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MILITARY HANDBOOK

SITE SURVEY AND FACILITY DESIGN HANDBOOK

FOR

SATELLITE EARTH STATIONS

No Deliverable Data required by this Document

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DEPARTMENT OF DEFENSE
Washington, DC 20360

Site Survey and Facility Design Handbook for Satellite Earth Stations.

MIL-HDBK 412

1. This Military Handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, HQ USACEEIA, ATTN: CCC-CED-STD, Fort Huachuca, Arizona 85613; 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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1. SCOPE

1.1 Purpose. The purpose of this handbook is to provide general technical information pertaining to facility engineering of satellite earth stations, both fixed and vanized, and to serve as a guide to more detailed information contained in referenced engineering and planning publications.

1.2 Scope. This handbook presents selected topics in earth station facility engineering to telecommunications engineers, managers, and senior operations and maintenance (O&M) personnel. These topics cover the site selection process and the design of site facilities (including physical structures and the electrical power and ground systems). Although this handbook applies mainly to medium and heavy earth stations, portions may be used for siting tactical or special-use terminals. The term "vanized equipment," as used here, applies both to Defense Communications System (DCS) equipment that is mounted in vans and to tactical equipment that is mounted in vans or shelters. The discussion of site selection information is augmented by the inclusion of sample worksheets (appendix A) as information collection aids.

1.3 Background and future trends. The satellite communication system has a number of advantages that makes it attractive as either a replacement for, or a backup to, present terrestrial systems. These advantages include increased channel capacity, relative terrain independence, and (under some conditions) higher resistance to jamming efforts. Satellite communications will continue to expand as a burgeoning technology provides advances in modulation techniques and frequency utilization. With these advances, satellite networks will readily lend themselves to the Defense Communications Agency (DCA) plan for increased use of digital communications. The systems engineering objectives for earth stations in the Defense Satellite Communications System (DSCS) will emphasize sustaining and improving survivability, durability, security, and interoperability. Terminal interconnectivity structure is expected to shift from the present configurations of terrestrial backbone transmission and switching networks to direct access via satellite.

1.4 Earth station configurations. The earth station (ES) is the total DSCS facility from the interconnect facility (ICF) circuit connections at the patch and test facility (PTF) of the servicing technical control facility (TCF) to the satelite radio frequency (rf) patch at the antenna of the ES. The ES includes the ICF, the communications subsystem (CSS), the rf generation and frequency conversion, tracking and antenna equipment, monitoring and control facilities, and the site power generation and distribution. Earth stations presently deployed in the DSCS, stage 1-C, have four basic configurations, as shown in figure 1 and described in the following paragraphs. Differences among the configurations involve the interconnect technique and the relative locations of the earth station, TCF, and CSS.

1.4.1 Configuration I. The earth station, including all the CSS equipment, is connected to the nearby TCF by multiple baseband cables or optical fiber bundles.

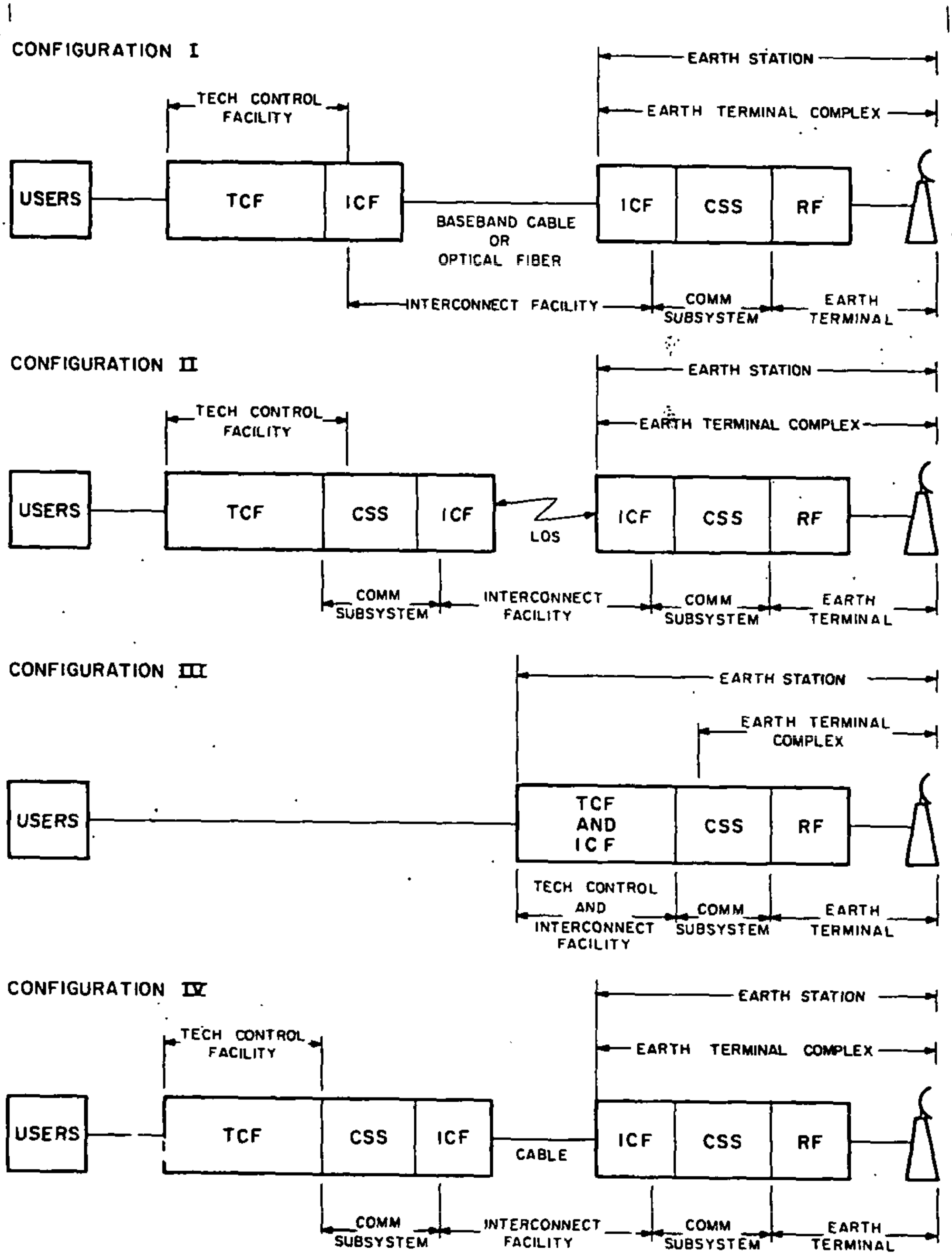


FIGURE 1. Basic earth station configurations.

1.4.2 Configuration II. The earth station is linked to the distant TCF by microwave radio. In this configuration, the CSS equipment is split up, with the modems located in the earth station, and the multiplex and line-conditioning equipment located in the TCF.

1.4.3 Configuration III. The earth station and the TCF are in the same building with the TCF, and interconnected with the CSS by cables.

1.4.4 Configuration IV. The earth station and the TCF are in nearby separate buildings and are interconnected by cable. The CSS is also split up in this configuration, as described in configuration II above.

1.5 Concepts of employment. A satellite earth station employed in a non-nodal capacity forms only a single link with another station; it has no relay capability. A satellite earth station employed in a nodal capacity is characterized by two or more antennas and may serve as a relay in multiple links of a network.

1.6 Safety. Safety considerations within the scope of this handbook are: (1) potential radiation hazards presented to ordinance, fuel, and personnel in the vicinity of the earth station antenna(s) and (2) electric shock hazards encountered in power panels and other high-voltage areas on the site. Lightning protection and fault protection subsystems, providing protection for both personnel and equipment, will be considered.

1.6.1 Radiation hazards. MIL-HDBK-238 and AFOSH 161-9 prescribe energy density level limits for the protection of personnel. Hazard standards for fuels and various electroexplosive ordinance devices are prescribed by the individual services, such as in T.O. 31Z10-4and AFM 127-100. All three military services maintain agencies responsible for conducting radiation-level surveys at operational and proposed sites (see DARCOM-P-706-410).

1.6.2 Electric shock hazards. Protection against shock hazards is best assured by proper ac wiring, bonding, and grounding practices (including lightning and fault protection subsystems and earth electrode subsystems).

1.7 Frequency coordination. At all earth stations, frequencies to be used must coordinated in accordance with the procedures of the service in charge.

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 handbook to the extent specified herein.

MILITARY SPECIFICATIONS

MIL-F-29046(TD)	Specification for Flooring, Raised, General

FEDERAL STANDARDS

FED-STD 1037	Glossary of Telecommunication Terms

MILITARY STANDARDS

MIL-STD-188-124	Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems
MIL-STD-633	Mobile Electric Power Engine Generator Standard Family Characteristics
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

MILITARY HANDBOOKS

MIL-HDBK-238 (Navy)	Military Standardization Handbook, Electromagnetic Radiation Hazards
MIL-HDBK-411	Power and Environmental Control for Physical Plant

PUBLICATIONS

DEPARTMENT OF DEFENSE

DOD Directive 3222.3	Electromagnetic Compatibility Program
DOD Directive 4270.1-M	Construction Criteria

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

OSHA 2206 (29 CFR 1910)	General Industrial Safety and Health Standards

DEPARTMENT OF THE NAVY

NAVFAC DM-2	Design Manual--Structural Engineering

PUBLICATIONS--continued

NAVFAC DM-4	Design Manual--Electrical Engineering

DEPARTMENT OF THE AIR FORCE

AFM 86-2	Civil Engineering Programming Standard Facility Requirements
AFM 88-15	Air Force Design Manual Criteria and Standards for Air Force Construction
AFM 127-100	Explosives Safety Standards
AFOSH 161-9	Occupational Health, Exposure to Radio Frequency Radiation
T.O. 31Z10-4	Electromagnetic Radiation Hazards

DEPARTMENT OF THE ARMY

TM 5-809-1	Load Assumption for Buildings
DARCOM-P-706-410	Engineering Design Handbook: Electromagnetic Compatibility

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

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Inc.

ASHRAE Handbook	Systems
ASHRAE Handbook	Fundamentals
ASHRAE GRP 158	Cooling and Heating Load Calculation Manual

(Application for copies should be addressed to the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329)

National Electric Code (NEC)

(Application for copies should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MASS 02210)

3. DEFINITIONS

3.1 Definitions. For definition of the terms used in this handbook, refer to Federal Standard 1037.

4. GENERAL REQUIREMENTS

4.1 Site selection criteria. This section of the handbook provides general criteria and guidance to aid systems planners in selecting the best available site from among potential candidates for the installation of a satellite earth complex.

4.1.1 Terrain and horizon profiles. The terrain around the earth terminal should be relatively flat (to preclude extensive site preparation). The horizon profile, in the direction of the satellite with which the terminal will be communicating, should be free of obstructions; that is, in the northern hemisphere, the southern horizon should be clear for geosynchronous satellites. If two antennas are to be installed on the recommended north-south line, a small downslope to the south is desirable to provide the northernmost antenna with unobstructed coverage.

4.1.2 Accessibility. Two aspects of accessibility should be considered. The primary concern should be whether an earth terminal at this site can accomplish the required interface between direct service users and the DCS or other long-haul systems. The second concern should be whether logistic support can be easily provided to the site during the survey, installation (or construction), and operational phases.

4.1.3 Available land area. The area needed for an earth terminal facility must be determined from master engineering design plans or from standardized layouts for the particular terminal equipment. This requirement may be compared with map plots of the candidate site to ascertain that the area that is available will accommodate: the terminal's technical equipment and power buildings; the antenna structures; storage areas for petroleum, oils, and lubricants (pol); and the administrative and logistic functions.

4.1.4 Power availability. Existing, locally available power must be adequate to meet the total operational requirements of the proposed earth station. A power system must be planned if locally available power is inadequate. MIL-HDBK 411 should be used for planning. (The use of the National Electrical Code (NEC) does not directly apply to communications facilities; however, its use, while not mandatory, is recommended to provide additional detailed information to the engineer.)

4.1.5 Survivability. "Survivability" refers to the ability of the earth terminal complex to withstand (and continue to function in) an environment made hostile by weather, conventional or unconventional warfare, or nuclear detonation. The Department of Defense, the military departments, or the Defense Communications Agency must provide the appropriate criteria and guidance regarding which of the following survivability factors must be considered (and the extent to which they must be considered).

4.1.5.1 Weather. Weather survivability criteria would apply to the construction methods and materials of site structures and enclosures (for example, the technical equipment building and the possible need for antenna radomes). Weather survivability is mandatory at all fixed sites. (For transportable or vanized sites, consideration must be given to those factors that may not be provided by the basic configuration.)

4.1.5.2 Warfare. Conventional and unconventional warfare includes electronic warfare (EW); chemical, biological, and radiological warfare (CBR); sabotage; and guerrilla or terrorist action. Warfare survivability criteria would be incorporated in site security criteria covering lighting requirements, perimeter fence requirements, and provisions for perimeter defense.

4.1.5.3 Nuclear. Nuclear criteria are measures of the facility's ability to function when exposed to the electromagnetic pulse and radiological, thermal, and blast/pressure effects of a nuclear detonation. Nuclear survivability criteria apply to such factors as exterior cable layouts, building entry points for cables, and redundancy in interconnect links.

4.1.6 Electromagnetic interference (emi). An extensive body of information and numerous military standards covering the field of emi are available to the systems planner. These information sources present both emi criteria and measurement techniques.

4.1.6.1 EMI assistance. Each of the three services has agencies available to conduct emi and electromagnetic compatibility (emc) field and desk studies, when requested, in accordance with applicable regulations. Additionally, the DOD Electromagnetic Compatibility Analysis Center (ECAC) at Annapolis, Maryland, provides assistance to users of all services. DARCOM-P-706-410 provides brief descriptions of the services performed by each emc facility and provides points of contact within each organization.

4.1.6.2 EMI areas of interest. Responsible planners and managers engaged in facility engineering of satellite earth stations must be concerned with emi considerations in the following areas:

a. Antenna radiation patterns.

b. Antenna gains at frequencies of receiver spurious responses (limited to frequencies greater than 0.9 of the cutoff frequency for waveguides).

c. Site electromagnetic signatures.

d. Proximity to public highways and attendant potentially interfering emissions from ignition systems and mobile transmitters.

e. Possible interference from terrestrial radiators.

f. Planned additional radiators in the vicinity of the site.

g. Possible interference from satellites in nearby orbits.

h. Nearby sensitive receivers, such as for radio astronomy.

i. Aircraft traffic patterns of any nearby airport.

4.1.6.3 EMC studies. EMC studies, theoretical and measurements, shall be conducted for new satellite earth stations to assure that the new station will be electromagnetically compatible with the environment. Taking into account all the areas of interest mention in 4.1.6.2, those portions of the rf spectrum which can be used by the earth stations shall be defined and provided to the appropriate frequency assignment authorities. The results of the emc studies provide the frequency assignment authorities the information they need to select proper operating rf which will result in the earth station being compatible with the environment. EMC studies should also be performed on existing earth stations which are to be upgraded for new rf uplinks and downlinks.

4.2 Existing facilities. Existing communications facility site information will provide a valuable tool for evaluating the suitability of the facility as a potential site for an earth complex.

4.2.1 Facility description. A description of the existing communications facility should include the following information:

a. Mission and function.

b. Location: Location information may be presented as geographical coordinates along with topographic maps (or references).

c. Type of existing structures (buildings, antennas, etc.).

d. Land area: A map plot, appropriately dimensioned, will show present land use and available open areas.

e. Available power versus power consumption, to be compared to the requirements of the proposed earth terminal complex.

f. Any other information that would enhance the facility description.

4.2.2 Present configuration. The present configuration of the candidate facility may be determined from as-built drawings. Specific items of interest include the following:

a. Technical control facilities.

b. Interconnect facilities to users and DCS backbone or other long-haul systems.

c. Multiplex and radio facilities.

d. Site power system.

e. Site ground system.

f. Digital communications subsystem (DCSS) equipment.

4.2.3 Pre-survey tentative site selection. A presite survey tentative site selection is required as early as practicable to permit military departments (MILDEPS) programing for procurement of emergency generators and uninterruptible power systems if required. These long-lead items are now procured by tri-service, multi-year contract for OCS requirements. Five Year Defense Program (FYDP) programing requirements result in the need to identify the quantity and size of generators and uninterruptible power systems (appendix B) prior to site surveys for individual communications projects.

4.2.4 Future expansion plans. Base master plans for the candidate site may be used to determine plans for future construction and land use. Examination of these plans may disclose conflicts in physical space and rf spectrum utilization that could make the site unsuitable for an earth terminal complex.

4.3 Presite-survey information. Information collected and evaluated before a site-survey crew departs for a proposed earth terminal complex site will greatly facilitate the actual onsite survey. Presite-survey information may be extracted from existing documentation such as system/project plans, base master plans, preliminary engineering studies, topographic maps, and weather records. The value of presite-survey information is directly proportional to its accuracy and comprehensiveness. The information may be compared to appropriate facility criteria to disclose any obvious discrepancies present in the proposed site. Time and money will be saved when the elimination of a proposed site is based on the presite-survey information. Additionally, knowledge of facility requirements will alert the survey crew, prior to the onsite survey, to areas that must be observed. This portion of the handbook discusses the various categories of presite-survey information required and provides samples of information worksheets (appendix A). These may be used as guidance for the collection of presite-survey information.

4.3.1 Administrative information. Administrative information includes: the location of the site, land availability, descriptions of existing structures, and the identity and location of earth terminal interfaces along with characteristics of their existing communication links. Worksheets for this information is presented in figures A-1 through A-4 of appendix A. An ECAC desk study and on-base files of master plans are among the suggested sources for such information.

4.3.2 Environmental conditions. The environmental conditions to which the earth station will be subjected are important considerations in facility design and may be reflected in criteria for the construction of site buildings, shelters, and antennas.

4.3.2.1 Historical weather and seismic activity information. Local weather stations keep such historical information as required by the area environmental conditions worksheet (figure A-5). Records of seismic activity are usually available from a nearby university.

4.3.2.2 Soil and drainage information. The information to be collected on the soil and drainage worksheet (figure A-6) provides a preview of the adequacy of the standard plans for the building/van foundation and antenna pads. Typically, such information will already be available for existing sites, but for new site locations the information must be collected during the onsite survey.

4.3.3 Maps, plots, and drawings. Supporting information such as maps, plots, and drawings of the proposed site must be made available to the site survey crew prior to the onsite survey. The map and drawing worksheet (figure A-7) indicates the type of information required, grouped to provide a convenient reference for gathering the available material.

4.3.4 Land requirements. The real estate and structure requirements must be made available to the survey crew to aid in determining whether the available real estate will accommodate the earth terminal complex, as presently planned, plus any known expansion plans. The land requirement worksheet (figure A-8) will allow the survey crew to consolidate this information.

4.3.5 Power requirements. The power requirements worksheet (figure A-9), when completed, will serve to inform the site survey crew of the site power requirements, including the primary, backup, and uninterruptible power supply (UPS).

4.3.6 Physical survivability of structures requirement. The requirements for the physical survivability of the proposed site structures with respect to weather (see the physical survivability worksheet, figure A-10) will allow the survey crew to evaluate the survivability of the existing facilities to determine whether they will satisfy the earth station requirements.

4.3.7 Nuclear survivability requirements. The DCA, or other agencies for non-DCS sites, will designate those satellite earth terminal complexes that will be hardened (in accordance with current criteria and direction) to resist the effects of high-altitude electromagnetic pulse (HEMP) and for blast effects produced by a nuclear detonation. If the proposed site has been so designated, responsible planners must alert the site-survey team to the requirement and must be prepared to obtain extensive related information during the onsite survey. The nuclear survivability requirement worksheet (figure A-11) will serve to document the hardness and fallout protection requirements. (NOTE: When information is logged on the form, it is likely that the form will then require a security classification marking.)

4.3.8 Earth station facility requirements. Facility requirements include the architectural, electrical, and environmental control requirements for the technical equipment spaces. The facility requirements worksheet (figure A-12) provides information entries for equipment area floor space, door, window, and ceiling requirements. It also provides entries for temperature and airflow requirements of the communications and other equipments.

4.3.9 Access requirements. Site access information is required to guide the responsible activities during all phases of the project (construction, acceptance testing, and operation and maintenance of the operational site).

The information provided by the site access requirements worksheet (figure A-13) will allow the survey crew to determine whether the present site access will accommodate the movement of heavy construction equipment and the site equipment transporters. This information may be extracted from existing documentation or obtained by direct observation during the onsite survey.

4.3.10 Support requirements. The logistics support requirements worksheet (figure A-14) will make the survey crew aware of the general support requirements that must be investigated in greater detail during the onsite survey. The general support categories covered by the worksheet are administration, personnel, housing, POL storage, and maintenance.

4.3.11 Site survey accuracy requirements. Third-order surveying accuracy (one part in 5000) should be maintained to establish site information such as azimuth and length of baseline, elevation, and reference markers.

4.4 Onsite-survey information. The onsite survey serves to verify the information obtained in the presite survey and to expand this information base with information that is available only through an actual site visit. (Actual measurements required for site information do not necessarily have to be made by the site-survey team; such information could possibly be obtained from other reliable sources.) This portion of the handbook provides guidance to the onsite-survey team when using the worksheets of appendix A. These worksheets may be duplicated and used as required.

4.4.1 Administrative information. The administrative worksheet (figure A-15) will serve as both a checklist and information; collection format for the gamut of administrative information, which ranges from physical information such as the site location, to logistic information on the availability of personnel housing and highway access.

4.4.2 Topography and terrain. The topography and terrain worksheet (figure A-16) provides for the collection of onsite information describing the site in terms of elevation above mean sea level, vegetation cover, and terrain features. Any large obstructions or unusal features observed by the survey team should be fully described in the remarks section of the worksheet.

4.4.3 Onsite obstructions and horizon profiles. Two specific profiles are required during the onsite survey: an overall horizon profile and a detailed profile of any prominent obstructions observed from the proposed antenna location.

4.4.3.1 Overall horizon profile. Figure A-17 provides a format for the collection of information for a horizon profile, which will be obtained over a full 360 degrees of azimuth about the antenna location. As the azimuth angle is varied, the elevation angle is taken with respect to main terrain features such as significant peaks or valleys. The azimuth angle is varied in increments of 1 degree in the vicinity of the normal antenna pointing angles and in increments of 5 degrees for the rest of the profile. The normal pointing angles may be found in the ephemeris for the earth station satellite. The method used to establish the north-south reference line should be described fully to allow the profile to be verified or corrected at a later date.

4.4.3.2 Specific obstruction profile. A detailed profile of all obstructions that could shield the station antenna from the satellite will be taken in the vicinity of each obstruction. The azimuth angle should be incremented in steps 1 degree to obtain this profile. The specific obstruction profile worksheet (figure A-18) provides space for recording information on three separate obstructions.

4.4.4 Photographs. A 360-degree panoramic view of the earth station may be obtained by photographing the horizon at different azimuths (the number of photographs required is determined by the resolution of the equipment used). As an aid for interpreting and identifying the photos, markers giving the site identification, and the azimuth angle should be used. The camera should be tripod-mounted and equipped with a calibrated leveling head. The highest clarity will be achieved through the use of infrared film with appropriate filters; otherwise, the use of panchromatic film in conjunction with a haze filter is recommended. The photographic worksheet (figure A-19) provides a convenient format for information recording. Site sketches, with camera locations noted, may be attached to augment the information.

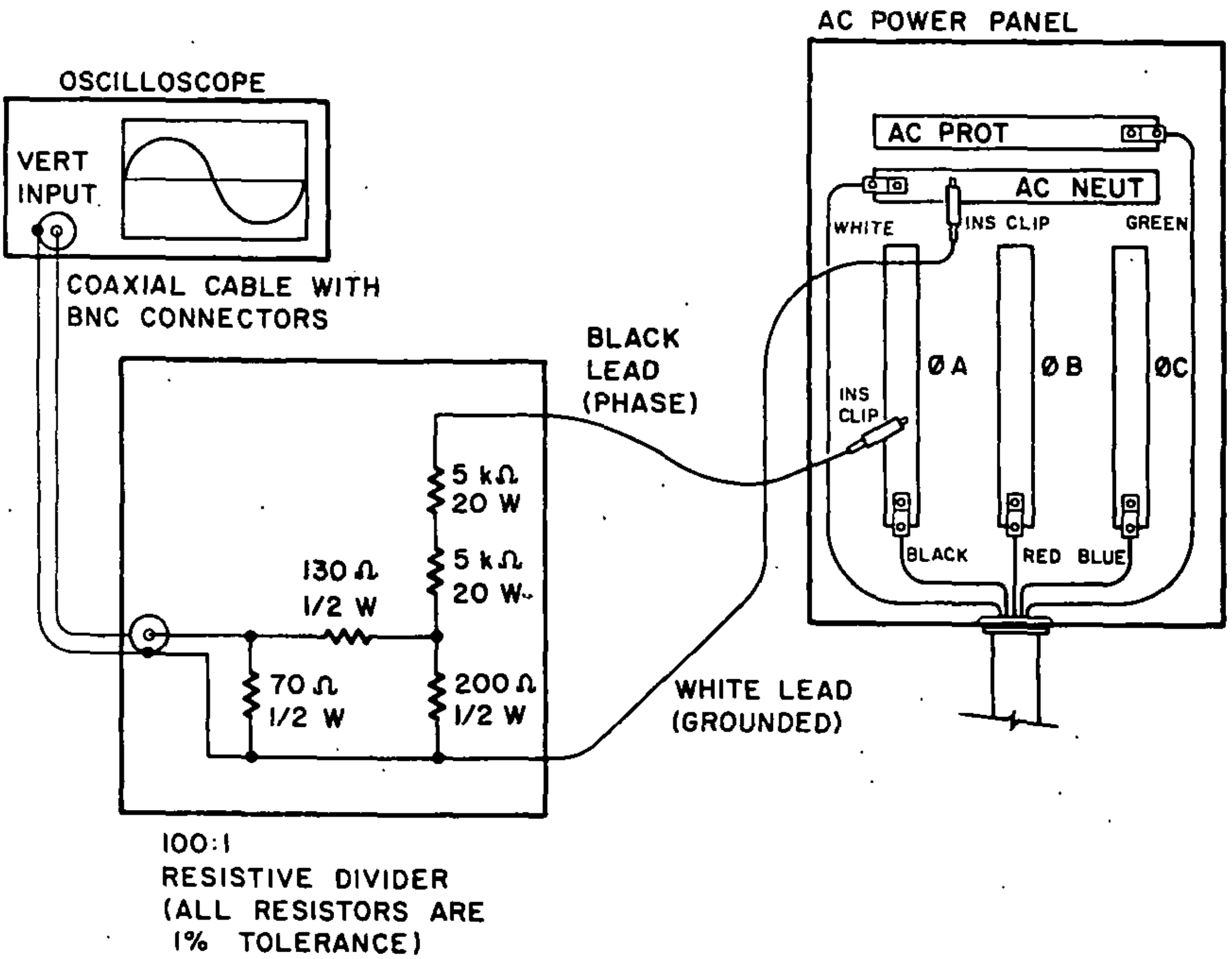
4.4.5 Existing power. The site-survey crew will be required to determine the amount and quality of electrical power available to, and consumed by, the existing facility. Areas of particular interest include the station load requirements, present and future, and characteristics of the power sources, both primary and auxiliary. These may then be used to determine whether additional power sources will be required to operate the proposed station.

4.4.5.1 Station load. The site power worksheet (figure A-20) provides a format for recording site load information such as high and low averages, peak values, and load phase balance. The values for peaks and high and low averages are found with the station high demand equipments, typically the air-conditioners, switched on and off.

4.4.5.2 Power characteristics. The characteristics of all classes of available onsite power sources are recorded on the existing power characteristics worksheet (figure A-21). These characteristics include line voltage and load current variations as a function of demand, and a record of power outages. The worksheet also provides for recording descriptions of the primary and auxiliary power sources and the uninterruptible power supply. A description of the power distribution system with its associated protective devices is required to complete the worksheet.

4.4.5.3 Noise measurement. The existing power system should be investigated to determine the magnitude of all transient noise voltages. The power noise worksheet (figure A-22) provides a format for recording the noise voltage information. Figure 2 shows one method of the test setup that allows the noise voltage measurement to be accomplished using the following equipments:

a. Portable battery-powered oscilloscope, HP 1707B, Tektronix 465 to 485, or equivalent.



<u>CAUTION:</u> THE CONDUCTOR COLORS AND WIRING IN THE AC POWER PANEL ARE REPRESENTATIVE ONLY. CHECK THE VOLTAGES ON EACH CONDUCTOR WITH REFERENCE TO A GROUND POINT (CASE) BEFORE CONNECTING THE OSCILLOSCOPE.

FIGURE 2. Powerline noise test setup.

b. Oscilloscope test cable constructed of RG-58/U or RG-59/U with BNC connections at each end.

c. Voltage divider, 100 to 1, with leads and clips, as shown on figure 2.

(For an accurate recording with printout of impulses, sags and surges, and average voltages, see 4.4.5.5.)

4.4.5.4 Station load power factor. The power factor (pf) for the composite load that the station's equipment presents to the powerline may be determined from the formula:

$$pf = \frac{\text{watts}}{\text{volt-amperes}} = \frac{W}{\Sigma V_{L-N} \quad \Sigma I_L}$$

where

W = 3-phase power, measured with a clamp-on wattmeter

V_{L-N} = line-to-neutral phase voltages for phases A, B, and C.

I_L = phase currents for phases A, B, and C.

4.4.5.5 Line voltage analysis. An analysis of the line voltage supplied to selected technical equipment will serve as a summary of the quality of the site power distribution system. This analysis may be made by monitoring the ac line voltage with a commercial line voltage analyzer. Measurements may be made at the technical power distribution power panel and values of short-term impulses, long-term sags and surges, and long-term average voltage may be recorded in the format provided by the line voltage analysis worksheet (figure A-23).

4.4.6 Earth resistivity. The earth resistivity of the proposed earth station facility is a valuable base for system planning purposes. Figure 3 shows the earth resistivity test setup using a null-balance earth tester. Four ground rods in a straight line and separated by a distance A should be driven into the ground to a depth not to exceed 1/20 of A. Separation distances of 3 to 6 meters (9.9 to 19.8 feet) with corresponding depths of 15 to 30 centimeters (6 to 12 inches) are convenient and practical. With the ground rods connected to the tester as shown, the tester resistance R is varied to obtain a null reading, and the earth resistivity, in ohm-meters, is found from $\rho = 2\pi AR$. The earth resistivity worksheet (figure A-24) provides a format for the collection of information. NOTE: All of the test leads used in this measurement should be of the same gauge and should be of sufficient size to minimize the effect of the ohmic resistence of the wire on the test.

4.4.7 Existing site ground system. The onsite-survey team must verify the existence of the ground system, and subsystems, on an existing site that is a candidate for the installation of an earth satellite terminal. As part of this verification, the team should obtain drawings of the existing ground

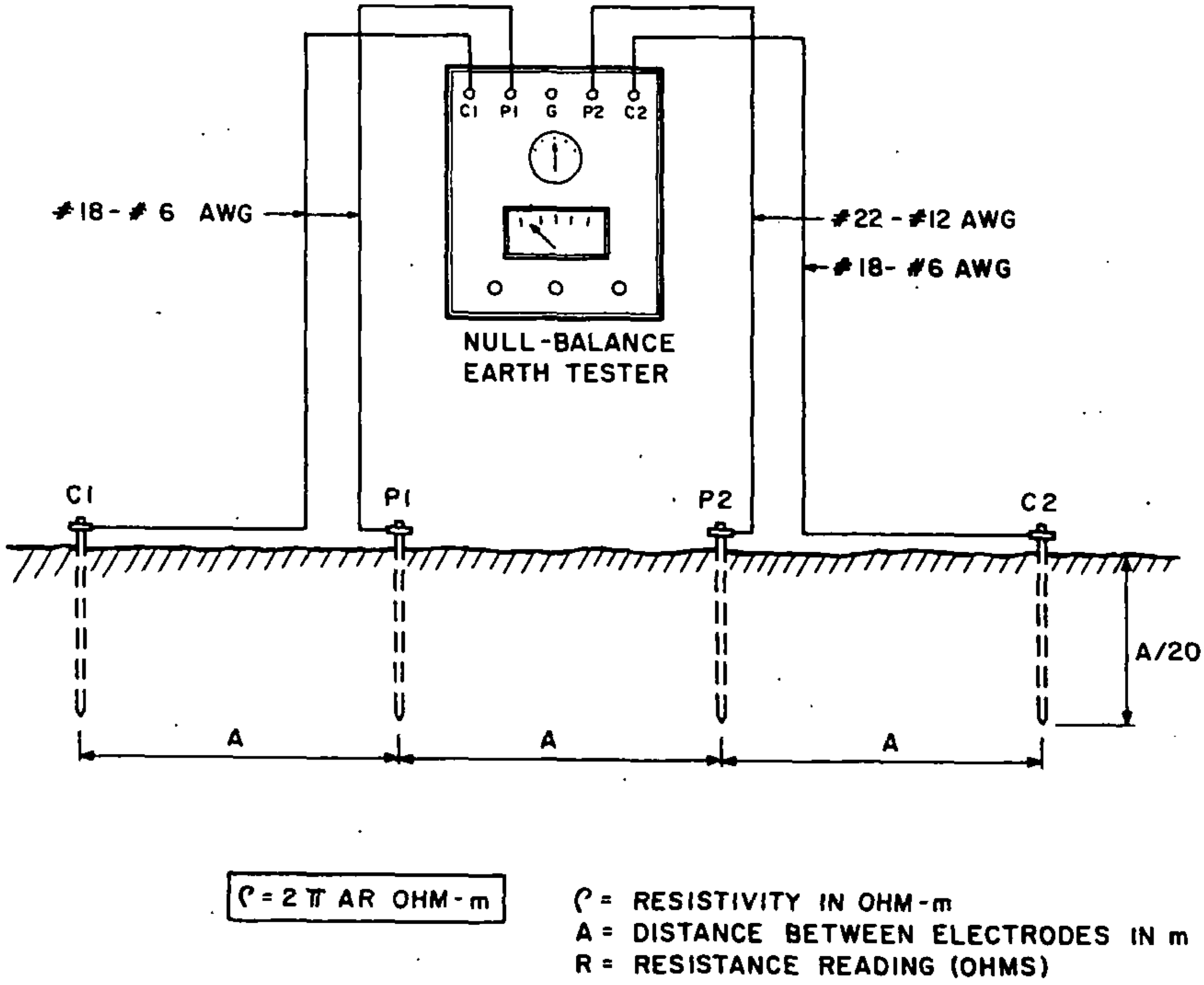


FIGURE 3. Test setup to measure earth resistivity with null-balance tester.

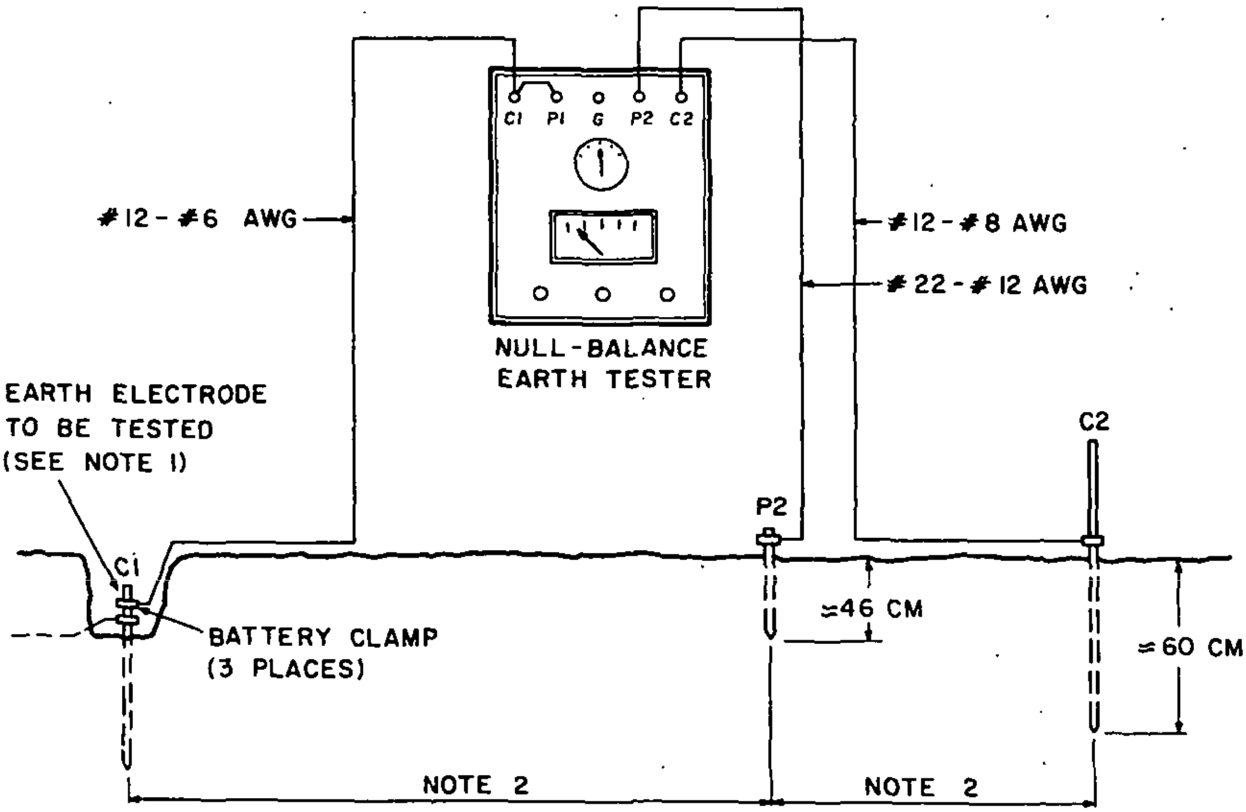
system and obtain measurements of the composite resistance/impedance to earth ground and the magnitudes of any ac and dc currents present on the ground network. The existing site ground system survey worksheet (figure A-25) will serve as a guide to alert the survey team to the extent of information required. The ground system survey information required for a given site must be determined on a case-by-case basis.

4.4.7.1 Resistance/impedance measurements. The value of the composite resistance or impedance between a test point and earth ground may be obtained by any of several methods. Three common methods are the fall-of-potential method, the comparison method (each of which requires a null-balance earth tester) and the triangulation method, which employs an earth resistance tester. The fall-of-potential is recommended and is described as follows:

Fall-of-potential method. Figure 4 is a schematic representation of the test setup for the fall-of-potential method. Ground rod P2 is located on a straight line between C1 and C2 and then moved toward C2 in discrete steps. Table I provides a guide for the initial placement of C2 and P2. As rod P2 is moved toward C2, the tester resistance setting that yields a null balance is recorded for each point. When these readings are plotted against distance, they produce a curve that increases to a certain point, levels off, and then increases again as C2 is approached. Figure 5 shows the shape of a typical curve. The level portion of the curve should occur when P2 is placed at a certain point that is approximately 62 percent of the distance between C1 and C2. If this leveling of the curve is not noted, the test series must be repeated with the C1-C2 distance significantly increased. Once the characteristic leveling is obtained, the tester resistance value(s) in the level region may be taken as the ground system resistance value. If the full test series is not feasible, a shortened test performed in the 50 to 70 percent region of the curve shown in figure 5 will yield reasonably accurate results. NOTE: All of the test leads used in this measurement should be of the same gauge and should be of sufficient size to minimize the effect of the ohmic resistence of the wire on the test.

4.4.7.2 Ground system ac current measurements. A design goal for communications systems is that there be no significant ac currents in the signal reference and equipment fault protection subsystems. (Commercially available clamp-on volt-ammeters have sensitivities limited to approximately 100 to 200 mA ac.) The onsite-survey team should check for the presence of ac currents in equipment ground leads, inside and outside ground conductor networks, in waveguide ground leads, and in equipment fault-protection ground leads. The test equipment should be used in accordance with procedures given by the manufacturers' equipment manuals. The ground conductor ac current worksheet (figure A-26) is provided to record the information.

4.4.7.3 Ground system dc current measurement. The presence of dc currents in a site ground system is, also, an undesirable condition. Available clamp-on dc milliammeters should be used to obtain the magnitudes of any dc currents in all equipment ground leads. The ground conductor dc current worksheet (figure A-27) provides an information record format.



NOTES:

1. THIS CAN BE THE EARTH GROUND RING AROUND A FACILITY, A TOWER LEG, AC POWER NEUTRAL GROUND, OR OTHER EARTH GROUND POINT.
2. THE DISTANCE OF P2 VARIES FROM 0 TO A C1-C2 DISTANCE FOR A COMPLETE CURVE. AS A MINIMUM, 70% OF C1-C2 IS REQUIRED.

FIGURE 4. Fall-of-potential resistance measurement method.

TABLE I. Guide to ground rod placement for fall-of-potential ground resistance measurement.

Maximum dimension of earth electrode network meters (feet)	C1-C2 distance meters (feet)
25 (82.5)	40 (132)
50 (165)	75 (247.5)
100 (330)	150 (495)
200 (660)	300 (990)
300 (990) and up	450 (1485)

NOTES: 1. C1-P2 distance should be adjusted to 62 percent of C1-C2 distance.

2. Use of this table in conjunction with the fall-of-potential method will yield measurements with a minimum accuracy of ±10 percent.

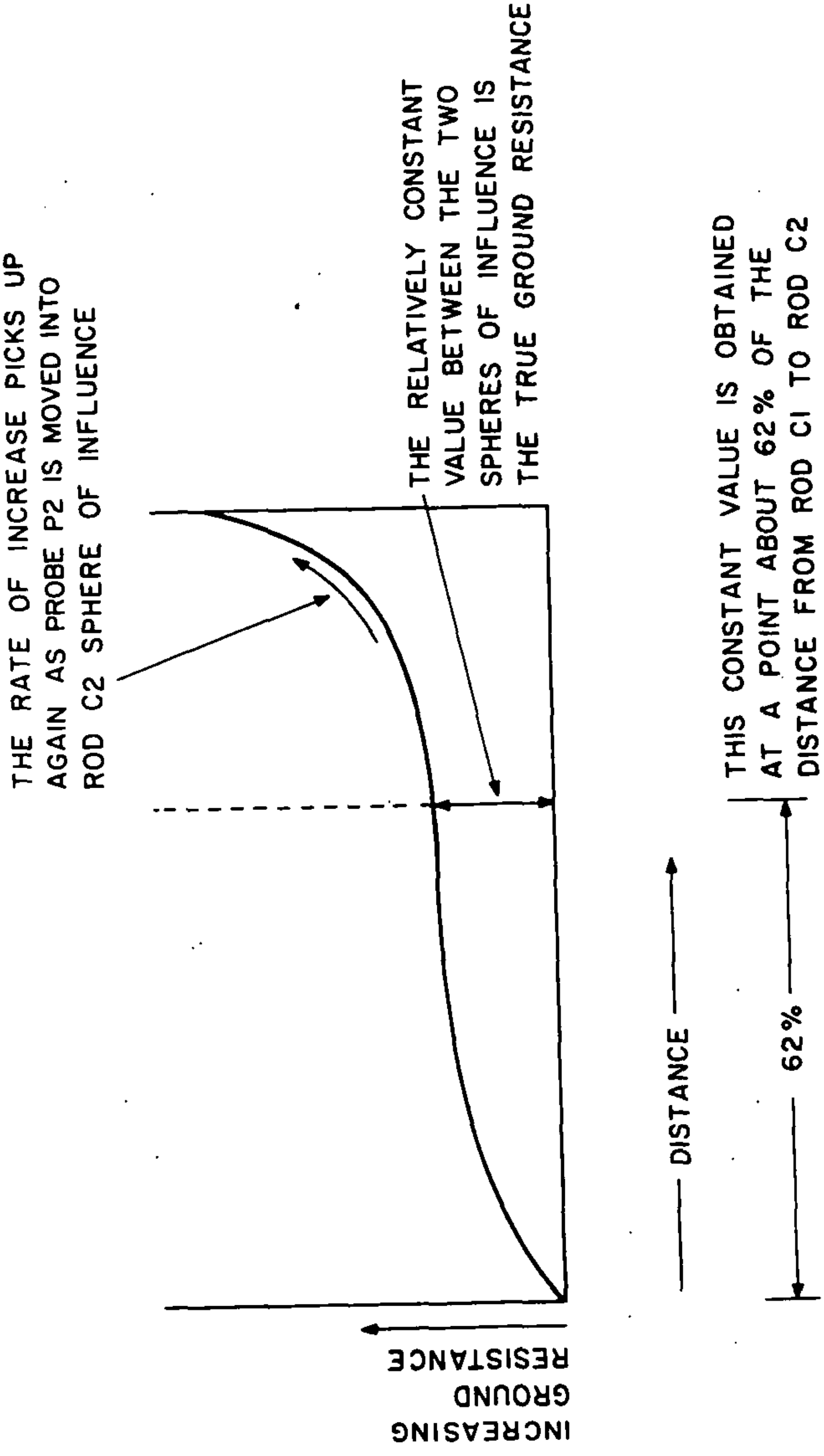


FIGURE 5. Typical curve produced by plotting fall-of-potential information set.

4.4.8 Nuclear survivability. The onsite-survey team may be directed to obtain an extensive nuclear survivability information base for those satellite earth terminal sites designated as hardened facilities (see paragraph 4.3.7). The nuclear survivability worksheet (figure A-28) provides a format for recording information describing those normal site elements that may act as unintentional receptors of the electromagnetic pulse (EMP) produced by a nuclear detonation. This information, augmented by existing engineering drawings and sketches made by the survey team, will be used to make order-of-magnitude EMP coupling calculations to determine the site's EMP vulnerability. The site's ability to sustain its operational function when exposed to the hostile environment created by the EMP or nuclear blast can be estimated from this information.

4.4.9 Physical security of site. The security classification of the site will have been determined during the presite survey, and any special security requirements will have been identified. The onsite-survey team will investigate security measures in force on existing sites and compare them to the requirements of the earth satellite terminal. The site security worksheet (figure A-29) provides a format for recording observations concerning the existing security scheme; including fences, lighting, intrusion sensors, and guard system.

4.4.10 Transmission link to DCS. The onsite-survey team must be made aware of the connecting communications links (present and projected) with the TCF, or other direct access activities, and the earth station. The team must ensure that no onsite obstructions or restrictions exist which would interfere with, or preclude the operation of, these links. With the transmission mechanism of the connecting link identified (for example, line-of-sight, cable, or fiber optics), the onsite-survey team will verify that link operation is feasible over the entire path. Figures A-30 and A-31 provide information records for line-of-sight and cable system links, respectively.

4.4.11 Logistic support. The procurement, distribution, maintenance, and replacement of material and personnel, during both the construction/installation phase and the O&M phase of the earth station's life cycle, are important considerations in the system design and engineering process. The onsite-survey team must investigate and report on all aspects of available logistics support (including communications, transportation, and legal considerations). The worksheet presented in figure A-32 offers a convenient format for reporting this information.

4.4.12 Weather information. The onsite-survey team must collect weather information from local weather stations to confirm the findings of the presite survey (see paragraph 4.3.2.1). Weather information may be recorded on worksheet figure A-5.

4.4.13 Real estate. The onsite-survey team must collect information on the real estate that must be acquired for a new facility or for the expansion of an existing facility to accommodate the earth satellite station. The real estate description worksheet (figure A-33) provides for recording information regarding the ownership, legal description, and expansion capabilities of the needed real estate. NOTE: The cognizant US Army District Engineer (or his overseas equivalent) must be contacted prior to any attempt to collect this data.

4.4.14 Utilities. Figure A-34 provides a format for the survey team to report on the commercially available utilities in the vicinity of the proposed site (i.e., electricity, water, telephone, and gas).

4.4.15 Soil load-bearing information and drainage. The onsite-survey team must collect soil and drainage information to confirm the presite survey information in the case of existing sites (see paragraph 4.3.2.2) or to complete the information package on an undeveloped new site location. Most probably, soil penetration information will not be required, given the load requirements of the equipments and structures of the typical earth satellite station and the fact that antennas and radomes will be installed on concrete pads; however, the soil load-bearing worksheet (figure A-35) makes provision for recording penetrometer readings for sites where it has been determined that detailed soil information is required. The soil and drainage worksheet (figure A-6) will be more useful for the routine recording of information such as soil composition, estimated water table depth and flooding history of the site.

4.4.16 Safety. The onsite-survey crew must be aware of the hazard standards prescribed by the individual military services (see paragraph 1.6.1) for personnel, fuels, and electroexplosive ordinance devices. The survey crew will be responsible for reporting, to responsible system planners, the presence of any radiator in the area of the proposed earth terminal site that could produce rf power density levels in excess of these standards. Seismic information (figure A-5) should also be obtained.

4.4.17 Electromagnetic compatibility. The installation of the satellite earth station shall conform to the requirements of the Department of Defense Directive 3222.3, to ensure that the stations' equipment will not interfere with existing onsite equipment nor with any civilian or military telecommunications equipment operating in the vicinity. Where electromagnetic compatibility problems are identified or suspected, an emc study may have to be conducted by an agency that specializes in this work, such as the ECAC (paragraph 4.1.6.1).

4.5 Introduction to facility design. Facility design encompasses the engineering and installation planning of the physical aspects of a satellite earth station, such as site selection, acquisition, and layout. Ancillary subjects include the station's power service requirements and grounding subsystems.

4.5.1 Scope of facility design. The portion of this handbook on facility design provides criteria from which construction plans and specifications may be developed for satellite earth stations in either fixed or vanized form. The facility requirements this handbook concentrates on are:

a. Roads and parking area.

b. Water supply.

c. Sewers.

d. Cable trench.

e. Antenna assembly foundation.

f. Security fencing.

g. Area lighting.

h. Site grading and drainage.

i. Personnel walkways.

j. Interior lighting.

k. Occupancy level per room.

l. Power systems.

m. Ground systems.

The requirements for support facilities (such as personnel and administration, technical control, link interface, and power building) are considered in less depth as reminders only.

4.5.2 Facility design goal. The facility design goal is that the supporting technical equipments have a minimum useful life of 15 years based on a three-shift, 24-hour-per-day, seven-day-a-week schedule.

4.5.3 Site layout considerations. The typical satellite earth station may be accommodated on a rectangular plot, 60 to 91 meters (200 to 300 feet) on a side, with an area of 549 square meters (1 or 2 acres). This area is sufficient to site the technical equipment building, one or two antennas, and the required power sources in accordance with the layout criteria applicable to the particular equipment to be emplaced. Site layout plans for selected equipments are provided in appendixes C through G, which identify the specific area and shape requirements, number of antennas and their relative orientation, and the site support structure requirements.

4.6 Site preparation. Site preparation is an aspect of facility design that must be considered early in planning the construction, installation, and operation of a satellite earth station. This portion of the handbook provides the planner with guidance and criteria for the general site preparation considerations introduced in 4.5.1, which, when coupled with specific technical requirements, will present the complete facility design requirements. Additional information is available in AFM 86-2 and AFM 88-15.

4.6.1 Roads and parking area. Site access roads shall be constructed to accommodate vehicles weighing up to 20,455 kilograms (45,000 pounds), with a maximum width to 3 meters (10 feet) and a maximum height of 4.28 meters (14 feet). Prior to antenna installation, an area (within a radius of 15.24 meters (50 feet) of the antenna foundation) shall be made suitable for all-weather operation of heavy construction equipment. The parking area shall accommodate a minimum of five passenger vehicles plus additional parking area as justified by the using command.

4.6.2 Water supply. Whether the earth station is to be installed on an existing facility or on a new independent site, provision must be made for a potable water supply for personnel usage (both drinking and sanitary). Additionally, a water supply shall be provided that is suitable for air-conditioning humidifier makeup, general housekeeping, and fire protection.

4.6.3 Sewers. Sewage systems of existing facilities will be investigated to ensure that they will accommodate the extra load imposed by the earth station personnel. Installation and engineering plans for new sites must include an adequate sewer system. A soil percolation test should be conducted at all new sites, without existing sewer systems, to determine whether the land can accommodate a sewage system.

4.6.4 Cable trench. For fixed satellite earth stations, a cable trench shall be constructed to connect the underfloor area of the technical equipment room to the antenna support structure. The routing and details of the cable trench may be found on the site layout drawings for the particular equipment (appendixes C through G). The cable trench is optional for the vanized configured station, with an overhead waveguide/cable tray as an alternative. If the site requirements dictate that a road cross the cable trench, the trench covers must be modified to accommodate the vehicular traffic (this situation is not recommended). The trench should be designed to avoid standing water, and a sump pump or gravity drain shall be installed as required.

4.6.5 Antenna assembly foundation. Foundations and support structures shall be provided for antenna erection at both fixed and vanized earth stations. Details of fixed site antenna assembly foundations may be found in the applicable drawings for any given item of equipment (appendixes C through G).

4.6.6 Security fencing. The specific requirement for security fencing will depend on the site selection and the existing security measures, if any. A general requirement for the fixed facility is that an area, with a minimum radius of 30 meters (100 feet) from the antenna foundation, be kept clear to allow antenna installation. The basic requirement for the AN/MSC-46 satellite terminal complex may be cited as an example of a vanized facility fencing requirement: 305-meter (1000-foot) perimeter of 2.5-meter (8-foot) chainlink fence topped with three strands of barbed wire. It is desirable that security fencing be at least 10 meters (33 feet) from buildings or vans.

4.6.7 Area lighting. The area lighting requirement exists for both security and personnel safety. Light intensity levels to satisfy security requirements depend on the local requirements of the individual sites. For safety, a minimum of 10 foot-candles, measured 1 meter (39 inches) from the ground, shall be maintained where there is mechanical equipment.

4.6.8 Site grading and drainage. Site grading must satisfy two requirements: drainage and transmitter-room/antenna orientation. Both fixed and vanized sites must be graded to provide drainage away from vans, structures, walkways, and cable trenches. The fixed site transmitter-room/antenna orientation requirement for the AN/GSC-39(V-1) and the AN/FSC-78(V) arises from the stipulation that elevations of the raised floor of the transmitter room and the floor of the antenna base must be selected so that the grade between them will not exceed ±3 percent.

4.6.9 Personnel walkways. Personnel walkways within the facility boundaries should be constructed to allow maintenance personnel free movement and easy access as they perform their duties.

4.6.10 Interior lighting. The interior lighting of the technical equipment area shall be maintained at 50 foot-candles measured 1 meter (39 inches) above the floor.

4.6.11 Occupancy level per room. Room occupancy levels will be developed by the responsible Engineering and O&M Command with consideration of American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and human-engineering guidelines.

4.7 Fixed-site facility design. This portion of the handbook outlines general criteria applicable to the physical plant aspect of fixed-site facility design. The purpose is to provide guidance regarding the structural, architectural, environmental, support facility, and fire protection design considerations of the technical equipment and support facility spaces for a fixed earth satellite station. Specific criteria for these design considerations are given in appendixes C through G. Additional information is available in AFM 86-2 and AFM 88-15.

4.7.1 Structural design. The structural design criteria for the technical equipment spaces shall ensure that the technical equipment housing conforms to the environmental protection requirements as defined by TM 5-809-1, or NAVFAC DM-2, or AFM 88-15, and DOD 4270.1-M.

4.7.1.1 Equipment load-bearing requirements. The maximum weights of all technical equipments must be tabulated and used as a guide for the load-bearing floors of the technical equipment spaces.

4.7.1.2 Special considerations. Special considerations falling within the purview of structural design may include requirements for equipment anchors, special foundations, and equipment frames and racks. Special considerations will be incorporated into the structural design on a case-by-case basis.

4.7.2 Architectural design. The establishment of overall architectural design criteria achieves a twofold purpose: (1) standardized placement of technical equipment allows installation crews to gain proficiency with experience, and (2) prefabricated interconnecting cable assemblies may be used.

4.7.2.1 Equipment floor space criteria. A floor plan for the layout of a typical technical equipment building should provide floor space for communications equipment and transmitter equipment.

4.7.2.2 Maintenance and supply space. Maintenance and supply space shall be provided adjacent to the technical equipment area.

4.7.2.3 Floor design requirements. The floors of the technical equipment space shall be composed of removable, interchangeable panels, shall conform to the requirements of MIL-F-29046(TD), and shall meet specific criteria with regard to:

a. Panel size.

b. Design loading, uniform.

c. Design loading, concentrated.

d. Allowable deflection.

e. Height above subfloor.

f. Panel surface material.

g. Resistance to lateral loads.

h. Leveling capability.

i. Air leakage.

j. Air registers.

k. Acoustics.

4.7.2.4 Door requirements. Both interior and exterior doors shall be the hollow metal type set in metal frames. Exterior doors will be insulated and weather-stripped. A vestibule is required at the personnel entrance. Exterior doors should be equipped with automatic closures. NOTE: Sites designated for hardening will have different criteria.

4.7.2.5 Window requirements. No windows shall be installed in the technical equipment spaces.

4.7.2.6 Ceiling requirements. The ceilings of the technical equipment room should be the suspended acoustical type with all light fixtures recessed. Designs which provide equivalent or better flexibility, accoustical properties, and energy efficiency are prefered. If required, air registers can be flush-mounted. The height shall be 2.7 meters (9 feet) minimum above the raised floor, with a 3-meter (10-foot) design goal.

4.7.2.7 Partition requirements. Interior partitions should be relocatable and shall be noncombustible.

4.7.2.8 Acoustical requirements. The noise in the communications equipment area shall not exceed a level of NC-45 (MIL-STD-1472). In the transmitter equipment area, the level will not exceed NC-60.

4.7.3 Environmental design. Design criteria are provided as guidance in planning the plumbing and environmental control systems.

4.7.3.1 Plumbing requirements. A floor drain will be provided in the transmitter equipment area to allow for periodic flushing of the heat exchangers. Toilet facilities must be provided for the O&M personnel, and a utility sink with hot water for general housekeeping functions would be desirable. Where used, raised-floor mounted air-conditioners will require condensate and humidifier drain lines and a humidifier water supply line.

4.7.3.2 Environmental control requirements. Environmental control in the technical equipment spaces is required on a year-round basis. Specific requirements for environmental control are as follows:

a. To accommodate the system availability criteria; either two complete air-conditioning systems must be provided, each capable of sustaining 100 percent of the total design load, or there must be multiple computer-room type air-conditioners, sized to satisfy the space cooling load, plus one redundant unit (or equivalent design which will provide the required reliability/availability.

b. The raised floor of the technical equipment room shall serve as the supply air plenum to deliver the conditioned air supply to the bottom of the transmitter and communications equipments. Relative humidity within the plenum shall not exceed 60 percent.

c. The room environment will be supplied by floor registers mounted in the floor panels and equipped with key-operated, adjustable volume dampers.

d. Where the two complete air-conditioning systems are used, return air should be collected at ceiling level and returned to the air handling unit intakes. Where the computer-room type air-conditioners are used, they should be dispersed so that the direct return-air-path distance is minimized and "hot-spot" potential is avoided.

e. Filtered outside air per room occupant will be required for ventilation and space pressurization (per ASHRAE and DOD guidelines). Review current CBR survivability requirements.

f. For the 100 percent redundant system, the recommended air-conditioner's refrigeration system should include a hermetically sealed compressor, a remote condenser, and an integral control panel supplied as a factory-assembled package.

g. The recommended computer-room type air-conditioner should be self-contained with disposable medium-efficiency filters and have integral controls for cooling, heating, steam humidifying, and dehumidification. The unit may be either the direct expansion air-cooled type or the chilled water type, whichever is more economical.

h. The temperature and humidity of the technical equipment spaces shall be controlled by the thermostats and humidistats as follows:

(1) The refrigeration will be controlled by a humidistat with an override by the thermostat.

(2) The refrigeration cycle will be activated by either a high relative humidity or a high temperature.

(3) The reheat coil will be controlled by a thermostat when it becomes necessary to lower the temperature for dehumidification.

(4) The humidifier will be activated when the humidistat senses a low-humidity condition.

4.7.3.2.1 Interior ambient conditions. Criteria must be established for the following interior ambient conditions in the technical equipment spaces:

a. Temperature.

b. Humidity.

c. Special air supply conditions for the transmitter equipment and filters:

(1) Minimum air flow per transmitter.

(2) Maximum air temperature.

(3) Minimum air pressure.

d. Pressure differential between the underfloor plenum and the technical equipment room. This differential shall not be less than .76-centimeter (0.30-inch) of water pressure.

e. The environmental control system must be designed to use the full range of the required ambient conditions. Energy will be saved by not over-specifying the environmental control above that which is required. Future electronics systems are expected to be able to withstand wide environmental conditions and to dissipate much less heat.

4.7.3.2.2 Load requirements. Space cooling and heating load requirements may be computed based on the load calculation form contained in ASHRAE GRP 158. For the nontechnical equipment spaces, interior ambient temperature shall be 20° CDB (68° FDB) winter and 26.6° CDB (80° FDB) summer.

4.7.3.2.3 Space pressurization. A positive air pressure shall be maintained in the technical equipment spaces.

4.7.3.2.4 Minimizing electrical sags and surges. Upon startup, the compressors of large-capacity air-conditioning systems characteristically impose high-level current surges (and corresponding voltage sags) on the site power distribution network. For example, one site study conducted on an operational fixed earth satellite station disclosed a phase current surge on the order of 400 amperes per phase at 440 V_{L-L} each time the 60-hp compressor motor started. This surge occurred at 30-minute intervals, as set by a timing control relay, and caused a corresponding undesirable sag in the supply line voltage, measured as 107 Vac (down from an average of 118 Vac). These sags were observed to be present for a period of 15 to 25 cycles. Slight surges resulted when the motor switched off. This undesirable situation may be alleviated by a number of methods, as follows.

a. The compressor motor cycle could be lengthened by adjusting the timing control relay. For example, if the 30-minute interval cited above was extended to 45 minutes, the effect would be to reduce the number of sags and surges by 50 percent. This would extend the operating life of equipment subjected to the voltage variations. The drawback to this method is that, although there are fewer sags and surges, the severity of those that remain is unaffected.

b. A second method, which would completely eliminate the sags and surges, involves lowering the joule (Btu) output of the unit and setting the control relay for continuous compressor motor operation. This solution may or may not be practicable, for the reduced joule (Btu) output may not efficiently accommodate the range of site air-conditioning requirements.

c. The most usual solution is to reduce the peak starting currents by introducing two- or three-step starting through modification of the motor control panel associated with the compressor motors where this is not used already. Proper selection of the starting resistors and time delay between steps can reduce the current peaks to one-half or less.

d. A fourth method to reduce starting current surges involves the computer-room type air-conditioner described in 4.7.3.2g. This type of air-conditioner will run almost continuously, under certain conditions, thereby reducing surges due to compressor startup. These conditions are: the air-conditioners are sized to match the cooling load; the outside ventilation air is set at minimum requirement; the air-conditioned space includes a superior vapor barrier; the air-conditioned space air infiltration/exfiltration is minimized and the space is insulated in accordance with DOD 4270.1-M.

4.7.4 Support facility design. Although the details of support facility design are outside the scope of this handbook; the responsible planner of fixed and vanized earth satellite terminals must be aware of the requirements (including environmental control). Requirements for personnel and administration space, the technical control facility, the system communications link interface or multiplex facilities, and the power building must all be considered. One or more of these support requirements may require consideration, depending on whether the planned satellite facility is to be emplaced on an existing or a new site. For details concerning the design of support facilities, the reader is directed to the appropriate documents listed in the reference document section.

4.7.5 Fire protection design. A fire alarm and protection system must be provided for the protection of equipment and personnel. The protection system must conform to service and local civil requirements. In addition, it is recommended that ionization type detectors be installed in the underfloor plenum, the equipment areas, and the ceiling spaces.

4.8 Vanized earth station facilities. The land area and shape requirements are approximately the same for the typical vanized and fixed earth stations using the same equipment; and the general site layout considerations presented in 4.5.3 are applicable to both types of facility. The major difference in the physical layout of the two types of sites is that, in the vanized configuration, the vans are drawn up along both sides of a vestibule structure which provides covered access between the vans.

4.8.1 Vanized site preparation. The general site preparation considerations given in 4.6 are essentially the same for the vanized and fixed facilities.

4.8.2 Building and structure requirements. Generally, the vanized configuration of an earth station will require antenna support and protective structures identical to those of the fixed configuration of the same equipment. The central building and vestibule is a fixed requirement in some vanized equipment configurations and optional in others, and it must be determined on a case-by-case basis. Where it is required, the building typically houses administrative office space, sanitary facilities, and the uninterruptible power supply.

4.8.3 Additional vans. Additional vans or shelters may be required to support ancillary functions such as logistics, maintenance, control, and interface.

4.9 Electrical power system design. The power sources and distribution system should be dependable, free from disturbances, and easily maintainable. The efficient operation of the earth complex requires a dependable power system that will minimize the number and length of communications outages. Added to the primary objective of dependability are: (1) cost effectiveness, to provide the best possible system for the least amount of money, and (2) standardization, to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411, AR 420-43, NAVFAC DM-4, AFM 88-15 and the National Electrical Code.

4.9.1 Power characteristics. Power characteristics for typical earth complexes are as follows:

a. Voltage: 208/120 V ±10 percent

b. Frequency: 50 or 60 Hz ±5 percent

c. Voltage balance: Line-to-neutral voltages shall not deviate from nominal by more than ±2.0 percent for any balanced load that varies from 0 to 100 percent. Line-to-neutral voltages shall not deviate from nominal by more than ±5 percent for 20 percent unbalanced loads.

d. Harmonic distortion: Total harmonic distortion shall not exceed 5.0 percent. No single harmonic shall exceed 3.0 percent.

e. Phase displacement: Phase displacement shall not exceed ±1.0 degree for balanced loads or ±5.0 degrees for 50-percent unbalanced loads.

f. Load characteristics: Actual power characteristics at a given site depend on factors such as: the type of earth terminal equipment, number of earth terminals, whether or not DCSS equipment is installed, loading of high-powered amplifiers, type and size of ICF, and support facilities (mess hall, barracks, guard post, outside floodlights, etc.). In addition to equipment, the noncritical utility and support power requirements must be added. The utility and support power requirements may differ from those of the earth complex. For example, large-capacity utility equipment in the United States may require an intermediate voltage such as 480/277 Vac, whereas in most of Europe the utility power is supplied at 380/220 Vac, 50 Hz. In other countries, the power may be supplied at voltages as low as 200/100 Vac (Japan), or as high as 415/240 Vac (Kenya and Cyprus). The standard frequency in all countries is either 50 or 60 Hz.

4.9.2 Station power factor. Stations using commercial power will be billed for the watts consumed, with the billing rate adjusted for power factor, peak demand, etc. The rate will increase as the power factor decreases. The power factor of the station load will be determined and power factor corrections made for values below 80 percent. The power factor can be improved by the use of capacitors or synchronous machines because both can supply reactive kilovars to the system. It is usually not cost-effective to improve the power factor beyond 95 percent.

4.9.3 Station power sources. Primary power may be furnished by an off-station source (either a commercial company or a Government source) or generated locally at the facility.

4.9.3.1 On-station power source. On-station prime power plants are considered only where the locally available power is either extremely unreliable or prohibitively expensive, where no power is available, or where self-sufficiency is required for survivability and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas turbine generators, steam turbine generators, nonstandard diesel engine generators, etc.) can also be used and should be considered when requirements for a wartime DCS dictate their use. An on-station prime power plant will use a minimum of three engine generator sets with one set online and carrying the station load, one set as a standby, and one set as a maintenance spare. A more reliable configuration is to use four or five generator sets with two sets online in a load-sharing mode, one as a cold standby unit and one or two as maintenance spares. Where the station's standby power requirements exceed 70 percent of the total power requirements and the standby power is redundant; a study should be made, in accordance with DOD 4270.1-M. The study should determine whether it will be more economical to provide a total energy system that produces both electrical and steam power to be used as needed.

4.9.3.2 Auxiliary power source. An auxiliary power source is required when the prime power is provided by a commercial or remote Government source on the same base. The auxiliary power source can be: a backup or standby generator facility located on-station, an auxiliary power plant on a nearby or host military installation, or an alternate high- or low-voltage feeder from a commercial power plant. An auxiliary power source located on-station should use two generators, with one unit in a standby state and one as a maintenance spare. Where a station is programed for a large future increase in load or has a new requirement that increases the load beyond the capability of one generator, an additional unit can be added. In this case, two generators will be maintained in a cold standby state with one maintenance spare. The two generators can then carry the station load in a load-sharing configuration. However, the trend to lower power use and integrated circuit electronics in modern systems must be considered. The past practice of adding an expansion factor should be resisted since changes to the electronics system will likely require far less power in the future. Where the auxiliary power source is an alternate commercial power feeder or an off-station auxiliary power plant, the distribution network should be arranged for a fast interconnection with an emergency generator. The emergency generator should be large enough to carry the site critical load and should be a tactical-type unit mounted on a trailer or skids. The generator need not be stored on-station but should be kept within an easily accessible area, such as at a local maintenance pool where it will receive regular service. A generator should be chosen from the DOD mobile electric power (MEP) standard generators, when the auxiliary power source is determined to be cost effective (as opposed to renewable energy sources or other techniques of power generation). Comprehensive information on MEP generators is presented in MIL-STD-633 and AFM 88-15. Table II summarizes the characteristics of selected generator sets.

4.9.3.3 Power source location. All onsite power sources and substations should be located at a point within the station boundary where there is adequate security. Additional guidelines for location of power sources and substations are given below:

a. The primary onsite power source should be located far enough from the station work areas to ensure an acceptable acoustical noise level, as outlined by the acoustical noise requirements of MIL-STD-1472.

b. The primary substation should be located so as to conveniently accept delivery of power from an off-station source and distribute the power to onsite facilities as required.

c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

TABLE II. DOD standard family generator characteristics.

kW	Freq (Hz)	Type engine	No. Ø	MTBF (hours)	Classification type/class	pf	MEP model no.
60	50/60	Diesel	3	500	I/2	0.8	006A
60	50/60	Diesel	3	500	I/1	0.8	105A
60	400	Diesel	3	500	I/1	0.8	115A
60	400	Gas turbine	3	1500	I/2	0.8	404A
83.3/100	50/60	Diesel	3	500	I/2	0.8	007B
83.3/100	50/60	Diesel	3	500	I/1	0.8	106B
100	400	Diesel	3	500	I/1	0.8	116B
167/200	50/60	Diesel	3	500	I/2	0.8	009A
167/200	50/60	Diesel	3	500	I/1	0.8	108A
417/500	50/60	Diesel	3	500	I/2	0.8	011A
417/500	50/60	Diesel	3	500	I/2	0.8	029A
625/750	50/60	Diesel	3	1500	I/2	0.8	409A
625/750	50/60	Diesel	3	1200	I/2	0.8	208A

d. Auxiliary power sources should be separated from the primary source or substation by enough distance to prevent the spread of damage resulting from fire or explosion.

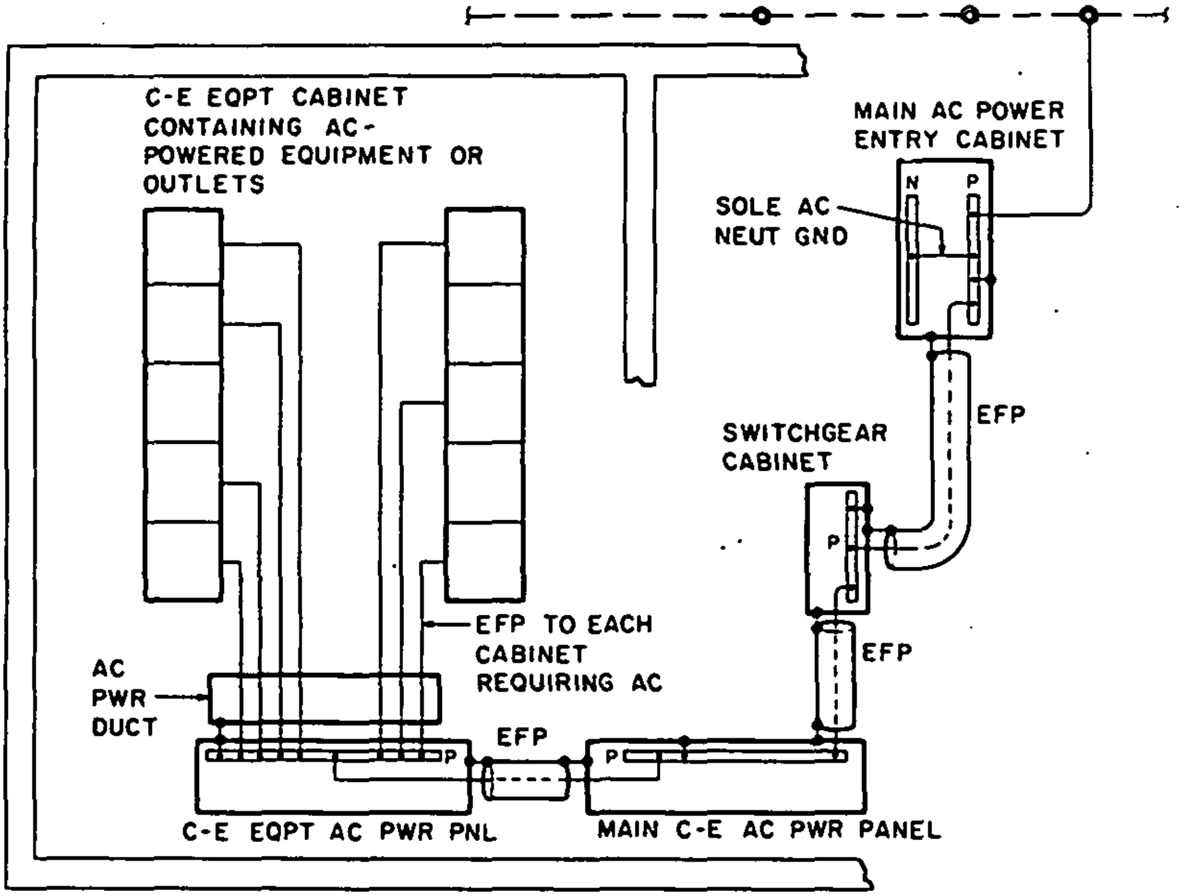
4.9.4. Uninterruptible power supply (UPS). An UPS is necessary to condition primary and auxiliary power to precise high quality power as required by electronic communications and to provide protection from power line transients and power outages. A solid state UPS consists of a rectifier/charger, batteries, inverter, protective equipment, static switches, and other accessories. Continuity of power during emergency periods of power transfer is maintained by an energy storage battery. Uninterruptible power is required at a satellite facility to avoid long communications outages, caused by short power outages which result in the loss of satellite tracking ability. The various types of UPS (static, flywheel-motor-generator, rotary, electronic, and hybrid) are discussed and compared in appendix B.

4.9.5 Protection and electrical noise reduction. Protection and electrical noise reduction requirements are more critical at a communications station than at any other type of facility because the equipment is highly susceptible to damage from transients and to operational limitations from electrical noise. The green grounding conductor shall be run with the phase and neutral conductors in accordance with MIL-STD-188-124.

4.9.5.1 Fault circuit protection. The purpose of fault circuit protection is to remove the fault voltage in the event of an equipment malfunction. The fault circuit network should provide a solid metallic path routed directly with the phase conductors from each ac powered load to the main station electrical ground point which will normally be the station transformer(s). A separate conductor should always be provided for this fault circuit and should be routed with the ac phase-neutral conductors. The conductor should be green-insulated and sized in accordance with the National Electrical Code. Figure 6 illustrates a simplified ac fault circuit protection installation at a communications station. A benefit of the type of network illustrated is that it channels the fault currents more directly to the source and thereby minimizes their effect on other ground conductors.

4.9.5.2 Transient voltage suppressors. Because of their proven effectiveness, small size, relative ease of installation, and low cost; transient (or impulse) voltage suppressors are recommended for installation at selected locations. For general equipment protection from source-generated transients, suppressors can be installed at intermediate ac power distribution points at the 480/277, 380/220, and 208/120 Vac levels. Equipment and source-generated transients can be "clipped" by installing suppressors in each power panel supplying critical technical equipment. Metaloxide varistors (MOV) have all of the above properties, plus relatively good "clipping" curves and high peak current capabilities, and can be used for general application.

4.9.5.2.1 MOV description and location recommendations. MOV are available in two basic configurations for power distribution applications. One configuration is recommended for power panels housing branch circuit breakers and the 208/120 V main distribution panels. The other configuration is recommended



NOTE:
AC PHASE AND NEUTRAL WIRES AND METAL-TO-METAL CONTACTS ARE OMITTED FOR CLARITY. THE GROUNDING LEAD (EFP) IS IN THE SAME ENCLOSURE OR CABLE WITH THE POWER CONDUCTORS.

LEGEND:

EFP —EQUIPMENT FAULT PROTECTIVE WIRE IN DUCT OR CONDUIT, GREEN INSULATION. SIZE IN ACCORDANCE WITH NEC.

N —AC NEUTRAL BAR

P —EFP BAR

(conduit symbol) —CONDUIT

◎ —GROUND ROD

CE —COMMUNICATIONS/ELECTRONICS

FIGURE 6. Simplified fault protection installation.

for distribution buses "upstream" from branch circuit panels. Gas spark-gap protectors are also useful at intermediate distribution points and at the primary power entrance point. Gas spark gaps have higher peak current and energy levels than MOV but require greater voltage differentials between operating and breakdown voltage.

4.9.5.2.2 Recommended suppressor installation criteria. The following recommendations apply to both the gas spark gap and the MOV:

a. Suppressors can be installed in ac power panels or separate enclosures next to power panels. If a separate enclosure is used, a transparent cover is desirable.

b. Suppressors are wired from phase to ground. At the primary disconnect point, this ground will be the common point where the protective (green wire) system and the earth electrode system are tied together. At intermediate power panels within the system, the ground to be used is the (green wire) protective ground. At external power transformer pads the suppressors are wired from each phase to ground.

c. When suppressors fail, they may short-circuit. For this reason, each suppressor should be wired through a ganged circuit breaker (one breaker per phase). These breakers should be included in new installations, or spare positions in existing panels can be equipped with new breakers.

d. If fuse holders and fuses are installed in existing circuit breaker panels, blown fuse indicators such as neon lamps are advisable to alert O&M personnel to the loss of transient protection.

e. Circuit breakers, fuse holders, and fuses must be selected with the appropriate voltage ratings, that is, 250 V for 208/120 Vac and 500 V for 480/277 Vac distibution lines.

f. Wire sizes of No. 18 AWG or larger are suitable for wiring the power panels MOV; No. 14 AWG or larger is recommended for the main distribution buses MOV. Lead length should be kept as short as possible to minimize inductive reactance, which causes the clipping voltage to rise for very fast transients.

g. Only high-melting-point connections (bolting, crimping, or other pressure contact, and silver soldering or brazing) should be used for connecting the suppressors.

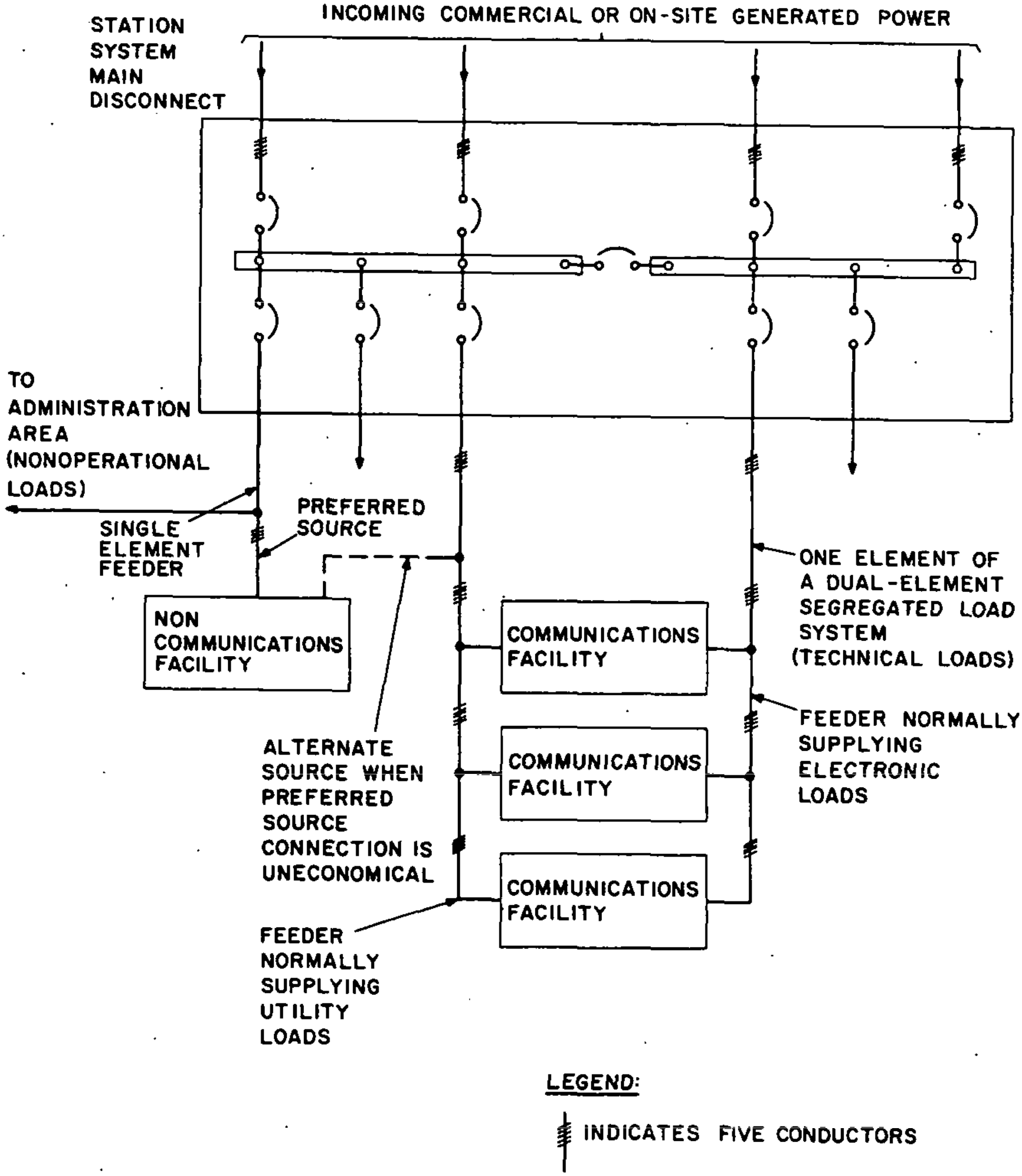
4.9.5.3 AC power filters. Common sources of noise on powerlines are noisy loads such as: the electronic uninterruptible power supply (EUPS), input rectifier-charger, and the AN/FSC-78 satellite terminal azimuth and elevation control units; all of which utilize high-current, silicon-controlled rectifiers (SCR). The SCR typically generate recurring high voltage spikes on the ac power supply lines. The spikes are conducted along the ac power distribution network and cause operating problems with the station equipment. Powerline filters or special noise-blocking isolation transformers should be installed at the input of equipment that generates recurring voltage spikes of this type. Alternatively, noisy equipment may be isolated from other station equipment by providing a separate power network for each.

4.9.6 AC power distribution and switching. The ac power distribution and switching network should be designed to provide dual redundant paths for ac power to critical equipment. The dual redundant network is not excessively difficult or expensive to provide and ensures that no loss of any single element will cause an extended station outage. Figure 7 shows an example of a dual redundant ac power distribution and switching network at a typical station.

4.9.6.1 AC wiring configuration. All communications station ac power wiring should be installed with deliberate ac protective conductors, as described in 4.9.5. All single-phase wiring should be installed on a three-conductor basis (that is, one phase conductor, one neutral conductor, and one equipment fault protective conductor). In those specific locations where required, 15- and 20-A receptacle outlets on single-phase circuits should be equipped in accordance with the National Electrical Code. All three-phase delta wiring should be installed on a four-conductor basis (three phase conductors and one equipment fault protective conductor). All three-phase, wye-wired circuits should be installed on a five-conductor basis (three phase conductors, one neutral conductor, and one equipment fault protective conductor). Utility wiring within communications stations should include equipment fault protective conductors.

4.9.6.2 Conduit and duct requirements. Ac power wiring should always be installed in either metallic conduit or metallic ducts. The conduit or ductwork should be grounded through conductive joints or actual wire bonds where joints may be suspect. The ac power supply wiring carries much higher current than typical signal wiring and generates time-varying fields around the wiring. These fields may be induced into the signal cables and cause noise. The grounded conduit or ductwork network helps to greatly reduce these fields. Signal cabling must never be routed in the same conduit or ductwork as ac power wiring unless special protective measures are provided (such as using separate electrical metallic tubing (emt) within the duct or partitioned duct).

4.9.6.3 AC distribution panels. Phase balancing is achieved at a three-phase ac distribution panel by even distribution of the load among the phases. Unbalanced phases will cause high ac neutral currents, which in turn cause noise if wiring problems exist. Unbalanced phases can also cause distortion of the sinusoidal ac supply waveform. Excessive imbalance on the power supply equipment limits power transmission and may shorten the life of the supply equipment. Main distribution and branch panels must be equipped with an insulated neutral bus, although panels that supply only three-phase, delta-wired loads (such as high-power amplifiers) need not have a neutral bus. All panels, without exception, must have an equipment fault protective bus. The insulated ac neutral network and the ac protective network must not be interconnected at any point except at the main station ac ground point. MIL-STD-188-124 requires a minimum of 1 megohm dc resistance between either side of



NOTE:

NEUTRAL IS GROUNDED BEFORE MAIN DISCONNECT AND SHALL MEET REQUIREMENT OF PARAGRAPH 5.1.2.2.3 OF MIL-STD-188-124.

FIGURE 7. Typical dual redundant ac distribution and switching network.

the ac line and the grounded ac protective network (measured with the circuit breaker open and the neutral disconnected). If the ac neutral and equipment fault protective circuits are interconnected at any point within the station, the neutral currents will divide and circulate throughout the station ground network to cause the familiar hum and other noise commonly heard on speakers, intercoms, and telephone circuits. Where the entire station is supplied with low-voltage ac power directly from a remote source, a single primary power entry panel can be provided, and the single ac neutral and protective interconnection can be made within this panel and grounded at this point.

4.9.7 DC power system. The main components of a dc power system are two or more rectifier-chargers, a multicell battery bank, a voltage control element, and a distribution network. Filters may also be required to isolate noisy loads on the dc power system.

4.9.8 DC power distribution. A properly designed, installed, adjusted, and wired dc power distribution system will provide optimum operation and minimal electrical noise when operated on battery power. A major design factor is to provide minimal voltage drop between the battery bank and the load. Most 48 V, dc-powered communications equipment operates improperly when the supply voltage has dropped to between 42 and 44 Vdc. Simply stated, the less the voltage drop in the leads, the longer the running time on battery power. Less than optimum float voltage adjustments also reduce the running time.

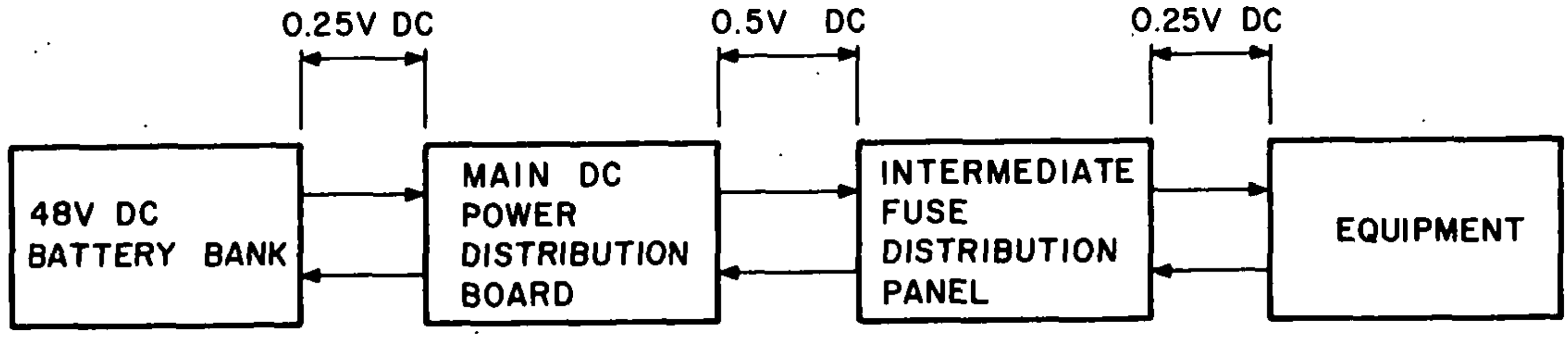
4.9.8.1 DC wiring. Wire size is selected on the basis of two criteria:

a. Normal current-carrying capacity. This criterion governs the wire selection for short loop lengths. The current-carrying capacities of copper wires are found in the NEC. These capacities are based on safety considerations and take into account the heating of the conductors.

b. Permissible voltage drop. This criterion governs the wire selection for long loops. The permissible voltage drops generally recommended by dc power equipment manufacturers are shown in figure 8. The voltage drop criteria must be transformed into wire size for each loop segment by calculation.

4.9.8.2 Wire resistance. Resistances, equivalent metric sizes, and values of melting currents of various sizes of copper wires are listed in table III. (The steady-state currents are useful for evaluating fault protective wire sizes while the 0.1 second values are useful for lightning protection applications.)

4.9.8.3 Network filters. The insertion of network filters into the distribution network will cause voltage drops. Unless the voltage drop of each segment of the distribution network is limited to a specific value, the terminal voltage may be too low. When filters are used, the additional drop must be considered. Such consideration usually requires further limiting of the voltage drop in the wires or selecting a filter on the basis of its voltage drop rather than its current-carrying capacity.



NOTE:
A VOLTAGE DROP OF 0.75V DC IS PERMITTED BETWEEN THE MAIN DC POWER DISTRIBUTION BOARD AND THE EQUIPMENT IN A POWER DISTRIBUTION NETWORK THAT DOES NOT INCLUDE AN INTERMEDIATE FUSE DISTRIBUTION PANEL.

FIGURE 8. Maximum voltage drop design objectives.

TABLE III. Resistance and melting currents of commonly used annealed copper wires.

AWG, B&S gauge (Note 1)	Equivalent metric size (Note 2)		Ohms per 305 m (1000 ft) at 20°C (68°F)	Approximate melting current in amperes	
	dia, mm	Area mm^2		Steady-state	0.1 sec duration
0000 (4/0)	11.63	107.2	0.04901	3,200	94,000
000 (3/0)	10.40	85.0	0.06180	2,690	74,000
00 (2/0)	9.27	67.5	0.07793	2,260	60,000
0 (1/0)	8.25	53.4	0.09827	1,900	46,000
1	7.33	42.4	0.1239	1,590	37,000
2	6.54	33.6	0.1563	1,340	30,000
3	5.83	26.7	0.1970	1,130	
4	5.19	21.2	0.2485	946	18,000
5	4.62	16.8	0.3133	795	
6	4.11	13.3	0.3951	668	12,000
7	3.67	10.6	0.4982	561	
8	3.26	8.35	0.6282	472	7,300
9	2.91	6.62	0.7921	396	
10	2.59	5.27	0.9989	333	4,500
11	2.30	4.15	1.260	280	
12	2.05	3.31	1.588	235	3,000
13	1.83	2.63	2.003	197	
14	1.63	2.08	2.525	166	1,800
15	1.45	1.65	3.184	140	
16	1.29	1.31	4.016	117	1,200
17	1.15	1.04	5.064	98.4	
18	1.024	0.823	6.385	82.9	730
19	0.912	0.653	8.051	69.7	
20	0.812	0.519	10.15	58.4	450
22	0.644	0.325	16.14	41.2	290

NOTES:

1. AWG: American Wire Gauge, B&S: Brown and Sharp

2. Metric sizes are specified by diameter (dia) in millimeters (mm) or by cross-sectional area in mm^2.

4.9.8.3.1 Noise filters. Additional filtering is generally required when the noise voltages (ripple, impulse, and wideband) across the supply distribution points of a station power supply or battery facility exceed 200 mV_{p-p}. If the electrical noise is mainly ripple, capacitor filters made up of several large electrolytic capacitors are generally used. Where wideband (10 Hz to 25 MHz) noise filtering is required, the inductance-capacitance (LC) filter is very useful, especially if input capacitors already exist as part of the power supply.

4.9.8.3.2 Filter location. Both LC and pi network filters are also effective isolating filters. Loads that generate electrical noise and conduct this to the supply lines are effectively isolated from each other if separate filters are used for the offending loads. Examples of such loads are dc-to-ac inverters. Considerable electrical impulse noise, up to 6 V_{p-p}, is generated by the input SCR of some inverters. The filters minimize the electrical noise at the common load distribution point. Separate filters are required to keep potential open or short circuits in one inverter from affecting the other units. If the communications load is substantially less than the inverter load, it is preferable to filter the communications load only and allow the distribution load bus bars to be electrically noisy. Additional decentralizing filters can be provided for the most sensitive communications loads, such as low-level vf, multiplex line-conditioning and interconnect equipment, and sensitive digital devices.

4.9.8.3.3 Filter design shortcomings. Although most powerline filters are designed for optimum performance when matched at each end with 50 ohms, this design performance is not usually obtained for a number of reasons:

a. Unavoidable mismatch may result in either poor filtering action in the low end of the stopband or an insertion gain of up to 40 dB in the upper passband.

b. Random or cyclical switching of loads and sources causes undesirable "ringing" on the powerline.

c. Mismatch safety margins achieved by brute force overdesign are too costly.

d. Measurements made without full load current during laboratory testing may not show the true operating characteristics of the filter when it is installed in a real-world large switched system.

e. Special emc filters are available to operate with mismatched terminations.

4.9.8.4 Grounding requirements. Sizable dc power equipment (100 ampere and up) such as rectifier-chargers, dc-ac inverters, and dc-dc converters are electrically noisy. These equipment cases require only a protective ground conductor to the ac circuit breaker panel that powers the equipment. These equipment cases shall not be grounded directly to the equipotential plane. For best results, medium to large dc equipment should be physically and electrically separate (insulated) from the communications equipment (such as; in order of preference, a separate building, the ac powerhouse, a basement, or a separate room in the communications building). High-power dc equipment is acoustically, as well as electrically, noisy. The voltage return load bus bar (plus bar for a negative facility) must be insulated from the equipment rack or cabinet. The ground reference should be connected, at only one point, to the common dc distribution point closest to the loads or at one central load that is not likely to be removed. Paragraph 4.10 provides more infor- mation on grounding techniques.

4.9.9 Battery facilities. Three types of battery facility wiring are commonly used at military installations. The choice of the type of facility to be used depends on the size of the load to be supplied and the degree of voltage control required.

4.9.9.1 Basic battery power source. Where close control of load voltage is not required, the basic battery facility shown in figure 9 is useful. Note that the battery terminals are the common interconnect point for the load and rectifier-chargers. The advantage of this four-conductor wiring is that it allows the battery bank to act more effectively as a filter for wideband electrical noise from the rectifier-chargers and loads.

4.9.9.2 Counter electromotive force (CEMF)-cell battery power source. For greater voltage control and for loads not exceeding 200-ampere dc, the CEMF-cell battery facility shown schematically in figure 10 is generally used. Again, four-conductor wiring is used. Additional filtering can be provided by means of a capacitor bank as shown. Transient peak limiting of the output voltage is desirable.

4.9.9.3 End-cell battery power source. The end-cell method of load voltage control is most economical for battery facilities with loads exceeding 200-ampere dc. A typical end-cell 48 Vdc, 400-ampere battery facility is shown schematically in figure 11. Two steps of 4 V each can also be used where lead length to the loads is exceptionally long.

4.9.10 Power requirements for a vanized facility. For the most part, the criteria for supplying power for a vanized satellite earth terminal facility are the same as for a fixed facility, as stated in 4.9.1. However, since a vanized facility is basically a portable installation, some consideration must be given to the performance of the vanized installation.

4.9.11 Primary power source for a vanized facility. Where the vanized facility is installed as a fixed or semifixed facility, or where the vanized facility is to be replaced at a later date with a fixed facility, the considerations already outlined for station power factor (paragraph 4.9.2) and station power sources (paragraph 4.9.3) are applicable. Where a vanized facility is installed as a tactical or temporary facility, the cost-effectiveness of installing an on-station prime power generating plant from the DOD standard family generator sets may in some cases offset the cost of obtaining commercial power. Power factor correction is usually not economical for a short-term installation.

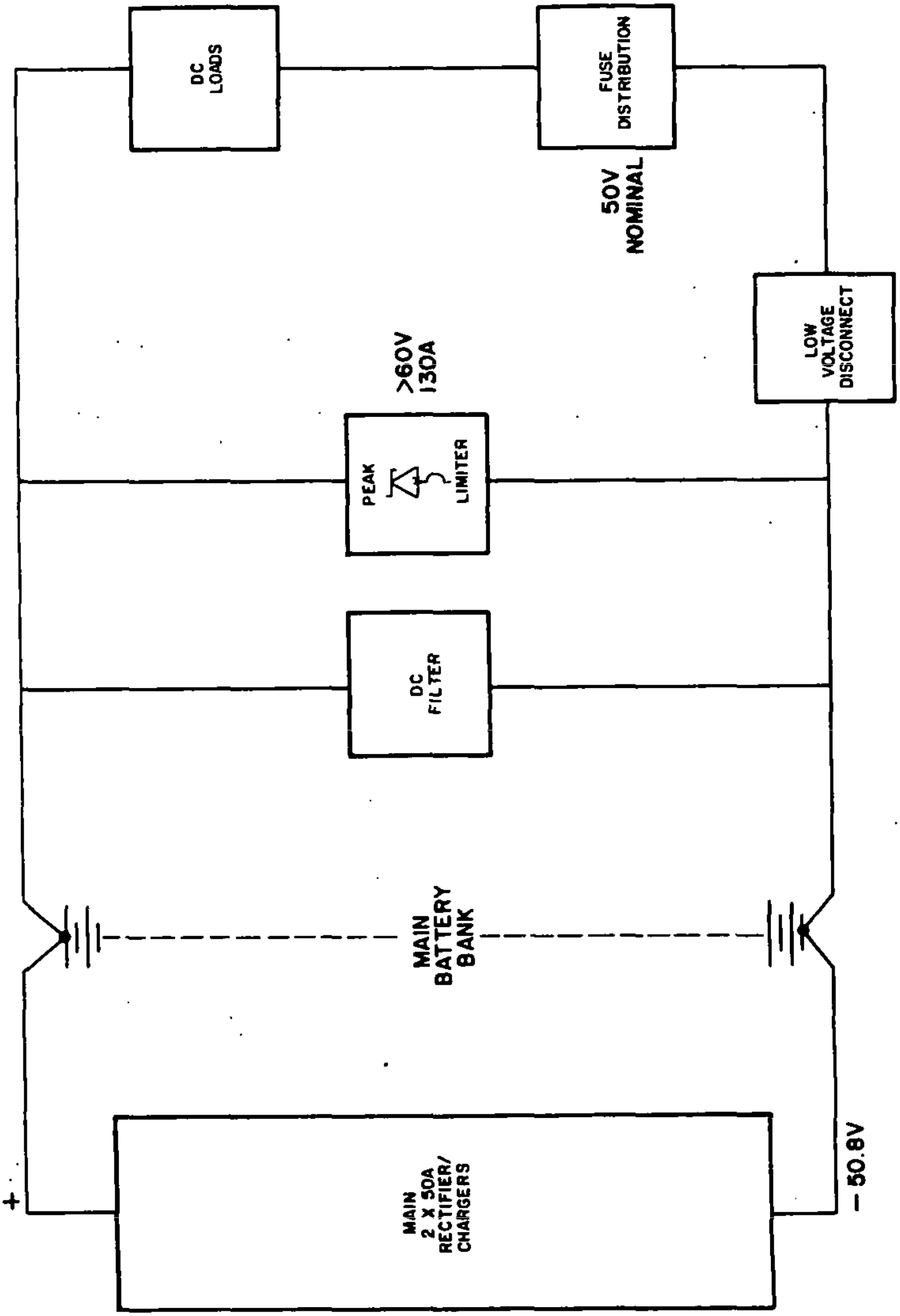


FIGURE 9. Basic battery facility without load voltage control.

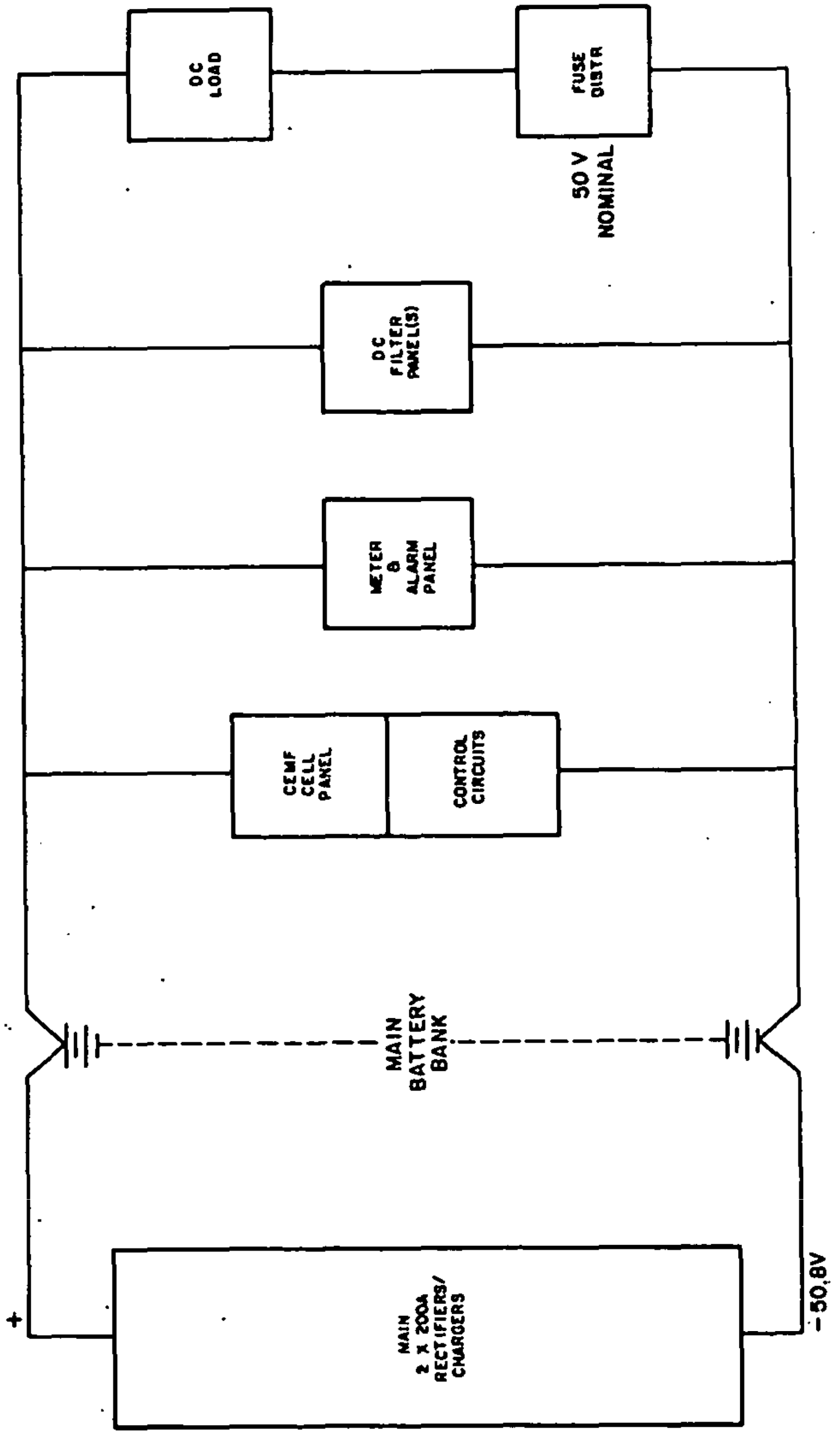


FIGURE 10. Typical low-noise 48 Vdc battery facility with CEMF-cell load voltage control.

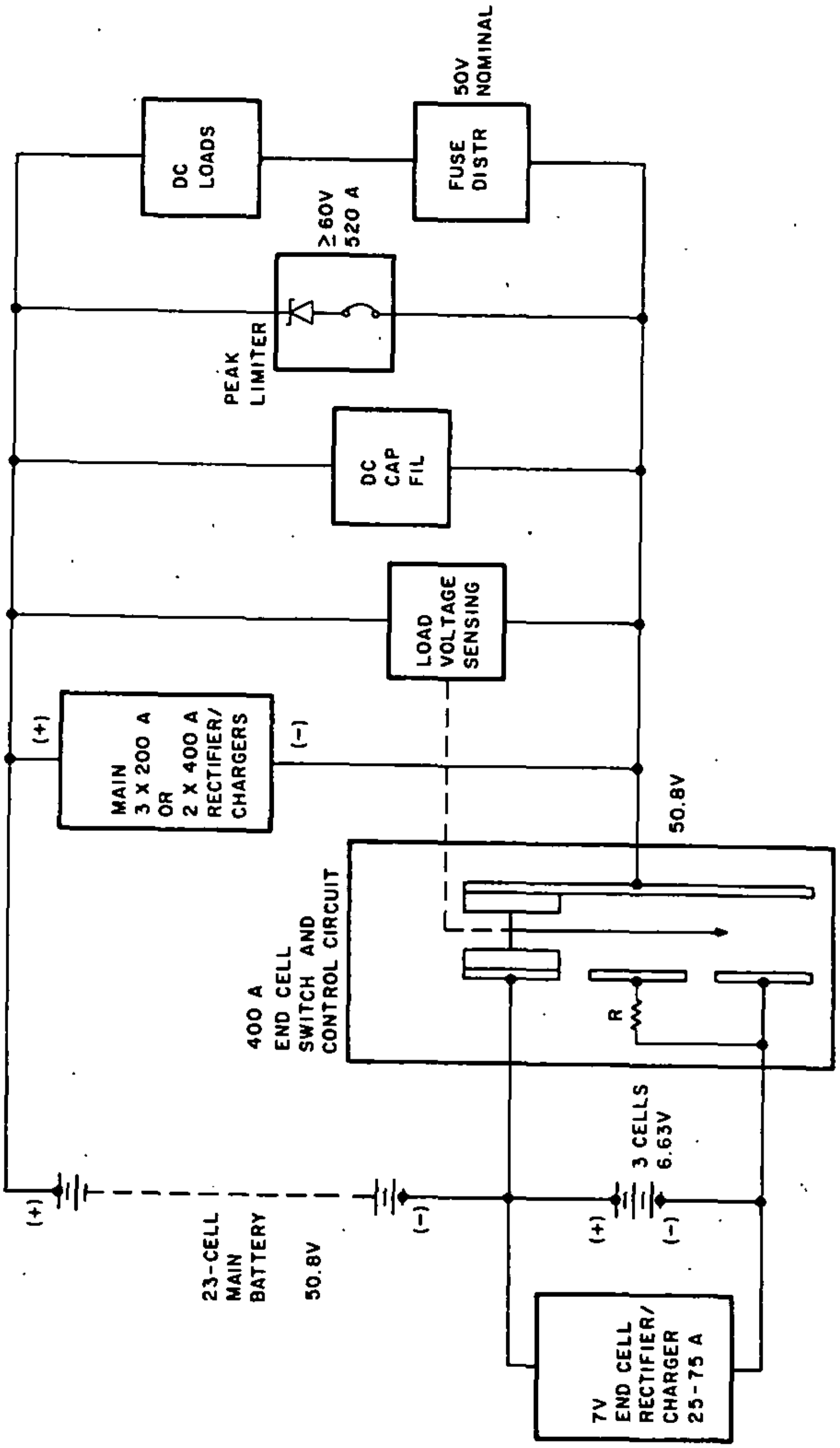


FIGURE 11. Simplified block diagram of 48 Vdc, 400-ampere battery facility with one-step, three-cell, end-voltage control.

4.9.12 Auxiliary power for a vanized facility. The auxiliary power source for a vanized facility will usually be the same as for a fixed facility, as outlined in 4.9.3.2. However, for temporary installations that will not be replaced with a fixed installation, the on-station auxiliary generator plant will normally not exceed two DOD standard family generators.

4.9.13 UPS for a vanized facility. The choice of an UPS for a vanized facility is somewhat more difficult than for a fixed facility. Some older vanized types of equipment do not provide separate distribution networks for critical and noncritical power. This means that if an UPS is used, it must be much larger than for an equivalent fixed installation.

4.9.14 Critical electrical power for a vanized facility. The critical electrical power requirements for a vanized facility are much the same as for a fixed facility. The total load requirements for vanized equipment are available from operating characteristics. Where segregated distribution networks are provided for the critical and noncritical equipment, the load requirements will be provided for separately. The cost of providing an UPS for temporary locations may override the benefits provided. Careful evaluation must be made of the expected length of earth terminal operation at the temporary location and the possibility of using the mobile diesel generators as a primary source.

4.9.15 Vanized power distribution system. A typical vanized power distribution system uses ruggedized power cables, which are laid on the bare earth or covered in a temporary duct for environmental protection. The cables should contain an ac protective conductor or overall shield which is used for the protective function. The network inside the vanized shelter should be continued to each ac-powered equipment. Figure 12 shows a typical installation of a terminal. The dashed lines show a recommended earth electrode interconnecting conductor to reduce impedance to earth and differences in potential. Generally, dc power supplies will not be required for vanized satellite earth terminal installations. However, an interconnected facility may require dc power. For ease of installation, maintenance, and relocation; large amounts of dc-powered equipment should be avoided for short-term installations. For long-term vanized installations, the same criteria apply as for fixed installations, as outlined in 4.9.6.

4.9.16 Noise reduction and surge protection for vanized power distribution. The addition of the interconnecting earth electrode conductors will aid in the reduction of noise from fault currents, static charges, and lightning. The noise reduction and fault protection techniques outlined in 4.9.5 also apply for vanized installations.

4.10 Ground system design. This portion of the handbook provides criteria for achieving effective ground system design for fixed and vanized satellite earth stations (see MIL-STD-188-124 for minimum standards). The total facility ground system comprises four subsystems:

a. The earth electrode subsystem establishes the conductivity to earth for the entire facility.

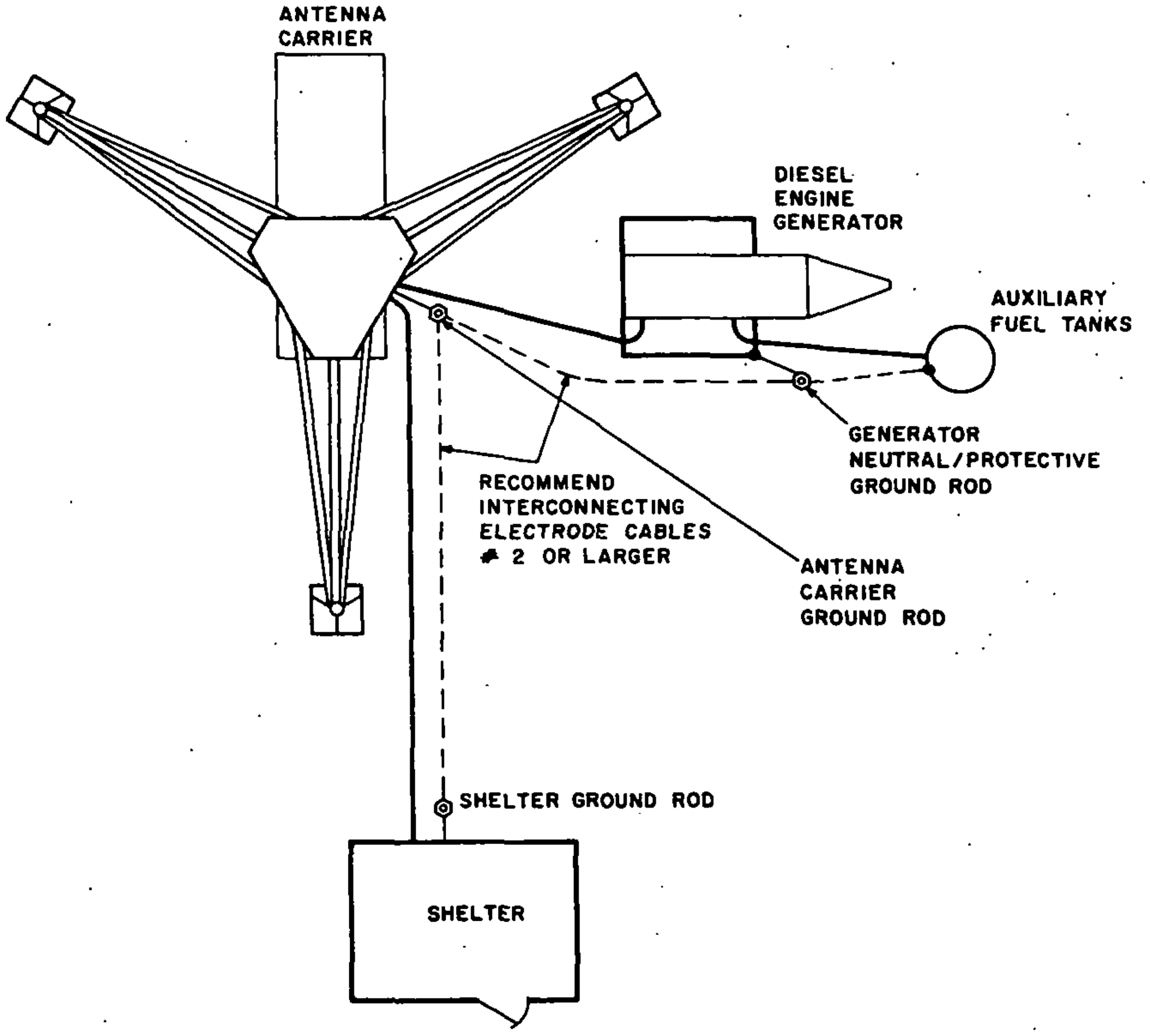


FIGURE 12. Typical temporary power cable installation.

b. The lightning protection subsystem provides a low-impedance, non-destructive path to earth for energy; either from direct contact or induced; produced by lightning strikes on facility structures, buildings, or antennas.

c. The equipment fault protective subsystem protects personnel from shock hazards, and equipment from damage, due to faults that may develop in the facility electrical system and electromagnetic energy induced by external sources.

d. The signal reference subsystem maintains relative signal voltage levels and ensures that unacceptable noise voltages do not occur on signal paths and circuits.

Figure 13 depicts, schematically, the multiple ground interconnects between equipments sharing a common power source and ground system.

4.10.1 Fixed facility earth electrode subsystem. The earth electrode subsystem consists of the network of driven rods, metallic pipes, metallic structural members, metal fence posts, and the interconnecting wires and wire grids that provide electrical contact with the earth. Considerations in designing an effective earth electrode subsystem are: (1) earth resistivity and soil composition, (2) electrode configurations and design objectives, (3) conductors and ground rods, (4) bonding, and (5) miscellaneous underground pipes and other metal objects.

4.10.1.1 Earth resistivity and soil composition. Earth resistivity values provide a basis for engineering the size of the earth electrode network required to achieve a given impedance to earth. The resistivity of the soil should be measured for several onsite locations. Measurement techniques are presented in 4.4.6. Table IV presents representative values of earth resistivity for various soil and terrain conditions. Because earth resistivity is a function not only of the soil composition but also of its moisture content and temperature, measurements should be repeated over a period of a year to obtain information on the seasonal variations. Figures 14 and 15 show the relationships of moisture and temperature to soil resistivity. If an extensive earth electrode network is used in soils with resistivities ranging from 10 to 10^2 ohm-meters, station composite ground impedances of less than 1.0 ohm are obtainable. With soil resistivities of greater than 2×10^3 ohm-meter, impedance values of 6 to 25 ohms may be achieved with an extensive ground plane at a high cost. Table V presents comparative values of composite ground impedance and earth resistivity for seven operational earth terminal complexes.

4.10.1.2 Earth electrode configurations and design objectives. The earth electrode subsystem may be composed of two types of elements:

a. Metallic objects intentionally placed in the earth as electrodes such as driven rods, buried wire grids, mats, and straps.

b. Metallic material and constructions buried in the earth that serve coincidentally as electrodes while performing another and primary function.

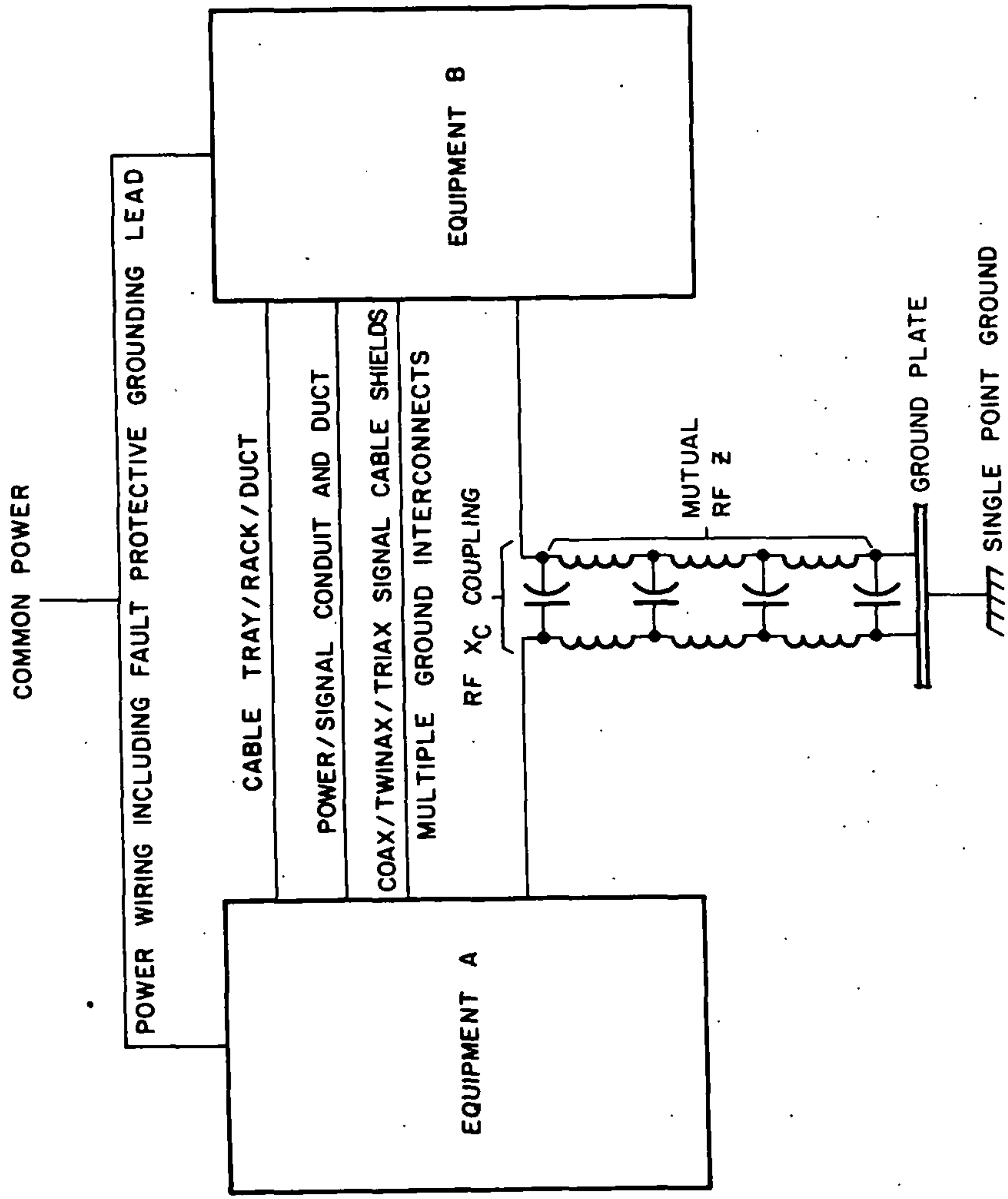


FIGURE 13. *Single-point ground network.*

TABLE IV. Resistivities of various soil compositions and terrain conditions.

	Resistivity (ohm-m)		
	Minimum	Average	Maximum
Surface soils, loam, gumbo.	1		5 x 10
Clay.	2		10^2
Sand and gravel	5 x 10		10^3
Surface limestone	10^2		10^4
Limestone	5		4 x 10^3
Shale	5	4 x 10	10^2
Sandstone (dry)	10^2		10^5
Sandstone (wet)	1		10^2
Granite, basalt, etc.		10^3	
Decomposed gneisses	5 x 10		5 x 10^2
Slate, etc.	10		10^2
Fresh water lakes		2 x 10^2	2 x 10^5
Tap water	10		5 x 10
Sea water	2 x 10^{-1}	1	2
Pastoral, low hills, rich soil; typical of Dallas, Texas and Lincoln, Nebraska areas		3 x 10	
Flat country, marshy, densely wooded; typical of Louisiana near Mississippi River	2	10^2	
Pastoral, medium hills and forestation; typical of Maryland, Pennsylvania, and New York, exclusive of mountainous territory and seacoasts		2 x 10^2	
Rocky soil, steep hills; typical of New England.	10	5 x 10^2	10^3
Sandy, dry, flat; typical of coastal country	3 x 10^2	5 x 10^2	5 x 10^3
City, industrial areas.		10^3	10^4
Fills--ashes, cinders, brine wastes .	6	2.5 x 10	7 x 10
Clay, shale, gumbo, loam mixture. . .	3	4 x 10	2 x 10^2
Same as above, with varying proportion of sand and gravel . . .	10	1.5 x 10^2	10^3
Gravel, sand, stones, with little clay or loam; granite	5 x 10^2	10^3	10^4

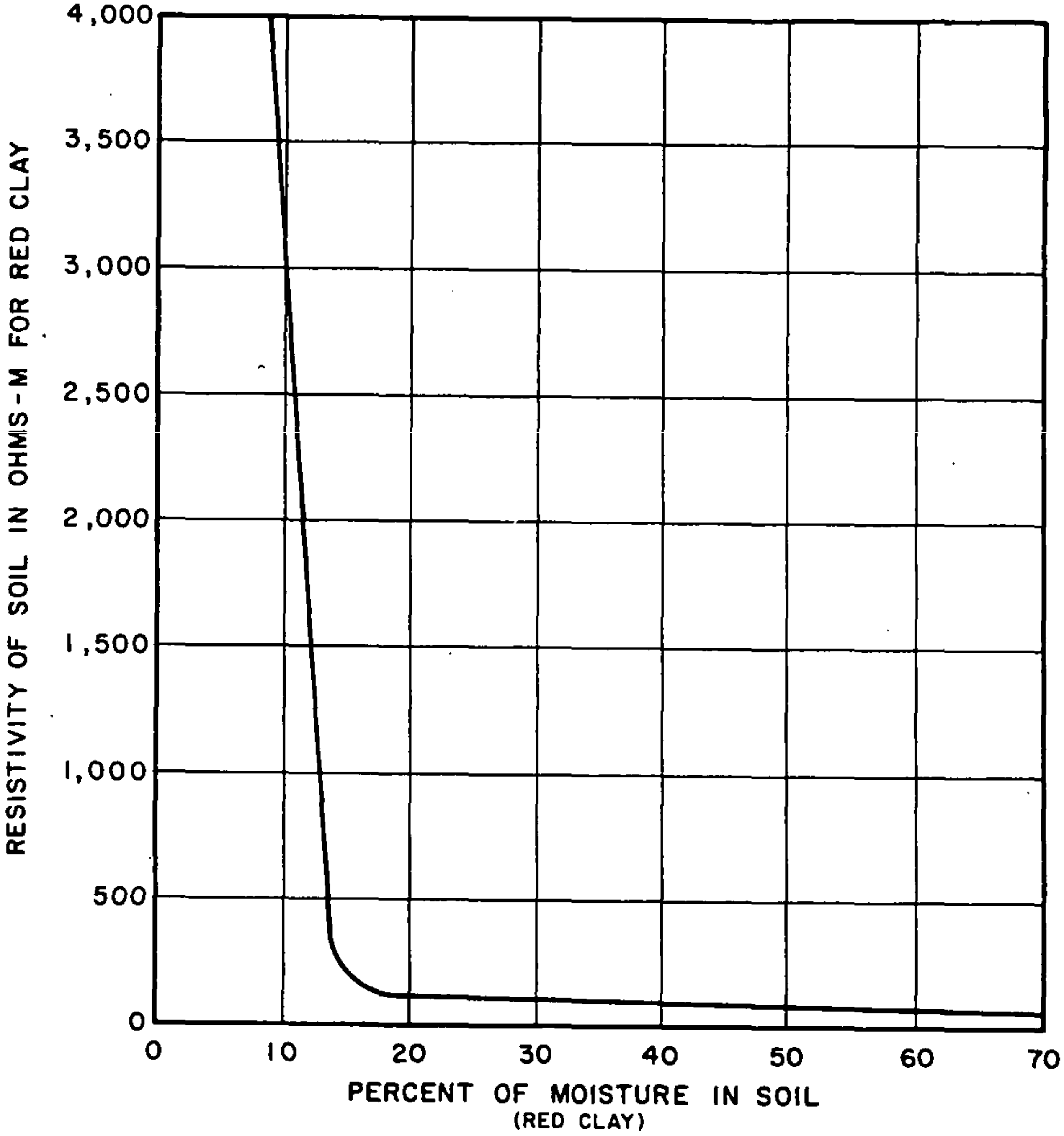


FIGURE 14. Resistivity versus moisture content for red clay.

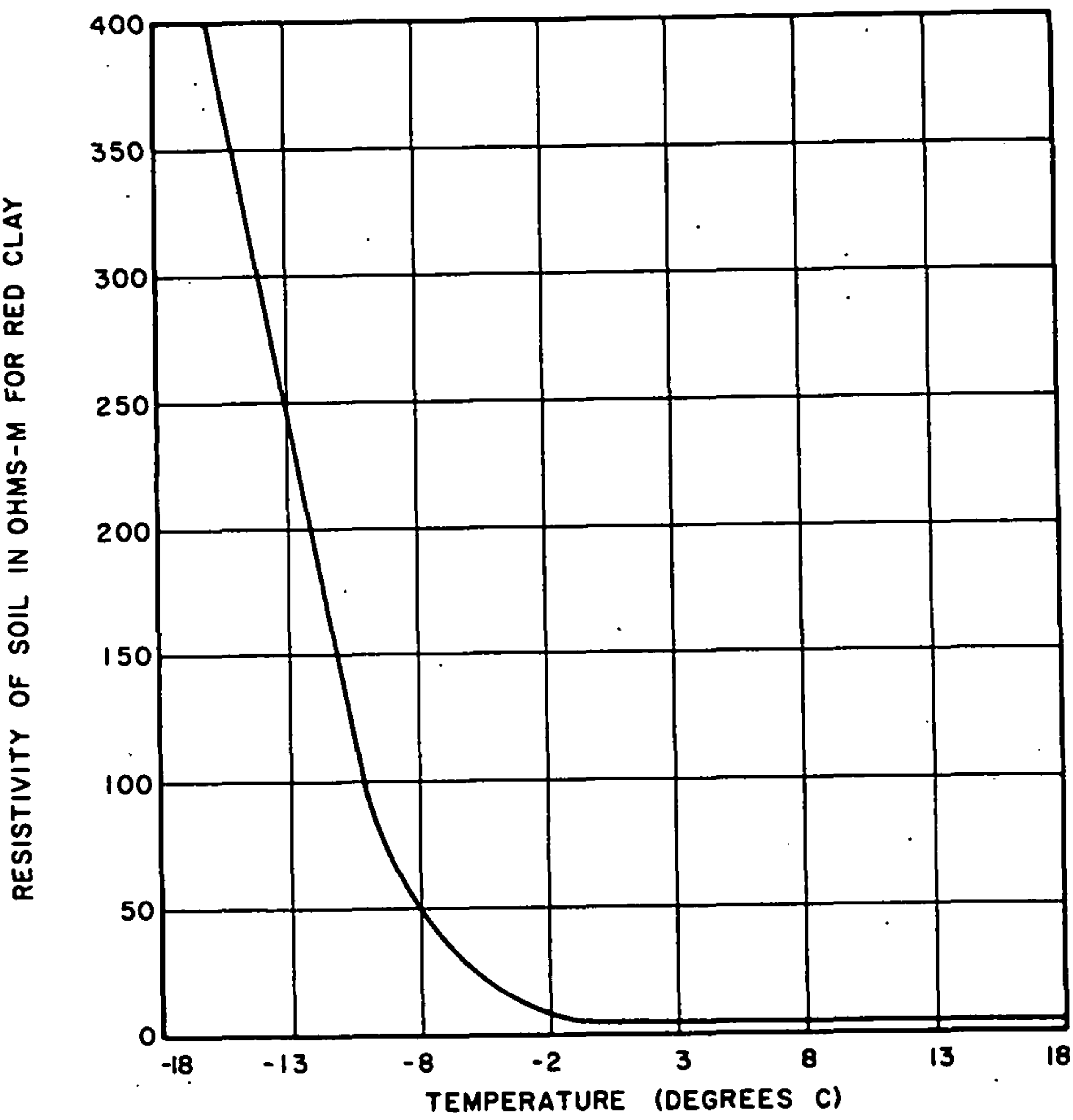


FIGURE 15. Resistivity versus temperature for red clay.

TABLE V. Site composite impedances to earth and soil resistivity values.

Earth Terminal	Site impedance to earth, ohms*	Soil resistivity ohm-m	Type of soil
Song So, Korea	0.20, ±10 percent	14 to 57	Moist loam
Camp Roberts, CA	0.35, ±10 percent	11 to 106	Sand and clay
Ft Buckner, OKI	0.50, -10 +20 percent	120 to 510	Sand and clay over coral
Menwith Hill, UK	0.50, ±10 percent	28 to 210	Loam
Ft Detrick, MD	0.90, ±10 percent	95 to 230	Loam
Landstuhl, FRG	2.80, ±10 percent	210 to 1,400	Sandy topsoil over sandstone
Ft Meade, MD	9.00 to 13.00	3,800 to 10,400	Loose sand, nonhomogeneous

*Tolerances are estimates based on total measurement distance versus size of network, steepness of curve, other nearby conductors in the earth, and any measurement limitations.

Examples are water pipes, well casings, reinforcing bars of building and tower foundations, and underground storage tanks.

The best way to achieve a minimum impedance to the earth is to establish a single, extensive, interconnected network of electrodes rather than multiple separate electrode networks for the various interior communications. The grid ground electrode configuration shown in figures 16 and 17 is recommended for all new installations (see Resistance To Earth in MIL-STD-188-124.). Ground rod spacing has been established as twice the length of the rod. The grid network shown consists of ground rods spaced at twice their length and interconnected by bare, coarse-stranded, No. 1/0 AWG copper cable. The cable is brazed to the steel reinforcing bars at 6-meter (20-foot) intervals. The ground rods extend 5 to 15 centimeters (2 to 6 inches) above the concrete subfloor to facilitate connection of interior ground leads. The grid extends beyond the walls of the building and provides attachment points for grounding of lightning downleads, tactical vans, and other site structures. This type of grid ground electrode should also be used in generator or other collocated communications-electronics (C-E) buildings that will interface with the earth station. The grid network should be interconnected with the antenna ground electrode network, power building(s), site transformer, water pipes, and buried tanks (as shown in figure 18). At earth terminal facilities that will make use of existing buildings or where additional grounding is required at an operating earth terminal complex, a ground rod network arranged around the communications building meets the minimum requirements of MIL-STD-188-124. Figure 19 illustrates the use of an exterior ring ground electrode. This configuration uses ground rods (3 meters x 1.9 centimeters (10 feet x .75 inches)) spaced 6 meters (20 feet) apart and connected by No. 1/0 AWG bare copper cable buried at least .3 meters (12 inches) below grade level. The cable must be welded or brazed to each ground rod and should form a complete loop whenever economical. The exterior electrode network should be connected to the interior ground interconnect bar(s) or terminals with No. 1/0 AWG (coarse strand or solid) copper cable. Both the grid and ring ground electrodes use ground rods where the tops are driven to at least .3 meters (12 inches) below grade level.

4.10.1.3 <u>Conductors and ground rods</u>. Ground rods are available in various lengths and sizes. <u>MIL-STD-188-124</u> specifies a minimum length of 3 meters (10 feet) and a minimum diameter of 1.9 centimeters (.75 inches). If ground rods of this size are not available, shorter rods may be used, provided they are driven to the same depth. Copper-clad steel rods are recommended for use whenever possible when corrosion of other buried metal objects such as fuel tanks or water pipes does not present an electrolysis corrosion problem. The choice of whether to use galvanized or stainless steel or copper for earth electrodes and interconnecting conductors is dependent upon the predominant grounding material already present, the necessity of protecting buried steel tanks and other objects, and the relative cost of the types of materials. At points that require access for testing or inspection; tile, cement block, or pipes can be placed over the ground rod as shown in figure 20. Conductors used to interconnect ground rods and other elements of the earth electrode subsystem should be No. 1/0 AWG solid or coarse-stranded, bare copper cable or other material with the same resistance.

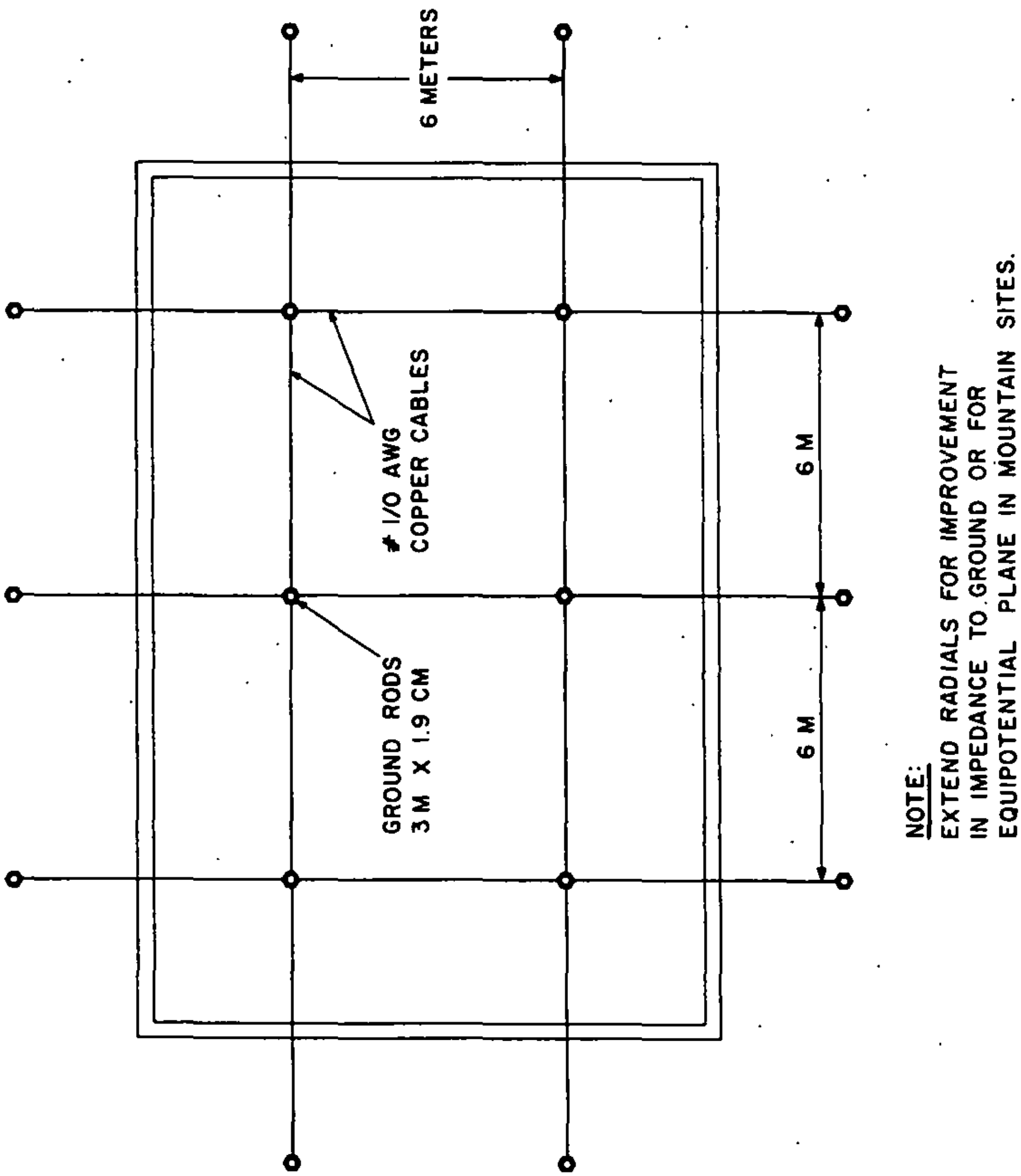


FIGURE 16. Grid ground electrode layout.

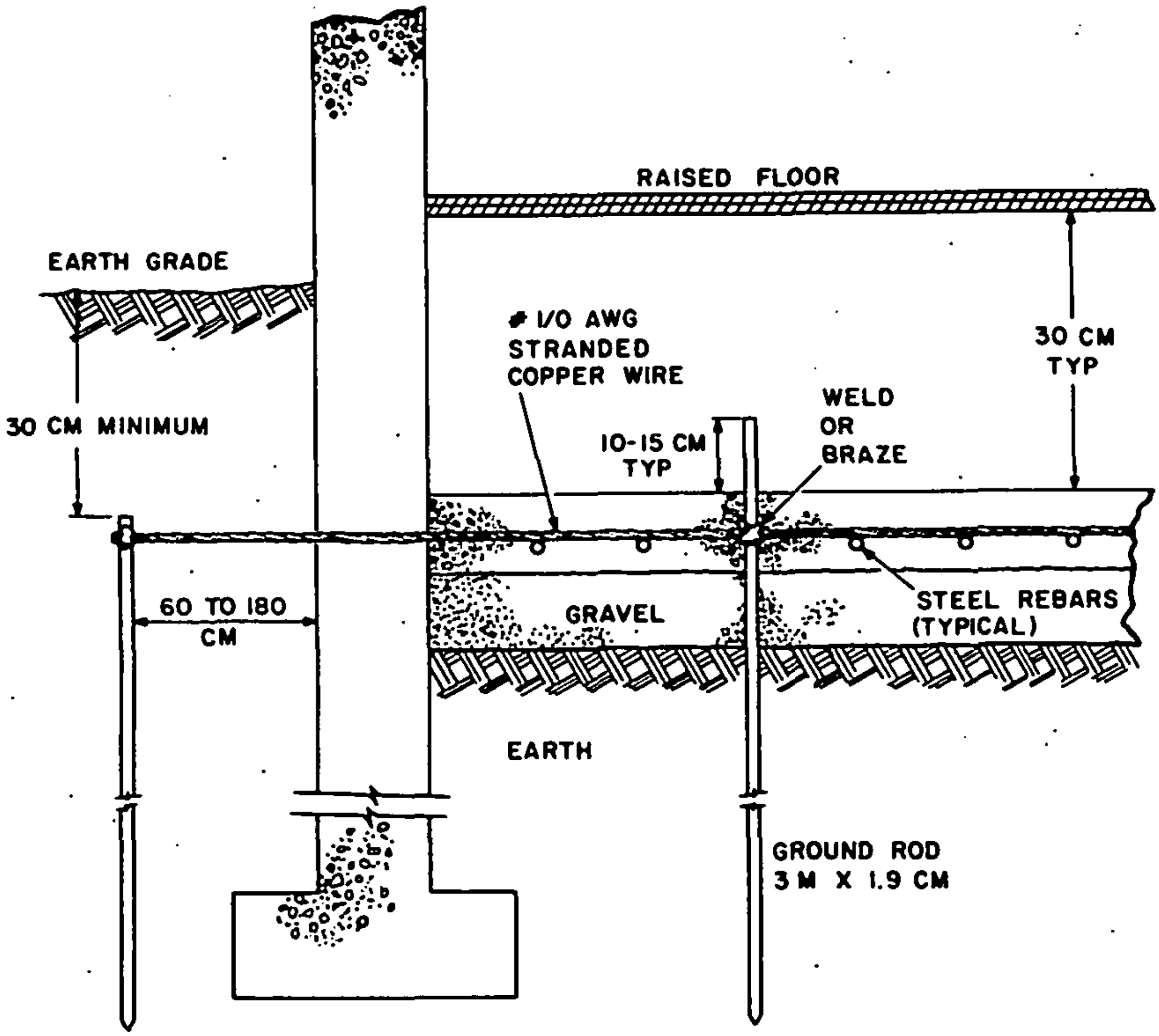


FIGURE 17. Grid ground electrode.

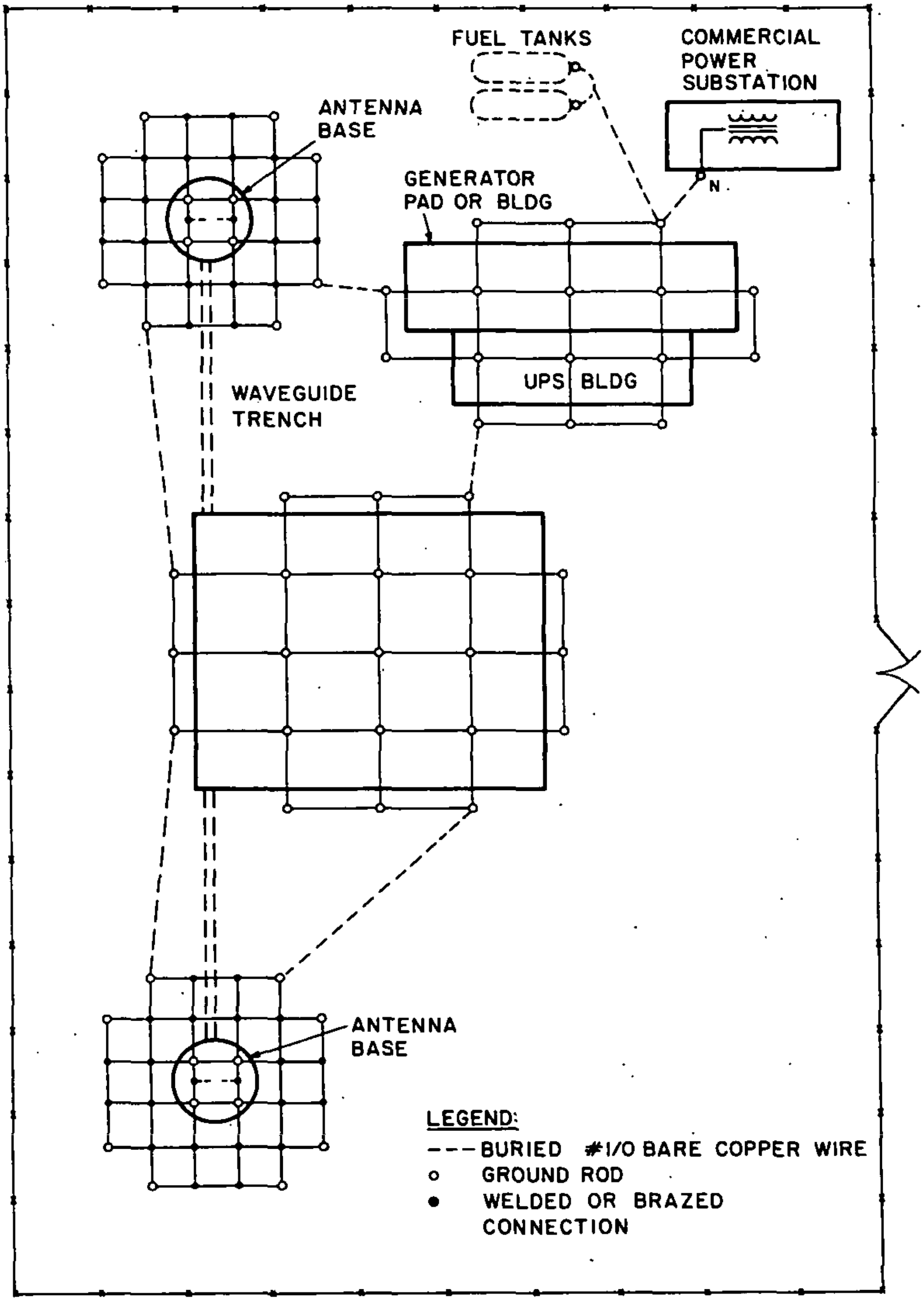


FIGURE 18. Grid ground electrode network.

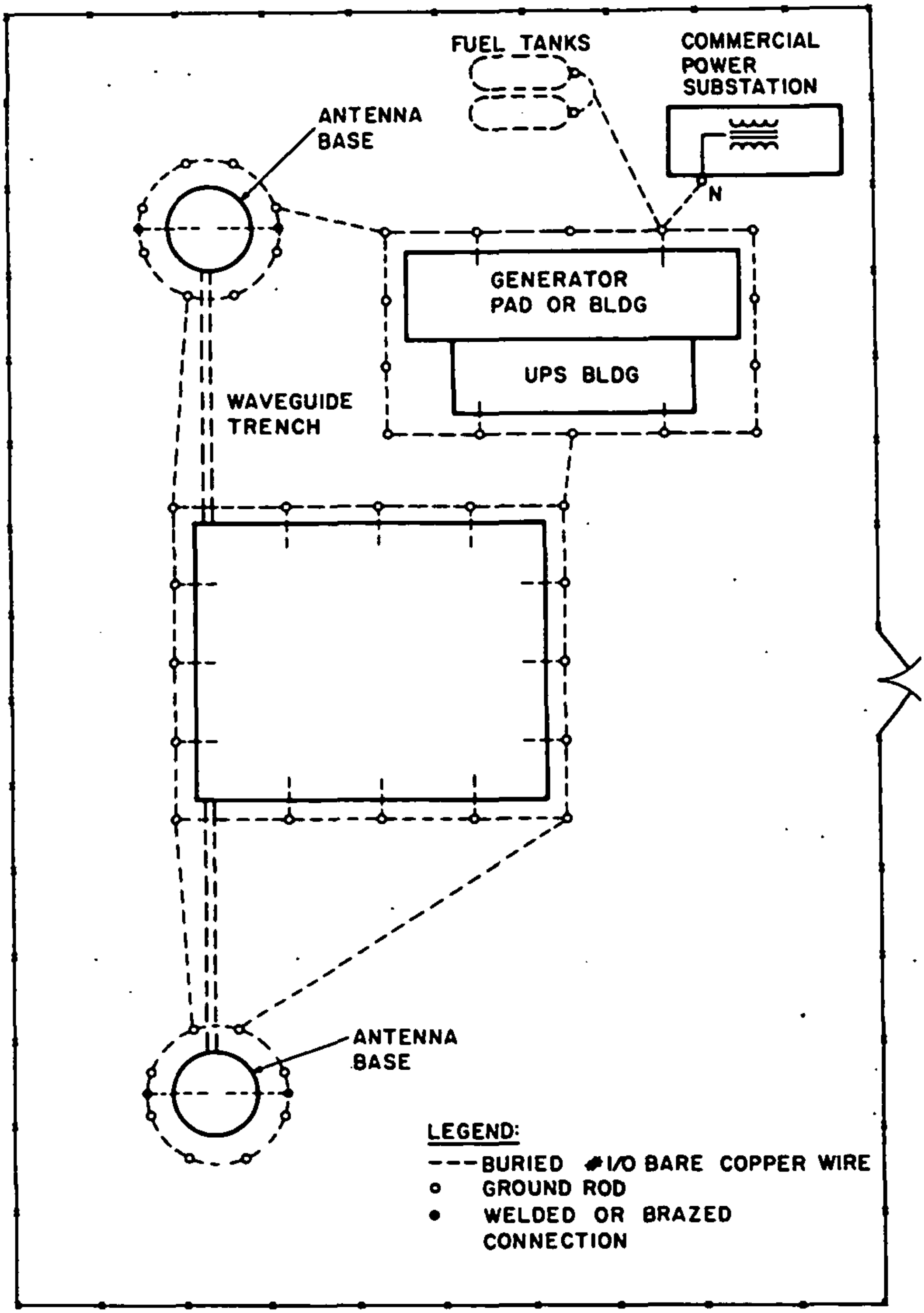
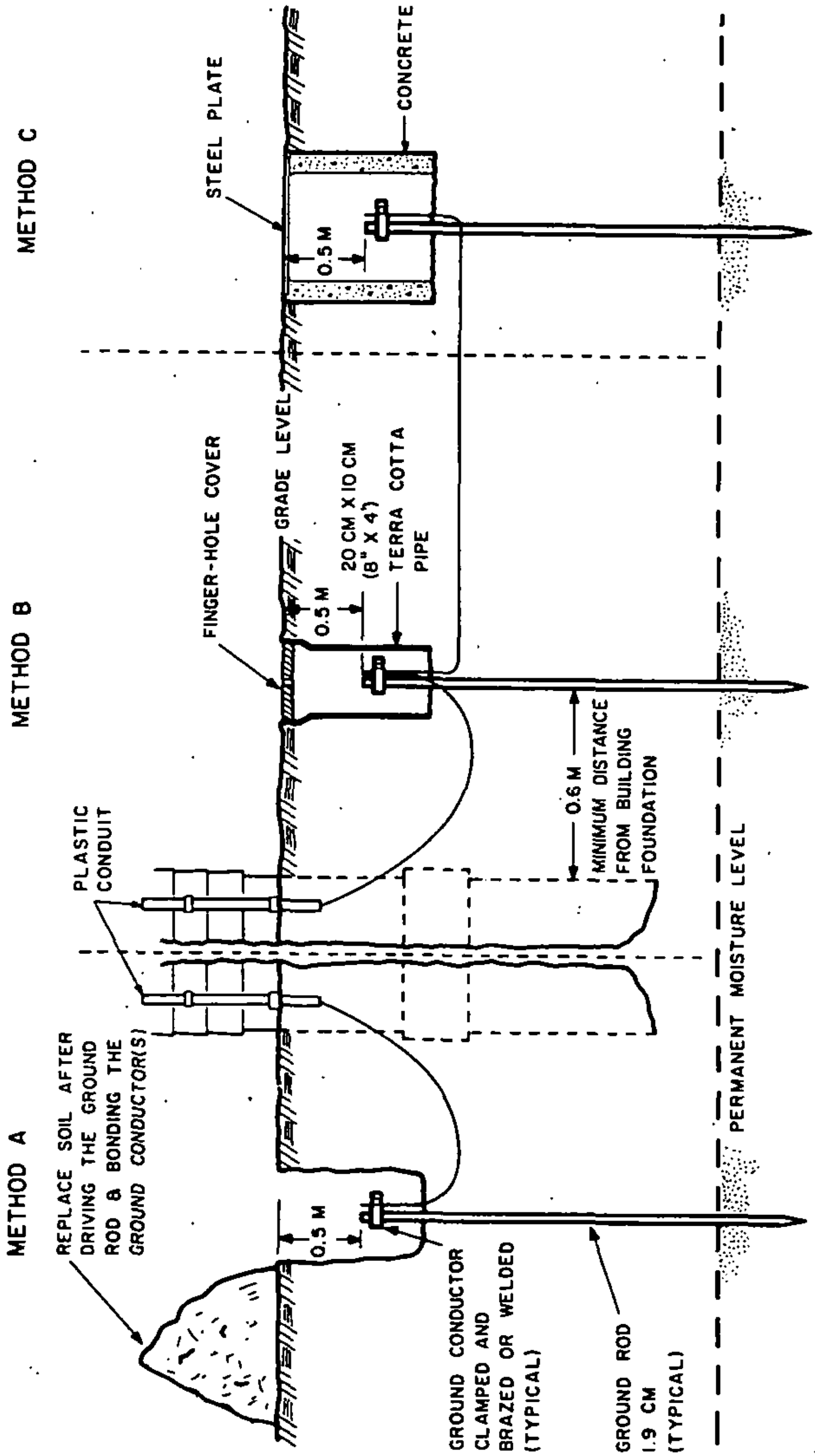


FIGURE 19. Ring ground electrode network.



NOTE:
METHODS B AND C PROVIDE READY ACCESS FOR INSPECTION, TESTING, AND MAINTENANCE. LIMITED TO KEY POINTS ONLY.

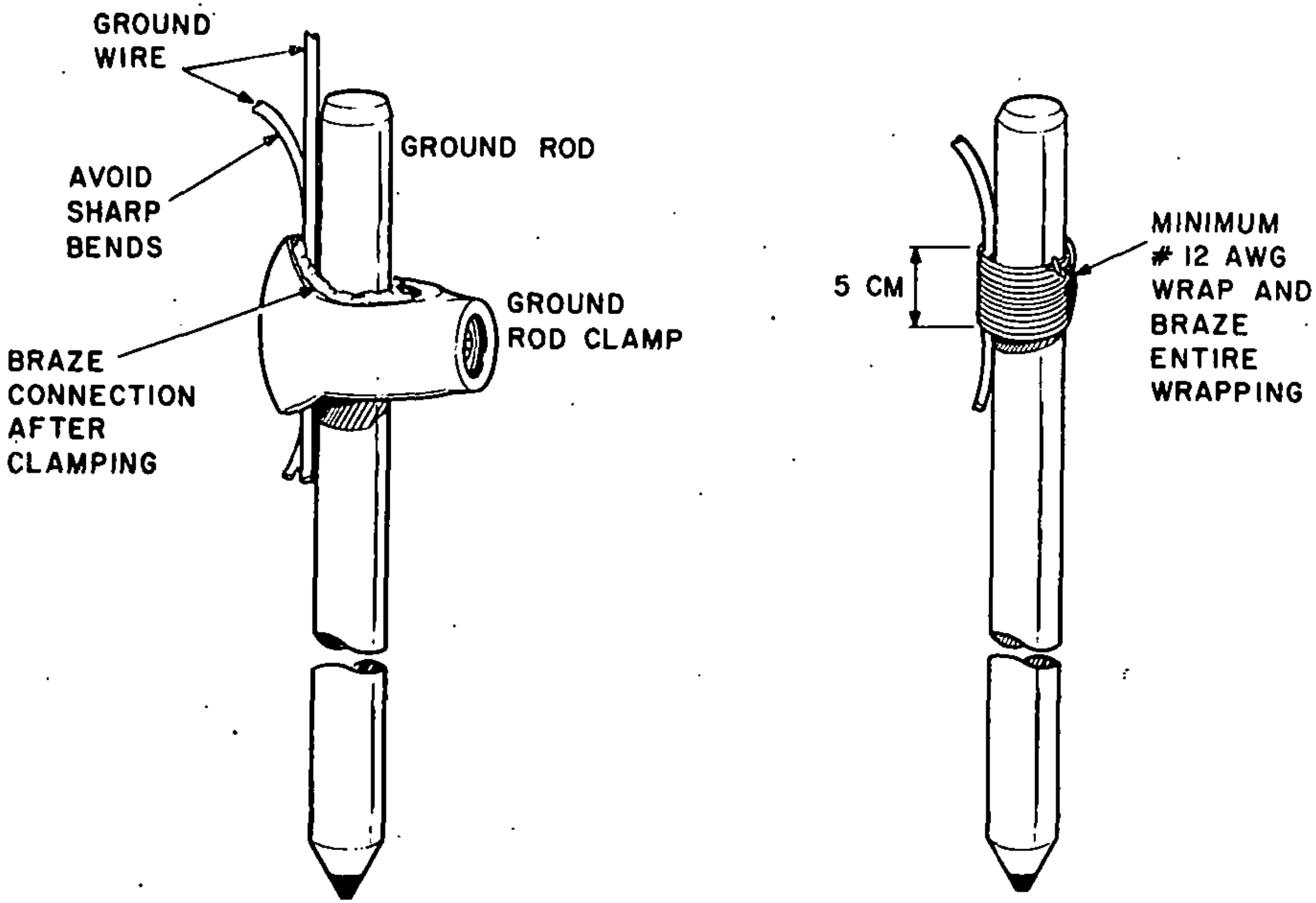
FIGURE 20. Typical ground rod installations.

4.10.1.4 Bonding. The principles of bonding the various components of the earth electrode subsystem require that low-impedance, mechanically strong connections be made at all joints of the earth electrode subsystem. Permanent bonds are made by welding, brazing, or silver hard-soldering. Exothermic welds are advantageous for welding cables together, welding cables to ground rods, or welding cables to flat surfaces of structural members. Exothermic welding requires molds of the specific cable or conductor cross section to confine the molten metal to the bond region. Brazing is a widely accepted method of bonding ground connections. Figure 21 illustrates two methods of ensuring mechanical strength in a brazed joint. All methods of bonding require that mating surfaces be cleaned of protective films such as oil, grease, paint, or varnish. All bonds in the earth must be welded or brazed. Bonds of dissimilar metals must be protected against severe corrosion. Some acceptable corrosion-inhibiting compounds and tapes are listed in table VI.

4.10.1.5 Miscellaneous underground pipes and other metal objects. When present, metallic underground water-pipe networks should be integrated into the earth electrode subsystem, provided they are electrically continuous and free of ac and dc currents. Test procedures for obtaining current measurements are described in 4.4.7. All water-metering devices should be bypassed with a jumper of a size not less than that required for the ground conductor. Metal underground fuel tanks should be included as elements of the earth electrode subsystem and should be interconnected with all other elements. Metal fences can be connected to the composite earth electrode network if HEMP protection is not a requirement.

4.10.2 Fixed facility lightning protection subsystem. All satellite stations must be protected against lightning in proportion to thunderstorm activity at the site location. Isokeraunic maps, such as shown in figure 22, have been developed by the National Oceanographic and Atmospheric Administration to show the frequency of thunderstorms. Similar charts are available to show the average number of thunderstorms throughout the world. This information, along with information on the severity and frequency of lightning strikes, can be used to determine how comprehensive a lightning protection subsystem must be to provide the degree of protection required at a given site. Aspects of the lightning protection subsystem covered in the following paragraphs include buildings, structures, and antennas; air terminals, conductors, and bonds; exterior wires and cables; and lightning arresters.

4.10.2.1 Buildings, structures, and antennas. The propensity of tall buildings or structures to attract lightning serves to protect nearby shorter buildings and structures by establishing a cone of protection projected from the highest point of the tall structure. This cone of protection is created by installing a vertical conducting rod (air terminal) or mast on the tall structure and providing downleads to earth. Figure 23 shows the extent of protection thus provided, expressed as a function of the ratio of the horizontal protected distance D to the height H of the vertical rod or mast. The communications building at a satellite earth station would fall within the 1:1 ratio recommended for mission-essential buildings. The required cone of protection could be provided by a vertical conductor installed on the antenna structure or on a microwave tower at the site. Proper lightning protection of



NOTES:

1. CORRODED AND DIRTY RODS SHOULD BE CLEANED WITH ACID AND WASHED, THEN BRAZED OR WELDED.
2. BRAZED, WELDED, BOLTED, AND CRIMPED BONDS ARE ACCEPTABLE ABOVE GROUND.

FIGURE 21. Clamped and brazed ground rod connection.

TABLE VI. Corrosion-inhibiting tape and compounds for earth electrode bonds.

Type	NSN and AF Catalog #	Use	Unit of issue
Asbestos-base putty	NSN 8030-00-281-2337 AF Catalog # 3667	For sealing openings of ducts and terminal boxes and filling cracks in masonry.	5-lb bag
Tape, tar, cloth	NSN 8030-00-524-9720 AF Catalog # 2083	For wrapping underground bonds to rods, pipes, etc.	75-ft roll
Insulation putty	NSN 5970-00-045-3699 AF Catalog # 3520	For sealing openings in cable against moisture and contact with adjacent structures.	5-ft roll
Special compound (NO-OX-ID)	NSN 8030-00-598-5915 AF Catalog # 8440	Corrosion prevention compound and moisture sealant. Air Force preferred protective compound	1-lb can
Tape, rubber, adhesive	NSN 5970-00-184-2002 AF Catalog # 1081	Serves as a sealant and protection for buried bonds	30-ft roll
Tape, rubber	NSN 5970-00-275-1863 AF Catalog # 6077 or NSN 5970-00-933-7750 AF Catalog # 6078	Serves as a sealant and protection for buried bonds	15-ft roll
Roofing tar	NSN 5030-00-664-7042	Common roof repair and sealing material, may be used as a corrosion inhibitor applied to buried bonds	

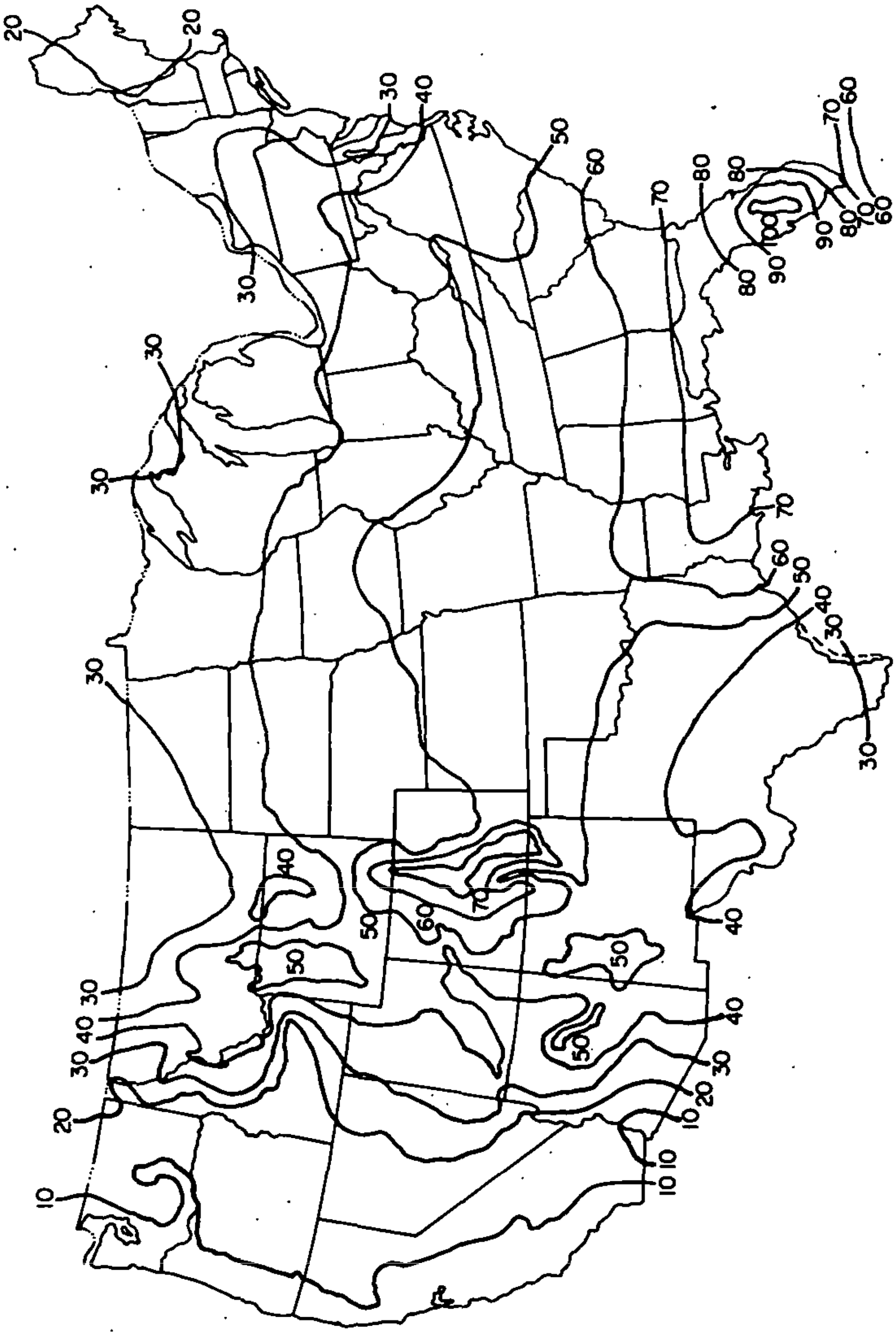
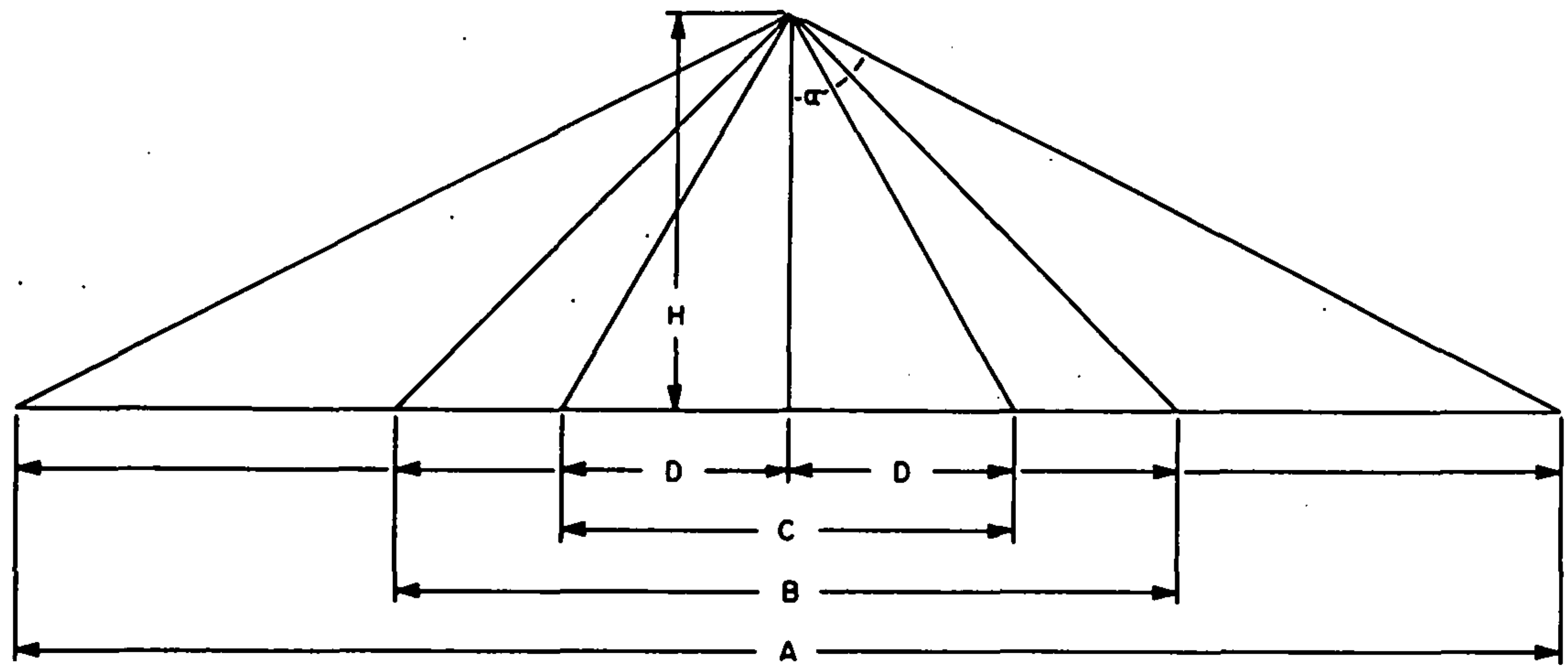


FIGURE 22. U.S. isokeraunic map of annual mean number of thunderstorm days.



ZONE	D/H	α	REFERENCE	RECOMMENDED FOR
A	2/1	63°	NFPA 78	ORDINARY CASES
B	1/1	45°	NFPA 78 BRITISH CODE	ORDINARY STRUCTURES
C	0.58/1	30°	BRITISH CODE	CRITICAL STRUCTURES

LEGEND:

D/H - DISTANCE-TO-HEIGHT RATIO

α - SHIELDING ANGLE

NFPA - NATIONAL FIRE PROTECTION ASSOCIATION

FIGURE 23. Some commonly used lightning shielding angles.

a fixed earth terminal antenna requires that all reinforcing bars (rebar) used in the concrete pedestal be welded and all antenna metalwork be connected to the rebar and to ground rods.

4.10.2.2 Air terminals, conductors, and bonds. Air terminals of solid copper, copper-clad steel, or aluminum rods with a tapered point and a diameter of not less than 1 centimeter (.4 inch) should be installed on the upper perimeter of the antenna/radome and on buildings outside the zone of protection, as required. Air terminal lengths range upward from 0.4 meter (1.3 feet). Buildings provided with air terminals should have the terminals installed at each end of the roof peak as a minimum. The grounding conductor cables (downleads) are connected to the air terminals by welding, clamping, or brazing. Down-leads should be copper-clad steel or copper wire, stranded, ranging between No. 2 and No. 2/0 AWG. Downleads should have no bends with a radius of less than 20 centimeters (8 inches) or turns of greater than 90 degrees. All bonds between downleads and the earth electrode subsystem must be welded or brazed.

4.10.2.3 Exterior wires and cables. Exterior wires and cables should be protected by gas-tube or carbon block or MOV devices, or, as MIL-STD-188-124 specifies, by completely enclosing such cables in electrically continuous conduit. The conduit must also be bonded to the earth electrode at each terminating facility.

4.10.2.4 Lightning arresters. Lightning arresters are protective devices used on power distribution systems. Lightning arresters are larger and have greater peak energy capabilities than the protectors used for surge protection on communications circuits. These arresters are capable of diverting or providing a bypass path directly to ground for lightning that strikes a conductor. Primary arresters are those located in the high-voltage (2400 V or higher) portion of the power distribution system. Primary arresters would typically be installed at transformer stations or on the poles carrying the ac feeder lines. Secondary arresters provide protection to the secondary portion of the power distribution system and are located in or near the ac power entrance.

4.10.3 Fixed facility fault protection subsystem. The fault protection subsystem has been discussed in 4.9.5.1.

4.10.4 Fixed facility signal reference subsystem. The signal reference subsystem is designed to control noise currents and resultant voltages and to establish a common reference for signals between sources and loads to minimize interference. The signal reference subsystem is a composite of various networks. The configuration of these networks is determined by the frequencies involved, the functions being performed by the equipment involved, and the amplitude of the signals on the communications wires or cables. All satellite station signal reference subsystems are hybrid type as defined by the Signal Reference Subsystem section of MIL-STD-188- 124.

4.10.4.1 Higher-frequency network. A higher-frequency signal reference network is an equipotential (multiple-point) ground network utilizing many conductive paths from the earth electrode subsystem to the various electronics equipment cabinets and racks within the facility. The equipotential configuration therefore provides minimum impedance between associated electronic components. For new earth station installations, a metal grid network placed below the raised floor (preferably in the structural floor) should be used for the cabinet/chassis and signal grounds. This configuration would apply to DSCS and DCSS equipment cabinets. Details of a typical metal grid network are shown in figures 24 through 28. For existing earth station installations, cabinets should be bonded to each other, to the raised floor panels/stringers, and to the underfloor grid as shown in figure 29. Requirements for this signal reference network may be found in MIL-STD-188-124.

4.10.4.2 Wiring and bonds. Signal reference grounds will normally be bolted to ground conductors or will use approved clamps or compression-type connectors. In a high-frequency network, the C-E equipment installed in a cabinet should be bonded to the cabinet, and the cabinet in turn should be connected to the signal reference ground. A No. 8 AWG insulated cable may be used to connect cabinets to the signal reference. Table VII shows typical wire sizes used in signal reference applications. Table VIII and figure 30 show connector types. MIL-STD-188-124 specifies that all higher-frequency signal reference points and planes should be directly grounded to the chassis and the equipment case, and that there be no isolation between equipment chassis and case (reference MIL-STD-188-124, Higher Frequency Network).

4.10.4.3 Shield grounds. For higher-frequency signal lines, MIL-STD-188-124 requires that all connectors be of the type that provide a low impedance path from the signal line shield to the equipment case. Shields of coaxial cables and shielded balanced transmission lines should be terminated by peripherally grounding the shield to the equipment case. Coaxial shields and connector shields should be grounded at junction boxes, patch panels, signal distribution boxes, and other interconnection points along the signal path.

4.10.5 Earth electrode subsystem for a vanized facility. The earth electrode requirements for a vanized facility are much the same as those outlined in 4.10.1 for a fixed facility. However, another consideration is that the vanized facility may also require setup and operation in a short time period. If the vanized facility is added temporarily to a fixed site, the fixed facility electrode network should be used. If the vanized facility is deployed in a temporary configuration, not at a fixed site, an earth electrode system of the type shown in figure 12 is recommended. If long-term operation is expected, a more extensive ground system should be installed.

4.10.6 Lightning protection subsystem for a vanized facility. As in the case of fixed earth station facilities, the antenna is the most susceptible to lightning strikes. Air terminals should be installed, on the communications shelter and generator, and connected to the earth electrode subsystem. To protect personnel, ground rods should be driven approximately every 6 meters (20 feet) under walkways and interconnected with No. 2 AWG or larger copper cable. This system should also be interconnected with the earth electrode to reduce step potential voltage. All external signal cables should be protected through the use of gas-tube or equivalent cable protectors.

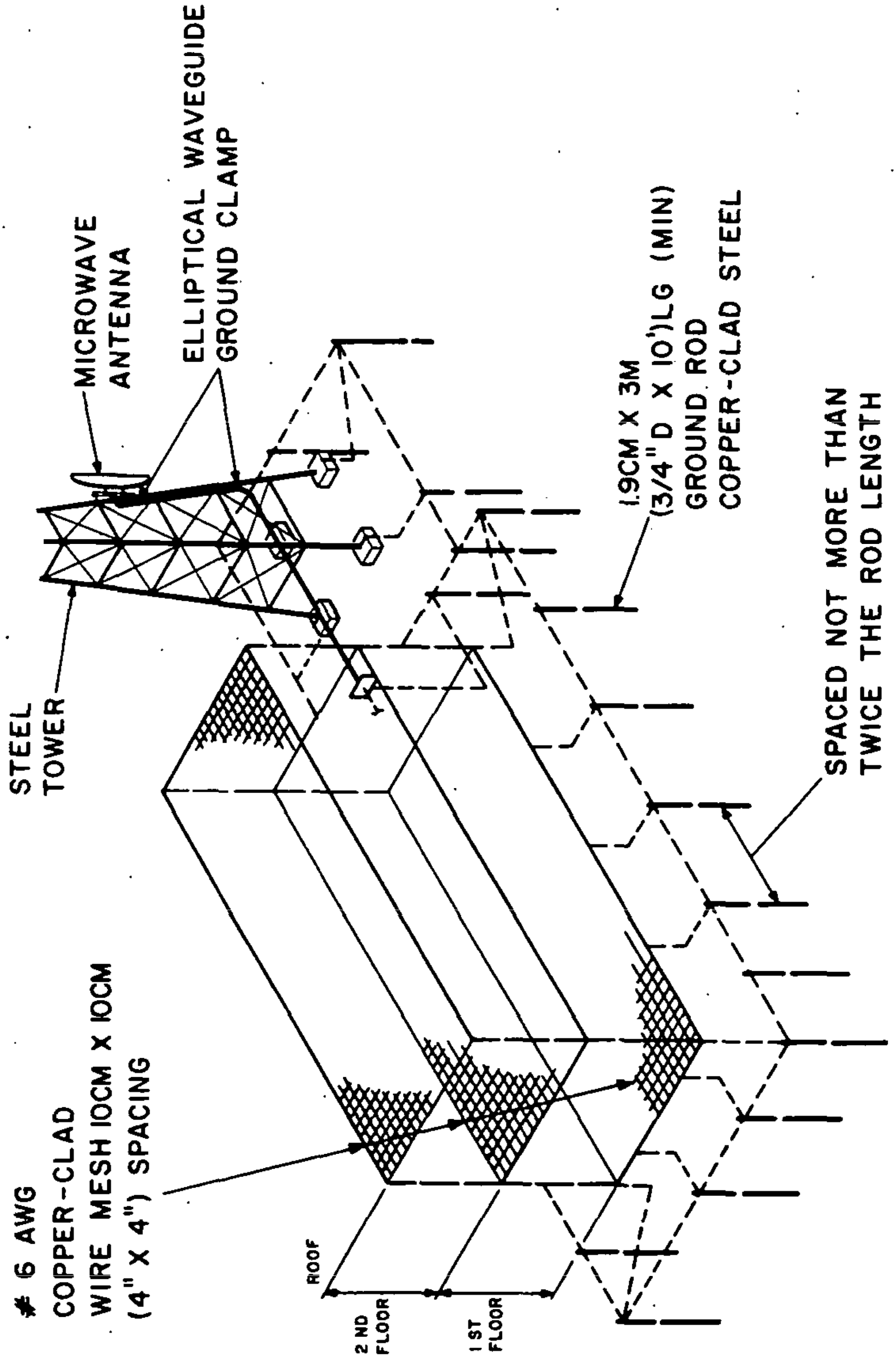


FIGURE 24. Metal grid network in a multideck building.

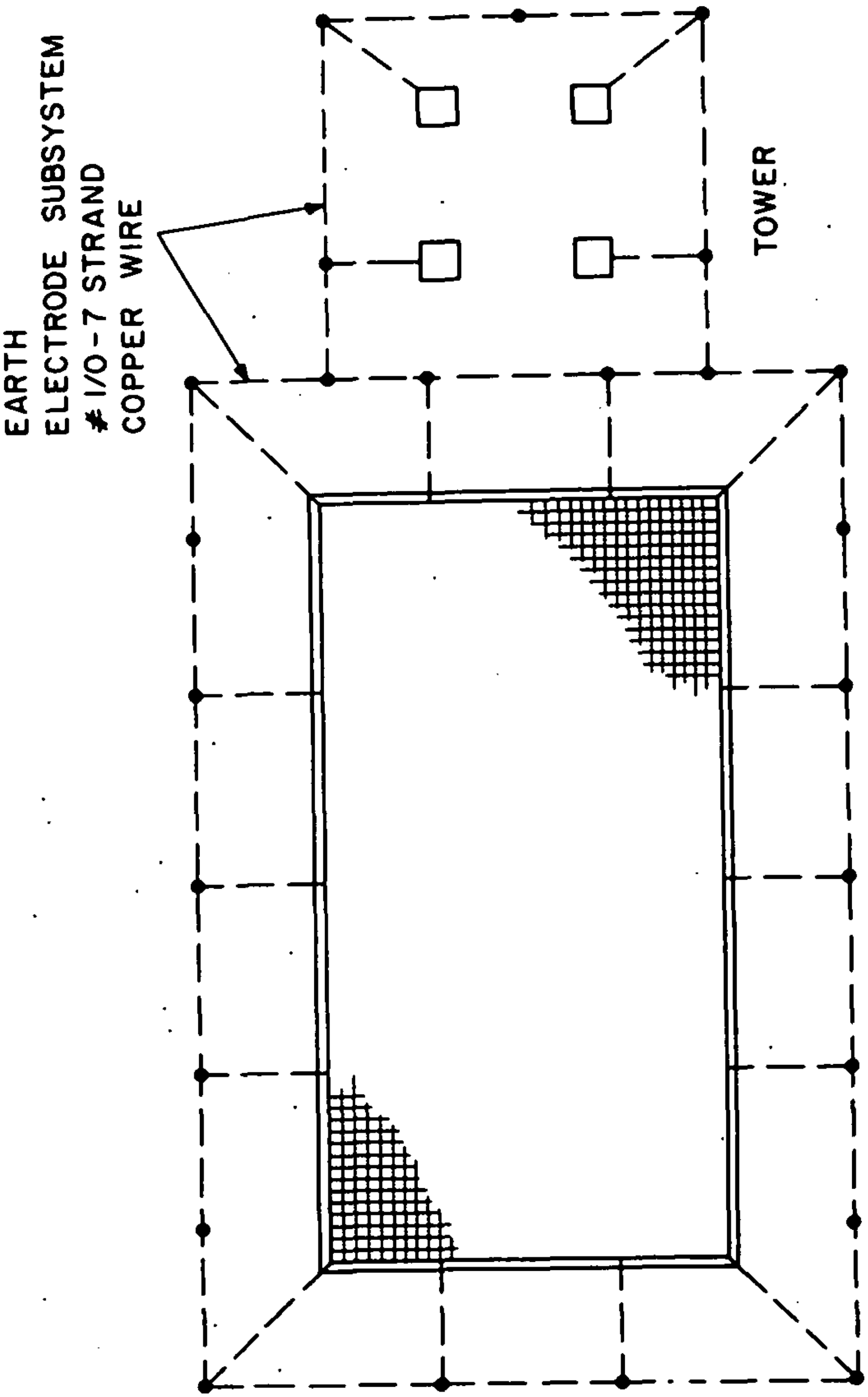


FIGURE 25. Metal grid network in a typical building floor plan.

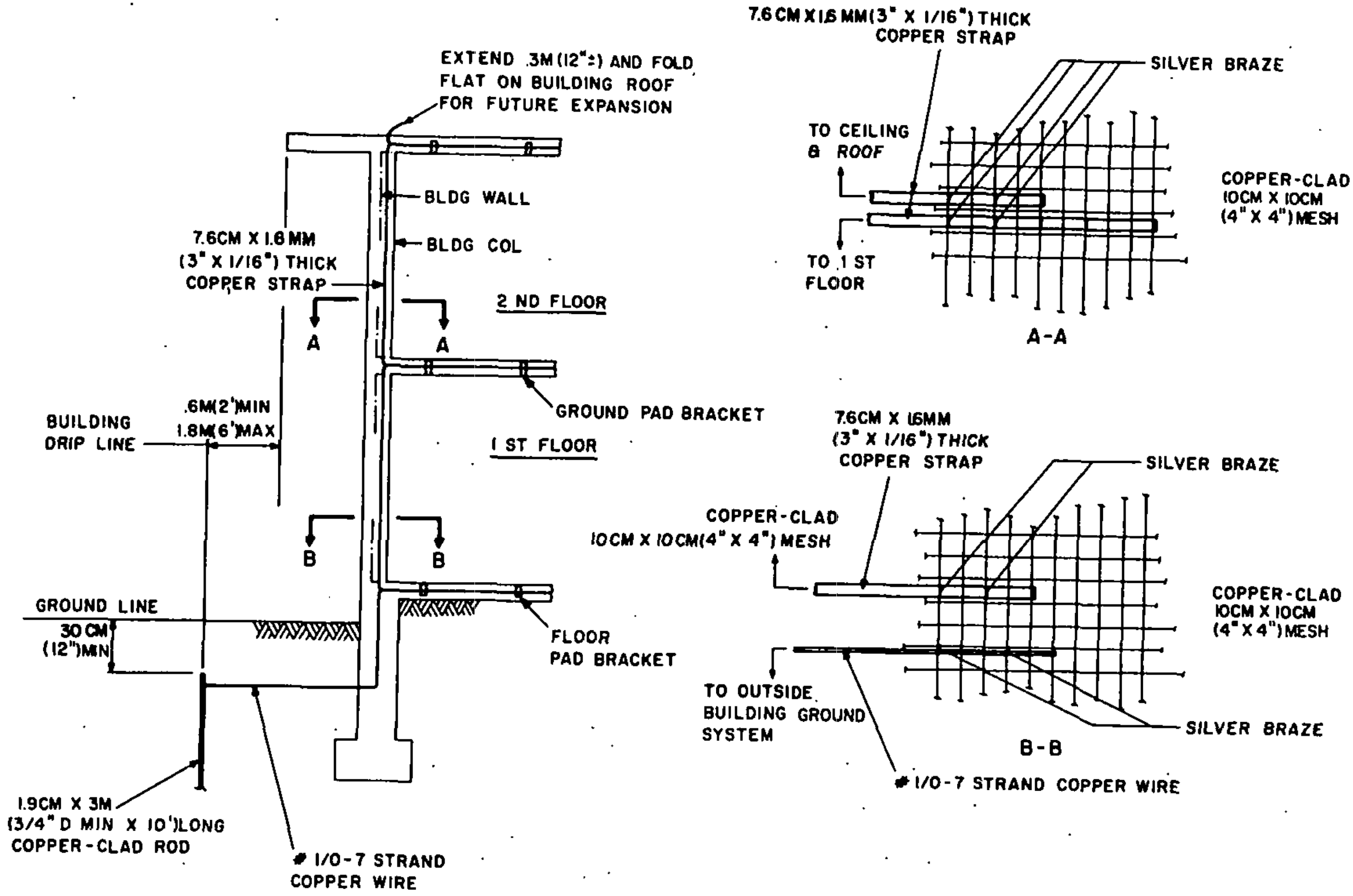


FIGURE 26. Metal grid network, floor plan detail.

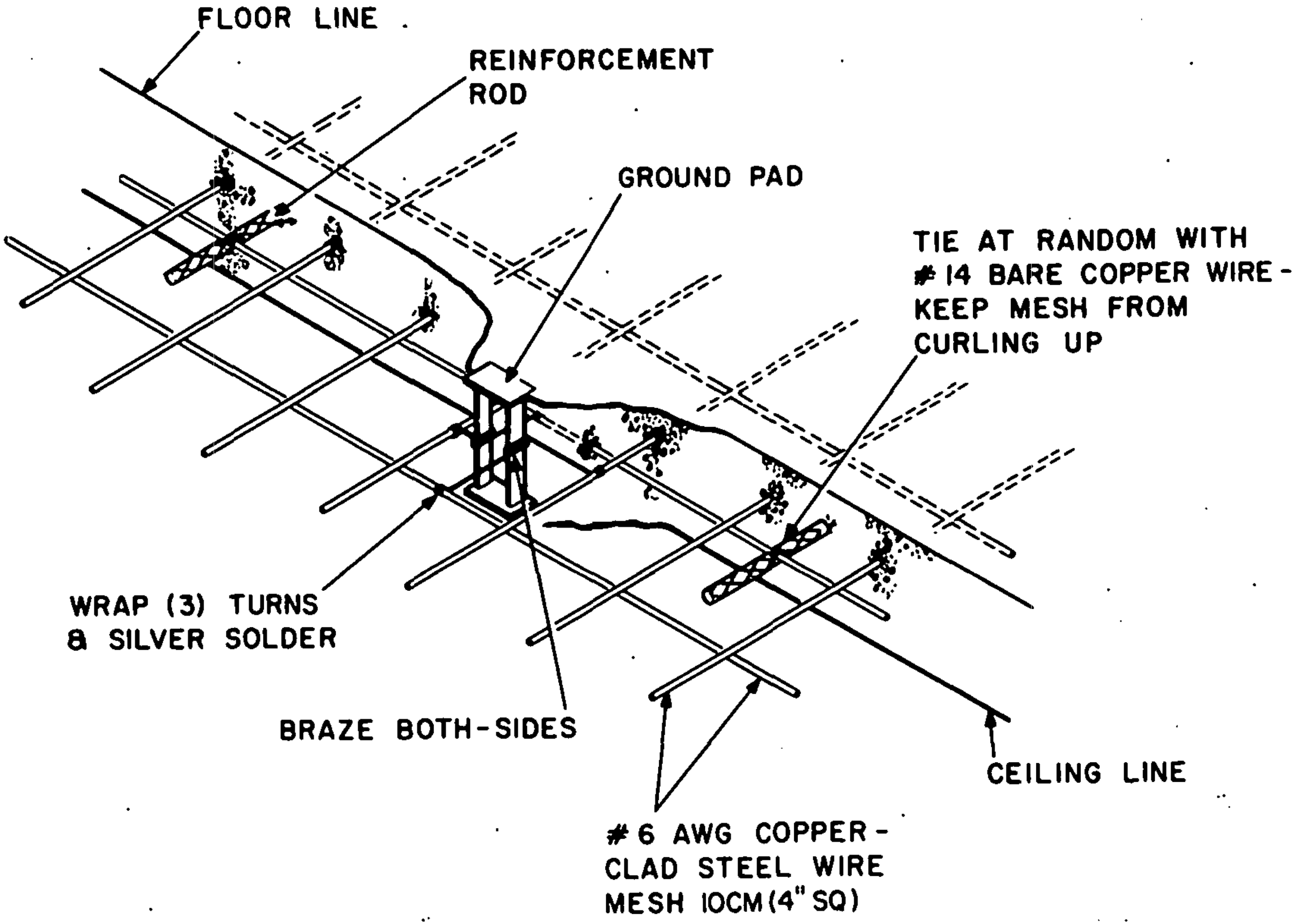


FIGURE 27. Metal grid network, floor/ceiling detail.

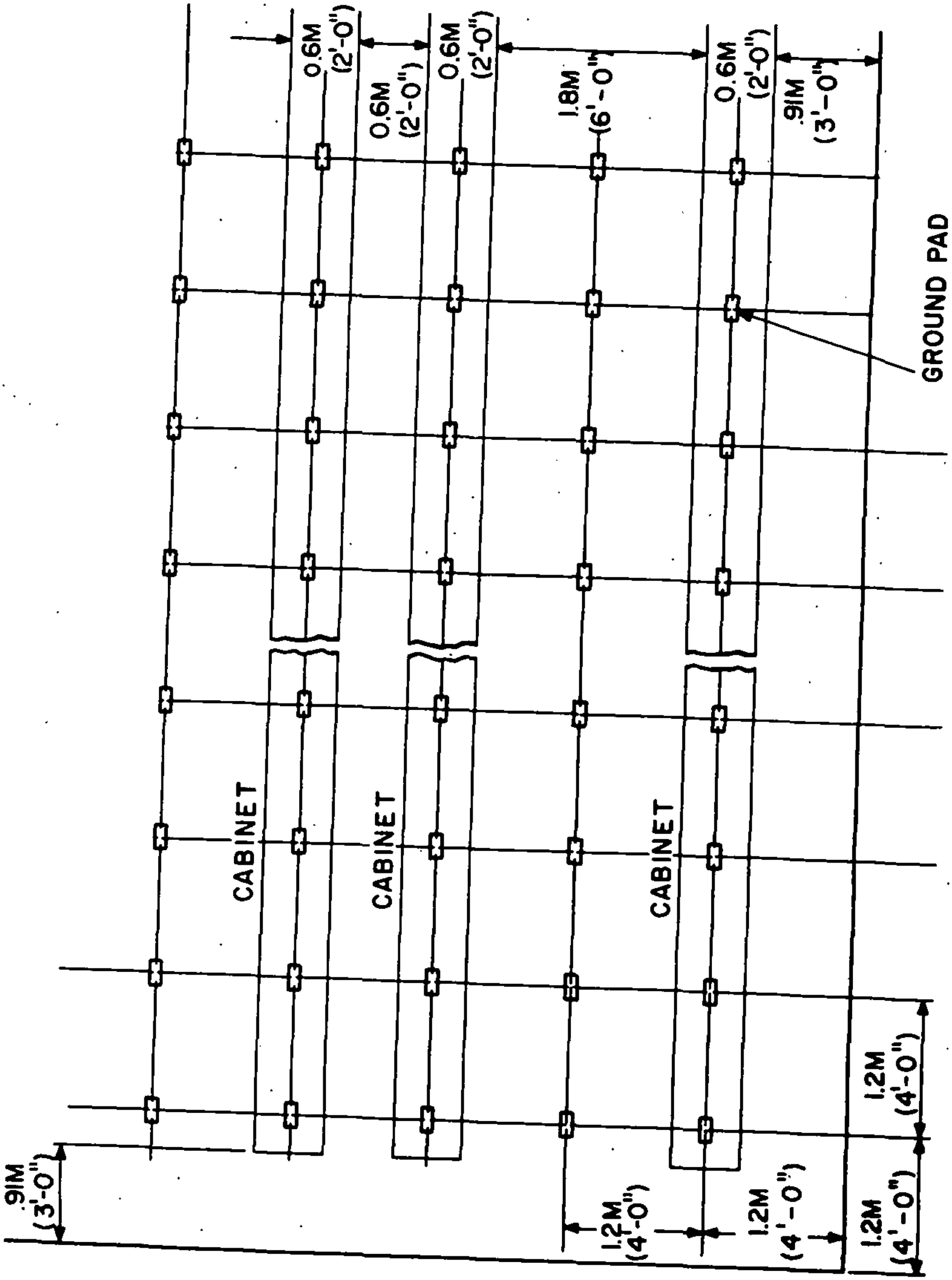


FIGURE 28. Metal grid network, ground pad location.

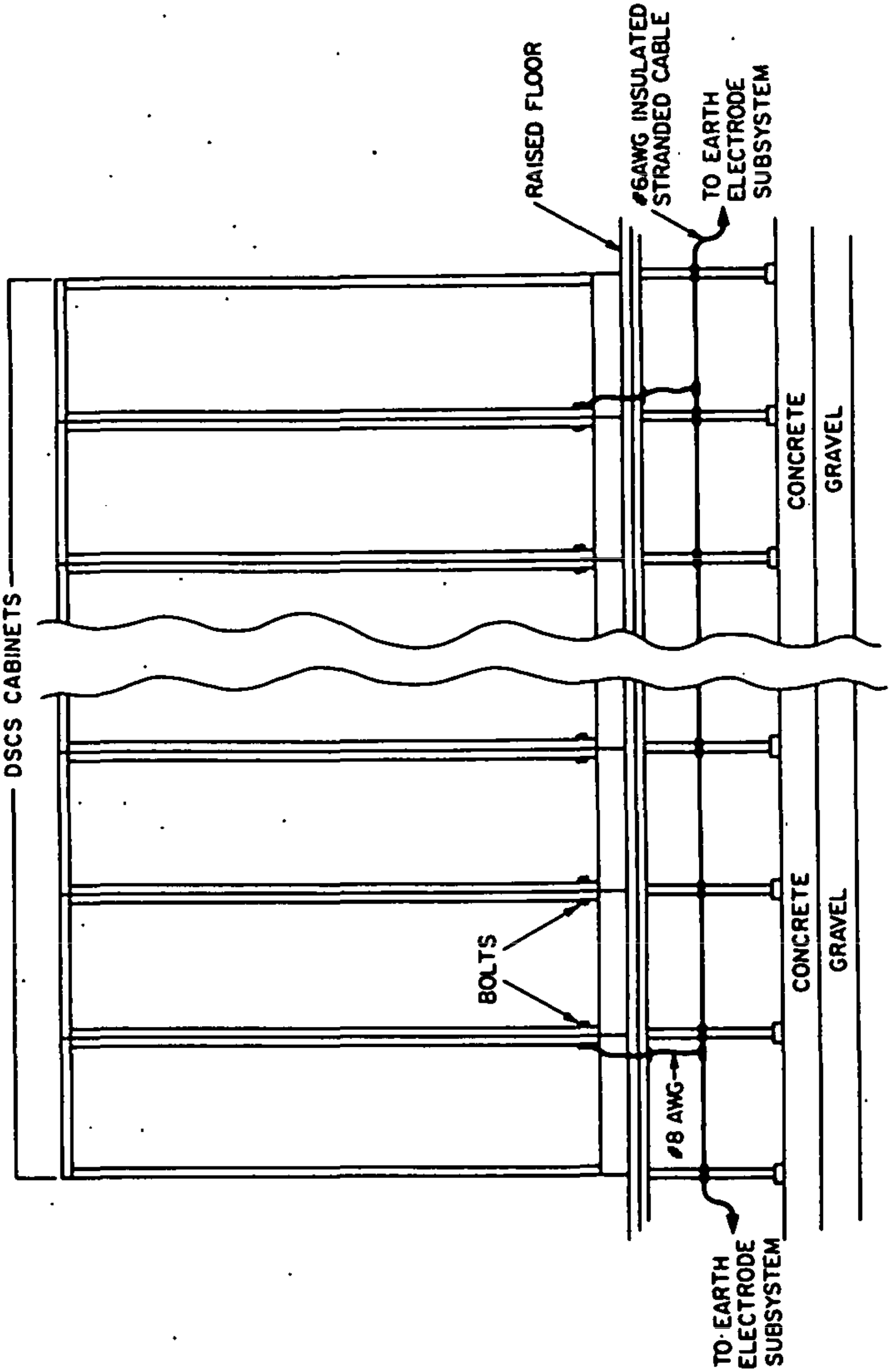


FIGURE 29. Equipotential signal reference network for existing installations (DSCS).

TABLE VII. Wire types and sizes for signal reference applications.

Application	Wire size range (AWG)	Typical recommended
Ring ground to inside ground grid	#2 to #4/0	#1/0 solid or coarse-stranded wire, insulated, yellow*
Main inside ground wires (ring)	#4 to #2/0	#2 stranded, insulated, yellow
Spurs from main ground wires (grid)	#6 to #4	#6 stranded, insulated, yellow
Downleads from main inside ground wires to cabinets or racks	#10 to #6	#8 stranded, insulated, yellow
Inside cabinet or rack ground wires	#18 to #10	#12 solid or stranded, insulated, yellow
Combined CDF ground wire harness	#14 to #10	#12 solid, insulated, yellow
Ground wires to terminal blocks on CDF	#18 to #12	#18 solid or stranded, insulated, yellow
Ground pin straps on terminal blocks	#22 to #20	#22 solid, bare

*Protected by plastic conduit on exterior exposed walls and bare = .6 meters (2 feet) below the surface of the soil.

TABLE VIII. Representative signal reference subsystem hardware.

Fig. 30 reference, and item name	NSN	AF cat. No.	Remarks
A T-splice connector	5940-00-691-9172	212	NSN depends on size
Cross ground clamp	5999-00-811-9937 or 5940-00-087-3994	828 5915	Similar items
C Splice sleeves	5940-00-665-9574 5940-00-549-8086 5940-00-849-6734 5940-00-241-6460	719 722 3685 3686	NSN depends on size and type of sleeve
D Terminal lugs	5940-00-012-0942 5940-00-549-8826 5940-00-577-1877 5940-00-549-1984	6332 3042 3199 1150	NSN depends on size and shape of terminal lug
E Loop clamp	5340-00-989-9224 5340-00-988-3210	79 1683	Nylon; NSN depends on size
F Two-hole cable clamp	5340-00-190-6798 5340-00-281-1536	5532 5538	NSN depends on size
G Ground clamp for flat surfaces	5999-00-899-1333	1374	--

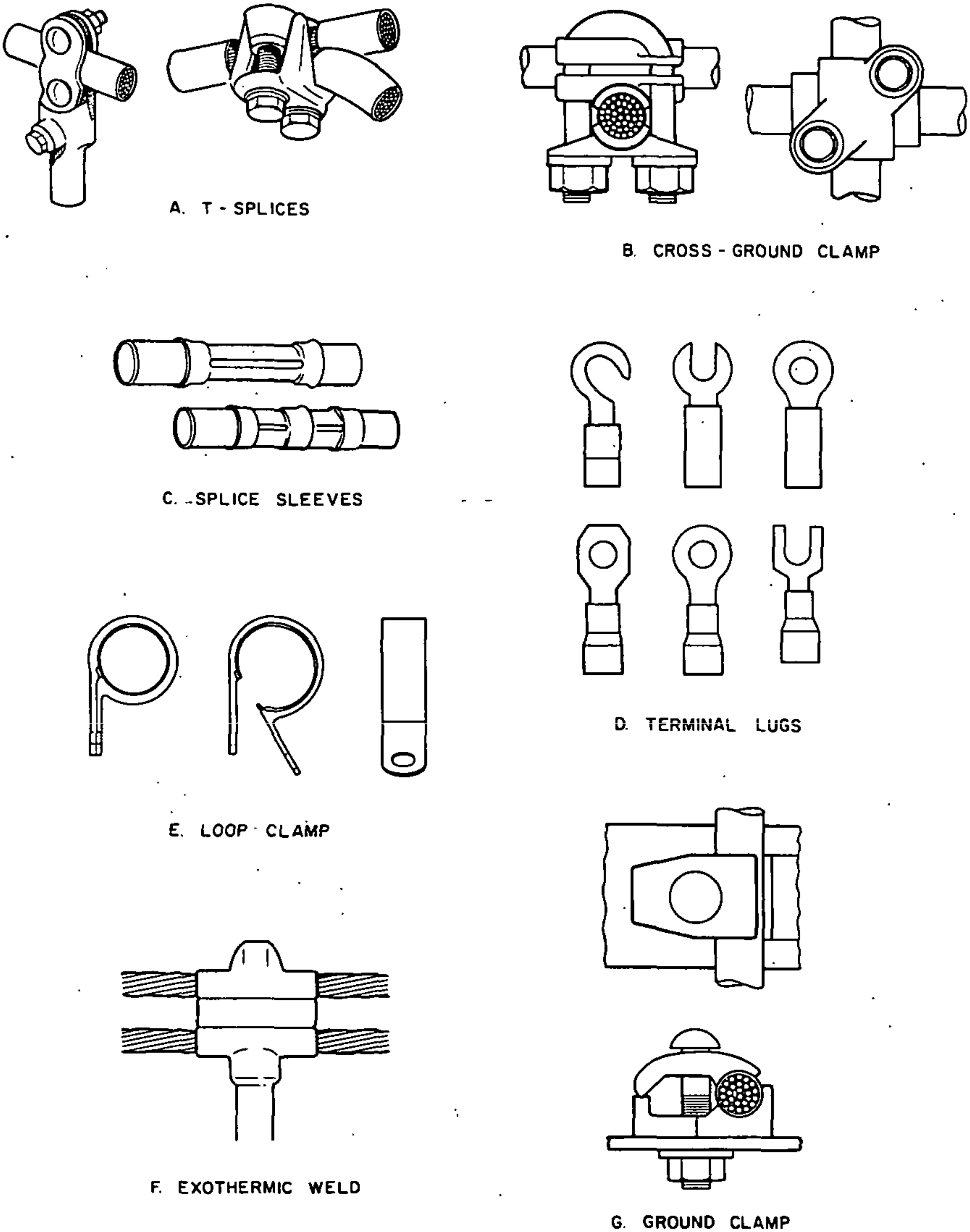


FIGURE 30. Typical signal ground lead connectors and clamps.

4.10.7 <u>Fault protection subsystem for a vanized facility</u>. Fault protection requirements will generally follow the criteria outlined in 4.9.5. If power cables do not provide for a fifth (protective) conductor; then a green-insulated copper wire, No. 6 AWG or larger, must be periodically attached to the cable with tape or straps at intervals along the length of the cable. This protective ground wire should be equipped with an appropriate crimped or mechanical lug at each end. One end shall be attached to the power entrance ground lug panel at the van or shelter, and the other end shall be bonded to the power generator ground connection.

4.10.8 <u>Signal reference subsystem for a vanized facility</u>. Signal reference criteria for a vanized facility are essentially those outlined in 4.10.4 for fixed earth station facilities. A vanized facility, however, will normally be provided with a single connection point to the earth electrode subsystem. In the DCSS vans, the signal reference ground stud is located in the power rack.

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

Review activities:
Army - CR
Navy - YD
Air Force - 13, 17, 89

Other interest:
TRI-TAC-TT
JCS - J6
NSA - NS
DEA - DC

Preparing activity:
Army - SC

(Project SLHC-4120)

APPENDIX A. INFORMATION WORKSHEETS
(When completed, some worksheets may require a security classification)

10. GENERAL. This appendix provides samples of information worksheets (figures A-1 through A-35) which may be used as guidance for the collection of presite-survey information.

WORKSHEET APPLICABILTY KEY

Figure No.	Worksheet title	Applicability	
		Presite	Onsite
A-1	Facility identification	X	X
A-2	Land availability	X	
A-3	Available building/floor space	X	X
A-4	Interface	X	X
A-5	Area environmental conditions...............	X	X
A-6	Soil and drainage	X	X
A-7	Map and drawing	X	X
A-8	Land requirement	X	
A-9	Power requirements..........................	X	
A-10	Physical survivability requirements.........	X	
A-11	Nuclear survivability requirements..........	X	
A-12	Facility requirements.......................	X	
A-13	Site access requirements	X	X
A-14	Logistics support requirements..............	X	
A-15	Administrative	X	X
A-16	Topography and terrain		X
A-17	Overall horizon profile		X
A-18	Specific obstruction profile		X
A-19	Photographic		X
A-20	Site power load		X

WORKSHEET APPLICABILTY KEY

Figure No.	Worksheet title	Applicability	
		Presite	Onsite
A-21	Existing power characteristics.............		X
A-22	Power noise		X
A-23	Line voltage analysis......................		X
A-24	Earth resistivity		X
A-25	Existing site ground system survey.........		X
A-26	Ground conductor ac current		X
A-27	Ground conductor dc current		X
A-28	Nuclear survivability		X
A-29	Site security		X
A-30	Link profile		X
A-31	Cable route survey		X
A-32	Logistics support		X
A-33	Real estate decription.....................		X
A-34	Utility availability		X
A-35	Soil load-bearing		X

FACILITY IDENTIFICATION

==

Site ID number or designation: ______________________________

Site location

Nearest town/military installation: ______________________________

Site latitude: ____________ Longitude: ________________

Elevation: ____________ above mean sea level

Available maps: ______________________________

____

Existing facility: Yes _____ No_____

If yes, complete remainder of form.

Operations and maintenance organization: ______________________________

____

Address: ______________________________

____

Point of contact: ______________________________

Local phone: ______________ AUTOVON: ____________

==

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________

____

Direct observation: Yes _____ No _____

==

FIGURE A-1. Facility identification worksheet.

LAND AVAILABILITY

==

Maximum area available: ______________________ m^2 (ft^2)

Dimensions: _________ m (ft) x __________m (ft)

Legal description: ____

____

Sketch of plot boundaries w/dimensions:

==

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

==

FIGURE A-2. Land availability worksheet.

AVAILABLE BUILDING/FLOOR SPACE

==

Buildings existing: Yes_________ No_______

Suitable for use by _________________________________ Yes _____ No _____
(earth terminal, ICF, etc.)

Size: _________________ x ____________________

Available floor space: ____ m^2 (ft^2)

Dimensions: ___________________ x __________________

___________________ x __________________

___________________ x __________________

Type construction

Permanent: ____
(masonry, brick, frame, etc.)

Temporary: ____
(frame, prefab, etc.)

Remarks:

==

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

==

FIGURE A-3. Available building/floor space worksheet.

INTERFACE

Station description/location:

Circuit requirements

Distance from earth station: ______________________ km (mi)

Link requirement: ______________________
(LOS, leased lines, etc.)

Type of circuits: ____________ Number of circuits: ____________

Circuit characteristics

Terminating impedance: ________ ohms

Bandwidth: Baseband ________ Hz Channel ________ Hz

Remarks:

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________

____

Direct observation: Yes _____ No _____

FIGURE A-4. Interface worksheet.

AREA ENVIRONMENTAL CONDITIONS

Name and location of weather station: ______________________________

Station elevation: __________ Distance from site: ______________________

Maximum frostline depth at site: ______________________________ m (ft)

Describe site unusual weather phenomena (monsoons, hurricanes, tornados, sandstorms, and detrimental effects of seashore, environment, industrial pollutants, smoke, etc.):

Seismic zone (at site): ______________

Describe any unusual seismic activity at site: ______________________
____

Frequency of tremors: ____________ Frequency of damaging quakes: ________

Date of latest damaging earthquake at site: __________________________

Richter (or other) scale intensity: _______ Duration: _______ min (sec)

Location of epicenter: _______________________________________

Distance from site: _________ Direction from site: ______________

Distance from site to nearest damaged structure: ______________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes ____ No ____

If yes, identify documentation: ______________________________
____

Direct observation: Yes ____ No ____

FIGURE A-5. Area environmental conditions worksheet (sheet 1 of 2).

AREA ENVIRONMENTAL CONDITIONS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall mm (in.) Max recorded ___ ___ ___ ___ mm in. mo yr												
Snowfall mm (in.) Max recorded ___ ___ ___ ___ mm in. mo yr												
Humidity (percent) Mean avg ____ May/Sept ____ Oct/Apr ____												
Temperature °C (°F) Max ________	max											
Min ________ Mean avg ____ May/Sept ____ Oct/Apr ____	min											
Wind velocity kmph (mph)	kmph (mph)											
Max ________ Direction ___	dir											

FIGURE A-5. Area environmental conditions worksheet (sheet 2 of 2).

SOIL AND DRAINAGE

==

Name and address of base civil engineer: ______________________________

____

Name and address of soil core analysis laboratory: ____________________

____

Average estimated soil bearing strength: ______________ kg/m^2 (lb/ft^2)

Soil composition by depth: ____

Soil percolation test results: ____

____

Water table depth estimate: ______________ m (ft)

Drainage (runoff) conditions; describe: _______________________________

____

____

Flooding history/potential: ____

____

____

Estimated civil works required: _______________________________________

____

==

SOURCE OF WORKSHEET INFORMATION (identify):

==

FIGURE A-6. Soil and drainage worksheet.

MAP AND DRAWING

Vicinity maps of earth station complex (attach copies)

Source	Date	Identification No.	Remarks

Plots and drawings

Identification	Reference No.
Earth station site plan	
Interconnect plan	
Multiplex plan	
Building No. ____ layout	

SOURCE OF MAPS AND DRAWINGS:

FIGURE A-7. Map and drawing worksheet.

LAND REQUIREMENT

Minimum overall site area required: ____ m (ft) x ____ m (ft)

BUILDINGS/VESTIBULES		Present requirements m (ft) x m (ft)	Expansion requirement m (ft) x m (ft)
Buildings/vestibules #1			
Type: ____________	Area:	________	________
Buildings/vestibules #2			
Type: ____________	Area:	________	________
Buildings/vestibules #3			
Type: ____________	Area:	________	________
Buildings/vestibules #4			
Type: ____________	Area:	________	________

TRANSPORTABLE SHELTER/VAN			
Shelter/van #1			
Type: ____________	Area:	________	________
Shelter/van #2			
Type: ____________	Area:	________	________
Shelter/van #3			
Type: ____________	Area:	________	________
Shelter/van #4			
Type: ____________	Area:	________	________

FIGURE A-8. Land requirement worksheet (sheet 1 of 2).

LAND REQUIREMENT

ANTENNA

Pad dimensions m (ft) x m (ft): ____________________

Dual site expansion: ____

____

____

Tower required: Yes ____ No ____

Height: ____ m (ft) Base area m (ft) x m (ft): ______________

Radome required: Yes ____ No ____

Height: ____ m (ft) Base area m (ft) x m (ft): ______________

Antenna frontal clearance required: ______________________________

Antenna/building separation required: ____________________________

Remarks:

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes ____ No ____

If yes, identify documentation: ______________________________

____

Direct observation: Yes ____ No ____

FIGURE A-8. Land requirement worksheet (sheet 2 of 2).

POWER REQUIREMENTS

PRIMARY

_______ Vac ± _____ percent

Phase: _____________ Frequency: _________ Hz ± _____ percent

kVA: ________ maximum, _________ minimum

BACKUP, class (A,B,C): ____________

_______ Vac ± _____ percent

Phase: _____________ Frequency: _________ Hz ± _____ percent

kVA: ________

UPS: Yes ____ No ____ Type (flywheel, battery, etc.): _____________________

_______ Vac ± _____ percent

Phase: _____________ Frequency: _________ Hz ± _____ percent

kVA: ________

Remarks:

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

FIGURE A-9. Power requirements worksheet.

PHYSICAL SURVIVABILITY REQUIREMENTS

BUILDINGS:

Must withstand winds up to _____ kmph (mph)

Roof must accommodate snow/ice loads up to _____ kg/m^2 (lb/ft^2)

Insulation requirements:

VANS:

Must withstand winds up to _____ kmph (mph)

Roof must accommodate snow/ice loads up to _____ kg/m^2 (lb/ft^2)

Insulation requirements:

Remarks:

FIGURE A-10. Physical survivability requirements worksheet.

NUCLEAR SURVIVABILITY REQUIREMENTS

==

Has site been designated as hardened installation? Yes _____ No _____

If yes complete remainder of worksheet.

==

1. Degree of hardness required: _____ kg/m^2 (psi)

2. Fallout protection required: Yes _____, No _____

   Length of time requirement: _____ hours/days

3. Distance from site to potential targets

   a. Target #1 ID: ____________________ Distance ____________________ km/mi

   b. Target #2 ID: ____________________ Distance ____________________ km/mi

   c. Target #3 ID: ____________________ Distance ____________________ km/mi

   d. Target #4 ID: ____________________ Distance ____________________ km/mi

Remarks:

==

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

==

FIGURE A-11. Nuclear survivability requirements worksheet.

FACILITY REQUIREMENTS

ARCHITECTURAL:

Technical equipment area

(1) Floor requirements

a. Panel size: ______________________________ m^2 (in.^{2})

b. Design loading, uniform: ____________________ kg/m^2 (lb/ft^2)

c. Design loading, concentrated: __________________ kg (lb)

d. Allowable deflection: __________________________

e. Height above subfloor: _________________________ m (in.)

f. Raised-floor air register: ________ m (in.) x ______ m (in.)

g. Special requirements: ____

____

____

(2) Door requirements:

____

____

(3) Window requirements:

____

____

(4) Ceiling requirements:

Height: ____

Acoustic treatment: ______________________________________

FIGURE A-12. Facility requirements worksheet (sheet 1 of 3).

FACILITY REQUIREMENTS

ENVIRONMENTAL CONTROL:

(1) Equipment space interior ambient conditions

Temperature: ________ °C (°F), ± ________ °C (°F)

Humidity: ________ percent rh, ± ________ percent

(2) Special equipment requirements

a. Transmitter equipment

Temperature: ________ °C (°F)

Air Flow: ________ m^3/min (ft^3/min)

Pressure differential: ________ Pa (in.)

b. Communications equipment

Temperature: ________ °C (°F)

Air Flow: ________ m^3/min (ft^3/min)

Pressure differential: ________ Pa (in.)

c. Other equipment (specify): ________

Temperature: ________ °C (°F)

Air Flow: ________ m^3/min (ft^3/min)

Pressure differential: ________ Pa (in.)

d. Other equipment (specify): ________

Temperature: ________ °C (°F)

Air Flow: ________ m^3/min (ft^3/min)

Pressure differential: ________ Pa (in.)

FIGURE A-12. Facility requirements worksheet (sheet 2 of 3).

FACILITY REQUIREMENTS

ENVIRONMENTAL CONTROL (continued):

(3) Total equipment cooling requirement

	Heat dissipation joules/h (Btu/h)	Air flow m^3/min (ft^3/min)
Communications equipment area	____	____
Transmitter equipment area	____	____
Other: ____	____	____

(4) Air Filtration and circulation requirements:

____

Remarks:

NOTE: The ASHRAE load calculation form contained in appendix A of ASHRAE GRP 158, Cooling and Heating Load Calculation Manual, may either be substituted for, or used in conjunction with, this worksheet.

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes ____ No ____

If yes, identify documentation: ____

____

Direct observation: Yes ____ No ____

FIGURE A-12. Facility requirements worksheet (sheet 3 of 3).

SITE ACCESS REQUIREMENTS

==

HIGHWAYS

Distance from site access road and highway intersection to support base or town: ____________ kilometers (miles)

Classification: State _____ County _____ Municipal _____

Other (specify): ____

Type of surface: Concrete _____ Asphalt _____ Gravel _____

Stone _____ Dirt _____ Other (specify): ____________________________

Minimum width: ______________ m (ft)

Paved shoulders: Yes _____ No _____

Maximum grades: Paved roads _____ percent Dirt roads _____ percent

Months of year usable: __________________________

Bridge, tunnel, culvert limits: Total load: ____________ kg (tons), or

________ kg (tons)/axle Overhead clearance: __________ m (ft)

Total width: _____________ m (ft) Number of lanes: __________

Improvements required:

FIGURE A-13. Site access requirements worksheet (sheet 1 of 3).

SITE ACCESS REQUIREMENTS (continued)

EXISTING ACCESS ROADS (FROM SITE TO HIGHWAYS)

Length of access road: __________ kilometers (miles)

Classification: State _____ County _____ Municipal _____

Other (specify): ______________________________

Type of surface: Concrete _____ Asphalt _____ Gravel _____

Stone _____ Dirt _____ Other (specify): ______________________________

Minimum width: __________ m (ft)

Paved shoulders: Yes _____ No _____

Maximum grades: Paved roads _____ percent Dirt roads _____ percent

Months of year usable: ______________________________

Bridge, tunnel, culvert limits: Total load: _______kg (tons), or

_______ kg (tons)/axle Overhead clearance: __________ m (ft)

Total width: __________ m (ft) Number of lanes: _______

Improvements required:

FIGURE A-13. Site access requirements worksheet (sheet 2 of 3).

SITE ACCESS REQUIREMENTS (continued)

NEW ACCESS ROAD

Length required: _________ kilometers (miles)

Culverts required (number, size, and approximate amount of fill per culvert):

Bridges required (number and approximate span of each):

Location of required new work and necessary field data are shown on drawing or sketch number ____________________

Existing tramways: Yes _____ No _____

Capacity: _____ m^3 (ft^3), _____ kg (tons-lb)

Car dimensions: _____

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

FIGURE A-13. Site access requirements worksheet (sheet 3 of 3).

LOGISTICS SUPPORT REQUIREMENTS

ADMINISTRATIVE:

Number of people: ______________________

Office area requirement: ______________________ m^2 (ft^2)

PERSONNEL HOUSING:

Number of people: ______________________

Remarks:

PETROLEUM, OILS, and LUBRICANTS (POL)

Total storage area required: ______________________ m^2 (ft^2)

Required storage capacity

Gas: ____l (gal) Heating oil: ____l (gal) Fuel oil: ____l (gal)

Maintenance area required: ______________________ m^2 (ft^2)

Other (water supply, sanitary facilities): ______________________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes ____ No ____

If yes, identify documentation: ______________________

____

Direct observation: Yes ____ No ____

FIGURE A-14. Logistics support requirements worksheet.

ADMINISTRATIVE

==

SITE ID NUMBER OR NAME: ____________________

Site location

Nearest town/military installation: ____________________

Site latitude: __________ Longitude: __________

Map reference: ____________________

____

O&M ORGANIZATION:

Point of contact: ____________________

Local phone: __________ AUTOVON: __________

Address: ____________________

==

Source of site information

Existing documentation: Yes ____ No ____

If yes, identify documentation: ____________________

Direct observation: Yes ____ No ____

____

FIGURE A-15. Administrative worksheet (sheet 1 of 8).

ADMINISTRATIVE (continued)

SUPPORT AGENCIES

Facility/base civil/public works engineer

Point of contact: ______________________________

Local phone: ______________ AUTOVON: ______________

Address: ______________________________

____

Army Corps of Engineers/AF Engineering and Services Directorate/Naval Facilities Engineer Command

Point of contact: ______________________________

Local phone: ______________ AUTOVON: ______________

Address: ______________________________

____

Onsite contact

Point of contact: ______________________________

Local phone: ______________ AUTOVON: ______________

Address: ______________________________

____

Remarks:

Source of support agencies information:

FIGURE A-15. Administrative worksheet (sheet 2 of 8).

ADMINISTRATIVE (continued)

AIRFIELDS

Name(s) and address(es) of airport(s) in area:

____

____

Ownership: Government _____ Municipal _____ Private _____

Terminal facilities: Passenger _____ Freight _____

Maximum size of plane accommodated: ______________________

Name(s) and address(es) of commercial carrier(s):

____

____

____

Route from airport to site (w/distances): ______________________

____

____

Reliability (months of year usable): ______________________

Source of airfields information

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________

____

Direct observation: Yes _____ No _____

FIGURE A-15. Administrative worksheet (sheet 3 of 8).

ADMINISTRATIVE (continued)

CIVILIAN POPULATION CENTERS

Name of nearest large city: ____________________

Distance to nearest large city (kilometers/miles): ____________________

Population of nearest large city: ____________________

Name of nearest town: ____________________

Distance to nearest town (kilometers/miles): ____________________

Population of nearest town: ____________________

Prevailing nationality of population: ____________________

Political situation: ____________________

Principal language spoken: ____________________

PERSONNEL SUPPORT

Housing available (officer, EM, CIV, contractor)

On-base housing, bachelor and family

Type and quality: ____________________

Method of assignment: ____________________

Waiting time: ____________________

Availability of funishings: ____________________

Off-base housing

Location: ____________________

Distance from site: ____________________

FIGURE A-15. Administrative worksheet (sheet 4 of 8).

ADMINISTRATIVE (continued)

PERSONNEL SUPPORT (continued)

Hotels: Plentiful ______ Scarce __________ None __________

Quality: Excellent _________ Adequate ________ Poor _________

Lodging, average price per day: dollars ________

Food, average price per day: dollars ________

Private homes: Plentiful ______ Scarce ______ None __________

Accommodations: Excellent _______ Adequate ______ Poor ______

Average price per month: dollars ________ furnished/unfurnished

Utilities

Type available and approximate cost

Heating (oil, gas, electric): ______________________________

Water: ____

Electricity: ____

Electricity: Voltage ____ Frequency ____ Reliability ____

Telephone service, availability and cost: _______________________

____

Messing facilities (officer, EM, CIV, contractor)

Onsite: ____

Offsite: ____

Local restaurants: Yes ______ No _______

Prices compared to U.S.: ____ percent higher _____ percent lower

____ same

FIGURE A-15. Administrative worksheet (sheet 5 of 8).

ADMINISTRATIVE (continued)

PERSONNEL SUPPORT (continued)

Local merchants: Plentiful _____ Scarce _____ None _______

Prices compared to U.S.: ____ percent higher ____ percent lower _____ same

Import supplies: Yes ______ No _______

From where? ____

Remarks:

Medical and dental facilities

Military (distance): ____

Commercial (distance): Air km (miles) ______ Road km (miles) _______

Name and address: ____

____

Dispensary facilities or doctors: Yes _____ No ________

Distance: Air kilometers (miles) ____ Road kilometers (miles) ____

Remarks:

FIGURE A-15. Administrative worksheet (sheet 6 of 8).

ADMINISTRATIVE (continued)

PERSONNEL SUPPORT (continued)

Military exchange

Distance: ______

Size: ______

Type of stock: ______

______

Commissary

Distance: ______

Size: ______

Schools (distance and grades taught)

On-base: ______

Off-base: ______

Existing: Grade school ____ High school ____ College ____

Private tutors: Yes ____ No ____

Distance: ______

Standards: Excellent ____ Adequate ____ Inadequate ____

Sponsor: Government ____ Private ____ Municipal ____

Name of sponsor: ______

Availability of school transportation facilities:

FIGURE A-15. Administrative worksheet (sheet 7 of 8).

ADMINISTRATIVE (continued)

Personnel support (continued)

Recreation (TV, radio, sports, hobbies, movies, etc.)

On-base: ____________________

Off-base: ____________________

Churches

On-base: ____________________

Off-base: ____________________

Clothing supplies

Local merchants: Plentiful ____ Scarce ____ None ____

Prices compared to U.S.: ____ percent higher ____ percent lower ____ same

Import: Yes ____ No ____ From where?

Remarks:

Banking

Local banks: Plentiful ____ Scarce ____ None ____

Nearest large bank: Air kilometers (miles) ____ Road kilometers (miles) ____

Name and address: ____________________

____

Source of personnel support information

Existing documentation: Yes ____ No ____

If yes, identify documentation: ____________________

Direct observation: Yes ____ No ____

FIGURE A-15. Administrative worksheet (sheet 8 of 8).

TOPOGRAPHY AND TERRAIN

SITE ELEVATION (above mean sea level)

High: ___________ m (ft) Low: ___________ m (ft)

GENERAL DESCRIPTION

Vegetation: Heavy ___________ Light ___________ None ___________

Trees: Heavily wooded ________ Lightly wooded ________ None ___________

Slopes: Steep ______ Gentle _________ Rolling _______ Flat _________

Surface characteristics: Rock ________ Gravel _________ Sand _________

Clay ________ Silt __________ Other _________

Remarks:

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

FIGURE A-16. Topography and terrain worksheet.

OVERALL HORIZON PROFILE

Establish true north-south line; describe method:

Locate transit at proposed antenna location; describe and show location on sketch (add sheets if required):

Ground elevation at antenna location: ____________________

Height of transit above ground: ____________________

Record vertical angle to obstructions, at increments of 5° (maximum), for full 360°, where south = 180°, east = 90°.

Azimuth	Elevation	Azimuth	Elevation

FIGURE A-17. Overall horizon profile worksheet (sheet 1 of 2).

OVERALL HORIZON PROFILE (continued)

Vertical angels to obstructions (continued)

Azimuth	Elevation	Azimuth	Elevation

FIGURE A-17. Overall horizon profile worksheet (sheet 2 of 2).

SPECIFIC OBSTRUCTION PROFILE

Record vertical angles on obstructions of interest, designated as follows:

A ______________________________

B ______________________________

C ______________________________

(Add sheets for additional obstructions if necessary.)

Vicinity of A			Vicinity of B			Vicinity of C	
Azimuth	Elevation		Azimuth	Elevation		Azimuth	Elevation

FIGURE A-18. Specific obstruction profile worksheet.

PHOTOGRAPHIC

Photo No.	Azimuth	Remarks

FIGURE A-19. Photographic worksheet.

SITE POWER LOAD

===

Average station load

High: __________ kW Low: __________ kW

Peak station load

Value: __________ kW Duration: __________ seconds

Station load balance: _______ percent

Projected load requirements:

Increase			Decrease	
Equipment	kW		Equipment	kW

Remarks:

===

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________________

____

Direct observation: Yes _____ No _____

===

FIGURE A-20. Site power load worksheet.

EXISTING POWER CHARACTERISTICS

Primary ac power source description:

Demand voltage and current variations

Equipment/load	Line-to-neutral voltage (rms)	Phase current (amps)	kW

SOURCE OF AC POWER INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________

____

Direct observation: Yes _____ No _____

FIGURE A-21. Existing power characteristics worksheet (sheet 1 of 4).

EXISTING POWER CHARACTERISTICS (continued)

Outage record, primary ac power source

Outage No.	Date	Time	Duration	Remarks

SOURCE OF OUTAGE INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____________________________________

____

Direct observation: Yes _____ No _____

FIGURE A-21. Existing power characteristics worksheet (sheet 2 of 4).

EXISTING POWER CHARACTERISTICS (continued)

Auxiliary power source

Equipment description:

Operation description:

SOURCE OF AUXILIARY POWER INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________

____

Direct observation: Yes _____ No _____

AC power distribution system description:

SOURCE OF DISTRIBUTION SYSTEM INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________

____

Direct observation: Yes _____ No _____

FIGURE A-21. Existing power characteristics worksheet (sheet 3 of 4).

EXISTING POWER CHARACTERISTICES (continued)

Uninteruptible power supply (UPS)

	Characteristic	Spec value	Measured value
Input:	Voltage	______	______
	Current	______	______
	Bypass voltage	______	______
	Bypass current	______	______
	Power factor	______	______
	Total current distortion	______	______
	Current limit	______	______
Output:	Power		
	Voltage	______	______
	Phase voltage harmonic distortion	______	______
	Phase unbalance	______	______
	Phase separation	______	______
	Overload current	______	______
	Fault current	______	______
	Regulation	______	______
	Voltage transient response	______	______
	Voltage transient recovery time	______	______
	Load unbalance	______	______
	System efficiency	______	______

SOURCE OF OUTAGE INFORMATION

Existing documentation: Yes ____ No ____

If yes, identify documentation: ______________________________

____

Direct observation: Yes ____ No ____

FIGURE A-21. Existing power characteristics worksheet (sheet 4 of 4).

POWER NOISE

Load condition	Date/time	Waveform sketch w/magnitude	Remarks

FIGURE A-22. Power noise worksheet.

LINE VOLTAGE ANALYSIS

Line	Primary power	Auxiliary power
Average voltage		
Low average	________	________
High average	________	________
Sags		
Sags per hour	________	________
Sag voltage	________	________
Sag duration	________	________
Surges		
Surges per hour	________	________
Surge voltage	________	________
Surge duration	________	________
Impulses		
Impulses per hour	________	________
Impulse voltage	________	________
UPS Impulses		
Impulses per hour	________	________
Impulse voltage	________	________

Remarks:

FIGURE A-23. Line voltage analysis worksheet.

EARTH RESISTIVITY

Station: ______________________________

Operating unit: ______________________________

Type of soil: ______________________________

Weather conditions (weather conditions at time of measurement and general statement about precipitation in past week):

____

Previous earth ground resistivity measurement: ______________________________

Other observations: ______________________________

Location of measurement (describe)	Depth and spacing of rods	Resistance reading (ohms)
	15 cm; 3 m (6 in.; 10 ft)	
	30 cm; 6 m (12 in.; 20 ft)	
	45 cm; 9 m (18 in.; 30 ft) (optional)	
	15 cm; 3 m (6 in.; 10 ft)	
	30 cm; 6 m (12 in.; 20 ft)	
	45 cm; 9 m (18 in.; 30 ft) (optional)	
	15 cm; 3 m (6 in.; 10 ft)	
	30 cm; 6 m (12 in.; 20 ft)	
	45 cm; 9 m (18 in.; 30 ft) (optional)	

Tester(s): ______________________________ Date: ______________

____

Remarks: ______________________________

FIGURE A-24. Earth resistivity worksheet.

EXISTING SITE GROUND SYSTEM SURVEY

==

Configuration: ____
(ring or other type)

Conductor size: ____

Distance from building: ______________ Depth: ______________

Ground rod length: ______________ Type: ______________

Tower ground (type): ____

Conductor size: ____

Lightning rod (type): ______________ Length: ______________

Connection to ground: ____

Tower ground rods (number): ____

Power building

Type of grounding: ____

Conductor size: ____

Fuel tanks

Type of grounding: ____

Conductor size: ____

Perimeter fences and lampposts

Type of grounding: ____

Conductor size: ____

==

FIGURE A-25. Existing site ground system survey worksheet (sheet 1 of 2).

EXISTING SITE GROUND SYSTEM SURVEY (continued)

STATION GROUND RESISTANCE

Station: ______________________________

Operating unit: ______________________________

Type of soil: ______________________________

Weather conditions (weather conditions at time of measurement and general statement about precipitation in past week):

____

Previous measurement: Date:________ Org: ________ Resistance:________ohms

Other observations: ______________________________

Station ground resistance (all readings are in ohms)

				Operations building					AC powerhouse grounds							Other
Distance m (ft)	Tower legs NE	Tower legs SW	WG bridge support	Bldg gnd ext	Gnd box int	TCF/PTF	Radio/mux	Other	Ext gnd	Equip Fault prot gnd	AC neut gnd	Gen #1	Gen #2	other	fuel tanks	
15 (50)																
30 (100)																
46 (150)																
61 (200)																
76 (250)																
91 (300)																
107 (350)																
122 (400)																
137 (450)																

Tester(s): ____________________ Date: ____________________

____

Remarks: ______________________________

FIGURE A-25. Existing site ground system survey worksheet (sheet 2 of 2).

GROUND CONDUCTOR AC CURRENT

Station: ______________________________

Operating unit: ______________________________

Key point*	Location	ac current (amperes)	
		Test results	Test results after correction (if required)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

*Equipment ground leads, fault protection ground leads, etc,

Tester(s): ____________________ Date: ____________________

____

Remarks: ______________________________

FIGURE A-26. Ground conductor ac current worksheet.

GROUND CONDUCTOR DC CURRENT

Station: ______________________________

Operating unit: ______________________________

Key point*	Location	dc current (amperes)	
		Test results	Test results after correction (if required)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

*Note dc currents at key points (equipment ground leads)

Tester(s): ____________________ Date: ____________________

____

Remarks: ______________________________

FIGURE A-27. Ground conductor dc current worksheet.

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY

===

AC POWER, EXTERNAL NETWORK

Site access lines:

Surface: ________

Buried: ________ If buried, state the depth: ____________

Aerial: ________

Combination: ______________________________

Voltage: Primary: __________ kV Secondary: __________ V

Protection

Steel conduit: __________ (size) ______________

Plastic conduit: __________ (size) ______________

Reinforced concrete: ________ (size) ______________

Other: ______________________________

Reinforcement: ______________________________

Ground location: ______________________________

Arrester configuration: ______________________________

Building access lines, surface

a. Support structure

Construction: Steel ________ Wood ________

Other (specify): ______________________

Spacing (distance): ______________________________

Ground point location: ______________________________

===

FIGURE A-28. Nuclear survivability worksheet (sheet 1 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

b. Conductors

Number: ____________________

Arrangement on support structure: ____________________
(vertical, horizontal, etc.)

Spacing (distance): ______ Avg height above ground: ____________

Neutral ____________ or guard wire ____________

Position: ____________________

Neutral or guard wire grounded: ____________________

Spacing (distance): ____________________

Method: ____________________

c. Line protection

Method: ____________ Place: ____________

Protection devices

Manufacturer: ____________ Part No.: ____________

d. Branch connection to other facilities within 1/2 km (1/4 mi)of site (technical control, AUTOVON site, etc.)

Distance from site: ____________________

Describe branch point (indicate point by line drawing):

Branch load: ____________________

FIGURE A-28. Nuclear survivability worksheet (sheet 2 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

==

Describe branch load feeder point: ______________________________

____

____

e. Site feeder pole

Distance from: site penetration ______ site transformer ______

Conductor routing to transformer: Buried ______ Surface ______

If surface, describe conductor routing to transformer:

____

____

f. Describe building penetration by conductor (including weatherhead):

____

____

Building access lines, buried

a. Conduit construction

Steel ________ Concrete ________ Plastic ________

Size (diameter): ____________ Conduit vertical length (show sketch of masthead conduit details): ______________________

b. Protective devices

Manufacturer: ____________________ Type: ____________________

Part No.: ____

==

FIGURE A-28. Nuclear survivability worksheet (sheet 3 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

c. Describe building penetration by conductor:

Site transformers

Manufacturer: ____________________ Part No.: ____________________

Voltage: Primary: ____________ Secondary: ____________________

Rating: ____________ (kVA) Power factor: ____________________

Number of transformers: ____________ Number of stages: __________

Connectivity (Δ or Y): Primary __________ Secondary __________

Location: Pole __________ Ground __________ Buried __________

Grounding: Primary ____________ Secondary __________

Transformer case ____________________________

Number of conductors: Primary ________ Secondary ______________

Unique features of ac power system not described by data above (use sketches and photographs as required):

FIGURE A-28. Nuclear survivability worksheet (sheet 4 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (*continued*)

AC POWER, INTERNAL NETWORK

Use existing drawings or draw sketches of the internal ac power distribution network. Include details of the distribution panels, conduit or duct network, protective devices, wire and cable details, and other data. Take photographs as necessary to show details of routing, panel wiring, and wall penetrations. Indicate separate power runs for critical equipment (satellite communications and auxiliary digital) and noncritical equipment (air-conditioners, etc.).

Wire or cable distribution (indicate on drawing with AWG number, insulation type and number of conductors)

a. Protection (include size and material)

Rigid conduit: ______

Thin-wall conduit: ______

Flexible conduit: ______

Plastic conduit: ______

Duct or tray type: ______

Other (specify): ______

b. Distribution scheme (include the following)

Separation from communications cables: ______

Overhead distance from floor: ______

Floor duct size and depth: ______

Subfloor or raised floor: ______

Lengths of runs between panels or between panel and load: ______

______

FIGURE A-28. Nuclear survivability worksheet (sheet 5 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

Intermediate and equipment control and distribution panels

Conduit connections (show detail on photographs): ____________

Wall mounting (show sketch or photograph): ____________

Panel type and size: ____________

Panel description (show sketch or photograph): ____________

Protective devices (arresters, fuses, circuit breakers, etc.)

Type: ____________ Capacity: ____________

Wire sizes: ____________

Wiring arrangement of phase, neutral, and ground leads: ____________

AC power filters

Type: ____________ Manufacturer: ____________ Part No.: ____________

Location: ____________

Installation details (describe or sketch connections and mounting):

____

Protective devices

Primary: ____________ Type: ____________

Manufacturer: ____________ Part No.: ____________

Secondary: ____________ Type: ____________

Manufacturer: ____________ Part No.: ____________

Transformer to weatherhead to main circuit breaker: ____________

Distance from transformer terminals to weatherhead: ____________

FIGURE A-28. Nuclear survivability worksheet (sheet 6 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

DC POWER

Update existing engineering drawings or provide a sketch of the uninterruptible power supply (UPS) and dc power system. Include details of distribution routing and connectivity or control panels, as well as the following:

Equipment (inverters, rectifiers, etc.)

Type: ____________ Manufacturer: ______________ Part No.: __________

Conductor wire sizes: __________ Capacity (rated output): __________

Location of support racks or cabinets: ______________________________

____

Grounding details: ____

____

Distribution and control panels

Type: ________________________

Protective devices: ________ Manufacturer: ________ Part No.: ________

Loads (describe loads on each branch): ______________________________

____

Grounding details: ____

____

Conductors

Number and routing (describe arrangement, methods of mounting or attaching wires to structures, use of conduit, etc.)

Conduit type: ____

Wire sizes and type: ____

FIGURE A-28. Nuclear survivability worksheet (sheet 7 of 8).

WARNING
When information is entered, this form may require a security classification

NUCLEAR SURVIVABILITY (continued)

Battery facility

Connectivity from charging equipment: ______________________
Connectivity from batteries: ______________________
Batteries (number and type): ______________________
Manufacturer and part number: ______________________
End-cell arrangement: ______________________

GROUNDING AND SHIELDING

Grounding system (identify configuration characteristics, and represent configurations by sketches, including the following)

Earth electrode subsystem: ______________________
Fault protection subsystem: ______________________
Lightning protection system: ______________________
Signal reference subsystem: ______________________
Cable shield ground terminations: ______________________
Grounded at both ends? ____________ single end? ______

Shielding provisions

Buildings, rooms: ______________________
Ducts and trenches: ______________________
Cabinets, racks, and equipment cases: ______________________
Intercabinet cabling: ______________________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________

____

Direct observation: Yes _____ No _____

FIGURE A-28. Nuclear survivability worksheet (sheet 8 of 8).

SITE SECURITY

===

Description of existing fence(s):

Description of site lighting:

Description of present guard system (if any):

Description of alarm system (if any):

Proximity to existing civilian structures (such as houses):

Information on known terrorist/vandalism problems:

Remarks:

===

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____

____

Direct observation: Yes _____ No _____

===

FIGURE A-29. Site security worksheet.

LINK PROFILE

Link designation/terminal

Path distance: ______________________

Azimuth (from earth terminal): ______________________

Obstructions noted

Number: ______________________

Distance along path: ______________________

Description: ______________________

Link designation/terminal

Path distance: ______________________

Azimuth (from earth terminal): ______________________

Obstructions noted

Number: ______________________

Distance along path: ______________________

Description: ______________________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________

____

Direct observation: Yes _____ No _____

FIGURE A-30. Link profile worksheet.

CABLE ROUTE SURVEY

Link designation/terminal

Cable route length: ____________________

Azimuth (from earth terminal): ____________________

Obstructions noted

Number: ____________________

Distance along path: ____________________

Description: ____________________

Link designation/terminal

Path distance: ____________________

Azimuth (from earth terminal): ____________________

Obstructions noted

Number: ____________________

Distance along path: ____________________

Description: ____________________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____________________

____

Direct observation: Yes _____ No _____

FIGURE A-31. Cable route survey worksheet.

LOGISTICS SUPPORT

COMMUNICATIONS

a. Telephone service

Type of service: Military ________ Commercial ________

Distance to nearest telephone service connection: ______kilometers (miles)

Type of line construction:

Open wire ______ Aerial cable ______ Buried cable ________

Number of pairs available: ________________

Wire gauge of pairs: ________________

Estimated cost of line extension:

Open wire-dollars ____ Aerial cable-dollars ____

Buried cable-dollars ____

If on an existing base:

Type of base exchange switchboard: ________________

Number of lines: ________________

Number of line drops unassigned: ________________

Number of trunks to each connecting base: ________________

Remarks and source of information:

FIGURE A-32. Logistics support worksheet (sheet 1 of 6).

LOGISTICS SUPPORT (continued)

b. Radio service

Type of radio service (military or commercial) now available from the site to:

Nearest military base: ____________________

Area command headquarters: ____________________

Access to Defense Communications System: ____________________

Type of radio system for this service:

Tropospheric scatter link: ____________ Frequency: ____________

Ionospheric scatter link: ____________ Frequency: ____________

Microwave LOS link: ____________ Frequency: ____________

HF (or LF) link: ____________ Frequency: ____________

Number of channels

Voice: ____________

Teletype: ____________ wpm: ____________

Data: ____________ bps: ____________

Remarks and source of information:

FIGURE A-32. Logistics support worksheet (sheet 2 of 6).

LOGISTICS SUPPORT (continued)

c. Communications services available to construction contractor

Will the contractor be permitted to use Government-owned or operated commuications facilites for communication from the base during the construction and installation phase?

____

If such use is permitted, what is the approximate charge?

____

Will mobile and man-pack equipment be available during the installation?

____

d. Secure communications. Will secure communications facilities for off-base circuits be required:

During construction and installation? ____________________

After installation? ______________________________

TRANSPORTATION

a. Access waterway

Open sea ____ River ____ Canal ____ Lake ____ Bay ____

Name(s): ____________________________________

Channel depths:

Mean low water level ___ m (ft) Mean high water level ___ m (ft)

Name and location of harbor(s) nearest to site: ______________

____

Docking facilities: Good ________ Poor ________

Vessel size limitation: ____________________________

FIGURE A-32. Logistics support worksheet (sheet 3 of 6).

LOGISTICS SUPPORT (continued)

Reliability (months of year usable): ____________________

Route from dock to site (include distances): ____________________

____

Name(s) of shipping companies and local business addresses:

____

____

b. Railroads

Name and address of railroad owning nearest siding:

____

Reliability (months of year usable): ____________________

Route from siding to site (include distances): ____________________

____

Name and address of railroad owning nearest terminal:

____

Facilities: Passenger ________ Freight ________

Reliability (months of year usable): ____________________

Route from terminal to site (include distances): ____________________

FIGURE A-32. Logistics support worksheet (sheet 4 of 6).

LOGISTICS SUPPORT (continued)

c. Trucking

Name(s) and address(es) of nearest commercial firms:

____

____

Limitations on material handling (if any): ______________________________

____

____

d. Passenger service to and from nearest support base or town:

Bus ______ Taxi ______ Rental auto ______ None ______

LEGAL CONSIDERATIONS

Income taxes and other taxes:

Workmen's benefits, compensation, and social security:

Import/export restrictions and fees:

Employment statutes:

Entry regulations:

FIGURE A-32. <u>Logistics support worksheet (sheet 5 of 6)</u>.

LOGISTICS SUPPORT (continued)

Licenses or registration requirements:

Monetary restrictions and current exchange rate:

Health considerations/regulations:

Requirement for host-tenant agreement; host-country-base rights agreement:

Zoning restrictions (obtain copies of local zoning codes and attach to report):

Local government restrictions:

FIGURE A-32. Logistics support worksheet (sheet 6 of 6).

REAL ESTATE DESCRIPTION

===

Legal description of property: ______________________________

____

Present ownership of land

Name(s) of owner(s): ______________________ Address(es) ______________________

Agent(s) handling property ______________________ Address(es) ______________________

______________________ ______________________

Type of acquisition/lease: ______________________________

Cost of acquisition/lease: ______________________________

Acquisition of property for access roads

Name(s) of owner(s): ______________________ Address(es) ______________________

______________________ ______________________

Procedure for acquiring property: ______________________________

____

Easement requirements

Government: ______________________________

Landlord: ______________________________

Expansion of capabilities: ______________________________

____

Source of real estate information:

===

FIGURE A-33. Real estate description worksheet.

UTILITY AVAILABILITY

ELECTRIC POWER

Commercial or base supply; name, address, and telephone number of supplying company or base engineer:

____

Primary (to nearest available point of connection):

Voltage ______ Frequency ______ Phase ______ Wires ______

kW available for new facility: __________

Will available power be sufficient for new facility? Yes ____ No ____

Regulation: __________ Voltage: ______ Frequency: ________

Power outages: No. per year __________ Duration __________

Distance to nearest point of connection (line transformer, or substation) where takeoff of usable power can be effected):

____

Cost: dollars ____ per kWh

Does this include high-volume discount? Yes ______ No ______

Are power cables underground or overhead? ______________

Secondary (to nearest available point of connection; obtain distribution and switching diagram if possible and attach to this form):

Voltage ______ Frequency ______ Phase ______ Wires ______

kW available for new facility: ________ Cost: dollars _____

Alternate primary power

Is an alternate power supply available? Yes _____ No _____

Where is it located? ______________________________

FIGURE A-34. Utility availability worksheet (sheet 1 of 5).

UTILITY AVAILABILITY (continued)

Is feeder continuously energized? Yes ________ No ________

Voltage ________ Frequency ________ Phase ________ Wires ________

Is switching manual or automatic? ________________

Is there a standby charge? ________________

WATER SUPPLY

Potable

Nearest available source: ________________

Chemical and bacteriological analysis: ________________

____

Name, address, and telephone number of analyst: ________________

____

Source: Stream ________ Lake ________ Well ________ Piped ________

Other (specify): ________________

Reliability of supply: ________________

Present available maximum daily supply: ________ gpm

If existing pipeline: Pressure: ____ Pa (psi) Pipe size: ____cm (in.)

If well supply:

Location of well: ________________

Depth: ________________

Condition of well: ________________

FIGURE A-34. Utility availability worksheet (sheet 2 of 5).

UTILITY AVAILABILITY (continued)

Availability of general and detailed drawings, layouts, and schematics of present water distribution system in area of the site:

____

Required major modifications to the existing system to meet the requirements of the new facility:

____

Cost delivered to site: dollars ________ per liter (gal)

Other available water

Source: Lake __________ River ____________ Well __________

Other (specify): ____________________ None ______________

Name and address of owner: ______________________________

____

____

Distance to supply: ______________ kilometers (miles)

Elevation of supply relative to site: ____________________

Is water from this source being delivered to the site? Yes _____ No _____
If yes, how?

____

Remarks:

FIGURE A-34. Utility availability worksheet (sheet 3 of 5).

UTILITY AVAILABILITY (continued)

GAS (COMMERCIAL SUPPLY)

Name, address, and telephone number of gas company: ____________________

____

Distance to nearest gas line: ____________________

Pipeline pressure: ________ Pa (psi)

Pipeline capacity: ________ m^3/min (ft^3/min)

Service reliability: ____________________

Availability of general and detailed drawings, layouts, and schematics of present gas distribution system in the area of the site:

____

Possibility of modification or extension of present gas distribution system:

____

Required major modifications, construction and equipment:

____

____

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ____________________

____

Direct observation: Yes _____ No _____

FIGURE A-34. Utility availability worksheet (sheet 4 of 5).

UTILITY AVAILABILITY (continued)

TELEPHONE SERVICE

Military _____ or commercial ______

Distance to nearest telephone service connection ______ kilometers (miles)

Type of construction:

Open wire: _____ Aerial cable: _____ Buried cable: _____

Number of pairs available: ____________

Wire gauge of pairs: ____________

Estimated cost of line extension:

Open wire: $ _____ Aerial cable: $ _____ Buried cable: $ _____

If on an existing base, type of base exchange switchboard ______________

Number of lines _____ Number of line drops unassigned _____

Number of trunks to each connecting base ________________

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________________

____

Direct observation: Yes _____ No _____

FIGURE A-34. Utility availability worksheet (sheet 5 of 5).

SOIL LOAD-BEARING

TEST HOLE 1

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

TEST HOLE 2

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

TEST HOLE 3

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

TEST HOLE 4

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

TEST HOLE 5

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

TEST HOLE 6

Ground elevation:_______ m (ft)

Penetometer reading, Pa (psi)	Depth m (ft)	Soil description

SOURCE OF WORKSHEET INFORMATION

Existing documentation: Yes _____ No _____

If yes, identify documentation: ______________________________

____

Direct observation: Yes _____ No _____

FIGURE A-35. Soil load-bearing worksheet.

APPENDIX B. DISCUSSION AND COMPARISON OF VARIOUS UNINTERRUPTIBLE POWER SUPPLIES (UPS)

10.0 Introduction. The configuration of a basic UPS is shown in figure B-1. During normal station operation, the UPS will be supplied with ac power by the primary power source -- the UPS then changes the ac power into a storable dc electrical energy, to be used as a short-term, no-break power supply for critical equipment. Only a small amount of energy is used by the UPS to maintain the energy storage levels. The rest is reconverted into alternating-current electrical energy. The ac power input and ac power output of the UPS are isolated from each other by the energy storage medium. A means should be provided to bypass the UPS completely in the event of failure or maintenance. Where possible, the UPS shall be located outside the operations room, preferably with the other power equipment. The four common types of installed UPS are described:

10.1 Flywheel-motor-generator UPS. This type of unit can provide uninterruptible power only for very short periods and should be considered only where the auxiliary power source is capable of assuming the station load within 1 minute. The flywheel-motor-generator UPS consists of an ac electric motor-generator unit with a flywheel as the energy storage device. The primary ac power source provides the power for an ac induction drive motor, which provides rotary power to an ac generator and steel flywheel. When the primary power source is interrupted, the potential energy stored in the flywheel continues to provide rotary power for the ac generator.

10.2 Rotary uninterruptible power supply. The rotary uninterruptible power supply (RUPS) has the same components as the flywheel-motor-generator UPS, plus an engine and eddy current clutch. When the primary power source is interrupted, the flywheel provides rotary energy for the ac generator as before; but in addition, the sensing and control equipment operates the eddy current clutch, which connects the drive engine to the flywheel shaft. The rotary energy of the flywheel starts the drive engine, which then provides rotary drive power for the flywheel and ac generator. The RUPS will continue to provide critical power as long as the engine remains running.

10.3 Electronic uninterruptible power supply. The electronic uninterruptible power supply, or EUPS (figure B-2), consists of one or more ac-to-dc rectifier-chargers, an external battery bank, one or more inverters, and a static switch. The incoming prime ac power is changed into dc power by the rectifier-charger(s). The dc power is used to charge and maintain a large battery bank at float voltage and to provide power to the electronic inverter(s). The output of the inverter(s) consists of a series of dc voltage steps, which are filtered to approximate a sine wave. The static switch provides fast electronic switching to bypass the UPS in case of inverter failure or extreme load variations. The EUPS normally can provide uninterruptible power for 15 to 30 minutes at full load.

10.4 Hybrid uninterruptible power supply. The hybrid uninterruptible power supply (HUPS) is used at overseas AUTODIN switching centers (ASC). The HUPS

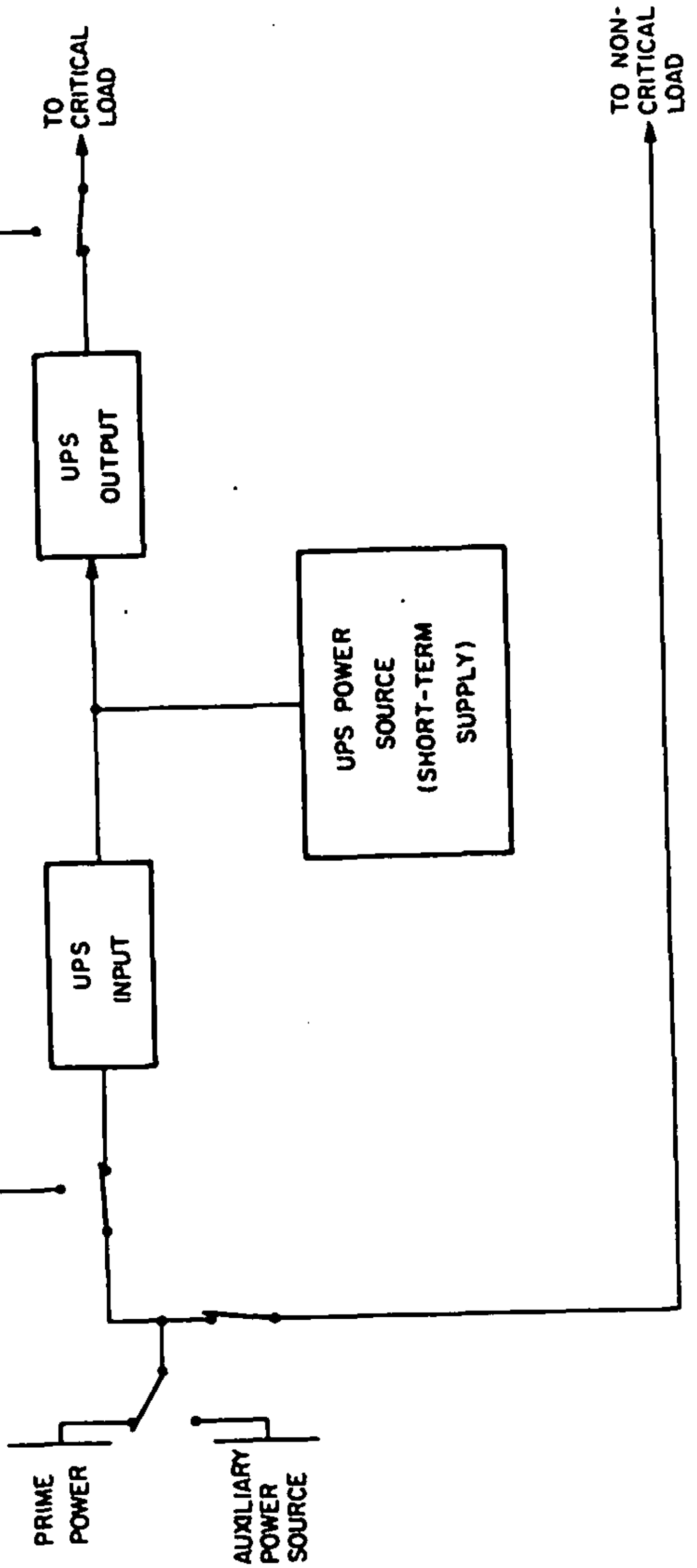


Figure B-1. Basic UPS configuration.

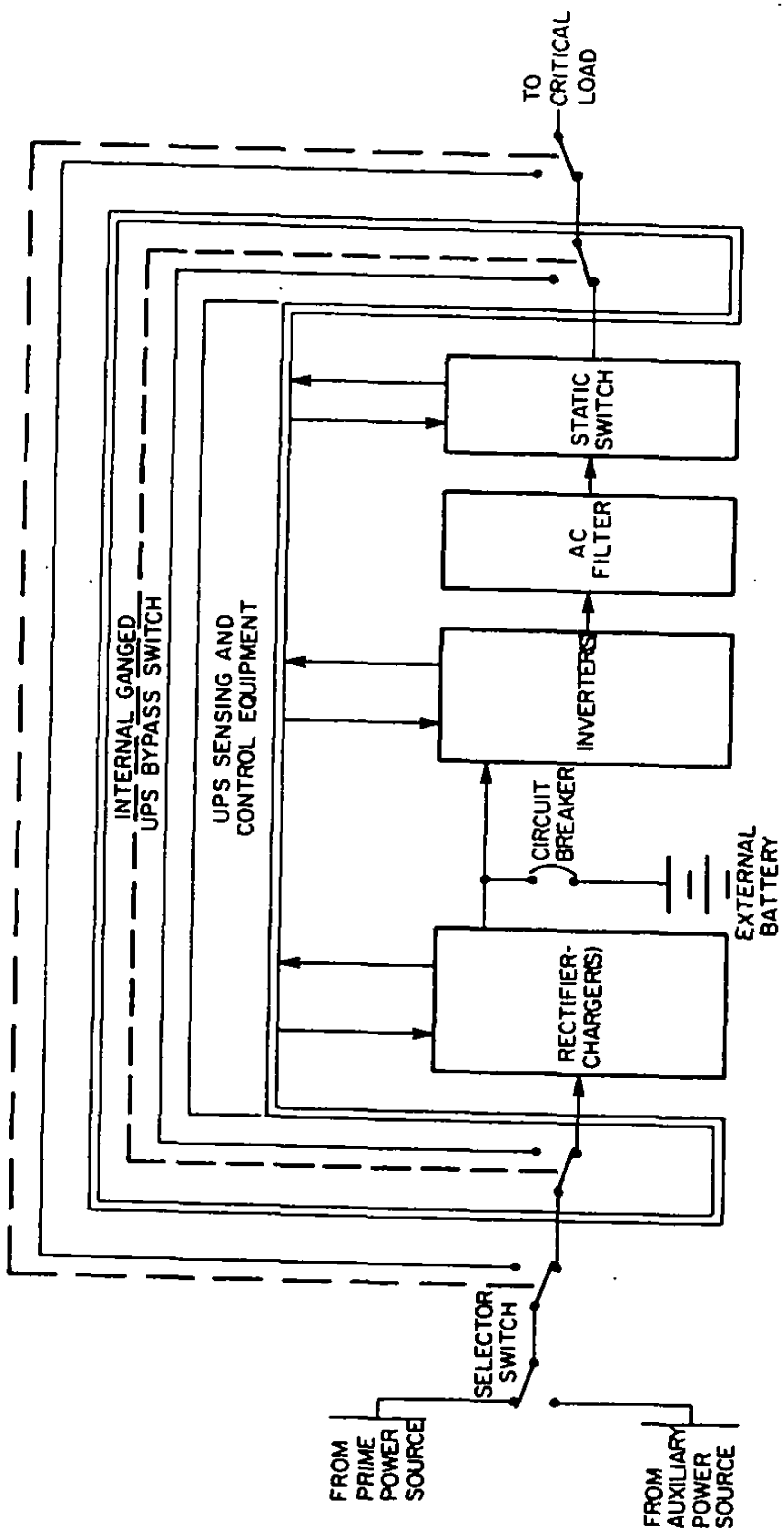


Figure B-2. Electronic uninterruptible power supply (EUPS).

consists of a redundant solid-state rectifier-charger, a float battery, and one or more motor-generator sets with associated controls. The rectifier-charger converts three-phase primary or standby input power to dc, to supply the dc motors that drive the ac generators. The rectifier-charger also supplies charging current to the float battery. Upon primary power failure, the battery bank provides dc power to the dc drive motors for about 15 minutes. In the following discussions of reliability and input-output quality, the HUPS has the input advantages and disadvantages of the EUPS and the output advantages and disadvantages of the RUPS.

20.0 UPS reliability. A modern solid-state UPS is a reliable source of conditioned power. The UPS is usually provided with an electronically-controlled static bypass switch where the input and output frequencies are identical. The static switch permits automatic bypass if there is a failure of the UPS. Also, a manual bypass switch is often provided to permit maintenance on any part of the total UPS system.

30.0 UPS output quality. All types of UPS typically provide a very high quality of sine wave output (when properly loaded). The output unit is either a filtered inverter or a synchronous generator which can generally provide an output quality equivalent to commercial power; however, the UPS output quality is very dependent upon the characteristics of the load served. Frequently, the load consists of rectifier inputs serving electronic power supplies that can create significant distortion of the UPS output waveform. Nevertheless, the UPS output total distortion should be no more than 5 percent.

40.0 UPS input distortion. The EUPS usually uses a silicon-controlled rectifier-charger as the input unit, which can cause large spikes on the input waveform. The input power to the EUPS should be filtered to limit total distortion to 5 percent at the supplying circuit breaker.

50.0 Noise and environmental considerations. Acoustically, the engine-driven RUPS is the noisiest type of UPS, it should be located with the auxiliary generator equipment or onsite in a separate building. Therefore, UPS should be separated from the station operating equipment areas. The EUPS is also electrically noisy, as voltage spikes can be induced onto the EUPS equipment cabinets and all metalwork that contacts the cabinets; the EUPS metalwork should therefore be electrically isolated from the satellite earth station equipment, with the exception of the fault ground connection to the main station electrical ground point. The EUPS should not require environmental controls to maintain temperature and humidity levels, but ventilation for the EUPS and the batteries will be required. When large additional power transformers are used with the EUPS, these should be located outside to minimize the heat load.

APPENDIX C. SPECIALIZED FACILITY DESIGN CRITERIA: AN/GSC-39(V-1)

Terminal Military Designation: AN/GSC-39(V-1)
Type: Fixed

10.0 Physical plant requirements.

10.1 Site layout, figure C-1

10.2 Access roads

10.2.1 Width requirement: 3 m (10 ft)

10.2.2 Clearance requirement: 3.81 m (12 ft 6 in.)

10.2.3 Load-bearing requirement: 18,200 kg (40,000 lb) gvw

10.3 Buildings

10.3.1 Technical equipment building, 168 m^2 (1,800 ft^2), single configuration; floor plan, figure C-2

10.3.2 Maintenance and supply space, 65 m^2 (700 ft^2)

20.0 Power requirements.

20.1 Primary input, general

20.1.1 Voltage: 208/120 Vac, ± 10%, 3-phase

20.1.2 Frequency: 50 or 60 Hz, ± 5%

20.1.3 Voltage balance

20.1.3.1 Line-to-neutral deviation, balanced load: ± 2%

20.1.3.2 Line-to-neutral deviation, unbalanced load: ± 5%

20.1.4 Phase displacement

20.1.4.1 Balanced load: ± 1 degree

20.1.4.2 50% unbalanced load: ± 5 degree

20.1.5 Harmonic distortion

20.1.5.1 Single harmonic: 3.0% maximum

20.1.5.2 Total distortion: 5.0% maximum

20.1.6 One-line power system, figure C-3.

20.2 Load requirements

20.2.1 Critical power		kVA
20.2.1.1 Communications power panel		15.6
20.2.1.2 Transmitter power panel		130.0
20.2.1.3 Antenna technical power		20.0
20.2.1.4 DCSS*		30.0
	Total	195.6
20.2.2 Noncritical power		
20.2.2.1 Antenna drive		23.0
20.2.2.2 Antenna utility		35.0
20.2.2.3 Margin		5.0
	Total	63.0
20.2.3 Total requirement:		258.6

30.0 Special requirements.

30.1 Antenna frontal clearance, 30.48 m (100 ft)

30.2 Ground system

30.2.1 System resistance: See MIL-STD-188-124, Resistance to Earth.

30.2.2 Antenna grounding plan, AN/GSC-39(V-1), figure C-4

30.3 Cable trench

30.3.1 Length: 27.4 m (90 ft)

30.3.2 Site layout, figure C-1

30.4 Environmental control

30.4.1 Technical equipment area

*Actual values vary by site, from approximately 18 kVA to 38 kVA. The value of 30 kVA is for preliminary planning only.

30.4.1.1 Room Temperature: 21.1° C (70° F) dry bulb ± 3° C (5° F)

30.4.1.2 Humidity: 50% rh ± 10%

30.4.1.3 Pressure: 12.44 Pa (0.05 in.), water gauge, positive

30.4.1.4 Under raised floor temperature: 15° C (60° F) dry bulb ± 3° C (5° F)

30.4.2 Equipment cooling requirements

		Heat Dissipation, joules/h (Btu/h)	Minimum air flow, CMM (CFM)
30.4.2.1	Communications equipment	1.34×10^8 (127,000)	227 (8,000)
30.4.2.2	Transmitter equipment	7.81×10^7 (74,000)	57 (2,000)

30.4.3 Additional requirements

		Transmitter	Transmitter filter
30.4.3.1	Air temperature	15° C (60° F)	15° C (60° F)
30.4.3.2	Air flow	21.2 CMM (750 CFM)	5.7 CMM (200 CFM)

40.0 Remarks. The facility specifications and requirements for the AN/FSC-78(V) SCT are very similar to those of the AN/GRC-39(V-1) fixed terminal complex. The main difference is the antenna size: 18 m (60 ft) diameter for the AN/FSC-78(V) versus 11.6 m (38 ft) for the AN/GRC-39(V-1).

50.0 References. USACEEIA Report SCA-5004C, AN/GSC-39(V-1) Fixed Site Criteria, dated 1 February 1979

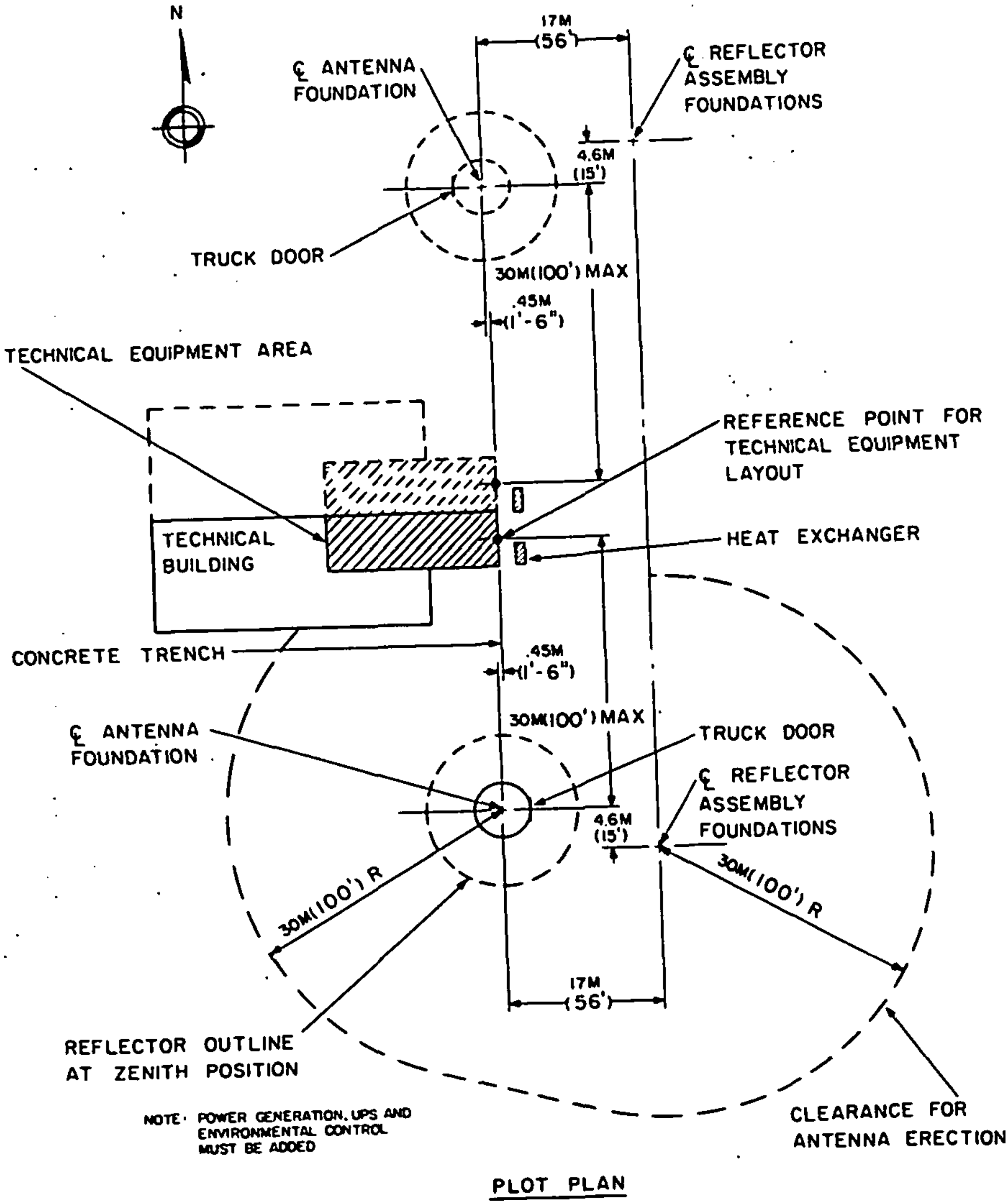
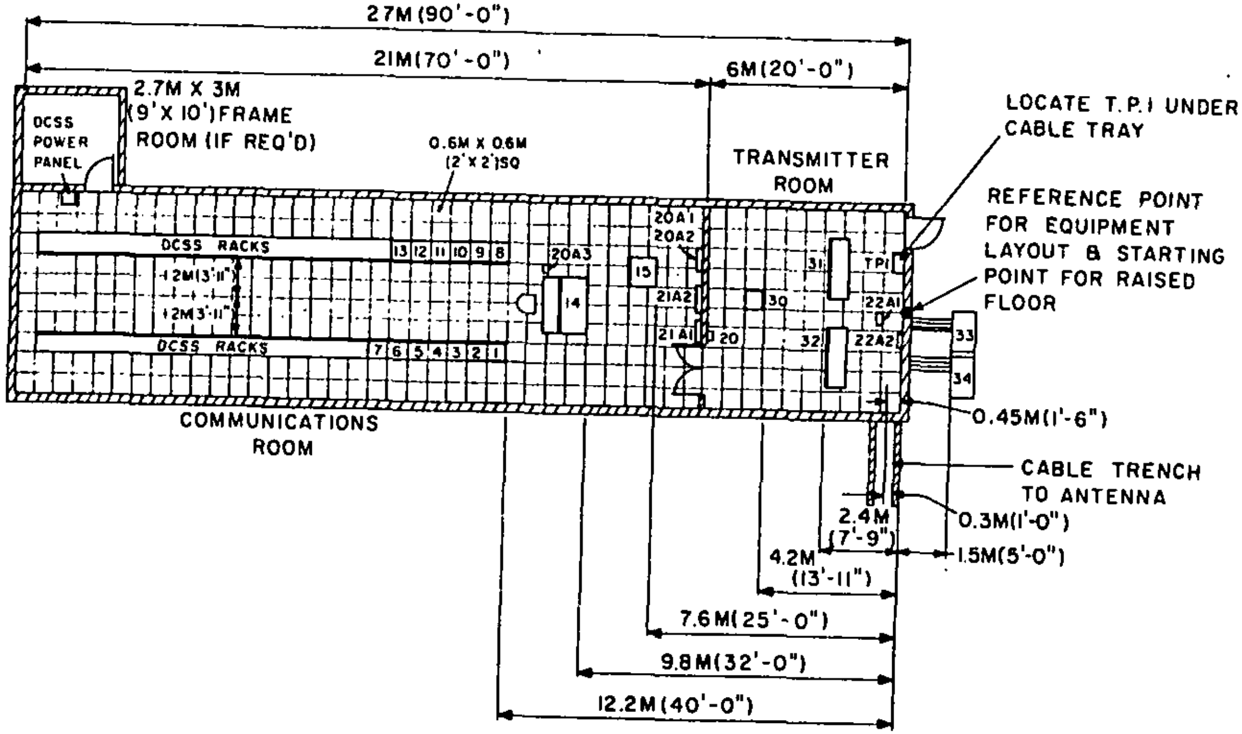


FIGURE C-1. Site layout AN/GSC-39 fixed site.



UNIT NO.	DESCRIPTION
1	INTERCONNECTING GROUP
2	MONITOR TEST GROUP
3	DOWN CONVERTER RACK
4	
5	
6	
7	DOWN CONVERTER RACK
8	AMPLIFIER MONITOR GROUP
9	UP CONVERTER RACK
10	
11	UP CONVERTER RACK
12	SIGNAL GENERATOR GROUP
13	AMPLIFIER GROUP
14	CONSOLE
15	CONTROL MONITOR GROUP
20A1	KEY SERVICE UNIT
20A2	AUXILIARY EQUIPMENT UNIT
20A3	CALL COMMANDER
20	TELEPHONE SET, INDOOR
21A1	INTERCONNECT BOX
21A2	CIRCUIT BREAKER BOX
22A1	TRANSMIT FILTER
22A2	LOW PRESSURE PANEL
DCSS	BASE BAND POWER PANEL
30	TRANSMITTER MONITOR UNIT
31	5 KW POWER AMPLIFIER
32	5 KW POWER AMPLIFIER
33	HEAT EXCHANGER
34	HEAT EXCHANGER

FIGURE C-2. Floor plan, AN/GSC-39.

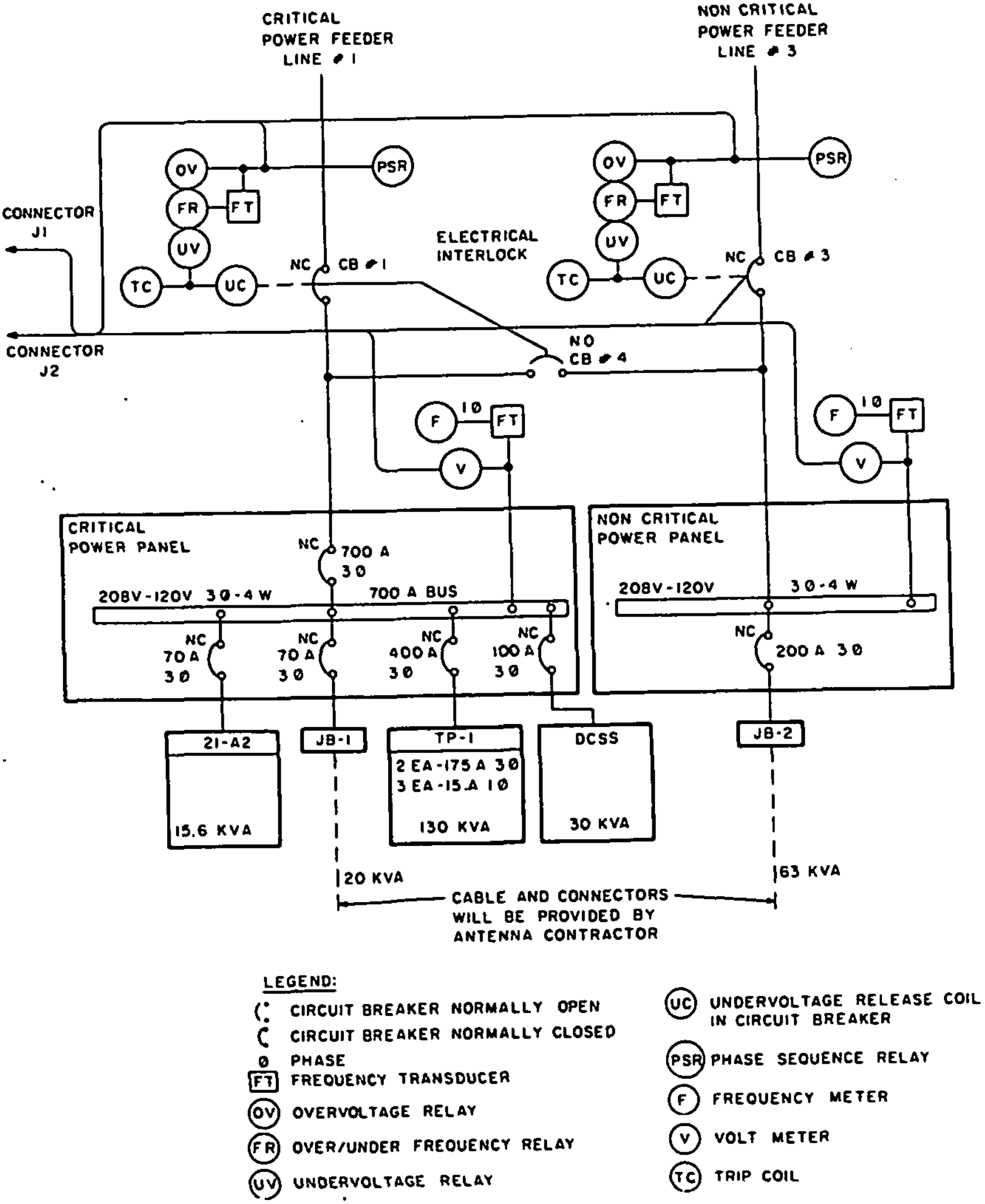


FIGURE C-3. One-line power system, AN/GSC-39(V-1).

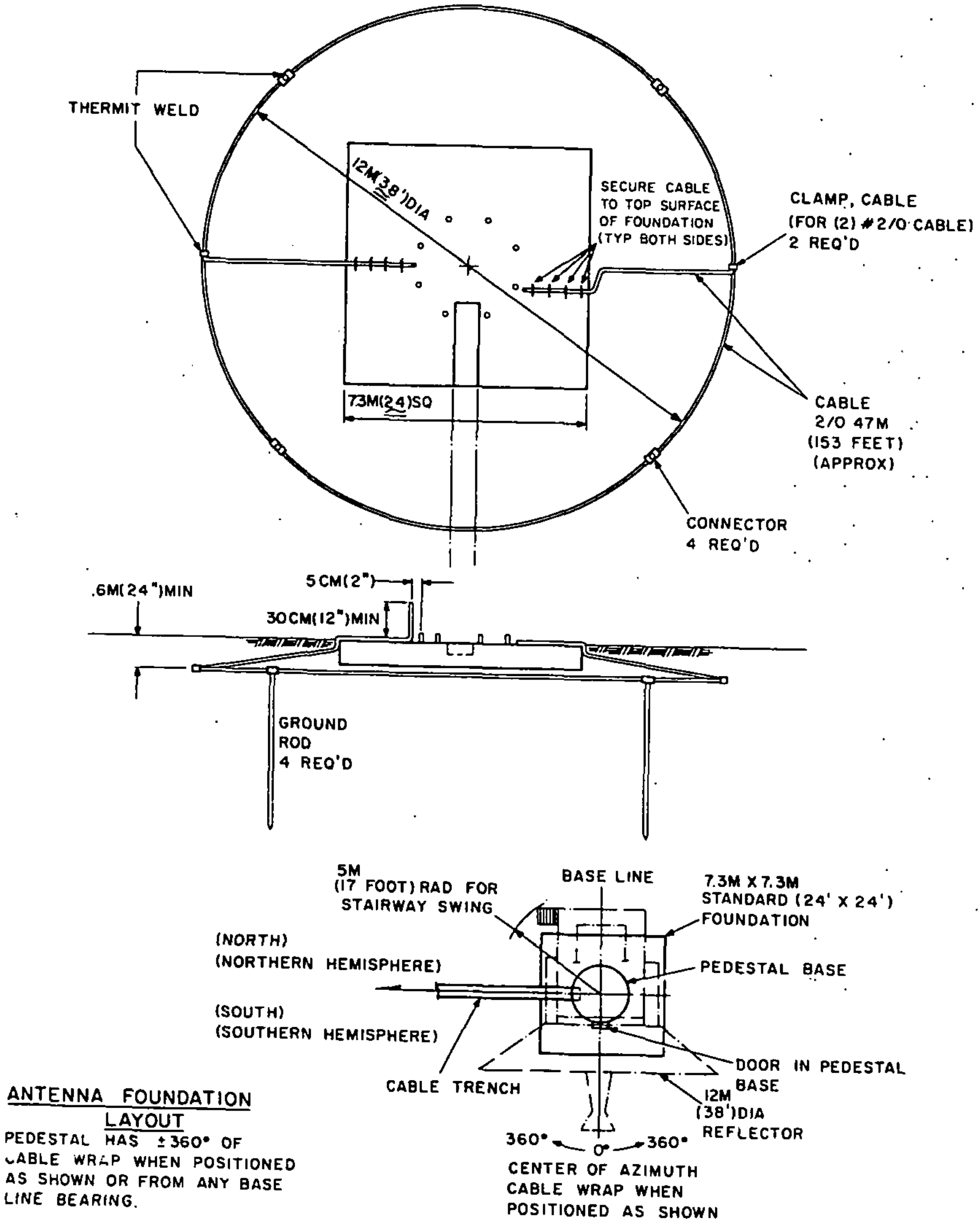


FIGURE C-4. Antenna grounding plan, AN/GSC-39(V-1).

APPENDIX D. SPECIALIZED FACILITY DESIGN CRITERIA: AN/GSC-39(V-2)

Terminal Military Designation: AN/GSC-39(V-2)
Type: Vanized

10.0 Physical plant requirements.

10.1 Site layout, figure D-1

10.2 Access roads

10.2.1 Width requirement: 3 m (10 ft)

10.2.2 Clearance requirement: 3.81 m (12 ft 6 in.)

10.2.3 Load-bearing requirement: 20,500 kg (45,000 lb) gvw

10.3 Vans/buildings

10.3.1 AN/GSC-39 vans

10.3.1.1 Four required

10.3.1.2 Use: transmitter, operations, maintenance, and supply vans

10.3.1.3 Figures D-2 through D-5

10.3.2 DCSS vans

10.3.2.1 Dorsey, Model CIC Special/82616-69

10.3.2.2 Two required

10.3.3 ACSS shelter

10.3.3.1 Type S280B/G

10.3.3.2 Use: analog communications

10.4 Foundations/pads

10.4.1 GSC-39 vans, figure D-6

10.4.2 DCSS vans, figure D-6

20.0 Power requirements.

20.1 Primary input, general

20.1.1 Voltage: 208/120 Vac, ± 10%, 3-phase

20.1.2 Frequency: 50 or 60 Hz, ± 5%

20.1.3 Voltage balance

20.1.3.1 Line-to-neutral deviation, balanced load: ± 2%

20.1.3.2 Line-to-neutral deviation, unbalanced load: ± 5%

20.1.4 Phase displacement

20.1.4.1 Balanced load: ± 1 degree

20.1.4.2 50% unbalanced load: ± 5 degree

20.1.5 Harmonic distortion

20.1.5.1 Single harmonic: 3.0% maximum

20.1.5.2 Total distortion: 5.0% maximum

20.2 Load requirements

	Critical, kVA	Noncritical, kVA
20.2.1 Vans		
20.2.1.1 Operations	15.6	31
20.2.1.2 Transmitter	137.8	91
20.2.1.3 Maintenance		27
20.2.1.4 Supply		19
20.2.1.5 DCSS	30.0	60
20.2.2 Antenna	20.0	63
Totals	203.4	291

30.0 Special requirements.

30.1 Ground system

30.1.1 System resistance: See MIL-STD-188-124, Resistance to Earth.

30.1.2 Antenna system drawing, figure D-7

30.2 One-line power system, figure D-8

40.0 Reference. USASATCOMA Report SCA-5003C, Facility Design Criteria AN/GSC-39 Earth Terminal Complex Van Configuration, dated 1 February 1979

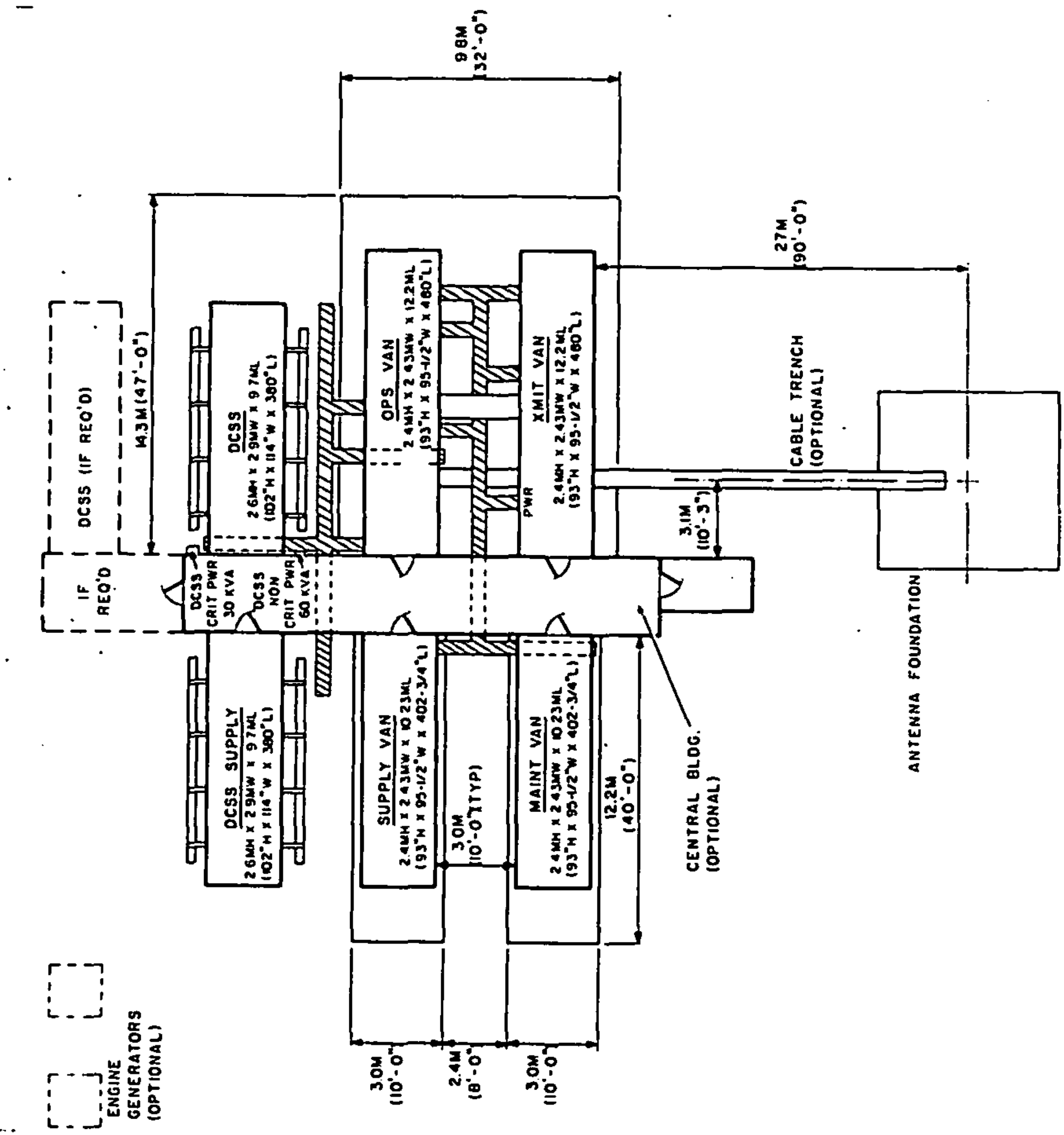
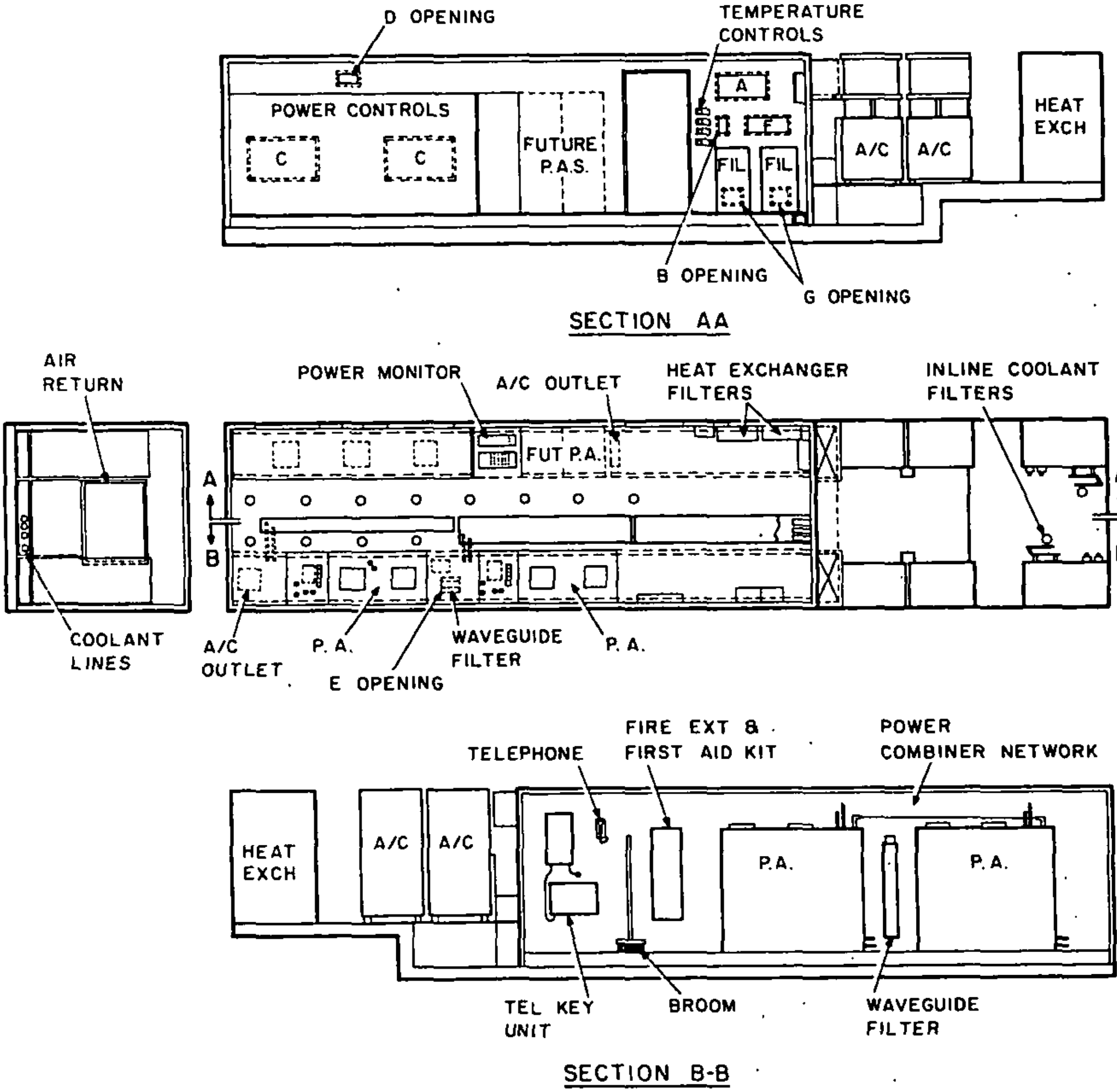


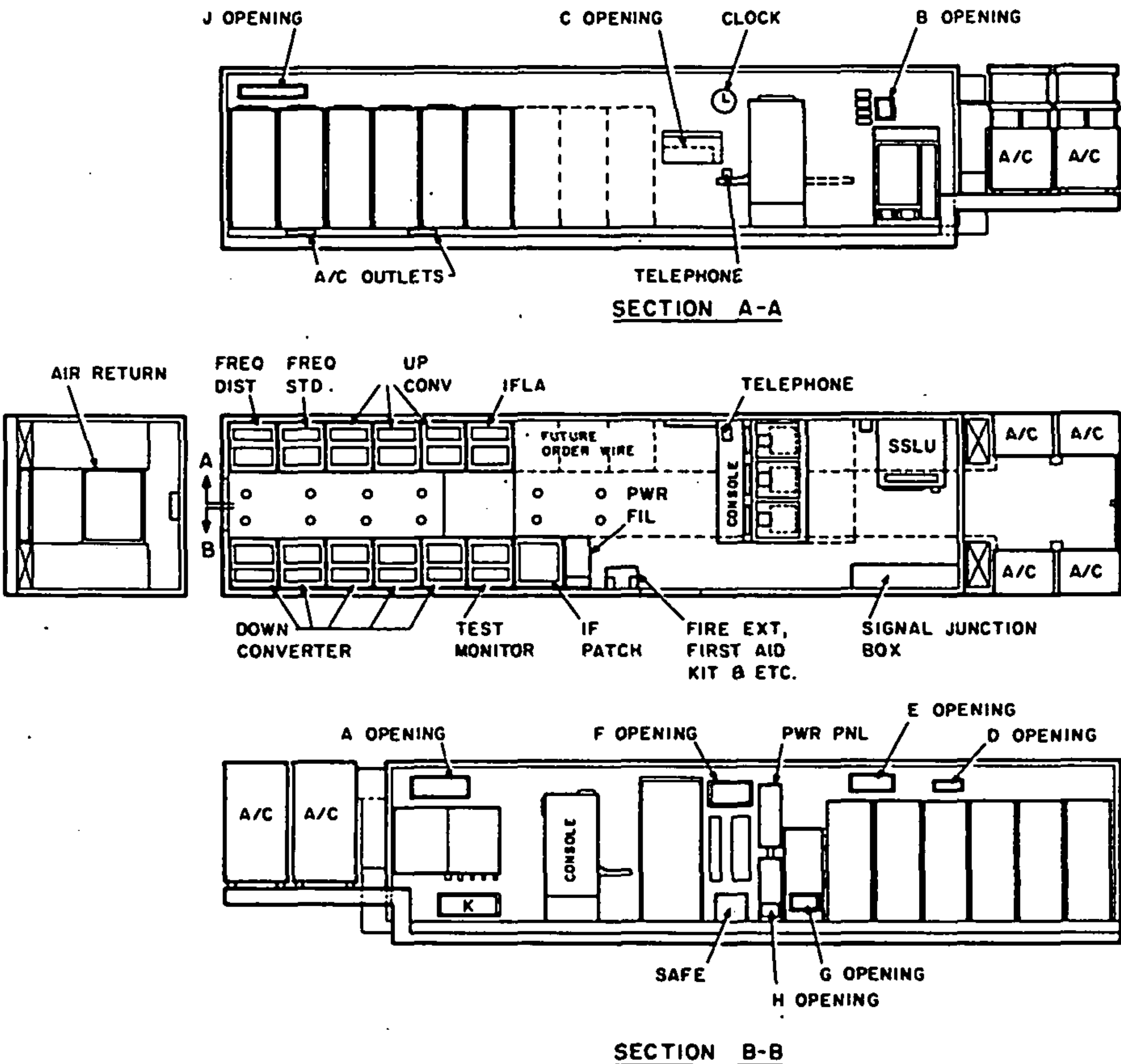
FIGURE D-1. Site layout, AN/GSC-39(V-2), vanized.



LEGEND:

A - CONNECTOR PANEL (SIGNAL CABLE TO OPS VAN)
B - CONNECTOR PANEL (TO XMIT VAN AIR CONDITIONERS)
C - POWER DISTRIBUTION BOX (2) (FOR SITE POWER INPUT & VAN POWER DISTRIBUTION)
D - CONNECTOR PANEL (WAVEGUIDE TO OPS VAN)
E - CONNECTOR PANEL (WAVEGUIDE TO ANTENNA)
F - CONNECTOR PANEL (TELEPHONE SYSTEM DISTRIBUTION)
G - CONNECTOR PANELS (2) (POWER FILTER BOX TO HEAT EXCHANGER)
P.A. - POWER AMPLIFIER
P.A.S. - POWER AMPLIFIER SUBSYSTEM

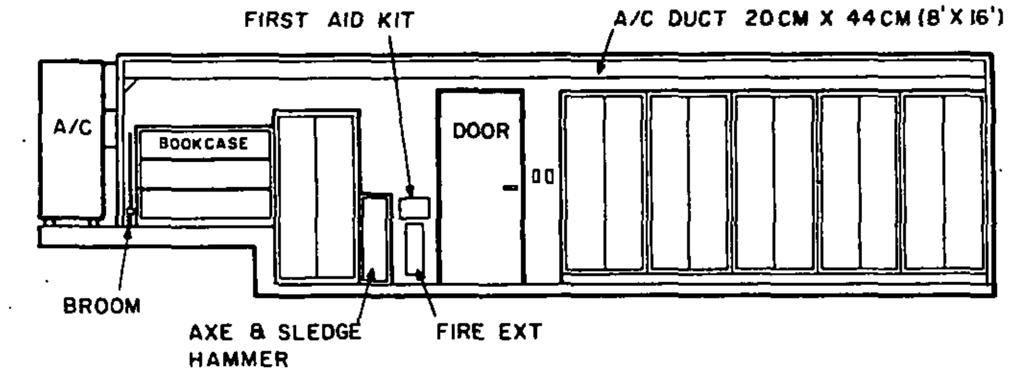
FIGURE D-2. Transmitter van, AN/GSC-39(V-2), vanized.



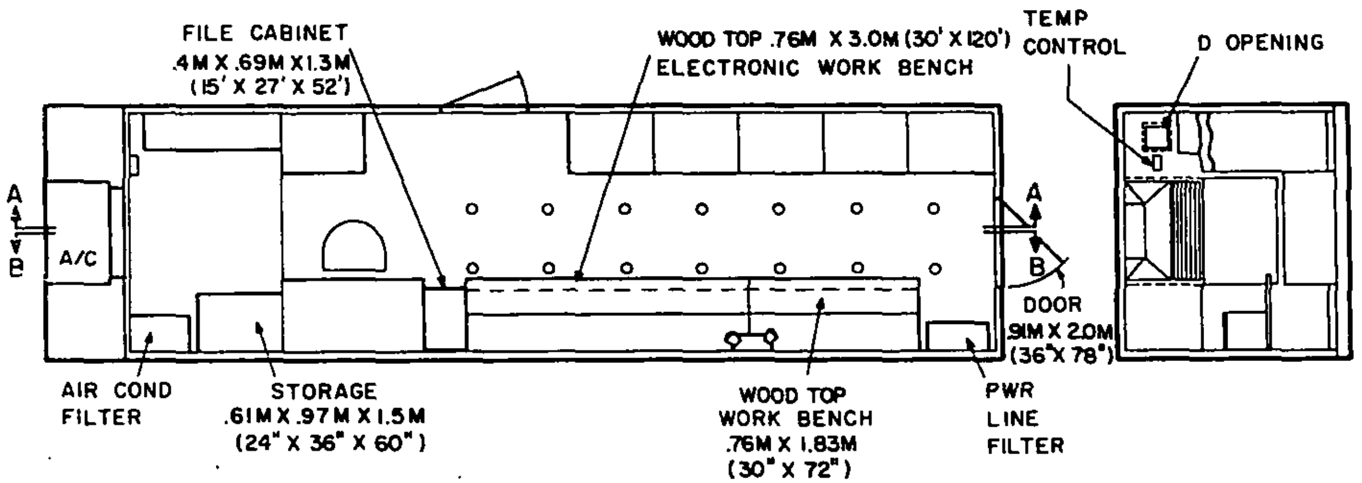
LEGEND:

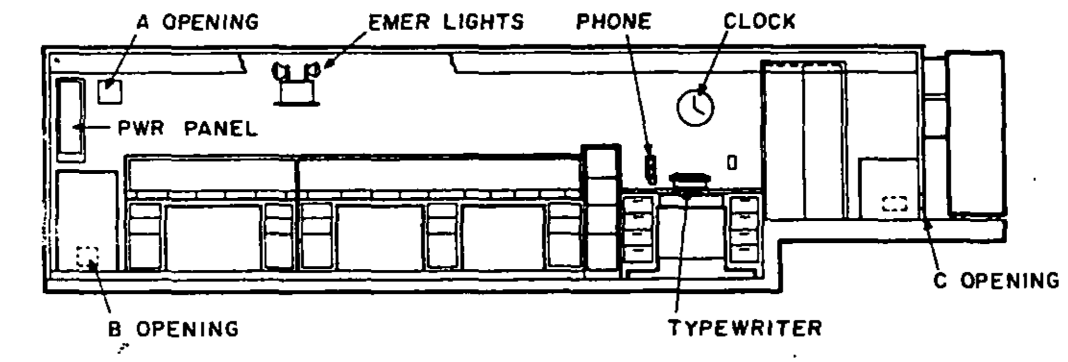
A - SIGNAL CABLE TO TRANSMIT VAN
B - TO OPS VAN AIR CONDITIONERS
C - DCSS JUNCTION BOX
D - WAVEGUIDE TO TRANSMIT VAN
E - WAVEGUIDE TO ANTENNA
F - USER PANEL
G - USER PANEL (IF PATCH)
H - A/C POWER FILTER BOX
J - TO USER
K - OPS TO ANTENNA

FIGURE D-3. Operation van, AN/GSC-39(V-2), vanized.



SECTION A-A

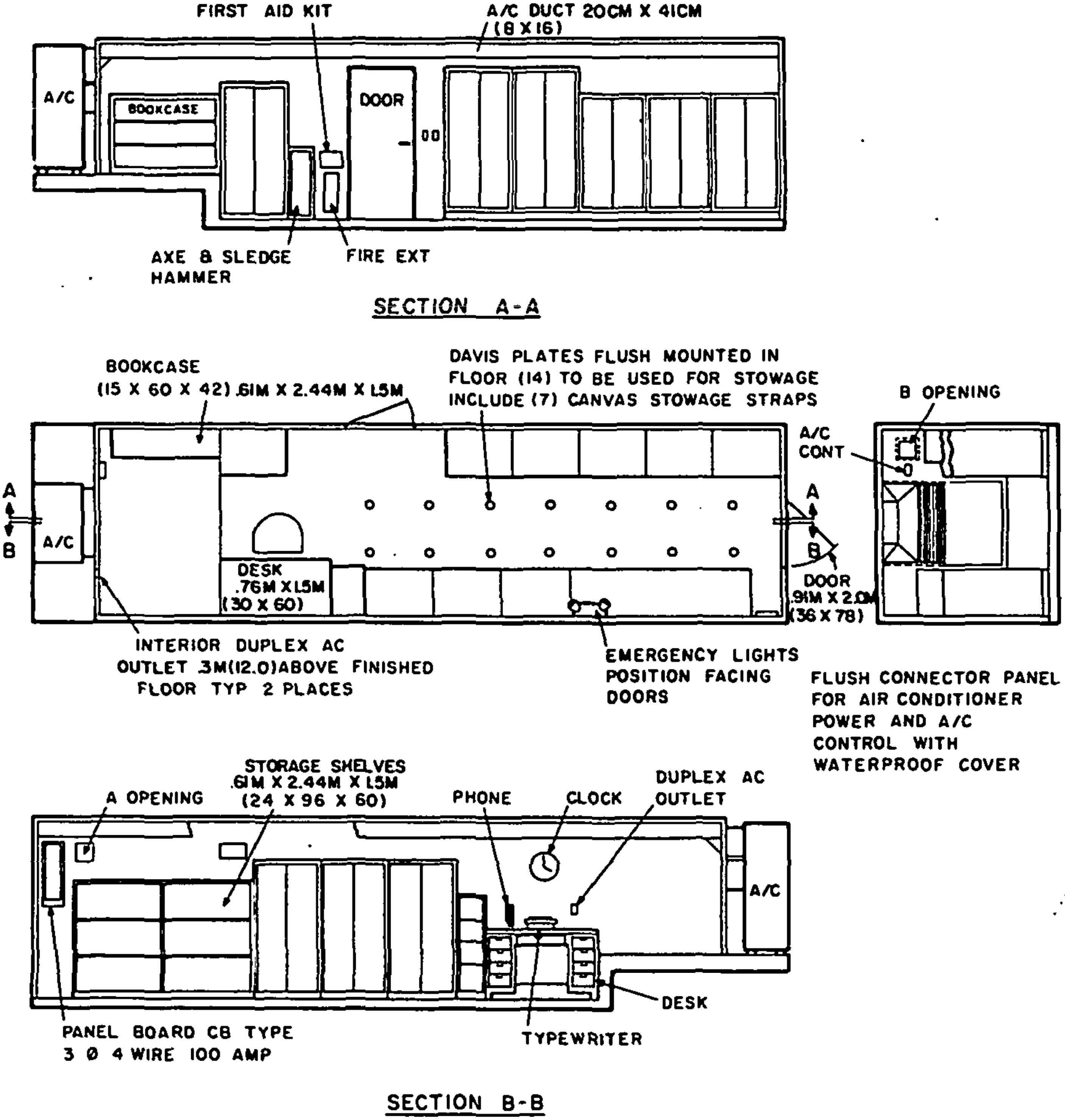




SECTION B-B

LEGEND:
A - SIGNAL INTERFACE
B - PWR INPUT INTERFACE
C - AIR CONDITIONER PWR IN
D - TEMP CONTROL INTERFACE

FIGURE D-4. Maintenance van, AN/GSC-39(V-2), vanized.



LEGEND:

A - TELEPHONE & MAIN PWR INTERFACE
B - AIR COND TEMP CONTROL INTERFACE

FIGURE D-5. Supply van, AN/GSC-39(V-2), vanized.

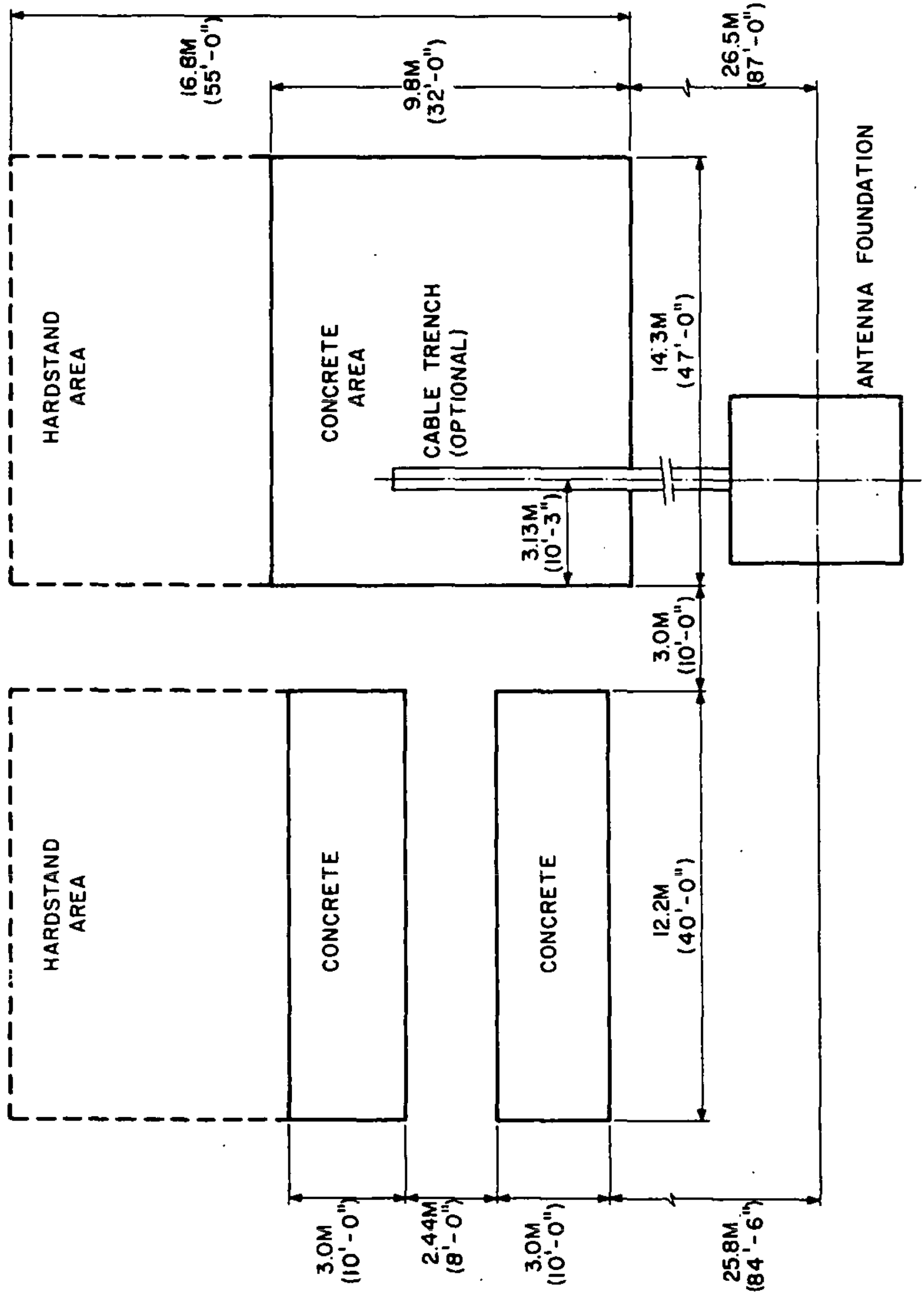


FIGURE D-6. Concrete foundations, AN/GSC-39(V-2), vanized.

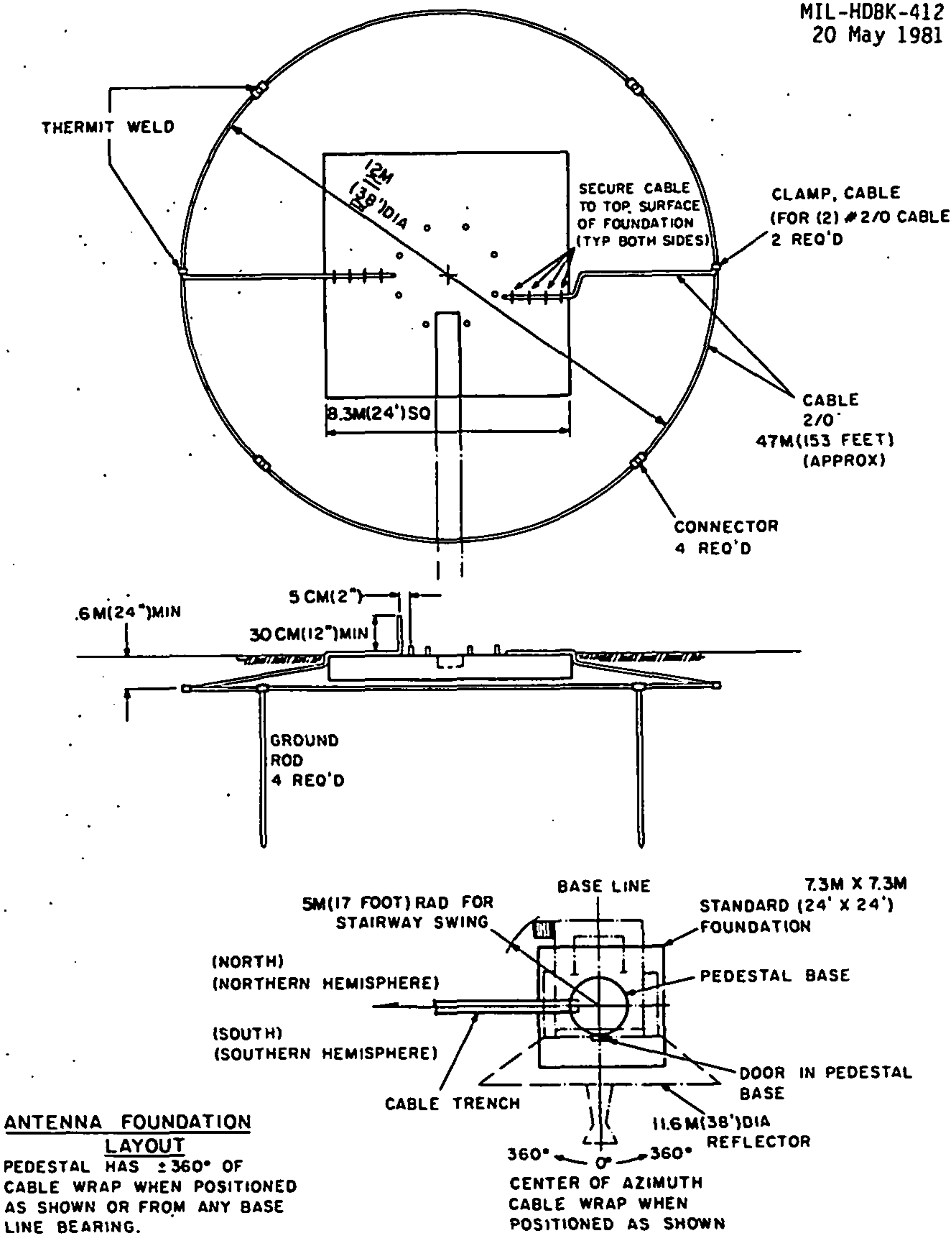


FIGURE D-7. Antenna system, AN/GSC-39(V-2), vanized.

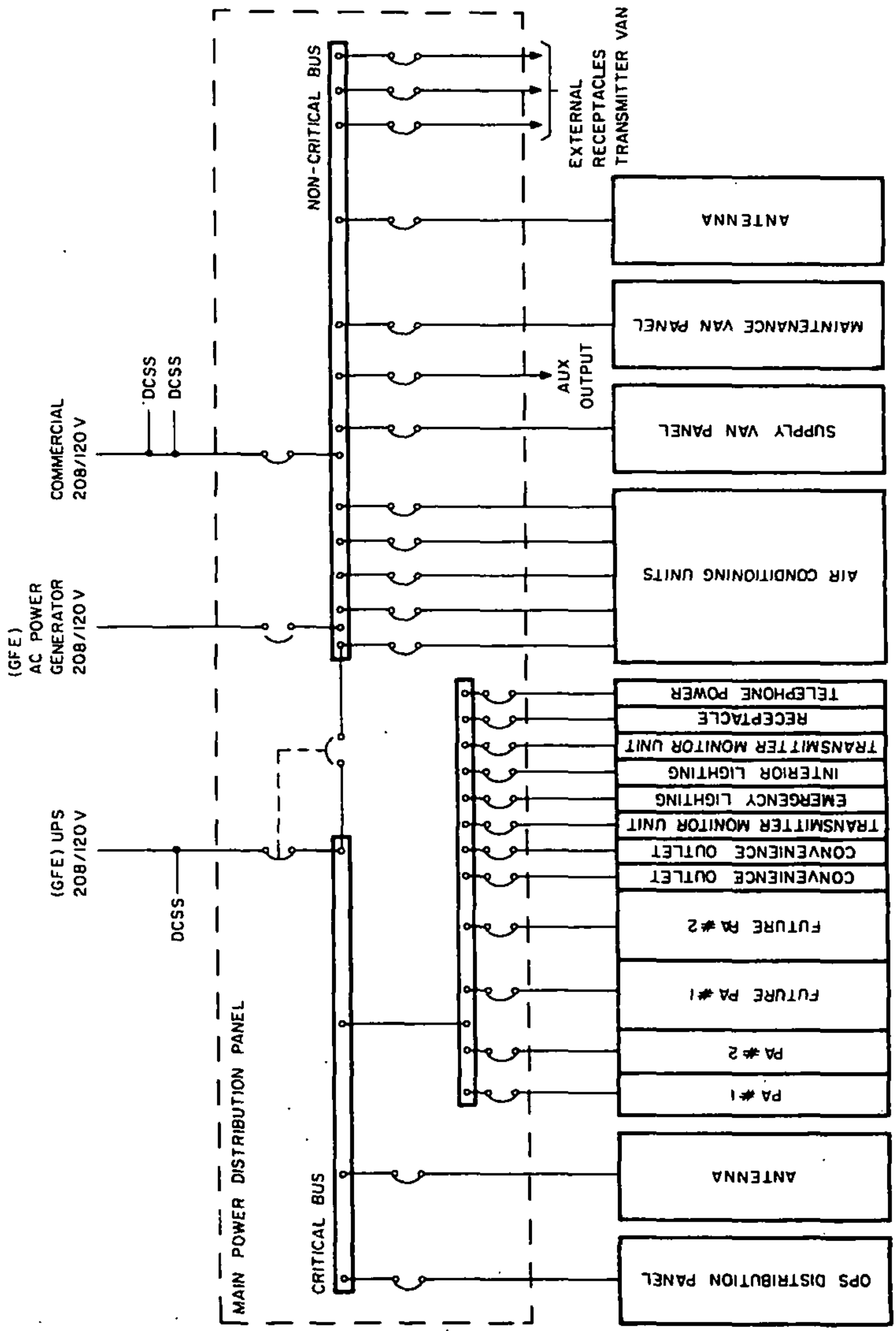


FIGURE D-8. One-line power system, AN/GSC-39(V-2).

APPENDIX E. SPECIALIZED FACILITY DESIGN CRITERIA: AN/TSC-54

Terminal Military Designation: AN/TSC-54
Type: Transportable Vanized

10.0 Physical plant requirements.

10.1 Site layout, figure E-1

10.2 Land/real estate requirement

10.2.1 Area: 10.7-m (35-ft) radius = 357.5 m^2 (3,848 ft^2)

10.2.2 Perimeter: 67 m (220 ft)

10.3 Access roads

10.3.1 Width requirement: 2.9 m (9 ft 6 in.)

10.3.2 Clearance requirement: 4.1 m (13 ft 6 in.)

10.3.3 Load-bearing requirement: 20,500 kg (45,000 lb) gvw

10.4 Vans/shelters/generators

10.4.1 Antenna-receiver-transmitter group OA-8244/TSC-54; mounted on V-395/TSC-54 dolly set

10.4.1.1 Length: 6.9 m (22 ft 10 in.)

10.4.1.2 Width: 2.4 m (8 ft)

10.4.1.3 Height: 2.8 m (9 ft 4 in.)

10.4.1.4 Weight: 3,340 kg (7,360 lb) gvw

10.4.2 Communications terminal group OW11/TSC-54; mounted on V-395/TSC-54 dolly set

10.4.2.1 Length: 5.3 m (17 ft 6 in.)

10.4.2.2 Width: 2.4 m (8 ft)

10.4.2.3 Height: 2.7 m (8 ft 10 in.)

10.4.2.4 Weight: 3,200 kg (7,540 lb)

10.4.3 Communications subsystem AN/TCC-79; mounted on XM-720 dolly set

10.4.3.1 Length: 5.3 m (17 ft 6 in.)

10.4.3.2 Width: 2.4 m (8 ft)

10.4.3.3 Height: 2.7 m (8 ft 10 in.)

10.4.3.4 Weight: 4,250 kg (9,365 lb) gvw

10.4.4 Generator set PU-401/M; trailer-mounted

10.4.4.1 Length: 4.3 m (14 ft)

10.4.4.2 Width: 2.4 m (8 ft)

10.4.4.3 Height: 2.3 m (7 ft 5 in.)

10.4.4.4 Weight: 3,860 kg (8,500 lb) each; 2 required

10.4.5 Generator set PU-495/G; trailer-mounted

10.4.5.1 Length: 4.8 m (15 ft 5 in.)

10.4.5.2 Width: 2.4 m (8 ft)

10.4.5.3 Height: 2.1 m (6 ft 11 in.)

10.4.5.4 Weight: 4,190 (9,228 lb) each; 2 required

10.4.6 DCSS van

10.4.6.1 Length: 9.6 m (31 ft 6 in.)

10.4.6.2 Width: 2.9 m (9 ft 6 in.)

10.4.6.3 Height: 2.6 m (8 ft 6 in.)

10.4.6.4 Weight: 13,600 kg (30,000 lb) gvw

10.4.7 DCSS supply van

10.4.7.1 Length: 5.6 m (18 ft 10 in.)

10.4.7.2 Width: 2.9 m (9 ft 6 in.)

10.4.7.3 Height: 2.6 m (8 ft 6 in.)

10.4.8 Shelter, maintenance, S-483/TSC-54; mounted on XM-720 dolly set

10.4.8.1 Length: 5.3 m (17 ft 6 in.)

10.4.8.2 Width: 2.4 m (8 ft)

10.4.8.3 Height: 2.7 m (8 ft 10 in.)

30.1 Ground system

30.1.1 System resistance: See MIL-STD-188-124, Resistance to Earth.

30.1.2 System drawing, figure E-1

30.2 Backup generators

30.2.1 400 Hz: 707/AM; MEP model 115A, 60 kW

30.2.2 50/60 Hz: 495/AG; MEP model 007A, 100 kW

40.0 Reference. USASATCOMA Report (Draft), Facility Design Criteria AN/TSC-54 Satellite Communications Terminal

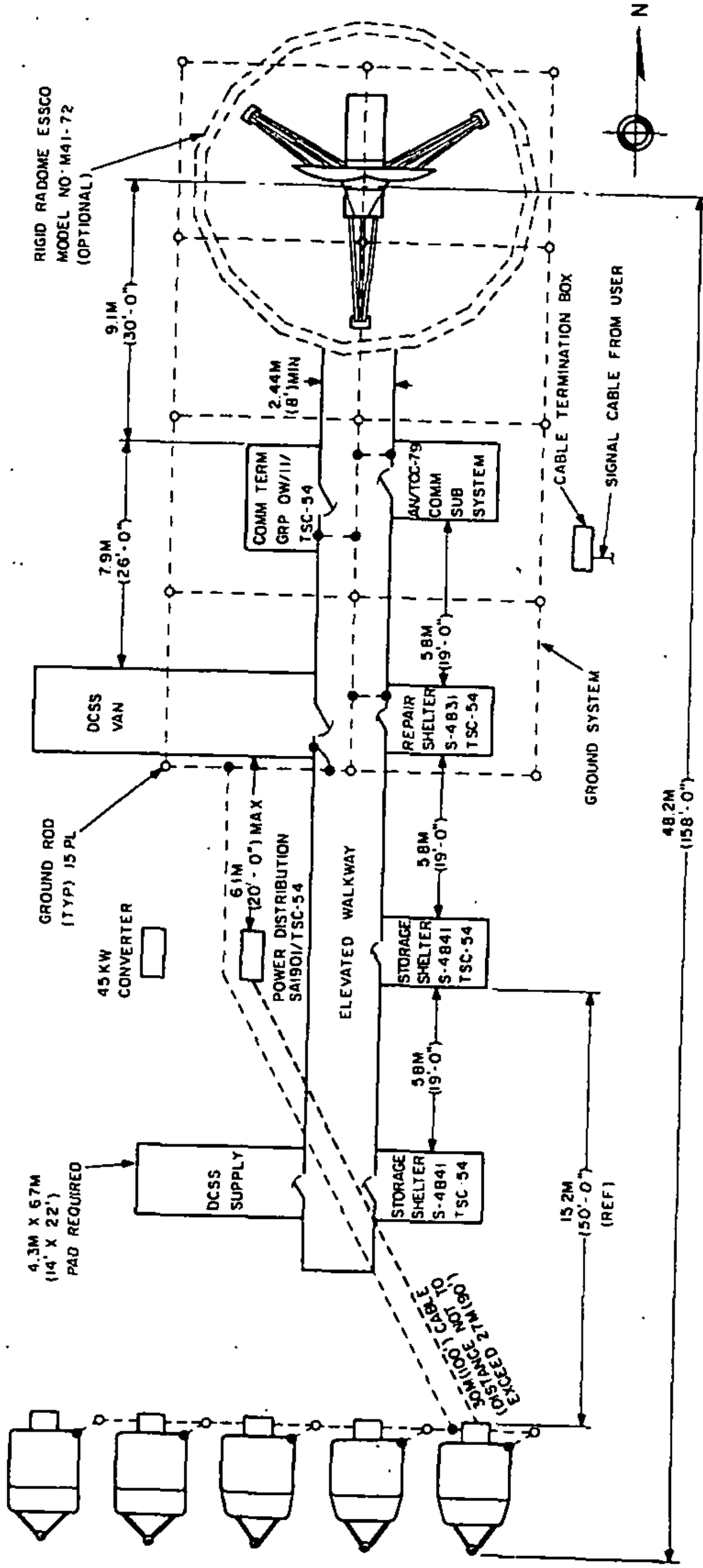


FIGURE E-1. Site layout, AN/TSC-54 terminal complex.

10.4.8.4 Weight: 2,380 kg (5,230 lb) gvw

10.4.9 Shelter storage, S-484/TSC-54; mounted on XM-720 dolly set

10.4.9.1 Length: 5.3 m (17 ft 6 in.)

10.4.9.2 Width: 2.4 m (8 ft)

10.4.9.3 Height: 2.7 m (8 ft 10 in.)

10.4.9.4 Weight: 2,380 kg (5,230 lb) gvw; 2 required

10.4.10 Power distribution switching unit, SA-1901/TSC-54; skid-mounted

10.4.10.1 Length: .9 m (3 ft)

10.4.10.2 Width: .6 m (2 ft)

10.4.10.3 Height: 1.5 m (5 ft)

10.4.10.4 Weight: 550 kg (1,200 lb) gvw

10.4.11 Static frequency converter, CV-3061/TSC-54; (60 Hz to 400 Hz)

10.4.11.1 Length: 1.5 m (5 ft)

10.4.11.2 Width: .6 m (2 ft)

10.4.11.3 Height: .6 m (2 ft)

10.4.11.4 Weight: 150 kg (330 lb) gvw

10.5 Foundations/pads

10.5.1 Pads or paving around antenna-receiver transmitter group shelters, and power units are optional. If desired, use dimensions and weights given in section 10.4, above, as design criteria.

10.5.2 DCSS van

10.5.2.1 Dimensions: 10.4 m x 4.3 m (34 ft x 14 ft)

10.5.2.2 Load-bearing requirement: 13,600 kg (30,000 lb) gvw

10.5.2.3 Material: concrete

10.5.3 DCSS van

10.5.3.1 Dimensions: 6.7 m x 4.3 m (22 ft x 14 ft)

10.5.3.2 Material: concrete

20.0 Power requirements.

20.1 Primary input, general (supplied to switching and distribution unit; SA-1901/TSC-54

20.1.1 Voltage: 208/120 Vac, ± 10%, 3-phase

20.1.2 Frequency: 50 or 60 Hz, ± 5%

20.1.3 Voltage balance: line-to-neutral deviation, balanced load: ± 2%

20.1.4 Phase displacement

20.1.4.1 Balanced load: ± 1 degree

20.1.4.2 50% unbalanced load: ± 5 degree

20.1.5 Harmonic distortion

20.1.5.1 Single harmonic: 3.0% maximum

20.1.5.2 Total distortion: 5.0% maximum

20.2 Input power requirements

20.2.1	Switch and distribution unit, SA-1901/TSC-54 (for antenna and all TSC-54 shelters)	75 kW
20.2.2	DCSS Van	34 kW (noncritical)
		25 kW (critical)
20.2.3	DCS supply van	20 kW

20.3 Auxilliary power requirements

20.3.1 Auxilliary power is supplied from, two each, 60 Hz engine generators (PU-495) and, two each, 400 Hz engine generators (PU-401/M). One generator of each type is used online with one, each, for a maintenance spare. Generators are used in the event of commercial power failure. Additionally, if the AN/TSC-54 does not have the CV-3061 static frequency converter, the PU-401 is used as the primary source of 400 Hz power.

20.3.2 PU-495 supplies 100 kW of 50/60 Hz power

20.3.3 PU-401/M supplies 45 kW of 400 Hz power

30.0 Special requirements.

APPENDIX F. SPECIALIZED FACILITY DESIGN CRITERIA: AN/MSC-46

Terminal Military Designation: AN/MSC-46
Type: Vanized Hybrid

10.0 Physical plant requirements

10.1 Site layout, figure F-1

10.2 Land/real estate requirement

10.2.1 Area: 76.2 m x 76.2 m (250 x 250 ft) = 5,806 m^2 (62,500 ft^2)

10.2.2 Perimeter: 305 m (1,000 ft)

10.3 Access roads

10.3.1 Minimum length: 30 m (100 ft)

10.3.2 Width requirement: 3.7 m (12 ft)

10.3.3 Clearance requirement: 3.81 m (12 ft 6 in.)

10.3.4 Load-bearing requirement: 27,200 kg (60,000 lb) gvw

10.4 Vans/buildings

10.4.1 Transmitter van

10.4.1.1 Dimensions: 9.45 m long, .9 m wide, 3.4 m high (31 ft x 3 ft x 11 ft)

10.4.1.2 Weight: 14,060 kg (31,000 lb)

10.4.2 Operations control van

10.4.2.1 Dimensions: 9.45 m long, 2.44 m wide, 3.4 m high (31 ft x 8 ft x 11 ft)

10.4.2.2 Weight: 13,200 (29,000 lb)

10.4.3 Maintenance van

10.4.3.1 Dimensions: 9.45 m long, 2.44 m wide, 3.4 m high (31 ft x 8 ft x 11 ft)

10.4.3.2 Weight: 11,800 (26,000 lb)

10.4.4 Storage van

10.4.4.1 Dimensions: 9.45 m long, 2.44 m wide, 3.4 m high (31 ft x 8 ft x 11 ft)

10.4.4.2 Weight: 10,200 kg (22,400 lb)

10.4.5 Digital communications subsystem van

10.4.5.1 Dimensions: 9.7 m long, 2.9 m wide, 2.6 m high (31 ft 8 in. x 9 ft 6 in. x 8 ft 6 in.)

10.4.5.2 Weight: 12,700 kg (28,000 lb)

10.4.6 FM communication subsystem van (optional)

10.4.6.1 FCC-55 type

10.4.6.1.1 Dimensions: 2.44 m long, 2.44 m wide, 2.6 m high (8 ft x 8 ft x 8 ft 6 in.)

10.4.6.1.2 Weight: 2,840 kg (6,250 lb)

10.4.6.2 TCC-78 type

10.4.6.2.1 Dimensions: 3.8 m long, 2.3 m wide, 2.2 m high (12 ft 3 in. x 7 ft 6 in. x 7 ft)

10.4.6.2.2 Weight: 3,510 kg (7,740 lb)

10.4.7 Administration building

10.4.7.1 Dimensions: 6.1 m x 18.3 m (20 ft x 60 ft)

10.4.7.2 Drawings, figures F-2, F-3, and F-4

10.4.7.3 Connected vestibule

10.4.7.3.1 Dimensions: 24.4 m x 2.44 m (80 ft x 8 ft)

10.4.7.3.2 Accommodation: up to 9 vans

10.5 Foundations/pads

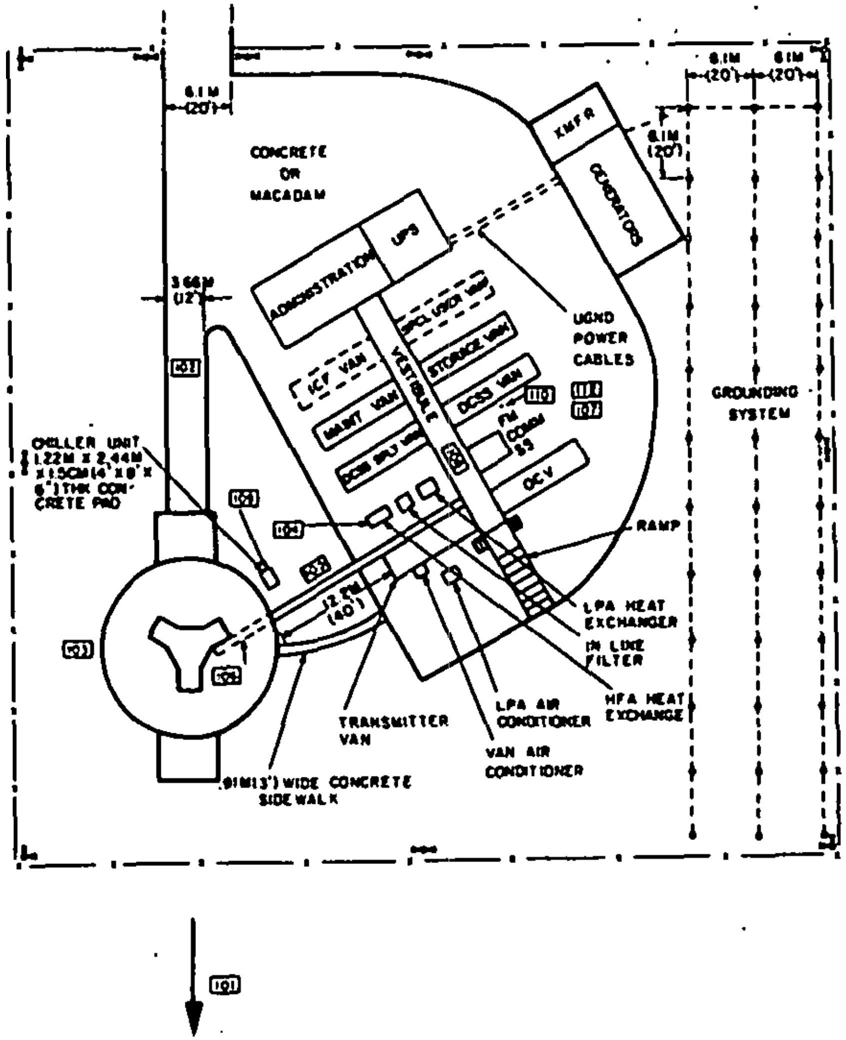
10.5.1 Van pads, figure F-1

10.5.2 Transformer and generator pad

10.5.2.1 Dimensions: 16.8 m x 7.3 m x 15 cm (55 ft x 24 ft x 6 in.) thick

10.5.2.2 Support requirements

10.5.2.2.1 500-kVA transformer: weight 2497 kg (5,500 lb)



LEGEND:

[101] INDICATES SEE NOTE 101

NOTES:

101. THIS ARROW MUST POINT TO THE EQUATOR. IF THE TERMINAL IS LOCATED NORTH OF THE EQUATOR, THE ARROW SHOULD POINT SOUTH (180°) AND IF THE TERMINAL IS LOCATED SOUTH OF THE EQUATOR, THE ARROW SHOULD POINT TO THE NORTH (0°).

102. 30 M (100 FT) MINIMUM STRAIGHT ROADWAY APPROACH 3.0 - 4.00 M (10 FT - 12 FT) WIDE IS REQUIRED TO PULL ANTENNA ONTO PAD. ROADWAY MUST BE ABLE TO SUPPORT APPROXIMATELY 27,200 KG (60,000 LBS) LOADS, NOT A PERMANENT REQUIREMENT.

103. THE RADOME BASE RING SEGMENTS MUST BE POSITIONED AS SHOWN AND THE CARGO DOOR, IF THE DOME HAS A CARGO DOOR, IS TO BE LOCATED AT THE ROADWAY FOR ENTRY OF THE ANTENNA.

104. THE HPA HEAT EXCHANGER COULD BE REMOVED FROM THE FRONT OF THE ENT VAN AND PLACED ON THE PAD AS SHOWN, AND SHOULD BE ELEVATED APPROXIMATELY 61 CM (24 IN) TO IMPROVE SERVICEABILITY AND MAINTAINABILITY.

105. THE SYSTEM CABLES ARE 42 M (140 FT) LONG AND THE DISTANCE FROM THE RADOME RING AND THE FRONT OF THE ENT VAN MUST NOT EXCEED 12.2 M (40 FT). IF THE ENT VAN AND OCV ARE INTERCHANGED, THE DISTANCE FROM THE RADOME RING AND THE FRONT OF THE OCV MUST NOT EXCEED 7.6 M (25 FT).

106. THE CABLE/WAVEGUIDE TRAYS SHOULD BE BELOW FLOOR LEVEL WITHIN THE RADOME AS A CONVENIENCE WHEN MOVING THE WORK SCAFFOLD. AS TERRAIN PERMITS, THE CABLES AND WAVEGUIDE CAN CONTINUE IN A TROUGH BUT MAY ALSO BE IN A METAL TRAY ABOVE GROUND. THE WAVEGUIDE MUST BE STRAIGHT SINCE IT IS RIGID.

WATER SHOULD NOT REMAIN IN THE TROUGH AND SHOULD BE DRAINED AWAY FROM THE CENTER OF THE RADOME.

THE CABLE TROUGH SHOULD BE 61 CM (24 IN) WIDE TO AFFORD USE OF DRILLS OR RAMSET ON THE TROUGH WALLS IF THE WAVEGUIDE IS LOCATED IN THE TROUGH.

107. CONCRETE IS TO BE 21100000 PASCALS (3,000 PSI) AT 28 DAYS AND WORK SHALL CONFORM TO ACI CODE. ALL PADS SHALL HAVE WIRE MESH OR REBARS INSTALLED TO PREVENT CRACKING OF PADS.

108. VESTIBULE FLOOR SHOULD BE ABLE TO SUPPORT THE BEAM TRANSFORMER ASSEMBLY IN CASE REPAIR OR ASSEMBLY IS NECESSARY. PHYSICAL WEIGHT OF ASSEMBLY IS 329 KG (725 LBS) AND IS 61 CM X 61 CM X 76 CM (24 IN X 24 IN X 30 IN) IN SIZE. PLATFORM FOR AN/TCC-78 OR AN/FCC-98 SHELTER SHOULD BE THE SAME HEIGHT AS VESTIBULE FLOOR CONSTRUCTED OF LOCALLY AVAILABLE MATERIAL.

109. PAD FOR THE COOLING UNIT SHOULD BE 10 CM (4 IN) THICK CONCRETE 1.22 M X 2.44 M (48 IN X 96 IN) ADJACENT TO THE CABLE WAY.

110. DSCS OR TLF INTERFACE POINT.

111. ALL PADS SHOULD HAVE HURRICANE TIEDOWNS IN THE CONCRETE FOR AIR CONDITIONERS, HEAT EXCHANGERS, VANS, ETC. AS DETERMINED BY LOCAL CODES.

112. GROUND AREA AROUND VANS SHOULD BE HARDSTAND.

fig F-1 1824/1202

FIGURE F-1. Site layout, vanized AN/MSC-46.

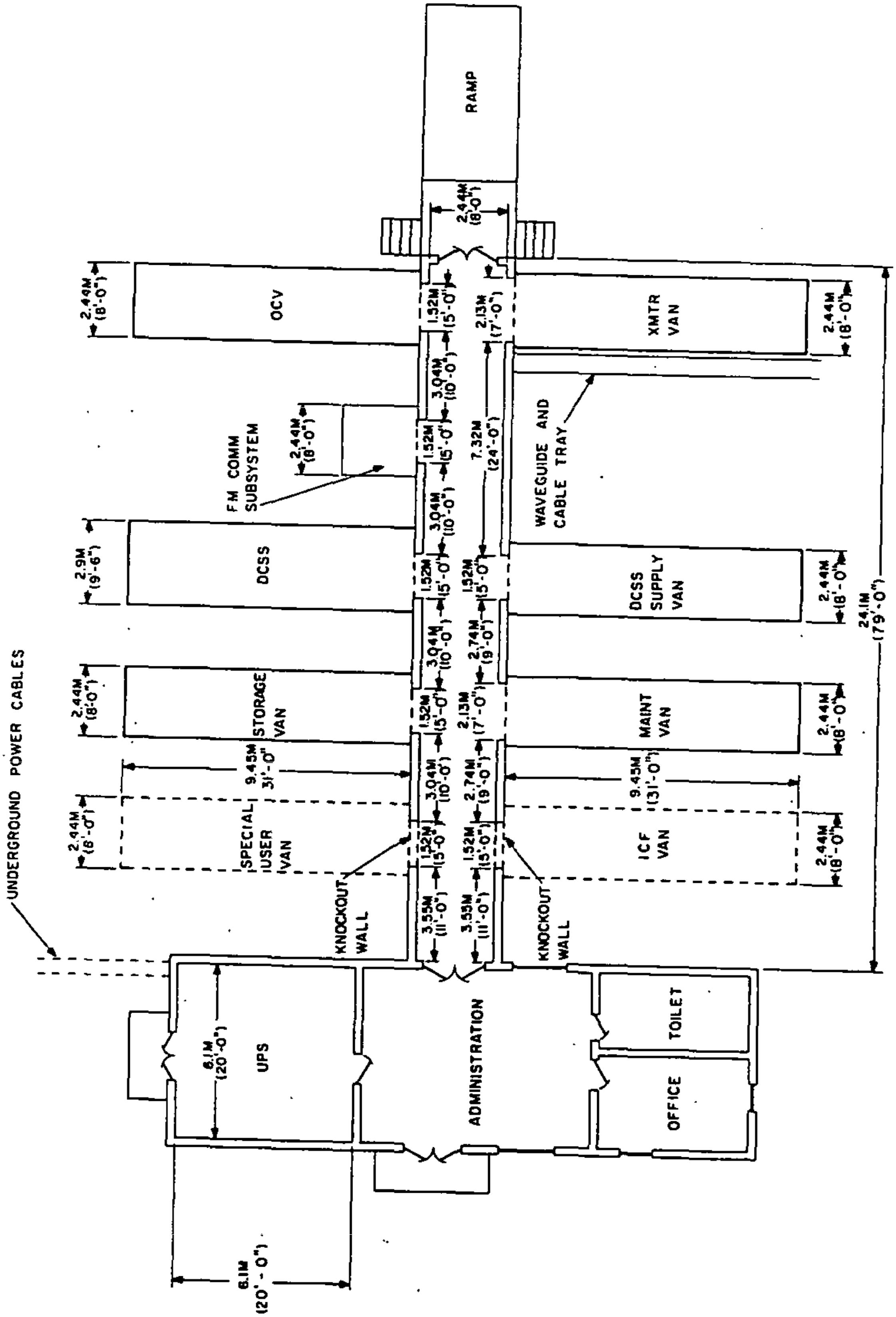


FIGURE F-2. Floorplan, administration building w/vestibule, vanized AN/MSC-46.

10.5.2.2.2 Three 200-kW generators: 4,540 kg (10,000 lb) each

20.0 Power requirements.

20.1 Primary input, general

20.1.1 Voltage: 208/120 Vac, ± 10%, 3-phase

20.1.2 Frequency: 50 or 60 Hz, ± 5%

20.1.3 Voltage balance: line-to-neutral deviation, balanced load: ± 2%

20.1.4 Phase displacement

20.1.4.1 Balanced load: ± 1 degree

20.1.4.2 50% unbalanced load: ± 5 degrees

20.1.5 Harmonic distortion

20.1.5.1 Single harmonic: 3.0% maximum

20.1.5.2 Total distortion: 5.0% maximum

20.2 Input power requirements

20.2.1	AN/MSC-46, antenna and DCSS van	237 kW
20.2.2	UPS charging	40 kW
20.2.3	UPS loss	25 kW
20.2.4	Climate control	10 kW
20.2.5	Building lighting	6 kW
20.2.6	Perimeter security lighting	3 kW
20.2.7	Site total requirement	321 kW

30.0 Special requirements.

30.1 Ground system

30.1.1 System resistance: 5 ohms or less

30.1.2 System drawing, figure F-1

30.2 Soil load-bearing requirement: 20,000 kg/(m^2) (4,000 lb/(ft^2)) with bulk modulus of 176,000 kg/(m^2) (250 lb/(in^2)) for antenna pad

30.3 Radome requirement: Electronic Space Structure Corp. (ESSCO) Model 68-78-1000

30.4 Backup generators

40.0 Reference: USASATCOMA Report, AN/MSC-46 Vanized Site Criteria, dated November 1976

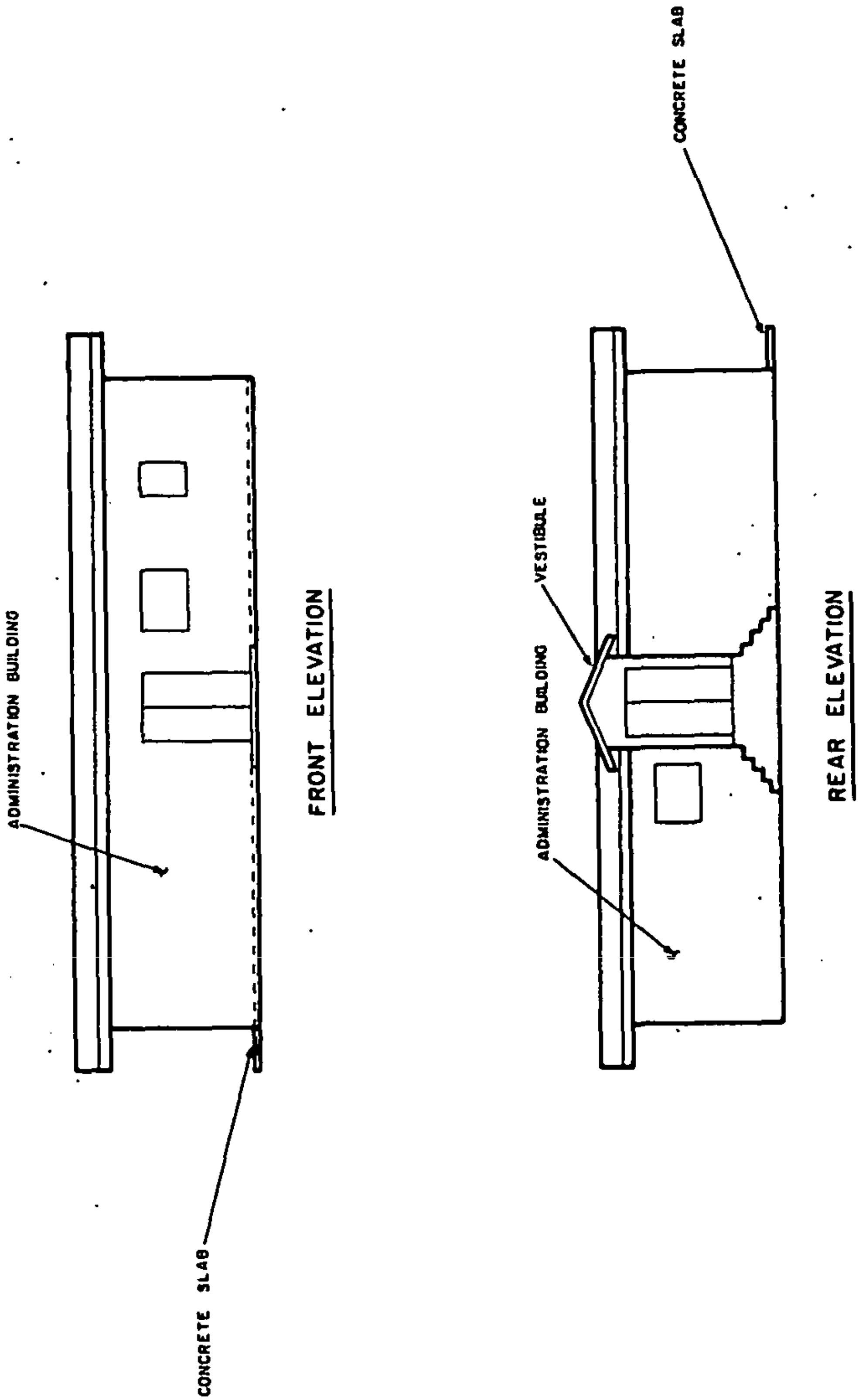


FIGURE F-3. Front and rear elevation, administraton building, vanized AN/MSC-46.

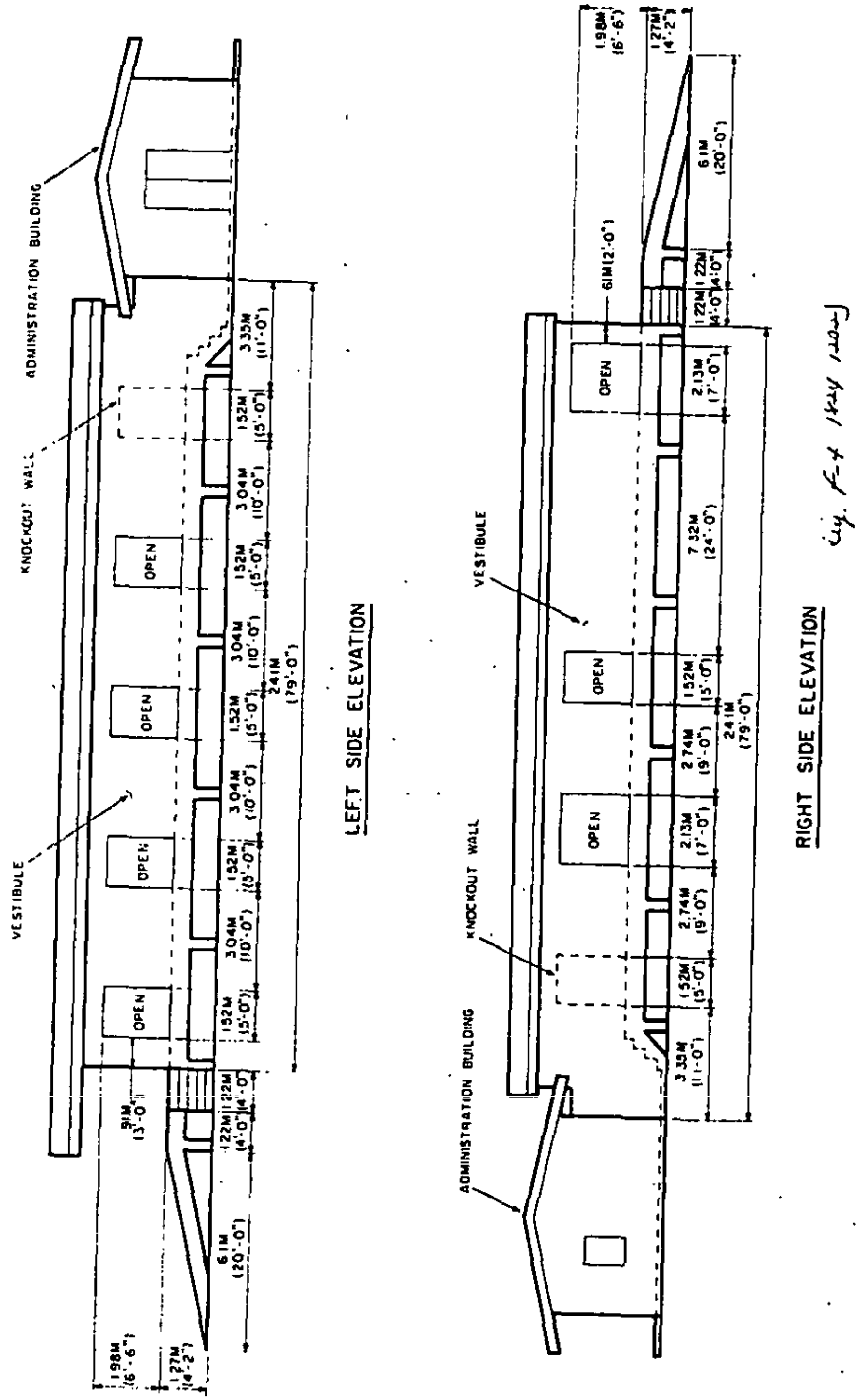


FIGURE F-4. Right and left elevation, administration building w/vestibule, vanized AN/MSC-46.

APPENDIX G. SPECIALIZED FACILITY DESIGN CRITERIA: AN/FSC-78

Terminal Military Designation: AN/FSC-78
Type: Fixed

10.0 Physical plant requirements.

10.1 Site layout, figure G-1

10.2 Access roads

10.2.1 Width requirement: 3 m (10 ft)

10.2.2 Clearance requirement: 3.81 m (12 ft)

10.2.3 Load-bearing requirement: 18,200 (40,000 lb) gvw

10.3 Technical building

10.3.1 Single configuration: 6.1 m x 18.3 m (20 ft x 60 ft)

10.3.2 Dual configuration: 12.2 m x 18.3 m (40 ft x 60 ft)

10.3.3 Floor plans

10.3.3.1 Single configuration, figure G-2

10.3.3.2 Dual configuration, figure G-3

10.3.4 Floor space

	Area m^2 (ft^2) Single	Dual
10.3.4.1 Communication equipment	74.3 (800)	148.6 (1,600)
10.3.4.2 Transmitter equipment	37.2 (400)	74.3 (800)
10.3.4.3 Maintenance	23.2 (250)	46.5 (500)
10.3.4.4 Supply	23.2 (250)	46.5 (500)

20.0 Power requirements.

20.1 Primary input, general

20.1.1 Voltage: 208/120 Vac, ± 10%, 3-phase

20.1.2 Frequency: 50 or 60 Hz, ± 5%

20.1.3 Voltage balance

20.1.3.1 Line-to-neutral deviation, balanced load: ± 2%

20.1.3.2 Line-to-neutral deviation, unbalanced load: ± 5%

20.1.4 Phase displacement

20.1.4.1 Balanced load: ± 1 degree

20.1.4.2 50% unbalanced load: ± 5 degree

20.1.5 Harmonic distortion

20.1.5.1 Single harmonic: 3.0% maximum

20.1.5.2 Total distortion: 5.0% maximum

20.2 Load requirements

20.2.1 Critical power

		Power, kVA
20.2.1.1	Communications power panel	10
20.2.1.2	Transmitter power panel	100
20.2.1.3	Antenna technical power	8.5
20.2.1.4	Margin	11.5
	Total	130.0

20.2.2 Noncritical power

		Maximum power, kVA
20.2.2.1	Antenna drive	82
20.2.2.2	Antenna utility	8
20.2.2.3	Margin	10
	Total	100

30.0 Special requirements.

30.1 Ground system

30.1.1 System resistance: See MIL-STD-188-124, Resistance to Earth.

30.1.2 System type: single-point radial or tree-type

30.2 Cable Trench

30.2.1 Length 27.4 m (90 ft)

30.2.2 Drawing, figure G-1

30.3 Environmental control

30.3.1 Technical equipment area

30.3.1.1 Temperature: 21.1° C (70° F) dry bulb ± 3° C (± 5° F)

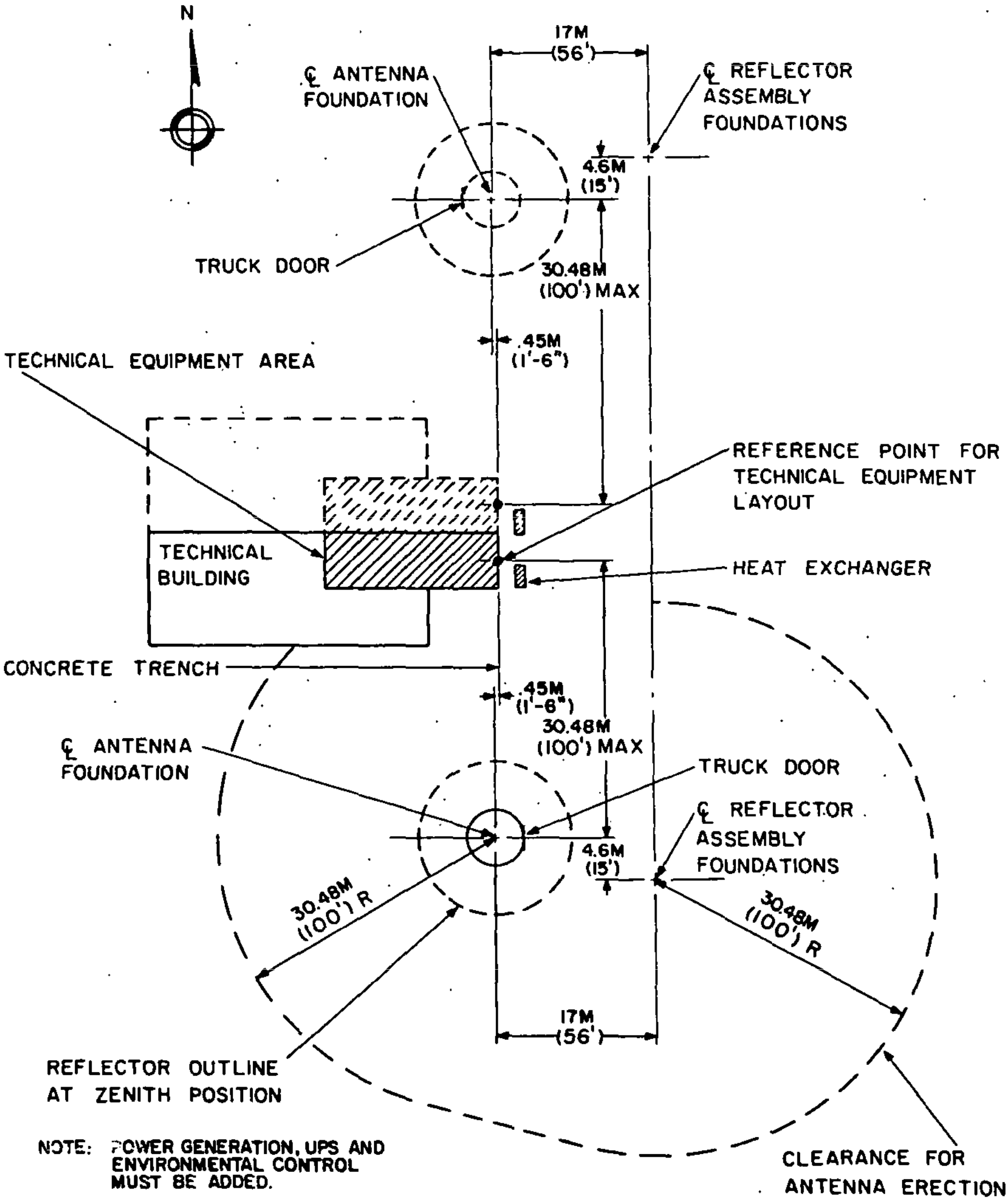
30.3.1.2 Humidity: 50% rh ± 10%

30.3.2 Equipment cooling requirements

		Heat dissipation, joules/h (Btu/h)	Minimum air flow CMM (CFM)
30.3.2.1	Communicatons equipment	3.59×10^7 (34,000)	57 (2,000)
30.3.2.2	Transmitter equipment	7.86×10^7 (74,000)	57 (2,000)

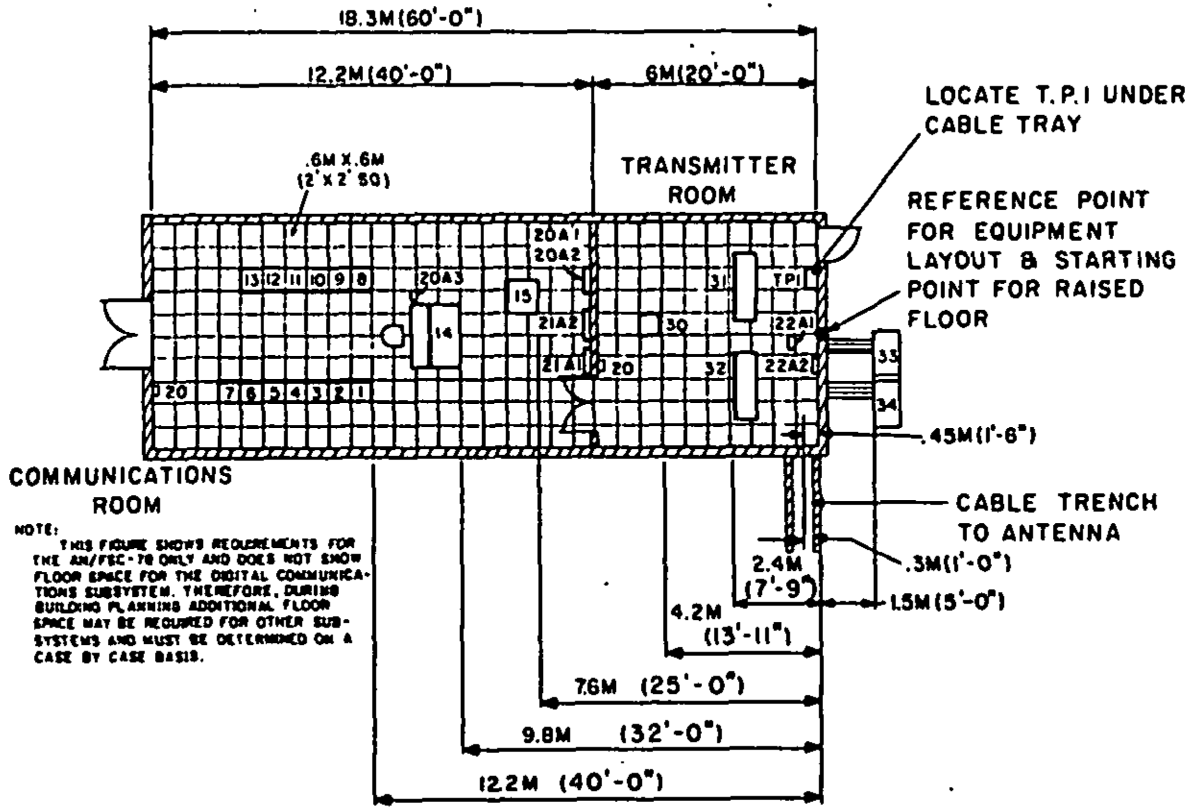
30.4 One-line power system, figure G-4

40.0 Reference. Philco-Ford Report WDL-TR5068A, FAcility Design Criteria for Fixed Site Satellite Communications Terminal, AN/FSC-78, dated 28 June 1974



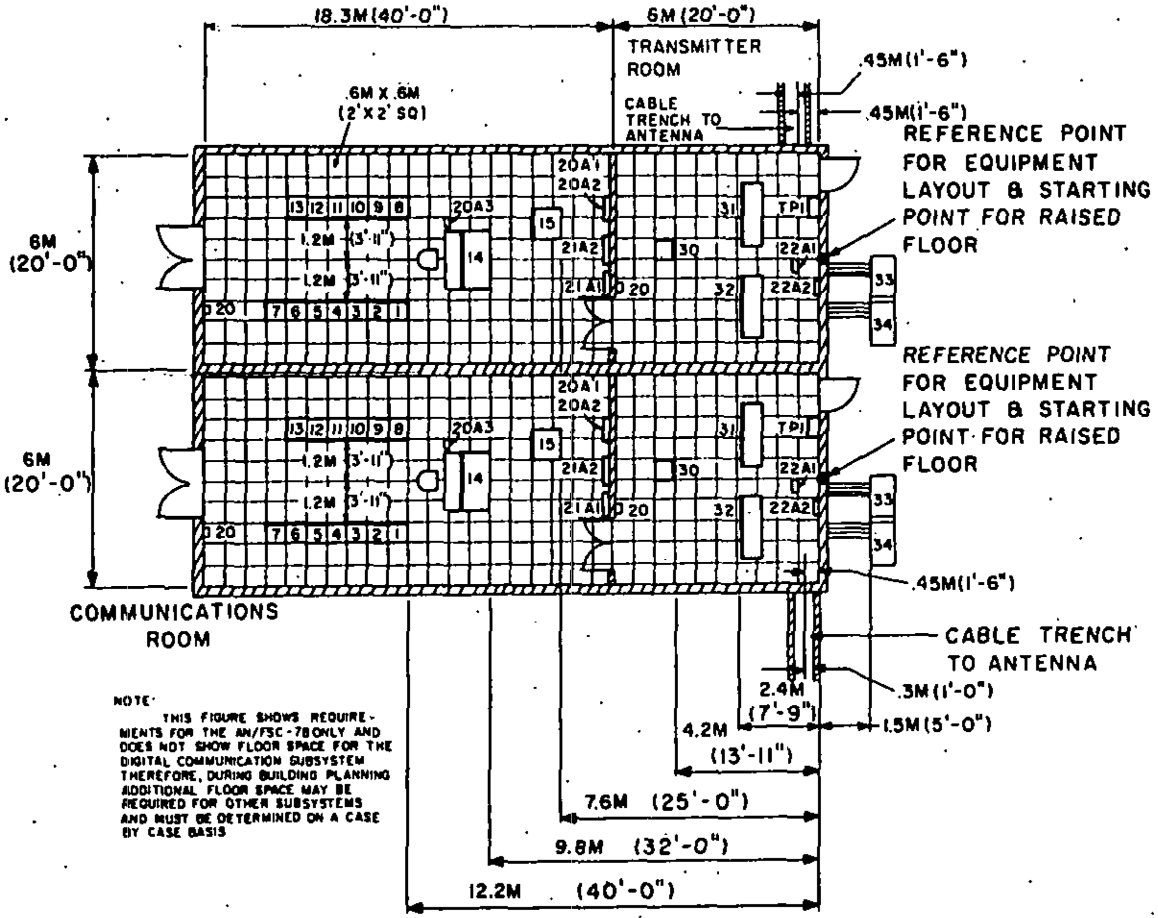
PLOT PLAN

FIGURE G-1. Site layout, AN/FSC-78.



UNIT NO.	DESCRIPTION
1	INTERCONNECTING GROUP
2	MONITOR TEST GROUP
3	DOWN CONVERTER RACK
4	″ ″ ″
5	″ ″ ″
6	″ ″ ″
7	DOWN CONVERTER RACK
8	AMPLIFIER MONITOR GROUP
9	UP CONVERTER RACK
10	″ ″ ″
11	UP CONVERTER RACK
12	SIGNAL GENERATOR GROUP
13	AMPLIFIER GROUP
14	CONSOLE
15	CONTROL MONITOR GROUP
20A1	KEY SERVICE UNIT
20A2	AUXILIARY EQUIPMENT UNIT
20A3	CALL COMMANDER
20	TELEPHONE SET, INDOOR
21A1	INTERCONNECT BOX
21A2	CIRCUIT BREAKER BOX
22A1	TRANSMIT FILTER
22A2	LOW PRESSURE PANEL
DCSS	BASE BAND POWER PANEL
30	TRANSMITTER MONITOR UNIT
31	5 KW POWER AMPLIFIER
32	5 KW POWER AMPLIFIER
33	HEAT EXCHANGER
34	HEAT EXCHANGER

FIGURE G-2. Technical building floorplan, single configuration, AN/FSC-78.



NOTE:
THIS FIGURE SHOWS REQUIREMENTS FOR THE AN/FSC-78 ONLY AND DOES NOT SHOW FLOOR SPACE FOR THE DIGITAL COMMUNICATION SUBSYSTEM THEREFORE, DURING BUILDING PLANNING ADDITIONAL FLOOR SPACE MAY BE REQUIRED FOR OTHER SUBSYSTEMS AND MUST BE DETERMINED ON A CASE BY CASE BASIS

UNIT NO.	DESCRIPTION
1	INTERCONNECTING GROUP
2	MONITOR TEST GROUP
3	DOWN CONVERTER RACK
4	| | |
5	| | |
6	| | |
7	DOWN CONVERTER RACK
8	AMPLIFIER MONITOR GROUP
9	UP CONVERTER RACK
10	| | |
11	UP CONVERTER RACK
12	SIGNAL GENERATOR GROUP
13	AMPLIFIER GROUP
14	CONSOLE
15	CONTROL MONITOR GROUP
20A1	KEY SERVICE UNIT
20A2	AUXILIARY EQUIPMENT UNIT
20A3	CALL COMMANDER
20	TELEPHONE SET, INDOOR
21A1	INTERCONNECT BOX
21A2	CIRCUIT BREAKER BOX
22A1	TRANSMIT FILTER
22A2	LOW PRESSURE PANEL
DCSS	BASE BAND POWER PANEL
30	TRANSMITTER MONITOR UNIT
31	5 KW POWER AMPLIFIER
32	5 KW POWER AMPLIFIER
33	HEAT EXCHANGER
34	HEAT EXCHANGER

FIGURE G-3. Technical equipment building floorplan, dual configuration, AN/FSC-78.

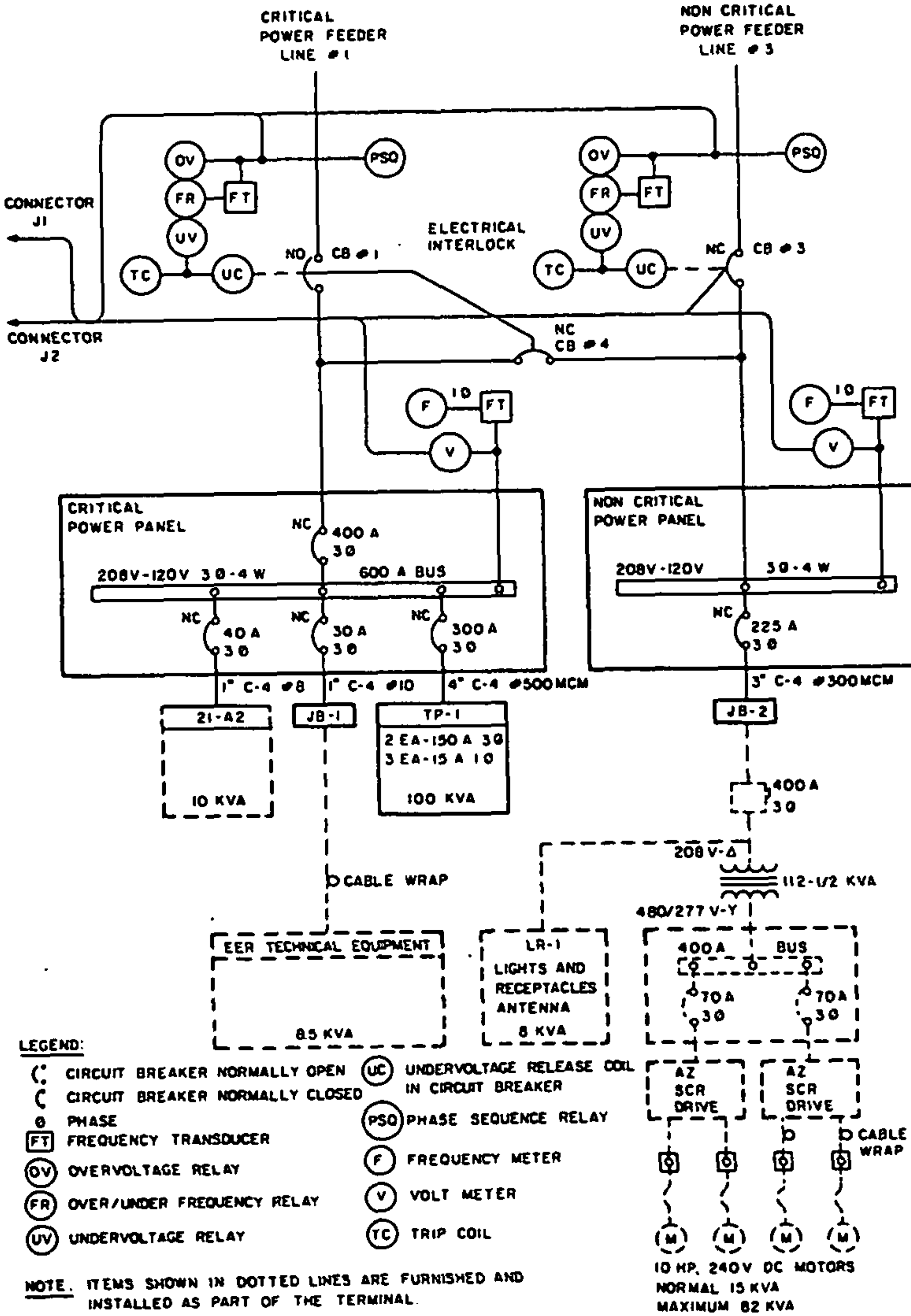


FIGURE G-4. One-line power system, AN/FSC-78.

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