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MILITARY HANDBOOK

ELECTRICAL UTILIZATION SYSTEMS

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ABSTRACT

This handbook provides basic design guidance that has been developed from extensive reevaluation of facilities. It is intended for use by experienced architects and engineers. The contents cover electric utilization such as interior electric power, lighting, communication, signal and fire alarm systems; emergency electric power systems; roadway, protective and area lighting; and design criteria for earthquake areas.

FOREWORD

This military handbook has been developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command (NAVFACENGCOM), other Government agencies, and the private sector. This handbook was prepared using to the maximum extent feasible, national professional society, association, and institute standards. Deviations from this criteria, in the planning, engineering, design, and construction of Naval shore facilities, cannot be made without prior approval of NAVFACENGCOM Code 04.

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to Commanding Officer, Naval Facilities Engineering Command, Chesapeake Division, Code 406, Washington Navy Yard, Washington, DC 20374; telephone commercial (202) 433-3314.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

ELECTRICAL ENGINEERING CRITERIA MANUALS

Criteria Manual	Title	PA
DM-4.1	Electrical Engineering Preliminary Design Considerations	CHESDIV
DM-4.2	Electrical Engineering Power Distribution Systems	PACDIV
MIL-HDBK-1004/3	Switchgear and Relaying	CHESDIV
MIL-HDBK-1004/4	Electrical Utilization Systems	CHESDIV
DM-4.05	400-Hz Medium-Voltage Conversion and Low-Voltage Utilization Systems	CHESDIV
DM-4.6	Electrical Engineering Lightning and Cathodic Protection	CHESDIV
DM-4.07	Wire Communication and Signal Systems	CHESDIV
DM-4.9	Energy Monitoring and Control Systems	HDQTRS
MIL-HDBK-1004/10	Cathodic Protection (Proposed)	NCEL

NOTE: Design manuals, when revised, will be converted to military handbooks and listed in the military handbook section of NAVFAC P-34.

This handbook is issued to provide immediate guidance to the user. However, it may or may not conform to format requirements of MIL-HDBK-1006/3 and will be corrected on the next update.

NOTICE OF CHANGE

MIL-HDBK-1004/4
NOTICE 1
15 FEBRUARY 1991

MILITARY HANDBOOK

ELECTRICAL UTILIZATION SYSTEMS

TO ALL HOLDERS OF MIL-HDBK-1004/4:

1. THE FOLLOWING PAGES OF MIL-HDBK-1004/4 HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
ix	15 February 1991	ix	31 October 1987
ixa	15 February 1991	ix	31 October 1987
x	15 February 1991	x	31 October 1987
29	15 February 1991	29	31 October 1987
29a	15 February 1991	29	31 October 1987
30	15 February 1991	30	31 October 1987
30a	15 February 1991	30	31 October 1987

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-HDBK-1004/4 will verify that all changes indicated above have been made. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military handbook is completely revised or canceled.

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ELECTRICAL UTILIZATION SYSTEMS

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Section 1: INTRODUCTION

1.1 Scope. This handbook presents data and requirements that are necessary for the proper design of interior electric power and lighting systems; communication, signal, and fire alarm systems; emergency power systems; roadway, protective, and area lighting systems; and design requirements for earthquake areas.

1.2 Cancellation. This handbook cancels and supersedes NAVFAC DM-4.4 of December 1979, including Change 1 of 1 April 1982.

Section 2: POLICY

2.1 Policies. The design of Electrical Utilization Systems shall conform to the requirements of paras. 2.1.1 through 2.1.7.

2.1.1 DOD Policies. For informatin pertaining to DOD policies, refer to MIL-HDBK-1190, Facility Planning and Design Guide.

2.1.2 National Codes. The National Fire Protection Association (NFPA) NFPA 70, National Electrical Code (NEC); American National Standards Institute (ANSI) ANSI C2, National Electrical Safety Code; NFPA 101, Code for Safety to Life from Fire in Building and Structures; and NFPA 110, Emergency and Standby Power Systems, shall be used to establish minimum standards of design and installation practices. Electrical materials and equipment should conform to the standards of the Underwriters Laboratories (UL) Inc., or other recognized testing agencies or laboratories.

2.1.3 Design Analysis. The design analysis covering electrical systems shall be made in accordance with good design procedures based on the conservation of energy and shall show all calculations used in determining ratings and capacities of such systems. Include the methods and tabulations used in sizing conductors, conduit, protective devices, and other equipment needed to complete a system. Clearly show all calculations so that any changes that become necessary can be made efficiently. When tables used in the design are taken from publications, plainly indicate the title, source, and date of the publication. Indicate the model number and manufacturer of each major piece of equipment on which space allocation was determined in the analysis. Equipment of at least three manufacturers shall be capable of being installed, serviced, maintained, and replaced in the space available.

2.1.4 Specifications. The design criteria in this section shall conform to the requirements of NAVFAC Guide Specifications NFGS-16301, Underground Electrical Work; NFGS-16302, Overhead Electrical Work; NFGS-16335, Transformers, Substations, and Switchgear, Exterior; NFGS-16402, Interior Wiring Systems; NFGS-16462, Pad-Mounted Transformers (75 kVA to 500 kVA); NFGS-16465, Interior Substations; and NFGS-16475, Interior Switchgear and Switchboards, Low-Voltage.

2.1.5 Requirements for Physically Handicapped. Specifications shall be used for making buildings and facilities accessible to and usable by physically handicapped people, refer to ANSI A117.1, Specifications for Making Buildings and Facilities Accessible by Handicapped People.

2.1.6 Architectural Considerations. Exposed electrical items shall be shown or indicated as such, and their use shall be inaccordance with the architectural design. For electronic facilities, the criteria in NAVFAC DM-12.01, Electronic Facilities Engineering shall apply.

2.1.7 OSHA Requirements. Provide all safety features in accordance with the Occupational Safety and Health Administration (OSHA).

Section 3: INTERIOR ELECTRIC POWER AND LIGHTING SYSTEMS

3.1 Local Codes. Although the Federal Government is not required to conform to city, state, or district building codes for property within Federal Government ownership lines, local codes should be considered. The design and installation of interior lighting systems, electric power facilities, and roadway and area lighting systems shall conform, as far as practicable, with adjoining community regulations and standards.

3.2 Service. Service wires to interior electrical systems shall be as short as possible. During installation of overhead services, consider possible future underground service installation. If feasible, install empty conduits from service rooms to points 5 ft (1.5 m) beyond building walls, 30 in. (762 mm) below grade, and provide below grade metallic marker to facilitate identification.

3.2.1 Service Equipment. Locate service equipment at the service-entrance point. Use circuit breakers according to the characteristics indicated for low-voltage switchgear (refer to MIL-HDBK-1004/3, Switchgear and Relaying). Fused switching devices shall be used only where special considerations necessitate their use. Such a situation may result when circuit breakers alone cannot provide adequate fault duty and must be coordinated with current-limiting fuses. Select the most economical devices consistent with short circuit and normal current requirements. Services with three-phase motor loads shall include protective devices that will open all three phases immediately upon failure of any one phase to prevent damage to the motors. Provide ground-fault protection in accordance with the NEC.

3.2.2 Service Conductors. The use of more than two conductors in parallel is discouraged. Either busway or a medium-voltage distribution system makes such usage necessary only for exceptional conditions, such as on piers where ships' services require large low-voltage currents. In such cases, consider providing individual conductors with limiter lugs having fuses which protect the size of cable used. All conductors serving the same load shall be of the same size, material, insulation, and length and shall be terminated similarly. Where conductors are paralleled in one or more raceways, each phase conductor and a neutral, if used, shall be installed in each raceway.

3.2.3 Metering. Provide all facilities on naval property, regardless of the operating agency, with a revenue-metering installation ahead of the main disconnecting device. Where required, install for future use, submetering provisions for energy-consuming mechanical/electrical systems such as lighting and heating, ventilating and air conditioning. Submetering provisions shall also be provided for multiple tenants in a building. For Energy Monitoring and Control System (EMCS) metering, refer to NAVFAC DM-4.09, Energy Monitoring and Control System.

3.2.4 Short-Circuit Considerations. Service protective devices must be able to clear available short-circuit current on secondary systems without damaging the unaffected portions of the system. Where service conductors are connected to low-voltage network systems, the service protective devices and the entire utilization system may be subjected to large short-circuit currents. Where available short-circuit currents reach values above ratings of ordinary protective devices, it may prove economical to use a short-circuit duty-reducing means instead of special switchgear. Short-circuit reducing equipment shall be selected from the criteria in paras. 3.2.4.1 through 3.2.4.3.

3.2.4.1 Current-Limiting Fuses. Current-limiting fuses shall be used for general reduction of short-circuit duty. Determine the maximum let-through current from fuse characteristic curves. The effective value of this current will determine the short-circuit rating of equipment placed on the load side of current-limiting fuses. Selectively coordinate current-limiting fuses in systems using multiple current-limiting devices. Fuses are the preferred method of limiting fault currents.

3.2.4.2 Current-Limiting Circuit Breakers. Current-limiting circuit breakers can be used for general reduction of short-circuit duty. Determine the maximum let-through current from breaker time-current characteristic curves. The effective value of this current will determine the short-circuit rating of equipment placed on the load side of current-limiting breakers. Selectively coordinate current-limiting breakers in systems using multiple current-limiting devices.

3.2.4.3 Other Methods. Other methods are available, but their use should be restricted in accordance with the following:

a) Reactors. Reactors shall be used to reduce short-circuit duty only where other current-limiting devices are not easily installed. Such installations have many limitations, and the designer must exercise exceptional judgment in selecting components based on the determination of the following factors:

1) Current-carrying capacity.

2) Maximum symmetrical short-circuit current available at the connecting point.

3) Bracing required to withstand mechanical stresses produced by such currents.

4) Minimum impedance per phase.

5) Allowable voltage drop.

6) Energy conservation requirements.

b) High-Impedance Busways. High-impedance busways can be used for small reductions only when other current-limiting devices are not economical. Use of high-impedance busways is not recommended (refer to MIL-HDBK-1004/3).

c) High-Impedance Transformers. Although high-impedance transformers can provide general reduction of short-circuit duty, the use of these transformers is highly discouraged due to economic and energy conservation considerations.

3.2.5 Service-Equipment Rooms. Utilities shall be accessible, and equipment room shall be sized to provide sufficient space for proper maintenance of equipment. If electrical equipment is located in a combination electrical-mechanical equipment room, adequate space for electrical equipment, including anticipated future equipment, must be reserved. Piping, ducts, or equipment foreign to the electrical equipment or to the architectural appurtenances shall not be installed in, shall not enter, or shall not pass through the space reserved for electrical equipment. Electrical equipment shall be protected from piping, ducts, or equipment not foreign to the space reserved for the electrical equipment. For access, ventilation, emergency lighting, fire protection, and coordination with other trades, refer to NAVFAC DM-4.02, Electrical Engineering Power Distribution Systems, and DM-4.07, Wire Communication and Signal Systems.

3.2.6 Service Grounding. Connect the neutral of a system to ground at one point and provide for grounding connection at the incoming main secondary disconnecting device. A four-wire system shall be used for an incoming single-phase service. Where several buildings are served via a single incoming three-phase service, a separate five-wire system should be utilized from the incoming service to each building. Grounding of transformers with delta secondaries shall receive special considerations (refer to Institute of Electrical and Electronics Engineers (IEEE) IEEE 142, Recommended Practice for Grounding Industrial and Commercial Power Systems. Size grounding conductors in accordance with the NEC, with the grounding electrode having a preferred resistance to ground of 5 ohms or less (refer to NAVFAC DM-4.02).

3.3 Wiring Systems. For locations of switchboards, power panelboards, and lighting panelboards in relation to the electric circuits, refer to NAVFAC DM-4.02 and MIL-HDBK-1004/3.

3.3.1 Standard Utilization Voltages. Select voltages at the highest level consistent with the type of load served. In the selection of system voltages, consider load magnitudes, distances to load centers, availability of utilization devices at voltages under consideration, safety, standards, and codes. Utilization voltage levels are as follows:

3.3.1.1 208 V Systems. A 208Y/120 V system is usually most economical when the major portion, 60 percent or more, of the load served consists of 120 V utilization equipment and lighting and when the average length of feeders is less than 200 ft (60 m).

3.3.1.2 480 V Systems. Supply this service voltage where large motors constitute a major portion of a mixed load, in buildings having one or more electrical services aggregating 600 A or more, and where more than 50 percent of the load may be served by a 480Y/277 V system. Design the lighting systemto operate at 277 V. All three-phase motors shall be served at 480 V. Small appliance loads, convenience outlets, and other loads requiring lower voltages shall be served from a dry-type transformer stepping down 480 V to 208Y/120 V.

3.3.1.3 Service to Motors. Motors of 1/2 hp and larger shall be three-phase type, unless three-phase service is not available. In that case, operate motors 1/2 hp and larger at phase-to-phase voltage rather than phase-to-neutral voltage.

3.3.2 Voltage Spread. Determine the voltage spreads in the system, taking into account the effects of overvoltages and undervoltages in the load types. After the voltage spread has been determined, distribute the total voltage drop among the elements of a system in the most economical way. In any facility, the combined feeder and branch-circuit voltage drop shall not exceed the limits imposed by the NEC.

3.3.3 Power Factor. Generally, utilization equipment having an inductive reactance load component shall have a power factor of not less than 90-percent lagging under rated load conditions. When the power factor of utilization equipment is less, switch power-factor correcting devices with the utilization equipment to provide a power factor of not less than 90 percent in accordance with MIL-HDBK-1190. Fluorescent lighting devices should be specified to have a power factor of not less than 95-percent lagging.

3.3.4 Wire and Cable. Select types of insulation, in conformity with NFGS-16402, according to duty and location. Refer to the NEC for descriptions and definitions of insulation types, operating temperatures, voltage classes, and applications. Do not exceed values of allowable current-carrying capacities listed in the NEC. Size branch circuits and feeder conductors at 125 percent of full-load ampacity to minimize I^2R losses. If future capacity sizing adequately provides this allowance, do not oversize the conductor by another 125 percent. For installation in abnormal ambient temperatures and for more than three conductors in a raceway, apply derating factors as directed by the NEC. Provide full-size neutral conductors for both single and three-phase systems where any part of the connected load is a single-phase load.

3.3.5 Raceways. Do not embed metal raceways in concrete that contain coral aggregate or is made with salt or brackish water. For these cases, use nonmetallic raceways. Raceways shall be selected in accordance with NFGS-16402 and paras. 3.3.5.1 through 3.3.5.8.

3.3.5.1 Electrical Metallic Tubing. Electrical Metallic Tubing (EMT) shall be used to enclose branch-circuit conductors, up to 1/0 AWG (53.5 mm^2) maximum size, only for exposed runs in dry locations, hung ceilings, hollow-block walls, and furred spaces. Do not install electrical metallic tubing underground, outdoors, or encased in concrete.

3.3.5.2 Flexible Steel Conduit. Flexible steel conduit shall be used for applications similar to those in which EMT is employed and for connection to vibrating equipment, between junction boxes and recessed lighting fixtures, between expansion joints in exposed runs, and for short connections.

3.3.5.3 Rigid Steel Conduits. Rigid steel conduits shall be used for runs encased in concrete and in wet and hazardous locations. Provide Polyvinyl Chloride (PVC) coating when corrosion protection is required.

3.3.5.4 Aluminum Conduit. Aluminum conduit shall be used for applications similar to those used for steel conduits, but do not install aluminum conduit by direct burial or encase aluminum conduit in concrete. Use for high-frequency circuits where steel would cause magnetic problems. Do not use in electromagnetically sensitive areas.

3.3.5.5 Nonmetallic Conduit. Nonmetallic conduit shall be used only where permitted by NFGS-16402.

3.3.5.6 Intermediate Metal Conduits. Intermediate Metal Conduit (IMC) can be used in lieu of rigid conduit, where permitted by NFGS-16402.

3.3.5.7 Wireways. Use wireways only for exposed work where permitted by the NEC. Do not fill wireways over 20 percent of their interior cross-sectional areas. For special conditions, refer to the NEC.

3.3.5.8 Electrical Floor Systems. Electrical floor systems shall be used in administrative areas where the distance between permanent partitions is more than 20 ft (0.16 m). A cellular floor system with trench headers is the preferred system. Underfloor duct systems may be used where cellular floor decking is not feasible, either structurally or economically. Power, signal, and telephone systems shall each be run in separate cells and through compartmented trenches or junction boxes. Locate cells to permit rearrangement of temporary partitions and room layouts without revisions to underfloor systems, other than the relocation of outlets and wiring. Locate cells so that no electrified cells will occur at partitions or on module lines.

a) Cellular Metal Floor System. Nominal size of each electrified cell shall be 9 in^2 (60 cm^2). Where smaller cells can be installed structurally, consider using two cells for telephone circuits. Telephone circuits should provide for use of call director telephones. Normally, a 30-line call director telephone has a 100 pair, 24 AWG (0.5 mm^2) line connection requiring a minimum conduit size of 1-1/4 in. (31.75 mm). Usually, if the cell size is adequate for call director telephone circuits, it is more than adequate for electric power and signal circuits. For trench header capacity, provide 2 in^2 (1,290 mm^2) per 1,000 ft^2 (93 m^2) of office space for each system in small buildings. For buildings having a gross administrative space in excess of 50,000 ft^2 (4,645 m^2), increase 2 in^2 (1,290 mm^2) to 4 in^2 (2,580 mm^2) for telephone circuits and decrease to 1-1/2 in^2 (968 mm^2) for electric power and signal circuits. Trench headers should not be run in corridors unless absolutely necessary. Refer to Federal Construction Guide Specification (FCGS) FCGS-16115, Underfloor Raceway System (Cellular Steel Floor), for material.

b) Underfloor Duct System. Size feeder ducts on same basis as trench headers. To avoid congestion in feeder ducts, provide parallel conduit feeders, usually 1-1/4 in. (31.75 mm) from panelboards or closets to load areas. Select cell sizes based on wiring requirements, providing for future area applications and load growth. The minimum cross-sectional area of ducts shall be 3.3 in^2 (2,129 mm^2). The maximum spacing between feeder ducts shall be 50 ft (15 m). The minimum concrete cover over ducts shall be 3/4 in. (19 mm). Base insert and junction sizes on the required wiring capacity and minimum bending radius of the largest wire or cable to be installed. Refer to FCGS-16113, Underfloor Duct System, for material.

3.3.6 Hazardous Locations. Hazardous locations shall conform with provisions of the NEC where the equipment and associated wiring are installed within hazardous areas.

3.3.7 Special Areas. Weatherproof, dustproof, dust-ignition-proof, dusttight and watertight equipment, and associated wiring as required and in accordance with the NEC shall be installed.

3.4 Electric Power Systems. Characteristics, types, and information for all motors and controllers are included under power plants in the NAVFAC DM-3 Series.

3.4.1 Electric Power Distribution to Motors.

3.4.1.1 Voltage Level. To determine the most economical voltages for electric power systems, find the break-even points between distribution and switchgear costs. For standard system voltages and raceway systems, refer to para. 2.2. For standard motor utilization (nameplate) voltages, refer to National Electrical Manufacturers Association (NEMA) Standards Publication MG-10, Energy Guide for Selection and Use of Polyphase Motors.

3.4.1.2 Electric Power Feeders. In general, feeders serving power circuits shall carry only power loads. Determine feeder sizes from the following:

a) Capacity. Current-carrying capacities of conductors serving motors under normal running conditions and under intermittent duties should be considered.

b) Voltage Drop. Continuous currents should not produce voltage drops that will reduce motor torques below minimum required values; starting currents of the largest motor should not produce voltage dips of such magnitudes as to actuate the undervoltage releases or to disengage smaller motors in a system. In any event, do not exceed maximum voltage drops of the NEC.

c) Short Circuits. Motors and associated equipment shall be protected against damaging short-circuit currents. Limit maximum fault currents at mains in the grouped protective equipment. Determine maximum short-circuit let-through currents, using the aforementioned methods for reduction of short-circuit duty. Consider the effects of the duration of in-rush currents through protective devices and excessive voltage drops.

3.4.2 Motor Control Requirements. Motor controllers (starters) shall be provided for motors larger than 1/8 hp and shall be in accordance with design requirements in NEMA ICS1-78, General Standards for Industrial Controls and Systems. For motors of 1/8 horsepower or less, refer to the NEC requirements.

3.4.2.1 Manual Type. Manual starters may be used for motors up to the maximum horsepower ratings given in Table 1. This applies only when the motor is not controlled by automatic devices, unless all automatic devices have adequate horsepower ratings.

3.4.2.2 Magnetic-Only Type. Magnetic controllers shall be full-voltage, nonreversing, across-the-line starting, except where reduced-voltage starting is required by the capacity of the system which supplies the motor. Such a case is where the transformer kilovolt-amperes are not much greater than the motor horsepower or where the motor starts many times an hour. Magnetic starters shall be of the ratings given in Table 2.

3.4.2.3 Reduced-Voltage Starter Types. Reduced-voltage starters shall be used where full-starting motor current would result in more than a 30-percent transient voltage dip. The SkVA, dependent upon motor type, may range from 250 to 1,200 percent of the motor's full-load kVA, with 600 percent an average value.

Curves of maximum voltage dip values resulting from motor starting for a generator plant bus are shown in Figure 1. These curves are typical for generators having a rotating speeds of 600 to 1,800 rpm and which utilize exciters rotating at 1,200 rpm or higher when the generators are already loaded to 50 percent of their rating. Maximum voltage dip values for a unit substation secondary bus (with unlimited short-circuit capacity available from the primary system) are also shown in Figure 1.

A comparison of these curves shows that the voltage dip on starting is much greater on the generator bus than on the unit substation secondary bus; this is because generators have a much higher reactance than do transformers. Figure 2 shows an example of the difference in voltage dip dependent upon whether the motor is supplied by the unit substation or the generator. For other situations, refer to Industrial Power Systems Handbook by Donald Beeman for calculations of voltage drops due to motor starting.

Basic types of motor starters include autotransformer, primary resistor, part-winding, wye-delta, reactor, and solid-state. The autotransformer-type starters have two autotransformers connected in an open-delta configuration. This configuration provides one reduced-voltage step, usually 50, 65, or 80 percent of full-line voltage as the first step and 100 percent of full-line voltage as the second step. Connection should be made to the lowest reduced-voltage tap which will deliver the required starting torque. Although the autotransformer starter consumes the least power of all starter types, it is, in general, an open transition-type starter. This type starter causes the motor to be completely disconnected from the line during voltage transition and, therefore, causes a second large voltage dip on the line. This voltage dip can be eliminated by providing a closed-transition autotransformer starter using the Korndorfer connection. This connection scheme connects the two autotransformers into a series-reactor configuration during voltage transition, thereby keeping the motor continuously connected to the line and diminishing the second current peak. The following are types of reduced voltage starters:

a) Primary resistor-type starters have one or more resistors in series with the line and the motor. They can provide one or more steps of reduced voltage. This produces very smooth starting characteristics by keeping the motor connected to the line during all voltage transitions. Starting torque will usually be 50 percent or less of full-load torques. Resistor starters consume the most power of any starter type, but usually cost less than autotransformer starters in the smaller size ranges.

b) Part-winding-type starters can be used on motors which are designed for use on either of two voltages (e.g., 120/240 V and 230/460 V). These starters connect one section of the motor winding to the line initially, then, after a predetermined delay, connect the other section of the motor winding with the first winding section. Starting torque will be less than 50 percent of full-load torque. Part-winding starters can be used only with dual-voltage motors, and overcurrent relays must be provided for each section of the winding.

c) Wye delta-type starters operate by first connecting the motor windings to the line in a wye configuration, then, after a predetermined delay, by changing the connection of the motor windings to the line into a delta configuration. The reduced-voltage step of these starters applies 57 percent of full-line voltage to the motor windings and provides only 33 percent of full-load torque on starting. Wye-delta starters are recommended for use only with compressors and other motors that can be unloaded for starting or those which can tolerate the extremely low starting torque. Wye-delta starters can be provided with either open-transition operation or closed-transition operation.

d) Reactor-type starters have reactance in series with the line and motor. Although these starters keep the motor continuously connected to the line during voltage transition, the resulting starting curve is not as smooth as that provided by a primary resistor-type starter and are more expensive than other types of starters. Reactor starters are recommended for consideration only on large motors as defined by NEMA Standards Publication MG-1, Motors and Generators. Solid-state type starters have phase-controlled thyristors in series with the line and motor. The thyristors are continuously variable and provide the smoothest starting of all types. The current and starting torque are easily adjusted.

Solid-state starters usually cost more than comparable conventional starters and, therefore, are recommended for use only where the line current is critical or where repetitive motor starting limits the life of electromagnetic contacts.

Table 1
Standard Magnetic Controller Ratings for 600 Volts and Below[1]

NEMA size	Amperes[2]	Volts	Maximum hp rating		Maximum hp rating for plugging and jogging[3]	
			Single-phase	Three-phase	Single-phase	Three-phase
00	9	115	1/3	-	-	-
		200	-	1-1/2	-	-
		230	1	1-1/2	-	-
		460[4]	-	2	-	-
0	18	115	1	-	1/2	-
		200	-	3	-	1-1/2
		230	2	3	1	1-1/2
		460	-	5	-	2
1	27	115	2	-	1	1
		200	-	7-1/2	-	3
		230	3	7-1/2	2	3
		460	-	10	-	5
2	45	115	3	-	2	-
		200	-	10	-	7-1/2
		230	7-1/2	15	5	10
		460	-	25	-	15
3	90	200	-	25	-	15
		230	-	30	-	20
		460	-	50	-	30
4	135	200	-	40	-	25
		230	-	50	-	30
		460	-	100	-	60
5	270	200	-	75	-	60
		230	-	100	-	75
		460	-	200	-	150
6	540	200	-	150	-	125
		230	-	200	-	150
		460	-	400	-	300
7	810	200	-	-	-	-
		230	-	300	-	-
		460	-	600	-	-
8	1215	200	-	-	-	-
		230	-	450	-	-
		460	-	900	-	-
9	2250	200	-	-	-	-
		230	-	800	-	-
		460	-	1600	-	-

1 From NEMA, ICS2-78, Industrial Control Devices, Controllers and Assemblies.
2 Continuous current rating for enclosed general-purpose controllers.
3 An example is plug stop or jogging (inching duty) which requires continuous operations with more than five openings and closings per minute.
4 Values for 575 V are the same as shown for 460 V.

Table 2
Standard Manual Controller Ratings for 600 Volts and Below[1]

NEMA size	Volts	Maximum horsepower rating	
		Single-phase	Three-phase
M-0	115	1	–
	200	–	3
	230	2	3
	460[2]	–	5
	115	2	–
	200	–	7-1/2
	230	3	7-1/2
	460	–	10
M-1P	115	3	–
	200	–	–
	230	5	–
	460	–	–

[1]From NEMA ICS2-78, Industrial Control Devices, Controllers and Assemblies.
[2]Values for 575 V are the same as shown for 460 V.

3.4.2.4 Reduced-Voltage Starter Selection. Select the type of starter to be used after consideration of the required starting torque, supply line limitations, required acceleration smoothness, power factor, energy consumption, and maintenance requirements. Consider a closed-transition type starter for all large motors as defined by NEMA MG-1.

3.4.2.5 Thermal-Magnetic Type. Consider use of thermal-magnetic circuit breakers for protection of all high-efficiency motors, motors with a Code H or higher locked-rotor value, and motors with a locked-rotor current greater than 600 percent of the full-load current.

3.4.2.6 Motor Control Centers. Generally, motor control centers shall be NEMA Class 1, Type B. Selection of motor control centers and types is covered in the NAVFAC DM-3 series.

3.4.3 Receptacles. Generally, receptacles for installation on 15- and 20-A branch circuits shall be of the grounding type with the grounding contacts effectively grounded and shall conform to requirements of Underwriters Laboratories Inc. (UL) UL 498, Attachment Plugs and Receptacles, and NEMA WD-1, General Requirements for Wiring Devices. In certain areas, provide ground-fault circuit-interrupting receptacles and isolation receptacles as required by the NEC.

3.4.3.1 Locking Type. Locking-type receptacles shall be used where positive engagement of plug is required or where a strain on the portable cord can be anticipated.

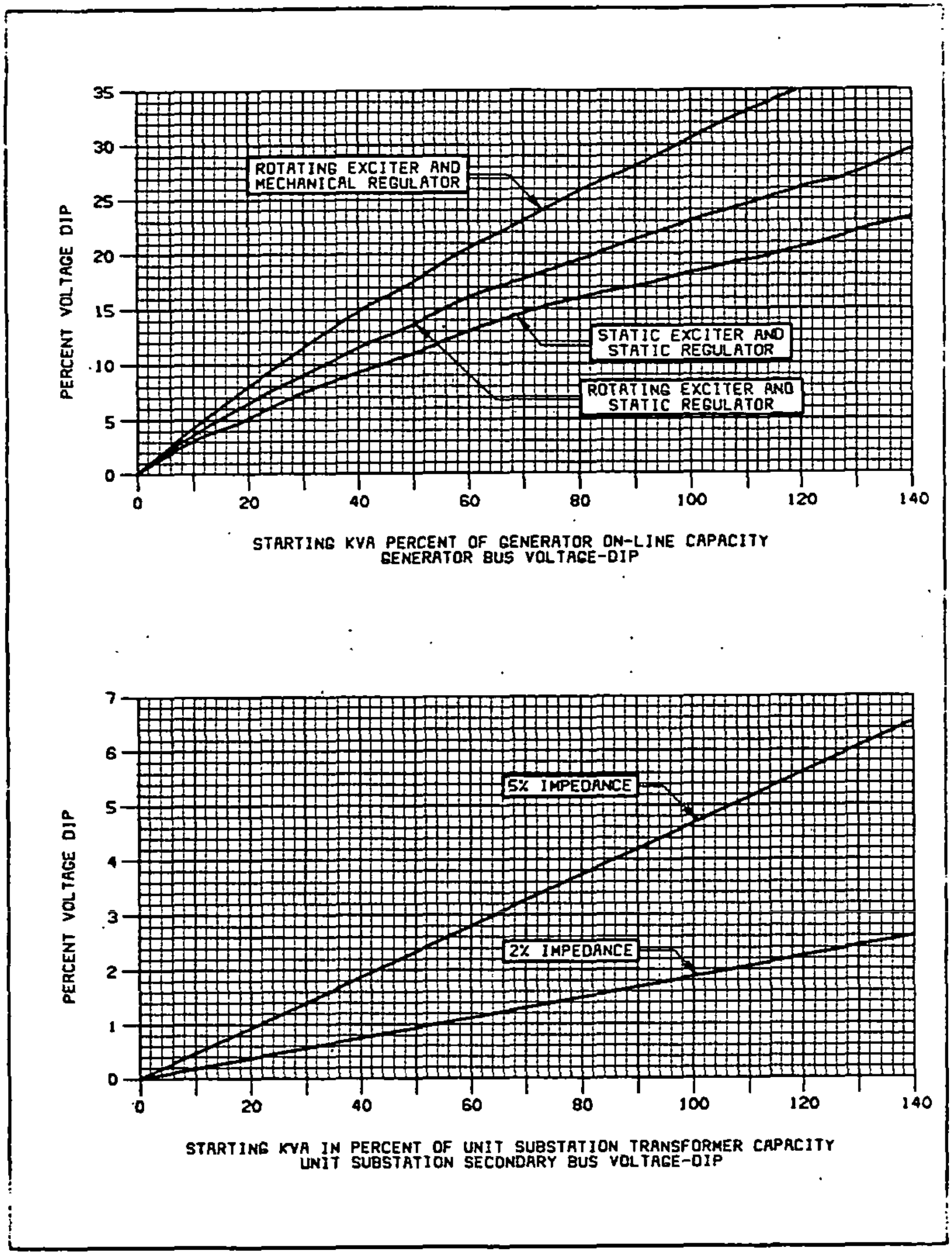
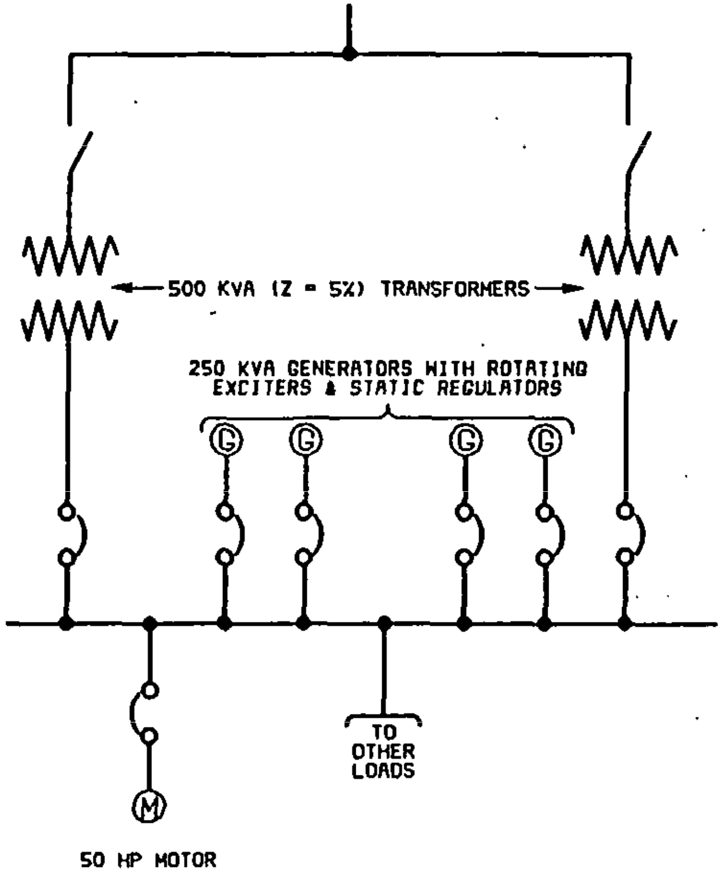


Figure 1
Motor-Starting Voltage Dips



ASSUME STARTING KVA (SKVA) = 6 X MOTOR HP FOR FULL VOLTAGE STARTING

GENERATOR SOURCE

SKVA IN PERCENT OF GENERATOR ON-LINE CAPACITY = $\frac{(6 \times 50 \text{ HP})}{(250 \text{ KVA})} \frac{(100)}{(4)} = 30\%$

FROM FIGURE 1 FOR AN ABSCISSA OF 30%, THE ORDINATE = 9% VOLTAGE DIP

SUBSTATION SOURCE

SKVA IN PERCENT OF SUBSTATION TRANSFORMER CAPACITY = $\frac{(6 \times 50 \text{ HP}) \quad (100)}{1{,}000 \text{ KVA}} = 30\%$

FROM FIGURE 1 FOR AN ABSCISSA OF 30%, THE ORDINATE = 1.4% VOLTAGE DIP

MAXIMUM MOTOR STARTING DIP = 9% WHEN A GENERATOR SOURCE IS USED

Figure 2
Voltage Dip on a Bus from Full-Voltage Starting

3.4.3.2 Enclosures. Enclosures shall be UL labeled for damp locations, wet locations, enclosed and gasketed, or explosion proof, as required, in damp, wet, or hazardous locations (refer to the NEC).

3.5 Lighting Systems. The design of interior lighting systems and lighting intensities shall be in accordance with MIL-HDBK-1190 and the Illuminating Engineering Society of North America (IES) Lighting Handbook. For lighting levels, luminaire types for special areas, and particular requirements, consult criteria for the specific facility.

3.5.1 Architectural Requirements. Lighting systems shall be coordinated with building designs for aesthetic and decorative effects, within the limits of visibility, visual comfort, economics, and energy conservation.

3.5.2 Design Analysis. Lighting calculations shall adhere to the established procedures of the IES as set forth in the IES Lighting Handbook. For general applications, average illumination may be calculated by the use of room cavity ratios and luminaire coefficients of utilization (zonal-cavity method).

3.5.3 Visibility. Luminaire placement and candlepower distribution shall be selected to minimize veiling reflections. Veiling reflections reduce the contrast of the components of the task and make seeing the task more difficult. Light coming over the workers' shoulders or from the sides generally produces better visibility than light coming from the front of the workers (offending zone). Equivalent Sphere Illumination (ESI) can be made when the specifics of the task are known, along with a knowledge of the task background and luminaire candlepower distribution and location in relation to the task. Generally, such detailed analyses will be unnecessary unless specifically required.

3.5.4 Visual Comfort Probability. Luminaire placement, candlepower distribution, and luminance ratios shall be selected to minimize discomfort glare. Discomfort glare is produced by a high brightness within the field of view. Visual comfort probability may be determined by making a VCP analysis or by requiring that the luminaire has a minimum VCP of 70 and also meets the other luminance requirements for visual comfort required in the IES Lighting Handbook.

3.5.5 Economics. For a large building, a comprehensive lighting study shall be required from an economic viewpoint to aid in the selection of lighting sources and sizes of lamps. When studying alternatives, consider the initial investment, life span of the installation, energy expense, cost of replacing light sources at the end of effective life, and cleaning cost. Life-cycle costs shall be calculated in accordance with NAVFAC P-422, Economic Analysis Handbook. Selection of the most economical alternative shall be based on the maximum luminous flux (lumens) per uniform annual cost.

3.5.6 Energy Conservation. Means shall be provided to reduce general lighting operating intensities in accordance with the criteria of MIL-HDBK-1190. These methods, fully covered by MIL-HDBK-1190, include reduction by manually turning off selected luminaires by the use of multiple switching circuits and time or photoelectric control. Multiple switching circuits can utilize alternative switching of luminaires, inboard-outboard switching of multitube fluorescent luminaires, local switching for task control, perimeter lighting control adjacent to glassed areas to take advantage of daylight, and use of Silicon-Controlled Rectifier (SCR) dimmers where economically feasible. Other methods include the use of lower wattage lamps or the provision of ceiling construction which easily accommodates luminaire relocation. Energy conservation methods shall apply not only to administrative areas but to all areas with illumination levels of 30 or more footcandles (30 dekalux).

3.5.7 Lighting Source. When selecting lighting sources for interior systems, the most important aspects are the characteristics of the source; however, also consider stroboscopic effect, radio frequency interference, chromacity, and color rendition.

3.5.7.1 Characteristics. Characteristics of light sources are given in Table 3. The light source and ballast used should be the most energy-conserving types consistent with usage.

3.5.7.2 Recommended Sources for Specific Task Areas. Table 4 gives the recommended usage for specific task areas.

3.5.7.3 Color Rendition. Unless there is a need for color matching, color rendition need not be considered. Where the color rendition of High-Pressure Sodium (HPS) lamps is unacceptable, metal halide lamps should be used if the available lamp wattage is suitable for the area. Consider the use of a combination HPS and metal halide lamps. The use of mercury vapor lamps is discouraged due to poor efficiency and lumen maintenance.

3.5.7.4 Chromacity. Chromacity within areas shall always be considered. Once the adaptation has been made to a lighting system of any color temperature, user acceptance is greater when another color source is not introduced. In a shop area using HPS lamps, the small office and toilet spaces commonly associated with the area should also use HPS lamps. If fluorescent lamps must be used in such an area, they shall be the warm-white type. The surrounding color environment (painted walls, ceiling, and floor) shall be compatible with the chromacity of the selected source.

3.5.7.5 Radio Frequency Interference. Fluorescent fixtures can be provided with shielded enclosures and filtered ballasts for use in areas where radio frequency interference must be minimized, for example, in an instrument calibration shielded room (refer to NAVFAC DM-12.01).

3.5.7.6 Stroboscopic Effect. Except for high-speed photography, rotating machinery, and other rare situations, stroboscopic effect generally will not be a problem. Flicker Index has been established by the IES as the measure of stroboscopic effect.

Table 3
Characteristics of Light Sources

Characteristics	Light Sources				
	High-intensity discharge (HID)[1]			Fluorescent	Incandescent
	HPS	Metal halide	Mercury vapor		
Luminous efficacy (lumens/watt)[2]	60-140	65-110	30-60	55-80	15-25
Lumen maintenance	Good	Fair	Poor	Fair	Good
Lamp life (1000 hours)	16-24	10-20	12-24	10-20	1-4
Lamp life[3] (years)	4-6	2.5-5	3-6	2.5-5	0.25-1
Start-up time (minutes)	2-4	3-5	5-7	____	____
Restrike time (minutes)	1-3	8-10	3-8	____	____
Color rendition	Fair	Good	Fair	Good	Good
Neutral surface color effect	Yellow-pink	White	White	Blue-white	Yellow-white

1 Incandescent safety lighting is required in large areas or corridors. For areas where HPS fixtures are used, consider installing emergency light sets with a 5-minute time delay off to take care of the restrike or start-up time. For other HID lamps, longer time delays should be provided.
2 Ballast losses are included.
3 Computed based on 4,000 burning hours a year.

Table 4
Recommended Sources for Specific Task Areas

Task area	Light source
Office areas	Fluorescent[1]
Low-bay shop areas[2]	Fluorescent, high-pressure sodium[5]
Medium-and high-bay shop areas[3]	High-pressure sodium[4]

1 In areas with ceilings 10 ft (3 m) or lower, use recessed fixtures with prismatic diffusing panels.
2 Ceilings less than 15 ft (4.5 m).
3 Ceilings of 15 ft (4.5 m) or higher.
4 In areas with ceilings of less than 25 ft (7.6 m), use 250 watt or smaller lamps. For ceiling of 25 ft or higher, use 400-W lamps.
5 High-pressure sodium sources for low-bay applications must be designated as low-bay high-pressure sodium.

3.5.7.7. Transient Voltages. Lighting sources shall be able to withstand transient voltages in accordance with IEEE 587, Guide for Surge Voltages in Low-Voltages AC Power Circuits, Category A, for normal and common modes.

3.5.7.8 Harmonic Currents. Lighting sources with high harmonic current distortion shall not be used with dedicated generators where the lighting sources constitute a sizable portion of the load. Under such conditions, the harmonic current distortion will cause nonsinusoidal voltage distortion, which may cause unsatisfactory operation of connected loads.

3.5.7.9 Sources Not Recommended. Incandescent lighting shall not be used, unless no other type of light source is suitable for the special conditions encountered. It has been included in Table 3 only for comparison purposes. Aesthetic reasons are not acceptable for using a short life span source of such low luminous efficacy. Low-pressure sodium lighting is not included as the color is monochromatic and, therefore, is not suitable for general use.

3.5.8 Luminaires. In general, luminaires shall conform to NFGS-16510, Interior Lighting. Particular effort shall be made to reduce the number of luminaire types in any one facility, building, or project, so that the number of spare part replacements required for maintenance will be kept to an absolute minimum. Luminaires, not otherwise covered by this specification, shall be manufacturers' standard types.

3.5.8.1 Architectural Criteria. The aesthetics of the luminaire shall be compatible with the area in which it is located.

APPENDIX A
INTERNATIONAL SYSTEM OF UNITS (SI) CONVERSION FACTORS

QUANTITY	U.S. CUSTOMARY UNIT	INTERNATIONAL (SI) UNIT	APPROXIMATE CONVERSION
LENGTH			
	foot(ft)	meter(m)	1 ft = 0.3048 m
	foot(ft)	millimeter(mm)	1 ft = 304.8 mm
	inch(in)	millimeter(mm)	1 in = 25.4 mm
AREA	square yard(yd^2)	square meter(m^2)	1 yd^2 = 0.836 127 m^2
	square foot(ft^2)	square meter(m^2)	1 ft^2 = 0.092 903 m^2
	square inch(in^2)	square millimeter(mm^2)	1 in^2 = 645.16 mm^2
VOLUME	cubic yard(yd^3)	cubic meter(m^3)	1 yd^3 = 0.764 555 m^3
	cubic foot(ft^3)	cubic meter(m^3)	1 ft^3 = 0.028 317 m^3
	cubic inch(in^3)	cubic millimeter(mm^3)	1 in^3 = 16,387.1 mm^3
CAPACITY	gallon(gal)	liter(l)	1 gal = 3.785 41 l
	fluid ounce(fl oz)	milliliter(ml)	1 fl oz = 29.5735 ml
VELOCITY, SPEED	foot per second (ft/s or fps)	meter per second(m/s)	1 ft/s = 0.3048 m/s
	mile per hour (mile/h or mph)	kilometer per hour (km/h)	1 mile/h = 1.609 344 km/h
ACCELERATION	foot per second squared(ft/s^2)	meter per second squared(m/s^2)	1 ft/s^2 = 0.3048 m/s^2
MASS	short ton(2000lb)	metric ton(t) (1000 kg)	1 ton = 0.907 185 t
	pound(lb)	kilogram(kg)	1 lb = 0.453 592 kg
	ounce(oz)	gram(g)	1 oz = 28.3495 g
DENSITY	ton per cubic yard(ton/yd^3)	metric ton per cubic meter(t/m^3)	1 ton/yd^3 = 1.186 55 t/m^3
	pound per cubic foot(lb/ft^3)	kilogram per cubic meter(kg/m^3)	1 lb/ft^3 = 16.0185 kg/m^3
FORCE	ton-force(tonf)	kilonewton(kN)	1 tonf = 8.896 44 kN
	kip(1000 lbf)	kilonewton(kN)	1 kip = 4.448 22 kN
	pound-force(lbf)	newton(N)	1 lbf = 4.448 22 N
MOMENT OF FORCE TORQUE	ton-force foot (tonf ft)	kilonewton meter(kN m)	1 tonf ft = 2.711 64 kN m
	pound-force inch(lbf in)	newton meter(N m)	1 lbf in = 0.112 985 N m

g) Restrike Options. Consider provision of a quartz lamp within the HID fixture that will automatically illuminate when the HID arc extinguishes during normal operation. The quartz lamp can also be specified to illuminate until the HID source attains 60 percent of its rated lumen output. The use of instant-restrike systems to facilitate rapid restrike is not recommended. Instant-restrike systems keep the arc tube hot.

3.6 Grounding. All electrical distribution systems, except those for ship power on piers and wharves, shall be provided with a grounded neutral connection. Each voltage level shall be grounded independently. Each voltage level grounding point should be located at the power source. Low-voltage systems shall be solidly grounded. Figure 3 indicates minimum grounding features. An equipment grounding wire shall be provided in accordance with NFGS-16402. For detailed grounding information, refer to MIL-HDBK-419, Grounding, Bonding, and Shielding for Electronic Equipment and Facilities, and IEEE 142.

3.6.1 Uninterruptible Power Supply (UPS) Grounding. Insulated and isolated ground systems shall be installed in conformance with the NEC. In order to eliminate ground potential differences in computer rooms and other similar areas, the following general criteria should be used:

3.6.1.1 Central Ground Point. Establish a central ground point for all systems.

3.6.1.2 Transient Suppression Plate. Install a 4-ft^2 (1.22 m^2) metal transient suppression plate beneath the raised floor.

3.6.1.3 Ground Mat. Provide a ground mat beneath the raised floor, and bolt it to the raised floor stringers.

3.6.1.4 Power Panels. Install all power panels in the room on the same wall, with no more than 2 ft (0.61 m) between panels. Connect all power panel enclosures together with conducting straps.

3.6.1.5 Additional Information. For detailed information, refer to Department of Commerce, Federal Information Processing Standards (FIPS) publication, FIPS PUB 94, Guideline on Electrical Power for ADP Installations.

APPENDIX A
AMERICAN WIRE GAGE (AWG) CONVERSION.

AWG	kCM	mm^2
20	1.02	0.517
18	1.62	0.823
16	2.58	1.31
14	4.11	2.08
12	6.53	3.31
10	10.4	5.26
8	16.5	8.37
6	26.2	13.3
4	41.7	21.2
2	66.4	33.6
1	83.6	42.4
1/0	105.6	53.5
2/0	133.1	67.4
3/0	167.8	85.0
4/0	211.6	107.0

Section 4: COMMUNICATION, SIGNAL, AND ALARM SYSTEMS

4.1 Communication Systems. The required communication systems shall be determined by the specific criteria for various types of facilities. Refer to NAVFAC DM-22 through DM-37 (REFERENCES) for a list of specific criteria.

4.1.1 Telephone Systems

4.1.1.1 System Selection. From criteria presented in NAVFAC DM-4.07, select a telephone system that will meet the requirements of the projected building.

4.1.1.2 Empty Conduit System. On drawings, indicate the locations of telephone outlet boxes, cabinets, backboards, equipment rooms, batteries, and similar components. Connect all system components by an empty conduit system. Prepare a riser diagram, indicating on it the sizes of conduits in accordance with Table 5. In general, a 4-ft x 8-ft x 3/4-in. (1-1/4-m x 1-1/2-m x 19-mm) painted wood backboard located in an equipment room is preferable to cabinets. Where cabinets must be used, they should be in accordance with Table 6. These tables only apply to single-circuit telephones. Where six-button or call director telephones will be installed, minimum conduit sizes should be 3/4 in. (19 mm) for six-button units and 1-1/4 in. (31.75 mm) for call director units. Backboards should be installed for such systems. The local telephone company should be consulted to be sure that the backboard size or closet area is adequate. A 120 V, 20 A, single-phase, 60 Hz power source should be provided adjacent to the telephone backboards. Pull wires should be provided in all empty conduits.

Table 5
Conduit Sizes for Telephone Systems

Location	pairs	Number of Conduit size in inches	(mm)
From outlet to backboard or cabinet	1	1/2	(12.7)
	2-3	3/4	(19)
	4-5	1	(25.4)
	6-8	1-1/4	(31.75)
Between backboards or cabinets	To 25	1-1/4	(31.75)
	50	1-1/2	(38.1)
	100	2	(50.8)
	200	2-1/2	(63.5)
	400	3	(76.2)
	600	3	(76.2)
	900	4	(101.6)
	1200	4	(101.6)

Table 6
Cabinet Sizes for Telephone Systems

Number of Circuits	Cabinet size[1] in inches (millimeters) W x H x D
10	10 x 12 x 4 (254 x 305 x 102)
15	10 x 16 x 4 (254 x 406 x 102)
25	12 x 24 x 4 (305 x 610 x 102)
50	16 x 28 x 5 (406 x 711 x 127)
100	24 x 32 x 5 (610 x 813 x 127)
150	36 x 36 x 5 (914 x 914 x 127)
200	30 x 54 x 5 (762 x 1,372 x 127)
250	30 x 54 x 5 (762 x 1,372 x 127)
300	36 x 60 x 8 (914 x 1,524 x 203)
400	48 x 60 x 8 (1,219 x 1,524 x 203)

[1]The minimum thickness of metal cabinets should conform to the NEC.

4.1.2 Intercommunications and Sound Systems. In selecting intercommunications and sound systems refer to the telephone system criteria of this section and NAVFAC DM-4.07. Provide a separate raceway for each system. Locate the devices on plans and show the number of wires in raceways on riser diagrams.

4.1.3 FM and TV Master Antenna, Closed-Circuit TV, and Central Dictation Systems. In selecting the FM and TV master antenna, closed-circuit TV, and central dictation systems, refer to the telephone system criteria of this section (refer to NAVFAC DM-4.07). Provide a separate raceway for each system. Locate the cabinets, boxes, and devices on plans, and show the number of wires in conduit on the riser diagram.

4.2 Signal Systems. The signal systems requirements for a specific facility shall be determined by its specific criteria (refer to NAVFAC DM-22 through DM-37). Locate the control panel, boxes, and other devices on plans, and show the number of wires in conduit on the riser diagram.

4.2.1 Nurse Call and Doctor Paging and Register Systems. Nurse call and doctor paging and register systems shall be provided in accordance with the criteria in NAVFAC DM-4.07. Auxiliary emergency power to this system shall also be provided.

4.2.2 Clock and Programming Systems. Select a clock and programming system from the criteria in NAVFAC DM-4.07, and show the locations of equipment on drawings.

4.3 Alarm Systems. The alarm system requirements for various types of facilities shall be determined by their criteria (refer to the apparent NAVFAC criteria manuals). Ascertain system requirements from NAVFACENGCOM or other authority to ensure integration with associated systems and operating procedures. Provide a separate raceway for each alarm system if combined systems are not provided. Locate the devices on the plans, and show the number of wires in raceways on the riser diagram. Auxiliary emergency power shall be provided for all alarm systems.

4.3.1 Fire Alarm Systems. For information on fire alarm systems, refer to MIL-HDBK-1008, Fire Protection for Facilities Engineering, Design, and Construction.

4.3.2 Watchman Tour Systems. Select electronic or manual systems from criteria in NAVFAC DM-4.07, and consider a combination of fire alarm systems with report systems for the watchman.

4.3.3 Disaster Alarm Systems. For actuating devices, signal devices, power sources, and controls, refer to NAVFAC DM-4.07.

4.4 Remote Control and Monitoring Systems. Safer and more economical operation can often be obtained by installing well-designed systems to bring operations for an entire section of a facility under the control of a duty dispatcher at the central supervisory control station. Such systems shall include any necessary protective shutdown devices and alarms to alert the dispatcher of abnormal situations as soon as they develop. These systems shall also make it possible for the dispatcher to obtain any readings such as pressure and tank gauges and to operate equipment such as pumps and valves, by the use of suitable communication links as described in NAVFAC DM-4.07.

Section 5: EMERGENCY POWER SYSTEMS

5.1 Criteria. The design of emergency power systems shall be in accordance with criteria in this section; MIL-HDBK-1190; IEEE 446, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications; NFPA 101; NFPA 110; and the NEC.

5.2 Essential Loads and Magnitudes. The operational loads and magnitudes shall be determined from criteria for specific buildings. Provide these loads with continuous energy. Selection of emergency power depends on capacities and required degrees of continuity of energy. Provide an Uninterruptible Power Supply (UPS) as required.

5.3 Minimum Essential Operating Electric Load. Estimate the minimum amount of power required to support the operational loads of the activity under conditions of minimum illumination. All convenience loads and other equipment loads having a large electric power demand (such as dry dock pumping, electric furnaces, electric welders, and wind tunnels) shall be scheduled to avoid concurrent operation.

5.4 Connection Ahead of Incoming Main Secondary Disconnecting Device. Certain emergency loads may be connected ahead of the building's incoming main secondary disconnecting device where no emergency power is provided. This arrangement permits continued operation in the event of electric faults within the building (refer to the NEC).

5.5 Alternate Service. Standby service of sufficient capacity to serve all emergency loads shall be provided .

5.5.1 Interconnections. This emergency service shall be electrically remote from the main service.

5.5.2 Switches. An automatic transfer switch shall be provided with a preferred position, connected to the main service.

5.6 Batteries. Batteries may be used as emergency sources of supply for loads served either by alternating current or by direct current. Battery selections depend on the following use requirements.

a) Individual Emergency Lighting Units. Individual emergency lighting units shall be used for illumination of small areas, such as corridors and stairs. Consider dual-function luminaires for general and emergency illumination by providing integral power supply units. Consider using exit signs for egress illumination by providing integral lamps and emergency power supply.

b) Central Lead-Acid Batteries. Central lead-acid (calcium-type) battery system shall be used for loads with large in-rush current or for general lighting and power application. This type of battery system has good electrical qualities but requires a certain amount of maintenance.

c) Central Nickel-Cadmium Batteries. A central nickel-cadmium battery system shall be used for applications where special considerations warrant. These batteries have a high initial cost which does not justify general use.

5.7 Emergency Generator. Where emergency generators are required for loads less than 25 kVA, gasoline or Liquified Petroleum Gas (LPG) engines may be used. For loads greater than 25 kVA, diesel engines shall be used. Steam turbine generators may be used if steam is being produced for on-site processes.

5.7.1 Generator Starting. Depending on the maximum permissible elapsed time between blackout and power restoration, select the engine according to the following requirements:

a) Automatic Starting. Automatic starting units are available to start, accelerate to rated speed, and assume load within 10 seconds. The interruption time will be 12 to 17 seconds depending on the time delay used to allow for electric power transients.

b) Stored-Energy Starting. Stored-energy starting shall be used where only short interruptions of power are permissible, such as for protective lighting systems. Energy shall only be stored in batteries. The use of flywheels, pneumatic pressure vessels, or similar units to provide stored energy is not acceptable. The stored energy is utilized to provide service during interruption of prime power service and until emergency generation is available. Where no power interruptions and quality power are required, refer to NAVFAC DM-4.01, Electrical Engineering Preliminary Design Considerations.

5.7.2 Generator Sizing. Loads to consider in sizing generators include lighting, computers, motors, Uninterruptible Power Supply (UPS) systems, pumps, fans, and static loads such as resistance heating. Motor load parameters to be considered include voltage, phase, locked-rotor KVA, full or reduced-voltage starting, power factor, and efficiency. For specific generator sizing calculations, refer to generator manufacturer's instructions.

5.8 Uninterruptible Power Supply. Where required, UPS systems will be furnished by the Government. Installation shall be in accordance with NAVFAC DM-4.01. For UPS systems in electronic facilities, refer to NAVFAC DM-12.01.

5.9 Location. Equipment shall be located as close to the load as possible. When located outdoors, units shall be mounted in a secure area not subject to weather hazards such as areas lying within a normal flood plain.

Section 6: ROADWAY LIGHTING

6.1 Lighting System. A roadway lighting system is necessary at a naval facility for safe movement of vehicles and pedestrians over frequented routes and places (refer to MIL-HDBK-1190 and NFGS-16530, Exterior Lighting).

6.1.1 Application. Lighting shall be provided for all primary and secondary roadways, piers, and other areas where pedestrian or vehicular traffic occurs.

6.1.2 Sources. Use High-Pressure Sodium (HPS) lighting as it is the most energy-conserving source which has an acceptable color rendition. For those cases where the yellow-pink color of HPS is objectionable, use metal halide lamps. Although the monochromatic color of Low-Pressure Sodium (LPS) lighting is unacceptable for general use, consider use of LPS lamps for installations in the close vicinity of observatories. Mercury vapor, fluorescent, and incandescent lighting sources should be used only where their poor efficiencies can be tolerated due to the need for a special lighting effect. See Table 3 for characteristics of light sources.

6.1.3 Design. Roadway lighting shall be designed in accordance with the procedures outlined in para. 6.5.4 of IES RP-8, Standard Practice for Roadway Lighting. Refer to MIL-HDBK-1005/5, General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas for NAVFAC guidance on laying out roadside utilities.

6.1.3.1 Roadway and Area Classification. Waterfront and main streets and fitting-out and supply piers shall be classified as local roadways in an intermediate area. Cross streets; residential streets; main streets in secondary naval facilities; and fleet-landing, hospital, submarine, destroyer, and POL piers shall be classified as local roadways in a residential area.

6.1.3.2 Light Shielding. Roadway lighting units in the vicinity of airfields shall be aimed or shielded so that no direct or stray light is emitted above the horizon to interfere with the nighttime visibility of control tower operators, and so that they will not be confused with runway navigational lights by incoming pilots.

6.1.3.3 Physical Interference. Roadway lighting standards (along tow-ways; waterfront streets; and areas used for general repair, fitting out, and supply) shall not interfere with cranes and other large equipment.

6.2 Wiring Systems. Multiple systems are the preferred method of lighting. All new systems should be the multiple-system type.

6.2.1 Multiple Systems. Multiple wiring systems shall be installed with individual lights switched by integral photoelectric devices, except where its use is clearly impractical. This system provides a high power factor; only one luminaire or a minor part of the system will black out in the event of control failure; and circuits are simple.

6.2.2 Series Systems. This type of system shall be used only for short extensions to existing systems where its use is clearly more economical than a multiple system. New series systems may be used only where specifically authorized by NAVFACENGCOM. Series systems have the disadvantages of high cost; a low power factor; a total blackout possiblity in the event of a control failure; required complex accessory equipment, including the central constant-current transformer and individual film cutouts and isolating transformers which provide a high-voltage hazard. There can also be difficulty in locating faults.

6.2.3 Electric Distribution. Electric distribution systems for roadway lighting shall conform to applicable criteria in NAVFAC DM-4.02. Paras. 6.2.3 and 6.2.3.2 provide information applies to each system part.

6.2.3.1 Lines. Where distribution lines run along entire lengths of roadway lighting circuits, it is economical to run conductors by the use of the poles or ducts of existing electric distribution system circuits. Where this situation does not exist, use new overhead or underground installation, as dictated by site conditions.

a) Overhead Method. The overhead method is the preferred and usually the most economical way of distribution. For characteristics, refer to NAVFAC DM-4.02. The minimum size of conductors for overhead distribution shall be No. 6 AWG (13.3 mm^2) medium, hard-drawn copper for Grade B construction and No. 8 AWG (8.37 mm^2) medium, hard-drawn copper for Grade C construction. Aluminum conductors and other materials such as copper-clad steel shall have a minimum size equivalent to copper as required by the NESC, which also gives grade definitions.

b) Underground Method. Use the underground method for principal streets, piers, and loading areas where required to avoid physical interferences and where required for aesthetic purposes, such as at certain housing areas. Follow the criteria in NAVFAC DM-4.02 and consider direct burial, where applicable.

6.2.3.2 Equipment Installation. Depending on location conditions and the type of distribution system, locate equipment in the following manner:

a) Overhead Method. Supply from the secondary of pole-mounted transformers. Overhead installation is the least expensive distribution system and may be desirable when electric distribution lines are run on the same poles as the roadway lighting units.

b) Underground Method. Supply from building secondary circuits or pad-mounted compartmental-type transformers where loads require a dedicated lighting service transformer.

6.2.4 System Control

6.2.4.1 Automatic Control. Use automatic controls for unattended roadway lighting systems and where manual control is not appropriate. Provide manual control for each circuit to override automatic devices for testing and emergency. Select from the following:

a) Time Switches. Use time switches for installations having predetermined hours of use. This type of control will require resetting after every electric power failure unless a spring carry-over feature is provided. Use an astronomical dial to compensate automatically for seasonal daylight changes. Timers shall be equipped with a 4-hour minumum back-up mechanism for short power outages affecting exterior street and area lighting.

b) Photocells. Special consideration shall be given to the locations of photocell units for system control. Light-sensitive devices shall face north to avoid sunrays and shall be mounted in a clear and unobstructed area. Time-delay devices shall be provided to prevent irregular operation from transient lights or shadows.

6.2.4.2 Manual Control. Manual controls shall be used for attended outdoor lighting installations. Manual control is not recommended for large or diversified installations, because individual switching becomes complicated and overall switching does not allow for different area requirements.

6.2.4.3 Group Control. Group control shall be used for existing series lighting circuits which use pilot wire, cascading, or carrier frequency where more than one constant-current transformer is controlled. The use of group control is discouraged.

6.2.5 Luminaire Control. Individual control by photoelectric cells should be provided for most multiple systems. This control is independent of dusk and dawn time changes, and failure of a photocell will cause outage of only one fixture. Individual control actuates roadway lighting units whenever daylight reaches preset intensities.

6.3 Auxiliary Equipment. Roadway lighting auxiliary equipment shall be selected as indicated in paras. 6.3.1 and 6.3.2.

6.3.1 Multiple Systems

6.3.1.1 Ballast Types. Where available, autoregulated-type ballasts shall be selected for use with all HID sources. This type is available for mercury vapor, metal halide, and larger HPS lamps. An autoregulated-type ballast is also known as constant wattage (mercury vapor), lead (HPS), and peak lead (metal halide). Power factor is high; starting current is less than the operating current; and voltage input range is plus or minus 10 percent. Where autoregulated ballasts are not yet available, as in the lower wattage HPS types, high-power-factor autotransformer or lag-type ballasts should be used.

Section 8: REQUIREMENTS FOR EARTHQUAKE AREAS

8.1 Criteria. The electrical design and installation shall be in accordance with NAVFAC P-355, Seismic Design for Buildings and P-355.1, Seismic Design Guidelines for Essential Buildings. The design shall be consistent with the degree of structural safety for which buildings or facilities in earthquake areas are designed. Refer to data given in NAVFAC DM-11.01, Tropical Engineering, when such construction is required in tropical and typhoon or hurricane areas. Provide emergency generator unit(s) to supply essential loads for facilities in accordance with Section 10 of NAVFAC P-355. These units should be located within the building served.

8.2 Interior Distribution

8.2.1 Luminaires. The luminaires, appurtenances, and outlet boxes shall be secured to prevent detachment when subjected to earthquake vibrations. All lenses shall be securely attached to the fixture housings by chains or wire rope or by similar means of sufficient size to prevent the lens from falling in the event it is jarred or vibrated loose from the fixture housing. A separate safety chain shall be provided to secure the fixtures and ballasts to building structural members. All installations shall be in accordance with NAVFAC P-355 (Section 8) and P-355.1.

8.2.2 Conduit. Except as limited by NAVFAC DM-11.01, rigid or intermediate steel conduit shall be considered for structural reasons in lieu of electrical metallic tubing. When steel conduit is embedded in concrete slabs, the outside conduit diameter shall not exceed 1/5 of the slab thickness, and conduits shall not be spaced closer than 5 diameters on centers, except at cabinet locations. At cabinet locations, design slab thickness shall be increased as necessary to prevent excessive loss of structural strength. Conduits and busways supported by hangers are subject to motions created by earthquakes, and sway bracing should be provided to prevent damage due to such motions.

8.2.3 Enclosures. Electrical equipment shall be in accordance with Section 8 of NAVFAC P-355.

8.3 Exterior Distribution

8.3.1 Overhead System. Overhead systems are the preferred method of distribution. Unless permitted or required by other criteria or regulations, the electric power distribution system should be installed overhead. When electric power is supplied by a public utility company only, its lack of redundancy shall not be used to establish the required redundancy for the on-station distribution system, since the power company has trained crews who can perform work on energized distribution systems and who can quickly restore service. Criteria for on-station redundancy should be established by the need for reliability and availability of the system and the required flexibility to permit repair work to be performed only on deenergized portions of the

6.4.5 Fiberglass. Fiberglass poles exhibit high-strength characteristics, are corrosion resistant, require minimal maintenance, and are usually cost competitive with other types of fabricated poles. Pole heights, however, are generally limited to less than 40 ft (12.2 m). A concrete base may be required.

Section 7: AREA LIGHTING

7.1 Area Lighting Systems. Floodlighting systems shall be provided for area lighting of storage yards, loading docks, nightwork areas, and protected areas to supplement roadway lighting.

7.1.1 General-Area and Sports Lighting. The design of area and sports lighting shall be in accordance with MIL-HDBK-1190.

7.1.2 Protective Lighting. The design of protective lighting shall be in accordance with MIL-HDBK-1013/1, Design Guidelines for Physical Security of Fixed Land-Based Facilities.

7.2 Sources. For selection of lighting sources, refer to para. 5.1.2.

7.3 Luminaires. Select types according to the floodlighting classifications given in NEMA FA-1, Outdoor Floodlighting Equipment.

7.3.1 Enclosures. NEMA designations shall be used. Select enclosures according to duties and consider initial costs and depreciation charges.

7.3.1.1 Heavy-Duty. NEMA Class HD, heavy-duty enclosed floodlights, shall be used for lighting piers, wharves, and areas where corrosion is a factor.

7.3.1.2 General Purpose. NEMA Class GP general-purpose enclosed floodlights shall be used where corrision is not a factor.

7.3.1.3 Open. NEMA Class O open floodlights shall be used for temporary construction where maintenance is not a factor.

7.3.1.4 Reflector Lamps. NEMA Class OI reflector lamps shall be used for portable and minor installations. This type of floodlighting has low initial costs, but high maintenance costs.

7.3.2 Beam Spread. Luminaires shall be determined according to the beam spread characteristics of NEMA classifications 1 through 6, from spotlights to floodlights.

7.4 Floodlighting Calculations. For the luminaire and source selected, ascertain photometric data including isocandle curves, beam lumens, and coefficient of beam utilization as necessary to calculate lumen distribution coverage.

7.4.1 Methods. Select a calculation method from either the Beam Lumen Method or the point-by-point method.

7.4.1.1 Beam Lumen Method. The beam lumen method shall be the method normally used.

7.4.1.2 Point-by-Point Method. Computer printouts are available from some manufacturers and provide an excellent means for establishing a point-by-point coverage where uniformity ratios must be kept within certain limits.

7.4.2 Intensities. Provide intensities in accordance with MIL-HDBK-1190 and MIL-HDBK-1013/1. Nightwork areas, including piers and loading platforms, may need to maintain an average horizontal illumination level of 10 footcandles when such criteria have been furnished by the using agency. Where no specific criteria are given in MIL-HDBK-1190 and MIL-HDBK-1013/1, use values recommended by IES including maximum-to-minimum uniformity ratios.

7.5 Special Considerations. Refer to Section 5 and paras. 7.5.1 through 7.5.4.

7.5.1 Glare. Select mounting heights that will result in minimum glare unless glare lighting is a requirement for protective lighting. For sports- lighting systems, keep glare to a minimum for both players and spectators.

7.5.2 Coverage. With the beam lumen method, ensure, by use of overlapping beam patterns, that uniformity and coverage are provided.

7.5.3 Stroboscopic Effect. Floodlighting of sports fields requires special considerations to avoid stroboscopic effects by the connection of light sources to alternating phases.

7.5.4 Wide-Area Coverage. Consider the use of high-mast lighting systems for area illumination using a minimum amount of luminaires and supports.

7.6 Wiring System. Use criteria for multiple roadway lighting systems (refer to para. 5.3.1). Make an economic study for optimum operating voltages. It may be more economical to increase voltages and to use incandescent floodlighting for systems that operate a few hours per year; however, this system may violate energy conservation requirements.

Section 8: REQUIREMENTS FOR EARTHQUAKE AREAS

8.1 Criteria. The electrical design and installation shall be in accordance with NAVFAC P-355, Seismic Design for Buildings and P-355.1, Seismic Design Guidelines for Essential Buildings. The design shall be consistent with the degree of structural safety for which buildings or facilities in earthquake areas are designed. Refer to data given in NAVFAC DM-11.01, Tropical Engineering, when such construction is required in tropical and typhoon or hurricane areas. Provide emergency generator unit(s) to supply essential loads for facilities in accordance with Section 10 of NAVFAC P-355. These units should be located within the building served.

8.2 Interior Distribution

8.2.1 Luminaires. The luminaires, appurtenances, and outlet boxes shall be secured to prevent detachment when subjected to earthquake vibrations. All lenses shall be securely attached to the fixture housings by chains or wire rope or by similar means of sufficient size to prevent the lens from falling in the event it is jarred or vibrated loose from the fixture housing. A separate safety chain shall be provided to secure the fixtures and ballasts to building structural members. All installations shall be in accordance with NAVFAC P-355 (Section 8) and P-355.1.

8.2.2 Conduit. Except as limited by NAVFAC DM-11.01, rigid or intermediate steel conduit shall be considered for structural reasons in lieu of electrical metallic tubing. When steel conduit is embedded in concrete slabs, the outside conduit diameter shall not exceed 1/5 of the slab thickness, and conduits shall not be spaced closer than 5 diameters on centers, except at cabinet locations. At cabinet locations, design slab thickness shall be increased as necessary to prevent excessive loss of structural strength. Conduits and busways supported by hangers are subject to motions created by earthquakes, and sway bracing should be provided to prevent damage due to such motions.

8.2.3 Enclosures. Electrical equipment shall be in accordance with Section 8 of NAVFAC P-355.

8.3 Exterior Distribution

8.3.1 Overhead System. Overhead systems are the preferred method of distribution. Unless permitted or required by other criteria or regulations, the electric power distribution system should be installed overhead. When electric power is supplied by a public utility company only, its lack of redundancy shall not be used to establish the required redundancy for the on-station distribution system, since the power company has trained crews who can perform work on energized distribution systems and who can quickly restore service. Criteria for on-station redundancy should be established by the need for reliability and availability of the system and the required flexibility to permit repair work to be performed only on deenergized portions of the system. Where the station has the capability of connecting to an on-station electric generating plant, construction of the on-station distribution system (vital electric power and communciations) should also conform to the structural and mechanical design of the electric generating plant.

8.3.2 Underground System. Where underground duct systems are permitted or required, a determination should be made whether or not they will contain electric power or communication lines required for vital operations. For those portions of the duct system containing lines for vital operations, consider the feasibility of providing reinforcing rods in the duct encasement and using rigid steel conduit in lieu of the types commonly used for underground ducts.

APPENDIX A
INTERNATIONAL SYSTEM OF UNITS (SI) CONVERSION FACTORS

QUANTITY	U.S. CUSTOMARY UNIT	INTERNATIONAL (SI) UNIT	APPROXIMATE CONVERSION
LENGTH			
	foot(ft)	meter(m)	1 ft = 0.3048 m
	foot(ft)	millimeter(mm)	1 ft = 304.8 mm
	inch(in)	millimeter(mm)	1 in = 25.4 mm
AREA	square yard(yd^2)	square meter(m^2)	1 yd^2 = 0.836 127 m^2
	square foot(ft^2)	square meter(m^2)	1 ft^2 = 0.092 903 m^2
	square inch(in^2)	square millimeter(mm^2)	1 in^2 = 645.16 mm^2
VOLUME	cubic yard(yd^3)	cubic meter(m^3)	1 yd^3 = 0.764 555 m^3
	cubic foot(ft^3)	cubic meter(m^3)	1 ft^3 = 0.028 317 m^3
	cubic inch(in^3)	cubic millimeter(mm^3)	1 in^3 = 16,387.1 mm^3
CAPACITY	gallon(gal)	liter(l)	1 gal = 3.785 41 l
	fluid ounce(fl oz)	milliliter(ml)	1 fl oz = 29.5735 ml
VELOCITY, SPEED	foot per second (ft/s or fps)	meter per second(m/s)	1 ft/s = 0.3048 m/s
	mile per hour (mile/h or mph)	kilometer per hour (km/h)	1 mile/h = 1.609 344 km/h
ACCELERATION	foot per second squared(ft/s^2)	meter per second squared(m/s^2)	1 ft/s^2 = 0.3048 m/s^2
MASS	short ton(2000lb)	metric ton(t) (1000 kg)	1 ton = 0.907 185 t
	pound(lb)	kilogram(kg)	1 lb = 0.453 592 kg
	ounce(oz)	gram(g)	1 oz = 28.3495 g
DENSITY	ton per cubic yard(ton/yd^3)	metric ton per cubic meter(t/m^3)	1 ton/yd^3 = 1.186 55 t/m^3
	pound per cubic foot(lb/ft^3)	kilogram per cubic meter(kg/m^3)	1 lb/ft^3 = 16.0185 kg/m^3
FORCE	ton-force(tonf)	kilonewton(kN)	1 tonf = 8.896 44 kN
	kip(1000 lbf)	kilonewton(kN)	1 kip = 4.448 22 kN
	pound-force(lbf)	newton(N)	1 lbf = 4.448 22 N
MOMENT OF FORCE TORQUE	ton-force foot (tonf ft)	kilonewton meter(kN m)	1 tonf ft = 2.711 64 kN m
	pound-force inch(lbf in)	newton meter(N m)	1 lbf in = 0.112 985 N m

APPENDIX A
INTERNATIONAL SYSTEM OF UNITS (Continued)

QUANTITY	U.S. CUSTOMARY UNIT	INTERNATIONAL (SI) UNIT	APPROXIMATE CONVERSION
PRESSURE, STRESS	ton-force per square inch ($tonf/in^2$)	megapascal(MPa)	1 $tonf/in^2$ = 13.7895 MPa
	ton-force per square foot ($tonf/ft^2$)	kilopascal(kPa)	1 $tonf/ft^2$ = 95.7605 kPa
	pound-force per square inch (lbf/in^2)	kilopascal(kPa)	1 lbf/in^2 = 6.894 76 kPa
	pound-force per square foot (lbf/ft^2)	pascal(Pa)	1 lbf/ft^2 = 47.8803 Pa
WORK, ENERGY, QUANTITY OF HEAT	kilowatthour(kWh)	megajoule(MJ)	1 kWh = 3.6 MJ
	British thermal unit(Btu)	kilojoule(kJ)	1 Btu = 1.055 06 kJ
	foot-pound-force (ft-lbf)	joule(J)	1 ft-lbf = 1.355 82 J
POWER, HEAT FLOW RATE	horsepower(hp)	kilowatt(kW)	1 hp = 0.745 700 kW
	British thermal unit per hour (Btu/h)	watt(W)	1 Btu/h = 0.293 071 W
	foot-pound-force per second (ft-lbf/s)	watt(W)	1 ft-lbf/s = 1.355 82 W
COEFFICIENT OF HEAT TRANSFER (U-value)	Btu per square foot-hour degree Fahrenheit(Btu/ft^2-hr°F)	watt per square meter kelvin (W/m^2K)	1 Btu/ft^2-h °F = 5.678 26 W/m^2K
THERMAL CONDUCTIVITY (K-value)	Btu per foot-hour degree Fahrenheit (Btu/ft-hr °F)	watt per meter kelvin (W/mK)	1 Btu/ft-h °F = 1.730 73 W/m.K

APPENDIX A
AMERICAN WIRE GAGE (AWG) CONVERSION.

AWG	kCM	mm^2
20	1.02	0.517
18	1.62	0.823
16	2.58	1.31
14	4.11	2.08
12	6.53	3.31
10	10.4	5.26
8	16.5	8.37
6	26.2	13.3
4	41.7	21.2
2	66.4	33.6
1	83.6	42.4
1/0	105.6	53.5
2/0	133.1	67.4
3/0	167.8	85.0
4/0	211.6	107.0

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101	Code for Safety to Life from Fire in Building and Structures
110	Emergency and Standby Power Systems

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DM-22	Petroleum Fuel Facilities
DM-23.01	Airfield Lighting
DM-23.02	Navigational and Traffic Aids
DM-23.03	Airfield Pavement and Construction Making
DM-24.01	Buildings and Other Structures
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DM-25.01	Piers and Wharves
DM-25.02	Dockside Utilities for Ship Service
DM-25.04	Seawalls, Bulkheads, and Quaywalls
DM-25.05	Ferry Terminals and Small Craft Berthing Facilities
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DM-26.01	Harbors
DM-26.02	Coastal Protection
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DM-26.04	Fixed Moorings
DM-26.05	Fleet Moorings
DM-26.06	Mooring Design, Physical & Empirical Data
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DM-27.01	Large Training Facilities
DM-27.02	Training Facilities Building
DM-27.03	Training Facilities, Other than Buildings
DM-27.04	Fire Fighting School Facilities
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DM-28.02	Shipyard Maintenance Facilities

DM-28.03	Maintenance Facilities for Ammunition, Explosives, and Toxics
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DM-36.04	General Messes
DM-37.01	Swimming Pools
DM-37.02	Child Care Centers
DM-37.03	Outdoor Sports & Recreational Facilities
DM-37.04	Brigs and Detention Facilities
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DM-37.07	Messes

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3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

☐ VENDOR ☐ EFD/PWO

☐ USER ☐ AE

☐ CONTRACTOR

☐ MANUFACTURER ☐ OICC/ROICC

☐ OTHER *(Specify)*: ______

5. PROBLEM AREAS

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b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

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