

CHAPTER 16A

INTERIOR ELECTRICAL

16A-01 GENERAL

This guide has been prepared to assist the quality assurance representative in obtaining the quality assurance of interior electrical installation required by the contract specifications. It is recognized that specialized technical aspects of this subject may require the services of an electrical engineer or technician. When the work appears to be beyond the scope of the QAR, assistance should be requested promptly from the immediate supervisor.

During the Preliminary Inspection of each phase of work, make an inspection of materials prior to installation for conformance with specification, plans, and approved shop drawings. ENG Form 4288, Submittal Register, which lists approved materials is essential to this inspection. Components for interior electrical work will be inspected before they are installed and energized. Initial Inspection and followup Inspections will follow work as required by ER 1180-1-6.

16A-02 GENERAL REQUIREMENTS

a. It is the intent that the electrical installation shall conform to the applicable rules of the current National Electrical Code (NEC)*, except where expressly modified by the plans and specifications. This requirement can be found in the general section of the project specification for INTERIOR ELECTRICAL. The appropriate edition of the code will be listed in APPLICABLE PUBLICATIONS. A copy of the applicable NEC should be readily available to the general inspector, and he should be readily available to the QAR, and he should be prepared to use it as a reference and an authority. However, the NEC is a minimum standard intended to assure a safe installation. Frequently, Corps of Engineers project specifications require a higher quality installation than that which is required by the minimum standards of the NEC. A substitution or change to the requirements of the project specification proposed on the basis of being "Okay under the Code" should not be casually accepted. NEC paragraph references in the text of this guide are to assist the QAR in using the Code and to lend authority to his demands for features not spelled out in the project specification.

b. Watch job conditions at all times to assure that the electrical work is done at the proper time in relation to other parts of the building construction.

c. Determine the existence, extent, and classification of hazardous locations as noted in the contract documentation. If such locations exist, the installation therein should be strictly in accord with appropriate sections of the NEC. Do not approve any doubtful material or workmanship (NEC 500 - 503). Do not fail to seek advice if needed.

*National Electrical Code (NFPA No. 70-84). Text references are to the 1984 edition. Copies can be obtained from the national Fire Protection Association at Batterymarch Park, Quincy, MA 02269 for \$15.00.

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d. Inspect materials and equipment and approved shop drawings. If materials are in accord with approved shop drawing but appear to be contrary to specifications, inform your supervisor.

e. Examine both contractor and government-furnished equipment for damage in shipment. Promptly report defective equipment to your supervisor and accept or reject such equipment, as directed.

f. Shop inspection by a Government representative may have been required for some equipment and material. Copies of reports of such shop inspections should be on hand before acceptance of material or equipment.

g. Storage of electrical equipment will be done per manufacturers requirement and in dry locations, free of dirt, dust, and corrosive fumes, with protection from physical damage. Storage of switchgear, engine generator units, and government-furnished equipment will usually require indoor storage. Temporary heaters may be required or specified to keep equipment free from effects of condensation. Equipment installed during construction phases should be protected from dirt and moisture. A requirement for this protection may be found in special conditions of the contract (ALSO NEC 110-11.)

h. Require the contractor to furnish all layout drawings required by the specifications. Electrical contract drawings should be reviewed and compared with architectural, structural and mechanical drawings for possible interferences. Examples of this are:

(1) Are the wall switches located with proper respect to door swing?

(2) Does location of wall outlets conflict with installation of baseboard heating units, casework, cabinets or lockers?

(3) Are there interferences with other building construction, such as pipes, ducts, overhead doors, sliding doors, accessibility, etc.? Especially check equipment room layout.

(4) Is relocation of ceiling lighting outlets required, especially in utility and boiler rooms, to avoid interference with mechanical equipment?

(5) Will transformers, bus duct or switchgear be subjected to moisture from overhead floor inadequate?

(6) Have suspended ceilings been lowered, making lighting fixture clearance from floor inadequate?

i. Temporary electric service will generally be required during the construction period for lighting, power, and sometimes heat. The contractor should make early arrangements for such service to prevent construction delays; and temporary installations will be located so as not to interfere with operation of existing facilities or permanent construction.

The contractor should arrange for frequent inspection and rehabilitation of temporary installation during the course of the contract to keep it in good repair (NEC-305).

j. Adherence to the requirements of Corps of Engineers Safety Manual, *EN 385-1-1, is a general provision requirement for all Corps of Engineers administered projects.

(1) Temporary open wiring should be guarded or isolated by elevation. Types NM in dry locations and/or NMC in damp locations (Romex) are suitable for temporary wiring when guarded or isolated by elevation (EM 385-1-1, paragraph 15D-01 and NEC 320, 336)

(2) Portable and extension cords shall be an Underwriter*s Laboratory (UL) listed type for the usage. Hard service cords Type S, SJ, SJO, SJT, SJTO, STO or ST are recommended for this service. Types NM or NMC are not approved as portable cables or covers (NEC 400).

(3) Ground fault circuit protection for construction sites is required on all 120 volt, single phase, 15 and 20 Amp receptacles per NEC 305-4.

k. Use by the contractor of equipment and facilities permanently incorporated in the structure should be carefully watched to see that circuits and equipment are not overloaded and that all work is left in essentially new condition. All protected safety and working lamps used for temporary lighting shall be removed when construction is completed, and new lamps shall be installed in permanent light fixtures (Project Specification: Lamps.)

1. ENG Form 4288, Submittal Register was prepared and included in the contract specifications prior to bidding the work. This list of required equipment will insure timely approval and will alert the QAR if the contractor has not procured all equipment. Generally, electrical construction materials and equipment must be built and tested according to UL requirements. Listed materials and equipment will bear the UL label. The Electrical Constructions Materials Directory is available form UL Inc., Publications Stock, 333 Pffingsten Road, Northbrook, IL 60062.

m. Check shop drawings for all equipment having electrical connections to be sure that rough-in conduits and circuits are correctly sized and located.

n. Manufacturer*s representatives are sometimes required to assist field and contractor personnel in the installation, assembly, testing and/or initial operation of electrical equipment. When Government Furnished Equipment is involved, be sure advance arrangements for such services are coordinated by Resident Engineer and contractor so that the representative is on hand when needed because usually the number of days are designated in the contract and an overrun will result in an additional cost to the Government. Maintain complete record of all adjustments and tests made during installation and startup, and of any peculiarities of the equipment which may be of use to those responsible for its operation and maintenance. Turn copy of record over to your supervisor for delivery to the using agency. Retain a copy of all records for the job file.

o. The using agency should be required to witness tests. The presence or absence of the using service personnel should be noted on the test report.

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p. Fire ratings of structures shall not be compromised by electrical installations (NEC 300-21).

16A-03 GROUNDING (NEC 250 and Project Specifications: Grounding)

a. Drawings and Specifications

Drawings and Specifications should be examined carefully to determine the nature and extent of the grounding system and the requirements for separate grounding of equipment and structures. Automatic Data Processing (ADP), Communications and Health Care Facilities may have special or separately derived grounding requirements.

b. Visual Inspection

Visual inspection should be made of all ground-system conductors, connections and electrodes as the work progresses. Ground resistance test: The resistance of all electrodes must be tested to assure resistance to ground of 25 OHMS or less (Job specifications or NEC 250-84).

c. Grounds to Metallic Water-Piping System

Grounds to metallic water-piping system should be made on the street side of the meter. Where this is impracticable, full size jumper connections should be made around any piping system elements which can be removed (NEC 250-112).

(1) Make sure that when the water piping system is used for a ground, the water pipe is a metallic pipe and that no insulating fitting has been interposed in the pipe between the ground wire connection and earth. (NEC 250-81). An additional ground electrode shall supplement the connection to the water pipe system (NEC 250-81 or NEC 250-83).

(2) Where metallic water main is not available, driven ground electrodes will be provided in conformance with specifications (NEC 250-83, and Project Specifications: Ground Rods).

(3) Interior metallic water piping shall always be grounded (NEC 250-80(a)).

d. Bolted Connections

Bolted connections should be examined to make sure that they are tight and that contact surfaces are cleaned and dry. Contact surfaces will be metal-to-metal. Painted surfaces should be cleaned to bare metal (NEC 250-75).

e. Exothermic Welding Connections

Exothermic welding connections will be made in strict accordance with the manufacturer's instructions and will employ the proper type and size of mold for the type and size of connection made.

f. Metallic Enclosures

Metallic enclosures for ground wires shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting (NEC 250-92(a)).

g. Incoming Service Conduit

Incoming service conduit must be grounded by lugs, pressure Connectors or clamps. Locknuts and bushings are not acceptable for grounding service conduit (NEC 250-32, -71(a) and -72).

h. Grounding Connection

Ground clamps for connection to water pipe or grounding electrode should be compatible with the pipe or electrode and UL approved for the purpose (NEC 250-115)

i. Ground Rods

(1) Check size, length, and material of ground rods or electrodes against contract drawings and specifications (NEC 250-83, Project Specification: Grounding)

(2) If suitable water pipe is not available, and if ground rods cannot be driven to a minimum depth of 8 feet, other means of establishing a ground must be utilized (NEC 250-83 and C 250-84)

j. System Neutral and Equipment Grounds

Grounding electrode conductor should be joined to grounding electrodes as shown on drawings (NEC 250-112). Some special electronic facilities may require additional isolated grounding electrodes and conductors (Project specification: Grounding.)

k. System Neutral

System neutral (Grounded circuit conductor) should be grounded (connected to the grounding conductor) on supply side of the service disconnecting means (main service switch(es)). This connection should be made within the service entrance equipment enclosure (NEC 250-23; 250-50) (Project Specifications: Grounding.)

l. Multiple Connections

The connecting of more than one grounding conductor to an electrode by a single clamp is prohibited, unless the clamp or fitting is of a type of specifically designed and approved by the Underwriters* Laboratory for such use (NEC 250-115).

m. Grounding Resistance

Grounding resistance should be verified by instrument measurement (Job Specification or NEC 250-84.)

n. Electrical Continuity

Electrical continuity should be verified throughout system, usually by visual inspection.

16A-04 WIRING METHODS (NEC 300)

a. Rigid Metal Conduit, Intermediate Metal Conduit (IMC) and Electrical Metallic Tubing (EMT)

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Check to determine requirements and limitations on use of rigid conduit, IMC, or EMT and special finishing or coating material (Steel with zinc coating or galvanizing is standard) other materials may be allowed or required (Project Specifications: Wiring Methods; NEC-345, 346, 347, and 348.)

(1) The project specifications generally require the service entrance raceway to be rigid metal conduit (Project Specification: Aerial Service.)

(2) Check size of installed conduit against plans and specifications and determine adequacy for number and size of conductors to be installed. Refer to tables in NEC (Project Specifications and NEC 345-7, 346-6, and 348-6 and Tables in Chapter 9.)

(3) Check minimum size of conduit permitted by specifications for both electrical system and communication system (Project Specifications: Telephone and Sig. System Raceways and NEC 345-6, 346-5, 347-11 and 348-5.)

(4) Check to be sure that all required conduits are in place before on-grade slabs are placed. Check stub-up locations against equipment shopdrawings.

(a) Generally, for slab-on-grade construction conduit must be placed under the slab and must be rigid type. (Check plans and specifications)

(b) Check project specifications for requirement that for stub-ups, couplings be installed at finished floor level for free standing equipment (Project Specification: Conduits.)

(c) Exposed conduit should be installed so that bent portion of stub-up will not extend above floor level.

(d) Be sure that all buried conduit has been surface treated as required by specifications (Project Specification: Conduit and Tubing Systems.)

(5) Inspect for damage and deformation of conduit systems (Project Specifications: Changes in Direction and NEC 345-10, 356-10, 347-13 and 348-9.)

(6) Is conduit system to be installed concealed or exposed? Check project specification and plans.

(7) Check for the use of the proper type of conduit fittings, i.e., concrete-tight, rain-tight cast fittings; expansion joints (NEC 345-9, 346-9, and 347-6 and 348-8).

(8) Check for installation of sleeves for future work in foundation walls and floors during correct stage of construction.

(9) Check maximum number of bends in any single conduit run. Do not exceed:

(a) Electrical System -4 (90 Degree) bends, including those bends located immediately at the outlet or fitting (NEC 345-11, 346-11, 347-14, 348-10.)

(b) Communication System - Check project specifications for requirements. Generally, not more than 3 (90°) bends.

(10) Make sure that all the conduit required for circuits involving equipment furnished by other sections of the specifications and approved shop drawings, as well as the electrical sections, is installed prior to placing of concrete, closing the walls, ceilings, etc.

(11) Check for bushings on ends of conduit. Bushings are not usually required on EMT fittings, because EMT connectors should have smooth internal surfaces (NEC 345-15, 346-8, 347-12).

(a) Check for use of insulating bushings and double lock nuts (NEC 373-6(c)).

(b) Check for use of double locknuts for circuits over 250 volts to ground (NEC 250-76b).

(c) See that locknuts, bushings, couplings, and connectors are made up tight to insure ground continuity (NEC 250-92(b)).

(12) See that field cuts of conduits and EMT are made square, ends reamed or filed, and cleaned of oil and filings, (NEC 345-8, 346-7, 348-11: Project Specifications).

(13) Use of running threads is not permitted at couplings (NEC 346-9).

(14) Correlate location of conduit terminations against approved shop drawings, equipment and building plans.

(15) Tubing and conduit should be securely fastened in place at intervals required. Means of support provided should be in accord with specifications and NEC requirements (Project Specifications, NEC 348-12, 348-12, 347-8, 346-12, 345-12.)

(16) Exposed conduit runs are to be installed parallel or perpendicular to walls and structural members. Vertical conduit runs should be plumb (Project Specifications: Conduit and Tubing Systems).

(17) Conduit runs in wet areas shall be mounted so that there is at least 1/4" air space between it and the wall or support surface (NEC 300-6(c)).

(18) Minimum radius of bends of conduit should be in accordance with table in the NEC (NEC 346-10, 348-9, 345-10). This table is based on utilizing conductors with 600-volt insulation. For cables with higher voltage ratings, and special cables such as telephone cable, consult manufacturer*s recommendations for minimum radius of bend.

(19) Check for supporting of vertical raceways at each floor level of multi-story buildings (Project Specifications).

(20) Install galvanized pull-wires in empty conduits when required by designs or specifications.

(21) Verify the use of corrosion-resistant materials in areas where corrosive influences exist (NEC 300-6: Project Specifications).

(22) Require means for prevention of entrance of foreign matter in conduits during construction (Project Specifications).

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(23) Use UL listed flexible conduit, standard or liquid tight, for connections to motors installed on slide rails, resilient mounts, those subject to vibration, and elsewhere as specified (NEC 350, 351; Project Specifications). Minimum size is ½" except as allowed in NEC 350-3, and a bonding jumper may be required.

(24) In areas classified as hazardous, be sure that installation is strictly in accord with Project Specifications and applicable NEC articles 500 through 517. All questions should be referred to qualified personnel. For Class 1, Division 1 areas, the following items should be carefully verified:

(a) Only threaded steel IMC or threaded rigid metallic conduit, or MI cable with approved connectors can be used, (NEC 501-4(a) and threaded joints must be up wrench tight, (NEC 500-1), unless a bonding jumper is installed.

(b) At least five full threads must be engaged at each threaded joint (NEC 501-4(a)). All field made threads must be tapered (NEC 500-1)

(c) All fittings, fixtures, boxes, and enclosures must be specifically involved. An Underwriter*s approval seal is generally affixed to the equipment. If not, secure other firm verification of approval.

(d) Explosion proof fittings, boxes and enclosures have screw or ground joints at openings. Be sure that surface of ground joints is clean, unscratched and smooth, so that the mating surfaces make intimate contact throughout their area. Covers must be tight and gaskets are not to be used.

(a) Be sure that all required seals are installed in the correct location and that they are of the correct type (NEC 501-5 and 502-5) . Be sure seals are the correct type of the application, vertical or horizontal.

(f) Check the mounting method of equipment to be sure that no holes have been drilled into the interior chamber of an explosion proof enclosure.

(g) Be sure that all flexible conduits bear the Underwriter*s listing seal for the hazard involved.

(h) See that proper approved type sealing compound has been installed in all sealing fittings. Follow manufacturer s recommendations (NEC 501-5(c)2).

(25) Where rigid non-metallic conduits is installed under the specification, it should be installed in accordance with NEC 347 and all special requirements of the Project Specifications.

(26) Provide conductor support in long vertical conduit runs (NEC 300-19).

(27) Pull wires are provided and are of type specified.

b. Cable Systems

(1) Mineral, insulated metal sheathed cable, Type MI, will be installed in accordance with Article 330 or the NEC and Project Specification requirements.

(2) Metal clad cable Types MC and AC (commonly called "BX") should be installed in accord with Project Specification requirements and Articles 333 and 334 of the NEC. See that insulating bushings or equivalent protection are provided between the conductors and the armor at terminations.

(3) Non-metallic sheathed cables, Type NM and NMC commonly called "Romex", should be installed in accord with Project Specification and Article 336 of the NEC.

(a) Type NM cable must not be used when non-metallic sheathed cable is installed in the cells of masonry block walls which are exposed or which are subject to excessive moisture or dampness. This includes exterior masonry walls. In dry, noncorrosive locations, type MN may be used. NMC is applicable in wet locations (NEC 336-3).

(b) See that nails will not be driven into cable. Protecting plates may be required (NEC 300-4).

(c) See that ground wire is properly fastened at terminating points and outlet boxes. Attach to each box of fitting by securely fastening the wire to the intended screw or with an approved grounding device (NEC 25C-114).

(d) See that cable is secured as required by the National Electrical Code, within 12" or every cabinet, outlet box of fitting and otherwise at intervals not exceeding 4 ½ feet (NEC 336-5). See also NEC 370-7(c) for support of cable entering non-metallic boxes.

(4) When authorized by the Project Specification, service entrance cable. Types SE, and USE should be installed in accord with NEC 338.

c. Busway Systems (NEC 364; Project Specifications.)

(1) Support busways at specified intervals (NEC 364-5; Project Specifications).

(2) Install sway braces when needed to limit lateral movement of busway (Project Specifications).

(3) Busway position, vertical or horizontal, will determine whether plugs are installed on the sides or on top and bottom. If plans do not indicate desired position, determination of appropriate location should be made.

(4) Install busway runs securely in straight alignment, parallel to floors and walls, with sufficient space either above and below, or on both sides, to permit installation, operation and servicing of bus plugs.

(5) Check to be sure that types of duct furnished are in accord with specification. Check conductor metal, enclosure type, duct type, wall flanges, and fire stops.

(6) Ground duct housing (NEC 250-33).

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(7) Vertical riser sections up to 6 feet above the floor must be unventilated type (NEC 364-6).

(8) Check plug-in features and tap off devices against specification.

(9) Check on trolley busways, trolleys, brushes, contact rollers, and flexible cables for no binding and good contact.

(10) Component sections to be legibly marked with voltage and current ratings and manufacturer*s name (NEC 364-15).

(11) Installation and furnishing of busways usually require that the contractor verify field dimensions. Be sure that timely ordering of busway is not delayed.

(12) Provide for expansion as required by the manufacturer.

d. Continuous Rigid Cable Supports or Cable Trays

Cable trays are installed to support cables. Only certain specified cables may be installed and loading of support is limited. Cable trays should be installed in accordance with Project Specification and NEC 318. Tray system with cable installed must not downgrade fire barriers (NEC 318-5(g), 300-21).

e. Wireways

Wireways or inclosed troughs are installed to house and protect wire and cable. In general, wires of the building wire type, such as TW, may be installed in approved wireways. The installation should be made in accordance with Project Specification and NEC 362. particular attention should be paid to NEC 362-5, which limits the number of conductors approved for wireway installation.

f. Auxilliary Gutters

The gutters commonly used for interconnecting large panels and switches fall under this article. Installation should comply with NEC 374.

g. Underfloor Duct Systems (NEC 354, 356)

(1) Install underfloor raceways of steel construction parallel with floor construction, and in straight alignment.

(2) Check to see that sufficient setting depth is available for junction boxes. These are the deepest elements of underfloor raceway systems.

(3) Check for tight joints between underfloor raceway sections and at junction boxes to keep water out of raceway systems (NEC 354-13, 356-9).

(4) Inserts of both the preset and after-set type will be mechanically secured to the underfloor raceway and set level with the floor (NEC 354-14, 356-10).

(5) Splices and tapes in underfloor raceway systems will not be made in outlets at inserts, but only at junction boxes to keep water out of raceway systems (NEC 354-13, 356-9).

(6) provide markers at ends of underfloor raceway runs, but the plans and specifications may require more (NEC 354-9, 356-8)

(7) Install end caps at ends of all underfloor raceway systems (NEC 354-10).

(8) Check tap-off locations to cabinets, panel boards, and receptacles against drawings.

(9) Verify from shop drawings relative positions of services in compartments. To be uniform throughout system.

(10) Check cross-sectional dimensions for adequate size (NEC 354-5, 356-5; Project Specifications).

(11) Be sure that grounding continuity is maintained at all connections in the system (NEC 250-75).

h. Movable Partition

Movable partitions, and similar enclosures unless specifically listed as raceways, cannot be used as enclosures for general wiring conductors. Instead raceways (such as conduit) must be installed: or else cable (such as type MI) appropriate for the application must be installed. See NEC restrictions for kitchen vent hoods (NEC 410-9).

i. Conductors (NEC 310)

(1) Check type of insulation and jacket, conductor material, conductor size and stranding in each circuit (Project Specifications and NEC).

(2) Observe pulling of wires and cables to detect damage to sheaths, jackets and insulation. This damage is usually caused when runs are "paid out" in a debris-laden area and then stepped on, or by raceways having sharp edges or contamination. Pulling-eyes or cable-gripping devices will be required for large cables.

(3) Install all conductors of a circuit, including neutral, in same raceway in conformance with NEC limitations (NEC 300-20; 215-4).

(4) Connections and joints will be clean and tight, with listed pressure-type connectors, and made in junction and outlet boxes, not in raceways (NEC 110-14, 300-15).

(5) Connectors, lugs and clamps used to connect copper and aluminum conductors must be suitable for use with the conductor material to prevent galvanic corrosion (NEC 110-14). Aluminum conductors must be covered with antioxidant before connection.

(6) Use only white or natural grey identified conductors for the grounded circuit conductor. Neutral (white or grey) conductor of the wiring system will be insulated throughout (NEC 200-7). Conductors having white or grey identified coverings shall only be used as the grounded circuit conductor except as allowed in exceptions 1 thru 3 in NEC 200-7. Generally, use the same white color for the entire system grounded conductors.

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(7) When a grounding conductor for equipment is run with circuit conductors it shall be bare, or green covered (NEC 250-57(b)). Project specifications may require insulated conductors.

(8) Enforce color coding of conductors of branch circuits when required by project specification.

(9) Branch-circuit conductors within 3" of a ballast within the ballast compartment shall be recognized for use at temperatures not lower than 90 degree C (194 degree F) (NEC 410-31).

(10) Check that branch circuit wiring is not undersized. Specification may require increased wire size when runs from panel board to center of load equal or exceed 100 feet for 120 volt circuits or 230 feet for 277 volt circuit.

(11) See that correct fixture wiring installation is made (NEC 410-22 to 34).

16A-05 OUTLETS

Check for requirements of cast boxes in exposed work, exterior work, wet locations, and hazardous locations (Project Specifications)

b. Require hub-type cast boxes when specified (Project Specifications)

c. Check size of junction and pull boxes (NEC 370-6, 18, 20).

d. Do not permit overcrowding of boxes with excessive number of conductors (NEC 370-6).

e. Check identification requirements of power and control conductors at terminals and in pull boxes and junction boxes. Fenders should be tagged to indicate electrical characteristics, circuit number, and panel designation (Project Specifications).

f. Check for boxes to be securely and rigidly supported (NEC 370-13). (Project Specifications: Boxes and Supports.)

g. Fit concealed boxes into walls and ceilings. On noncombustible construction, the front edge of box should be within 1/4 inch of finished surface, and on combustible construction flush with finished surface or project therefrom (NEC 370-10)

h. Any masonry or dry wall work required for installation of outlet, pull, or junction boxes is to be done by skilled workmen. The masonry section of the specifications requires the cutting of block for fitting installed items. Electrician should not be permitted to chop away masonry or dry wall work. Coordination is necessary between the electrical trade and masons and carpenters to effect a suitable installation. (Project Specifications).

i. Check for air space between box and wall or supporting surface in wet locations where surface-type units are used (NEC 300-6).

j. Are outlets that are exposed to the weather a weather-proof type (NEC 370-5 and 300-6, Project Specification).

k. Pull and junction boxes shall have free access (NEC 370-19).

l. Floor outlets shall be of required type and properly located.

m. Light outlets in mechanical and equipment rooms are located to suit servicing and maintenance and extend below ducts.

16A-06 DEVICE PLATES

See that device plates are of specified material and finish and that all surfaces are in contact with wall (Project Specifications and NEC 410-56). On surface mounted boxes the plates should be compatible with the box and without overhanging corners. Also, NEC 380-0. Plates should be plumb and not dished or bowed.

16A-07 RECEPTACLES

a. Check all receptacles to be sure that specified voltage, ampere, color, slots, etc., are furnished. Also be sure that plug is furnished if specified (Project Specifications).

b. Be sure that grounding continuity is maintained between grounded metal box and receptacle and that bonding jumper is installed when required or approved bonding type receptacle. Some designs require ground wire from panel to receptacle (NEC 250-74).

16A-08 WALL SWITCHES

a. Check wall switches for proper ampere rating, voltage rating, and type. Usually "A-C only" is required. AC only switches are marked "AC" or "AC only" on yoke, never "AC/DC." They can be used for alternating current only (Project Specification and NEC 380-14).

b. Wall switches will be in hot leg of circuit, not in neutral, and should be installed with the "on" position "up" (NEC 380-6)

c. Check for requirements of installing pilot lights on switches (Project Specifications).

16A-09 SERVICE EQUIPMENT

a. Check to be sure that the proper type of enclosure is furnished (such as drip-proof, totally enclosed, etc.) (Project Specifications.)

b. Standard NEMA (KS-1) designations are used to describe various enclosures for switches. The designations are as follows:

Type 1 - Indoor - General Purpose

Type 2 - Outdoor - Dusttight, Raintight and Sleet (Ice) Resistant

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Type 4 - Indoor/Outdoor - Watertight and Dusttight

Type 5 - Indoor Dustproof

Type 7 - Class I, Groups A, B, C and/or D - Indoor Hazardous Locations - Airbreak Equipment

Type 9 - Class II, Group(s) E, F and/or C - Indoor Hazardous Locations - Airbreak Equipment

Type 12 - Indoor - Industrial Use, Dusttight and Driptight with Knockouts "Weatherproof" is defined in the NEC as so constructed or protected that exposure to the weather will not interfere with successful operation (NEC 100) and raintight, rainproof or watertight equipment can fulfill the requirements for weatherproof.

c. Check whether fusible-type or circuit-breaker type of service switch is required (Project Specifications)

d. Check that the service-switch enclosure is bonded to the ground system (NEC 230-62, 63).

e. Check voltage rating and ampere rating of switch. Also circuit breaker trip and fuse sizes and interrupting capacities (Project Specifications and Plans)

f. Check ground fault protection of service equipment when required by NEC 230-95, or Design.

g. Check meter location when specified.

16A-10 LOAD CENTER TYPE PANEL BOARDS

Load center type panelboards are sometimes authorized for less critical applications compared to regular panelboards. Compliance with Project Specifications, Federal Specifications, and NEC 384-13 through 19 is required.

16A-11 PANELBOARDS

a. Be sure to inspect plug-in panel board devices to determine tightness of fit.

b. Check loads on panels to be sure of approximate balance among the phases. This is best done by use of clamp-on type ammeters on feeders while panel is carrying its normal load (operational test)

c. Be sure the panelboards typed directory is properly filled out so that area and devices served can be quickly identified (Project Specifications).

d. Circuit-breakers: switches, and fuses in panelboards should be inspected to determine that they have correct number of poles, proper voltage, current-rating, and proper interrupting capacity. Refer to contract drawings and project specifications.

e. Check panelboards for inclusion of blanked-off spaces for future circuit breaker installation. Space to be adequately sized for the rating of future circuit breaker. Also see that spare breakers required are in place in addition to blanked-off spaces.

f. Check mounting height of top switch or circuit breaker. It should be less than six feet six inches.

16A-12 CABINETS (NEC 373; Project Specifications)

a. Check on size of gutter space. A minimum of 5 inches is required for panelboards with thru feeders. Load centers should be in accordance with NEC 373-6(a).

b. Telephone cabinets are to be checked for inclusion of backboard painted with insulation varnish.

c. Compare size of telephone cabinets against contract drawings.

d. Mounting is to be rigid and independent of the support by conduits. In damp locations, there should be 1/4 inch minimum air space at back of panel (NEC 373-2).

e. Connections to conduits are to be tight, assuring electrical continuity (NEC 250-71 through 79)

f. Look for special features of construction and installation for areas other than normal, such as hazardous, wet, exposed to fumes, etc. (NEC 110-1i).

g. Examine for galvanized metal construction.

h. Check mounting height of panelboard cabinets. Distance from the highest position of top switch or circuit-breaker to floor should not exceed 6 feet, 6 inches (Project Specifications)

16A-13 FUSES (NEC 240-6 and 8)

Inspect for the following:

a. Specified voltage rating.

b. Specified amperage and interrupting rating.

c. Non-renewable cartridge types for over 30 AMP capacity (Project Specifications)

d. Are dual element time-delay fuses or current limiting fuses with special "reject" holders required? (Project Specifications)

16A-14 UNDERGROUND SERVICE CONDUITS (NEC 230-30 and 31)

a. Check detail requirements of plans and specifications (Project Specifications).

b. Check requirement for painting or coating of conduits (Project Specifications)

c. Check method and location of termination of conduit ends and grounding (NEC 230-55).

d. Seal building ends of raceways entering from UG distribution system (NEC 230-48).

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16A-15 AERIAL SERVICE

a. Locate the splice between service drop and service entrance (NEC 100) conductor at a level lower than the service entrance fitting (head), and bend conductors to form a "drip loop" at the entrance fitting. These precautions will prevent entrance of water into the service equipment (NEC 230-24).

b. Support aerial service-drops on buildings, providing required clearances from ground, building openings, and from roof where service crosses roofs (NEC 230-24).

c. Service-drop cable type is to be in accordance with specification requirements (NEC 230-22 and 23; Project Specifications)

d. If connections are aluminum to copper, insure that the type of connectors specified (usually tinned bronze) are utilized and that anti-oxidant compound is properly applied, if specified.

16A-16 MOTORS

a. Check motors for conformance with NEMA classification standards. NEMA classification is according to mechanical protection and methods of cooling. Installation should be made in accordance with project specifications. Dripproof and/or splash-proof motors when specified shall be installed with ventilation openings faced down to exclude moisture, dirt, etc.

b. Check motors to see that proper terminal connections are made for the operating voltage. A connection table should be securely attached to the motor by the manufacturer if several alternate connections are possible.

c. Be sure motor revolves in direction correct for driven device, Usually an arrow is placed on fans and pumps to show correct directions of rotation. Motor rotation and speed must be verified before connection to the load e.g. pumps, fans, etc.

d. Check reversing types of motors and multi-speed motors to insure that direction of rotation and speed of motor corresponds to setting of control.

e. Make ground connections of motor enclosure through conduit system or by separate grounding conductor (NEC 430-141, 142)

f. Check motor against specifications and UL listings for class of insulation, starting torque characteristics, class, and design. Assure high efficiency motors are used where indicated.

g. Check motors for proper voltage. When 208V, three-phase is specified, do not permit substitution of 230V, three phase and vice versa. A 200 volt rating is the correct name plate rating for application on 208 volt system. Proposed substitutions should be referred to an electrical specialist.

h. Note conditions of windings; to be free from moisture and dust. See that appropriate provisions are made to protect equipment prior to turn-over of project.

i. Motors should be operated under connected load to determine following operating characteristics:

- (1) Voltage and current to detect possible overloaded conditions
- (2) Speed of motor
- (3) Direction of rotation
- (4) Overheating
- (5) Vibration
- (6) Abnormal sounds or odors

If connected load is not possible, refer to the Resident Engineer. This normally can be done in conjunction with test driven equipment.

j. Connect motors subject to vibration, and motors on adjustable slide basis, with flexible conduit. Liquid-tight or explosion-proof flexible conduit may be required by installation conditions. Bonding jumpers may be required (Project Specification; NEC 349, 350, 351, 501-4(a)).

k. Motors installed in hazardous locations are to bear an Underwriters Laboratory nameplate, indicating the classification of areas in which the motor is listed for use.

l. Check lubrication requirements of motor prior to motor operation (Manufacturers Instructions).

16A-17 MOTOR CONTROL

a. Check with the contractor to assure that all motor controllers required by all sections of the specifications have been ordered. Quite often, controllers are not ordered due to disputes between subcontractors. The QAR should insure that the prime contractor has made necessary arrangements to insure timely procuring of motor controllers.

b. Check motor controllers for:

- (1) Horsepower, voltage and current rating of least equal to the rating of the motor which it controls.
- (2) Automatic control devices such as thermostats, float or pressure switches directly used as motor controllers, should be adequately rated.
- (3) Magnetic-coil voltage rating same as the control-circuit voltage (may be different from the motor voltage)
- (4) Selection of proper motor overload heaters; based on the nameplate full-load current of the motor, ambient temperature of controller location, temperature-rise limit of motor. Refer to instruction sheet pasted on inside cover of motor controller. Determine if automatic or manual reset is required for overload protection (NEC 430-34) (Project Specifications.)

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(5) Requirements for furnishing reduced voltage starters. (Project Specifications.)

(6) Excessive humming or noise under operating conditions.

(7) Requirements for furnishing pilot circuit devices such as "Hand - Off - Automatic" selector switches, pilot lights (Project Specifications.)

(8) Note three-phase motors are provided with the overload element in each ungrounded conductor (NEC Table 430-37).

(9) Be sure control enclosure is as specified in Project Specifications and is suitable for conditions of installation.

(10) Spare interlocks, if specified.

(11) Shipping blocking has been removed.

(12) Control and safety devices should be wired into the "hot leg", not the neutral leg of the control circuit. If motor is connected to a grounded power supply, control power circuit should also have a grounded conductor. The control power should be disconnected from all power sources by its disconnect means (NEC 430-74).

16A-18 MOTOR DISCONNECT MEANS

a. Disconnecting means that open all ungrounded conductors will be provided for motor driven equipment installations. By locking provisions or by being "in sight" the disconnect(s) will provide protection for persons working on control, motor, and driven equipment (NEC 430-101 thru 113).

b. Ratings of switches are to be checked against contract specifications.

16A-19 LAMPS AND LIGHTING FIXTURES

Lighting fixtures should be examined for:

a. Chipped porcelain, cracked glass and plastics, bent louvers, over-all finish, detachable sockets on RLM dome fixtures (when specified) and "push type" sockets on open fluorescent fixtures (when specified). (OCE standard fixture drawings.)

b. Required lamp type, wattage, and color characteristics.

c. Ballasts for fluorescent and mercury-vapor lamps suitable for circuit voltage and of high power-factor type; overload protection for ballasts, if specified ballasts should be suitable for low temperature operation. Ballasts for fixtures to be recessed in fire rated or insulated ceiling construction may be required to be "low loss" type to hold ambient temperature down.

d. Plumb installation and horizontal and vertical alignment.

- e. End-caps, canopies, louvers, side panel guards, globes in place and tight-glass side panels, if specified. Acrylic plastic lens when specified.
- f. Aiming of floodlights and all other adjustable fixtures.
- g. Lamps that are to be installed for the project shall be new, and installed just prior to completion (Project Specifications)
- h. Storage battery powered emergency lighting sets should be checked against applicable Federal Specification for requirement of Underwriters listing and other features. They should be permanently installed strictly in accordance with project specifications and NEC Article 700.
- i. Emergency lighting circuits should be installed in accordance with project specifications and NEC Article 700. Circuit wiring should be kept independent of all other wiring (NEC 700-17).
- j. End-to-end mounted fluorescent fixtures must have Underwriters approval for mounting end-to-end (NEC 410-31) when used as raceways.

k. Required characteristics specified.

l. Grounded properly.

16A-20 EQUIPMENT CONNECTIONS

- a. Refer to applicable paragraphs of this chapter.
- b. Check plans and specifications for any special features.
- c. If Government-furnished equipment is involved, insure the timely availability of all connection drawings.

16A-21 TRANSFORMER STATIONS (NEC 450)

a. Dry Type Transformers

Check enclosure for indoor or outdoor service. Install so that air circulation will not be restricted around the transformers. Close-to-ceiling installations should be avoided.

b. Transformer Taps

Connect to produce specified voltage under normal load.

c. Liquid-filled Transformers

Check to see that they are filled to proper level. Level mark is indicated on transformer.

d. Nameplate Data

Check against specification requirements and approved shop drawings (NEC 450-11).

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e. Accessories

Check liquid-filled transformers for compliance with specifications or with specified standards. Such include: Connections for sampling, draining and filtering of insulating liquid; level gage; thermometer; pressure and vacuum gages; external tap changer; provisions for jacking, rolling and lifting; provisions for pole, platform or slab mounting; provision grounding of case and windings; and alarm devices actuated by abnormal liquid level, temperature or pressure; and automatic control devices for operation of forced air or other oil cooling equipment which will permit operation of transformers at higher-than-normal ratings.

f. Bushings

Check to see that bushings are free of moisture, dust, chips and cracks.

g. Insulating Liquid

Check against requirements. Non-flammable fluid insulated power transformers are generally required indoors.

h. Grounding

Check grounding connections of metal housing, neutrals of primary and secondary winding to the grounding system (NEC 450-9 and 250-26).

i. Ventilation

See that ventilation is adequate (NEC 450-45)

16A-22 SWITCHGEAR (NEC 384)

Switchboard and Free-Standing Panel Installation - Check for:

- a. Level floor location for gear and any roll-out equipment.
- b. Anchor bolts and floor plates in proper location. Consult approved shop drawings and contract drawings.
- c. Conduit entrances and wiring trenches in proper location.
- d. Bus duct connection provisions suitable for duct attachment.
- e. Ground bus connections brought to proper location. Consult approved shop drawings.
- f. Plumb and level installation of gear.
- g. Installation in accordance with manufacturer*s instructions.
- h. Blocking removed from instrument and relays.
- i. Adjustments made where required, taps and plugs at proper settings. Consult manufacturer*s installation instructions.

- j. Fuses in place and of proper type -voltage, current, interrupting capacity -current limiting.
- k. Indicating lamps with proper color caps in place.
- l. Furnishing of spare fuses and lamps and any operating handles or cranks.
- m. Manufacturer*s instruction books, wiring diagrams. etc., delivered to responsible individual accepting installation. Make a list and have it signed and filed.
- n. Terminals marked in accordance with approved shop drawings and specifications.
- o. All wiring connections made up tight.
- p. If switchgear is to be installed in any hazardous locations, check the specifications and drawings for any required special constructions features.
- q. Check for sufficient clearance between back of switchboard and wall. Minimum of 30 inches required if equipment or wiring is accessible only from back. Additional clearance may be required (NEC 110-16 and 34).
- r. Check to be sure switchboard frame is grounded.
- s. Check to be sure conduit stub-ups have coupling installed at floor level if required by Project Specifications.
- t. Check to be sure that proper phase relationship and identification of connections including instrumentation has been accomplished.
- u. Special requirements, such as seismic.

16A-23 ENGINE GENERATOR SETS

- a. See Chapter 130 for installation of sets.
- b. Inspect for overall compliance with the specifications as to type and rating of components -kva, kw, horsepower, rpm, voltage -and in particular as to the following:
 - (1) Engine will be suitable for operation on the fuel specified.
 - (2) Voltage ratings of starter, battery, and battery charger will be the same. Voltage regulator may need to be reset if nickel cadmium batteries are furnished.
 - (3) Check spare parts provided with unit to see that the supply is complete and that they fit the unit furnished.
 - (4) Installation should be in accord with NFPA 30, 31, and 37, as required by Project Specifications. Check for proper calibration of gagestick.
 - (5) That ventilation is adequate.
 - (6) See that operation and maintenance manuals are posted in engine room.

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(7) Check operation of transfer switches.

(8) Check governor operation.

(9) Check cranking cycle for reset.

(10) Check to determine that emergency shut-down prevents recycling.

(11) Required field tests have been satisfactorily completed.

(12) Check automatic transfer switch, lab test reports, operation and settings.

16A-24 ELEVATOR INSTALLATIONS (NEC 620)

a. See Chapter 14A for installation features.

b. Check voltage rating of hoisting machinery.

c. Provide safety interlocks as specified and check operation.

d. Record all performance of specified tests.

16A-25 MISCELLANEOUS SYSTEMS (NEC 720, 725, 760, 770, 800, 810)

Include several types of audible and visual paging systems, nurses call, central dictation, intercommunication systems of loudspeaker and telephone type, fire alarm systems, clock systems and supervisory systems, and often these which combine more than one function in a single system. Products of different manufacturers of like systems may differ greatly. Manufacturer*s installation instructions will be rigidly adhered to. The following will apply to all systems generally:

a. Master sets and main or central station equipment and switchboards of miscellaneous systems will be so placed as to be easily accessible for operation and maintenance in locations having adequate ventilation.

b. Generally, component parts of miscellaneous systems will be products of one manufacturer.

c. Wiring between system components may be of special character. Inspect for requirement for use of optical fiber cable, shielded cables, twisted pairs, and isolation of any system from another.

d. Check installation of miscellaneous systems equipment to see that the proper type and sizes of fuses have been used, that leads are connected to proper terminals and that the equipment is designed to operate on the available supply voltage.

16A-26 TESTS

a. All Testing

(1) When testing of any electrical equipment or system is required, advise the electrical inspector or engineer and obtain his assistance. The following paragraphs cover a wide range of testing and it will be your responsibility to obtain assistance when such testing is beyond your capabilities or knowledge.

(2) Unless otherwise specified, testing should be performed by the contractor when the inspector is present. All arrangements for test should be made by the contractor. For tests of major equipment and high voltage cables, the contractor should also notify the manufacturers so they may witness the tests.

(3) The Using Agency should be notified when any unusual testing is to be performed so that they may be present to witness the test. Using Agency cooperation should be obtained well in advance for any tests which may affect their facilities or operations.

b. Precautions

Precautions should be taken to insure that test voltages are applied only to equipment or circuits under test, and that all instrument and control circuits are disconnected during the test. Verify that all electrical equipment can be LOCK-OUT/TAG-OUT.

c. Electrical Tests

Electrical tests should not be conducted under ambient conditions unsuitable for testing, such as excessively high humidity conditions.

d. Records of Tests

Records of tests should be complete, including ambient temperatures and weather conditions, circuit designation and extent or wiring systems tested, name and serial number of the machine tested, and signatures of those witnessing the tests.

e. Description of Tests

(1) De-energized operational testing will determine that moving parts do not bind, rotating parts work freely and are not obstructed by foreign materials, that they are lubricated as required, and that such limits or stops as may be necessary to restrict the motion of moving parts are in place and functioning.

(2) Operational testing will show that the equipment performs all functions for which it is designed in accordance with the design and manufacturer*s specifications.

(3) Continuity testing will determine that circuits are continuous through out the circuit.

(4) High potential testing will determine that the insulation has sufficient dielectric strength to withstand the surges to which it might be subjected and to insure freedom from pinholes and any other possible damage.

(5) Megger tests will determine that the wiring system and equipment is free from short circuits and grounds and will measure the insulation resistances of the circuit and/or equipment under test.

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f. Megger Tests

Megger tests of insulation resistance should be made when specified and approved if satisfactory.

g. Method of Testing

(1) High-potential field tests should be made in strict compliance with the applicable standards listed in the specifications and with the recommendations of the manufacturer of the equipment.

(a) Tests should not be repeated unless the necessity for repetition has been determined by an electrical engineer or specified.

(b) Make only after all safety precautions relative to grounding of the test equipment have been checked.

(2) Insulation resistance and high-potential tests of wiring systems should be made when required between one conductor and ground with all other conductors and sheath or conduit connected to the same ground. Tests should be made on each conductor in this manner. Windings of rotating equipment and transformers should be connected together and tested to ground.

(3) Rotating equipment operational tests should include an inspection for alignment with driven machine, proper lubrication, freedom from excessive vibration in operation, proper direction of rotation, voltage and current drain check against motor nameplate ratings, check of R.P.M. and excessive heating.

(4) Rotating equipment operational tests should include an inspection for alignment with driven machine, proper lubrication, freedom from excessive vibration in operation, proper direction of rotation, voltage and current drain check against motor nameplate ratings, check of R.P.M. and excessive heating.

(5) Switch and manual motor starter operational tests should include an examination for proper operation, alignment of contacts and contact pressure.

(6) Motor-starter operational tests should include manually operating the armature or plunger and contact-bar to determine that movement is free, contacts are in alignment, contact pressure is adequate and that auxiliary contacts function properly. The starter should be energized from all control points and the operation of all control-circuit interlocks should be checked.

(7) Reduced voltages starters should be checked for correct sequence and timing of application of incremental and full voltages.

(8) Variable and adjustable speed motor controls should be checked to see that operating speeds corresponds to the position of the speed control device.

(9) Circuit-breaker operational tests for large air circuit-breakers operating and test positions under manual operation and through control circuits from each control point. Checking of breaker mechanisms for alignment; freedom of motion and adequate pressure of contacts; tripping, devices; inspection

to insure that breaker cannot be moved from operating position while closed. Indicating lights, targets, annunciators and alarms should be observed for operation in connection with associated circuit-breakers, control switches and other operating devices to insure that the signal indication corresponds to the switch position of the indicating device.

(10) Protective relays should be checked to see that time and current settings have been made as specified.

(11) Operational tests of relays should include: Checking of operation at specified current or voltage and time values. Checking of peak current of instantaneous elements; checking of differential elements for operation only under condition of proper direction of power flow.

(12) Rod electrodes should be tested for resistance to ground. If resistance is greater than the specified resistance, or maximum of 25 ohms, additional rods or longer rods should be installed. Consult specifications (Project Specifications: NEC 250-83).

(13) Miscellaneous systems, for intercommunication, paging, clock-control fire alarms, etc., shall be given operational tests at all operating points to demonstrate that they will perform all specified functions. In particular, it shall be demonstrated that sounding devices are audible under normal ambient sound-level conditions in areas for which coverage is specified, that false signals cannot be transmitted over fire alarm systems specified to be of the non-interfering type, that reserve-power attachments for clock system will operate for the specified length of time, and that all special features and accessories specified for each system have been incorporated therein.

(14) Engine-generator tests include, but may not be limited to, the following:

(a) If diesel engine driven, reference is usually made to MIL-STD7058. This publication details electrical test requirement. Be sure all factory or shop tests have been completed as specified.

(b) Demonstrate starting of all units from all manual control points and from automatic control as specified.

(c) Demonstrate voltage and frequency regulation are held within specified limits under all load conditions.

(d) Establish load requirements for testing of units. Either connected load or created load such as obtained with salt water rheostat or other satisfactory method. Determine who will furnish load banks, if required.

(e) Engine-generator tests should incorporate full load tests. Specifications will at times required 110% load testing for a limited time.

(f) Satisfactory operation of transfer switch installation in accordance with specifications requirements should be demonstrated.

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(g) Operational check of all safety controls should be made. This will include operation of safety stop switches, operation of high water temp, low oil pressure, over-speed, and any other safety circuit required by the specifications.

(h) Demonstrate full load continuous operation without overheating of the engine.

(i) Be sure all field tests specified are performed and recorded.

(15) Transformers should be checked for shipping damage, leakage, proper voltage and tap settings, grounding, and for signs of water in the oil.

(16) Service equipment should be tested for ground fault protection as specified and NEC 230-95.

(17) Operational test should be made on all switches, dimmers, lighting, battery units and miscellaneous equipment.