered where communications equipment needs dictate the use of a raised floor. Generally, the space beneath the raised floor is used as a supply air plenum with an overhead ducted return or ceiling plenum return. Supply air diffusers or registers are installed in the raised floor and return air grilles are installed in the ceiling. A positive static pressure of 62.2 pascal (0.25 inches of water) gauge must be maintained in the underfloor plenum. A pressure differential gauge or manometer should be installed with the raised floor. For some communications equipment, the supply air can be fed directly to the equipment through the raised floor.

14.13.3.2.3 Ductwork, diffusers, registers, grilles. Ceiling supply air outlets and return air inlets should be readily relocatable without major alterations in order to vary the air distribution pattern with technical equipment relocations and to eliminate hot spots and maintain uniform temperatures throughout the room. Air supply ducts located outside the air conditioned spaces should be insulated with noncombustible insulation with integral vapor barrier. Interior duct linings should not be installed in air supply ducts serving the technical equipment rooms. Sound attenuators should be used when considered necessary. Each return air duct should be insulated, as required, depending on its relative location to the ceiling or roof insulation. Ducts located below roof insulation normally will not require insulation; however, ducts installed above ceiling insulation should be insulated.

4.13.4 Humidification systems. A humidification system should be provided for both the primary and secondary air conditioning systems. Humidification systems should be the direct steam injection or heated pan type. Atomizing type humidifiers should not be used due to the mineral dust problem. Generally, the steam grid type are used in large air handling systems and the heated pan type using steam, electric, or hot water coils are used in smaller air handling units such as the unitary packaged type air conditioning units. The humidification systems should provide the relative humidity levels required.

4.13.5 Economizer air cycle. An economizer air cycle should be considered for all air conditioning systems where the outside weather conditions indicate their use can be beneficial. These cycles allow the air handling units to supply up to 100% outside air and can reduce the refrigeration load when the outside air can be used for cooling. They can also provide emergency temperature control to some degree should the refrigeration equipment fail. Economizer air cycles are ideal for temperature control applications. They can be used for temperature and humidity control applications provided enthalpy controls are utilized to prevent high humidity levels. The use of an economizer air cycle should require the approval of the respective military department, based on the justification provided by the design agency.

4.13.6 Location of equipment. Air conditioning equipment should be located in areas that delay or deter intruders. Utilities and storage tanks should be installed underground. Air conditioning equipment such as air handling units, boilers, pumps, compressors and associated equipment should be installed in a mechanical equipment room within the structure it is supporting. Equipment installed outside the structure, e.g., condensers and cooling towers, should be installed at grade level and provided with fences, walls, barriers, or revetments.

4.13.7 Security. Fusible link fire dampers, anti-personnel barriers, sound attentuators, radio frequency waveguides and non-metalic flexible connections should be installed in ducts at points of ingress and egress to Limited Exclusion Area (LEA) or Controlled Access Area (CAA), as appropriate. (See MIL-HDBK-232). The equipment should be installed at the inside of the area. Non-metalic flexible connections or dielectric unions or couplings should also be installed at the inside of the space of all piping where it leaves or enters the controlled space. In almost all cases, controls can be designed so that no control wires pass from outside of sensitive security areas. However, where they do, all such power and control wiring should be installed in accordance with MIL-HDBK-232. As a minimum, control wiring cables should be shielded and installed in separate distribution facilities from RED cables. The need for filtering of the control cables should be determined after an instrumented TEMPEST survey has been conducted. Grounding of cable shields is delineated in MIL-HDBK-419.

4.13.8 Controls and instrumentation. Generally, computer room air conditioning units are factory equipped with a complete set of automatic controls, operating mode lighted signal systems. Where other types of air conditioning systems are installed, a complete automatic control system with manual override supervisory controls should be installed. Adjustable controllers for regulating temperature and humidity, as well as ambient pressure for some types of installations, should be provided. Included should be automatic controls with manual override to accomplish switchover to secondary systems when such an operation is required. Adequate thermometers and pressure and draft gauges should be installed at appropriate points to facilitate convenient monitoring of the system. In addition, sufficient thermometer wells, gauge tappings and ports should be provided for checking and adjusting the equipment. For central systems, a complete central control gauge and alarm panel should be installed within the mechanical equipment room. In addition, an alarm panel should be installed in one technical operations room having 24 hour occupancy. The central control panel should contain a single audible alarm, individual equipment indicating lights, gauges, and an associated push-button station. The alarm panel should include audible and visual alarms, responding to temperature and humidity sensors located in the conditioned areas to alert operating personnel when extremes of allowable operating ranges are being approached. Also, both alarms should indicate failure of the battery room fan, if applicable.

4.13.9 Operating, maintenance and repair recommendations. The air conditioning installation contractor should be required to provide as-built drawings and copies of operating, maintenance, and repair manuals for the system and each component of the system. For overseas installation, drawings and manuals should also be in the language of the foreign nationals who will maintain the system. The operating instructions, the preventive maintenance schedule, the wiring and control diagrams and the detailed control sequence should be framed under glass or plastic and should be posted in an appropriate location in the mechanical equipment room. Additionally, the contractor should be required to furnish a list of recommended spare parts and service supplies.

5. TESTING, ADJUSTING AND BALANCING

5.1 Procedures, instruments and forms. Information, forms, instrumentation and procedures for testing, adjusting and balancing the air conditioning system are presented in the Associated Air Balance Council (AABC) "National Standards for Field Measurements and Instruments", or in the National Environmental Balancing Bureau (NEBB) "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems", and in the ASHRAE handbook "Systems". Current related Federal and military department Guide and Type Specifications are based primarily on the AABC and the NEBB Standards and should be used in accordance with established practices of the design agencies.

Custodians:
Army-SC
Navy-YD
Air Force-90

Review activities:
Army-AD, CE, CR, ME
Navy-AS, EC, MC, OM, SH
Air Force-17

Preparing activity:
DCA-DC
(Project SLHC 4111)

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SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 22-R255

INSTRUCTIONS: This sheet is to be filled out by personnel, either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.

SPECIFICATION MIL-HDBK-411A, Power and Environmental Control For the Physical Plant Of DOD Long Haul Communications VOL II of 2 Volumes

ORGANIZATION

CITY AND STATE	CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO *(If "yes", in what way?)*

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity - Optional)*	DATE

DD FORM 1 JAN 66 1426 REPLACES EDITION OF 1 OCT 64 WHICH MAY BE USED.

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