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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z535.1 (2002) Safety Color Code

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480 (1981) Toggle Switches

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 (1998) American National Standards for Accessible and Usable Buildings and Facilities

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA FB 1 (2001) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies

NEMA KS 1 (2001) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

NEMA OS 1 (1996) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

NEMA OS 2 (1996) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

NEMA PB 1 (2000) Panelboards

NEMA RN 1 (1998) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 13 (2000) Electrical Nonmetallic Tubing (ENT)

NEMA VE 1 (2002) Metallic Cable Tray Systems

NEMA WD 1 (1999) General Requirements for Wiring Devices

NEMA WD 6 (2002) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005) National Electrical Code 2005 Edition

UNDERWRITERS LABORATORIES (UL)

UL 1	(2004) UL Standard for Safety - Flexible Metal Conduit
UL 1242	(2003) UL Standard for Safety - Intermediate Metal Conduit
UL 489	(2003; Bulletin Feb 11, 1992; Bulletin Mar 16, 1992) UL Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
UL 506	(2004) Standard for Specialty Transformers
UL 6	(2003) UL Standard for Safety for Electrical Rigid Metal Conduit-Steel
UL 797	(2003) UL Standard for Safety - Electrical Metallic Tubing
UL 870	(2002) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for the following:

Conduits, Raceway and Fittings
Wire and Cable
Splices and Connectors
Switches
Receptacles
Outlets, Outlet Boxes, and Pull Boxes
Circuit Breakers
Panelboards
Lamps and Lighting Fixtures
Dry-Type Distribution Transformers

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

Conduits, Raceway and Fittings
Wire and Cable
Splices and Connectors
Switches
Receptacles
Outlets, Outlet Boxes, and Pull Boxes
Circuit Breakers
Panelboards
Lamps and Lighting Fixtures
Dry-Type Distribution Transformers
Spare Parts

SD-06 Test Reports

Continuity and Insulation Resistance Test
Phase-Rotation Tests
Insulation Resistance Test

SD-08 Manufacturer's Instructions

Manufacturer's Instructions shall be submitted.

1.3 PREVENTION OF CORROSION

NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Section 09960 HIGH-PERFORMANCE COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation will break down most

standard coatings, causing a phenomena known as chalking, which is the first stage of the corrosion process. For additional information contact The Coatings Industry Alliance, specific suppliers such as Keeler and Long and PPG, and NACE International (NACE).

Metallic materials shall be protected against corrosion. Equipment enclosures shall have the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to Section 09960 HIGH-PERFORMANCE COATINGS. Aluminum shall not be used in contact with earth or concrete and, where connected to dissimilar metal, shall be protected by approved fittings and treatment. Ferrous metals such as, but not limited to, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous spare parts not of corrosion-resistant steel shall be hot-dip galvanized except where other equivalent protective treatment is specifically approved in writing.

1.4 GENERAL REQUIREMENTS

Material, Equipment, and Fixture Lists shall be submitted for the following items showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Manufacturer's Instructions shall be submitted including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

PART 2 PRODUCTS

2.1 MATERIALS

Materials and equipment to be provided shall be the standard cataloged products of manufacturers regularly engaged in the manufacture of the products.

2.1.1 Rigid Steel Conduit

Rigid steel conduit shall be in accordance with UL 6 and shall be galvanized by the hot-dip process. Where underground and in corrosive areas, rigid steel conduit shall be polyvinylchloride (PVC) coated in accordance with NEMA RN 1 or shall be painted with bitumastic.

Fittings for rigid steel conduit shall be threaded.

Gaskets shall be solid. Conduit fittings with blank covers shall have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Covers shall have captive screws and shall be accessible after the work has been completed.

2.1.2 Electrical Metallic Tubing (EMT)

EMT shall be in accordance with UL 797 and shall be zinc coated steel. Couplings and connectors shall be zinc-coated, raintight, gland compression

with insulation throat. Crimp, spring, or setscrew type fittings shall not be acceptable.

2.1.3 Flexible Metallic Conduit

Flexible metallic conduit shall be in accordance with UL 1 and shall be galvanized steel.

Fittings for flexible metallic conduit shall be specifically designed for such conduit.

Liquidtight flexible metallic conduit shall be provided with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Fittings for liquidtight flexible metallic conduit shall be specifically designed for such conduit.

2.1.4 Intermediate Metal Conduit

Intermediate metal conduit shall be in accordance with UL 1242 and shall be galvanized.

2.1.5 Rigid Nonmetallic Conduit

Rigid nonmetallic conduit shall be in accordance with NEMA TC 13 and shall be PVC with wall thickness not less than Schedule 40.

2.1.6 Wireways and Auxiliary Gutters

Wireway and auxiliary gutters shall be a minimum 100 by 100 millimeter 4-by 4 inch trade size conforming to UL 870.

2.1.7 Surface Raceways and Assemblies

Surface metal raceways and multi-outlet assemblies shall conform to NFPA 70. Receptacles shall conform to NEMA WD 1, Type [5-15R] [5-20R].

2.1.8 Cable Trays

Cable trays shall be ladder type conforming to NEMA VE 1.

2.2 WIRE AND CABLE

Conductors installed in conduit shall be copper 600-volt type [THHN] [THWN] [XHHW]. All conductors 3.15 millimeter diameter (AWG No. 8) AWG No. 8 and larger, shall be stranded. All conductors smaller than 3.15 millimeter diameter (AWG No. 8) AWG No. 8 shall be [stranded] [solid].

Flexible cable shall be Type SO and shall contain a grounding conductor with green insulation.

Conductors installed in plenums shall be marked plenum rated.

2.3 SPLICES AND CONNECTORS

Splices in 3.15 millimeter diameter (AWG No. 8) AWG No. 8 and smaller shall be made with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Splices in 4.1 millimeter diameter (AWG No. 6) AWG No. 6 and larger shall be made with [indentor crimp-type connectors and compression tools] [bolted clamp-type connectors]. Joints shall be wrapped with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

2.4 SWITCHES

2.4.1 Safety Switches

Safety switches shall be in accordance with NEMA KS 1, and shall be the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated. Switch construction shall be such that, with the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device shall be coinproof and shall be so constructed that an external tool must be used to open the cover. Provisions shall be made to lock the handle in the "OFF" position, but the switch shall not be capable of being locked in the "ON" position.

Switches shall be of the quick-make, quick-break type. Terminal lugs shall be approved for use with copper conductors.

Safety color coding for identification of safety switches shall conform to ANSI Z535.1.

2.4.2 Toggle Switches

Toggle switches shall be in accordance with EIA 480, and shall control incandescent, mercury, and fluorescent lighting fixtures and shall be of the heavy duty, general purpose, noninterchangeable flush-type.

Toggle switches shall be commercial grade toggle type, [single] [double]-pole, [three] [four]-way two-position devices rated 20 amperes at 277 volts, 60 hertz alternating current (ac) only.

All toggle switches shall be products of the same manufacturer.

2.5 RECEPTACLES

Receptacles shall be commercial grade, 20A, 125 VAC, 2-pole, 3-wire duplex conforming to NEMA WD 6, NEMA 5-20R.

2.6 OUTLETS, OUTLET BOXES, AND PULL BOXES

Outlet boxes for use with conduit systems shall be in accordance with NEMA FB 1 and [NEMA OS 1] [NEMA OS 2] and shall be not less than 40 millimeter 1-1/2 inches deep. Pull and junction boxes shall be furnished with screw-fastened covers.

2.7 PANELBOARDS

Lighting and appliance branch circuit panelboards shall be the circuit-breaker type in accordance with NEMA PB 1. Circuit breakers shall be bolted to the bus. Plug-in circuit breakers shall not be acceptable. Buses shall be copper of the rating indicated, with main lugs or main circuit breaker as indicated. Panelboards for use on grounded ac systems shall be provided with a full-capacity isolated neutral bus and a separate grounding bus bonded to the panelboard enclosure. Panelboard enclosures

shall be NEMA 250, Type 1, in accordance with NEMA PB 1. Enclosure fronts shall have latchable hinged doors.

2.8 CIRCUIT BREAKERS

Circuit-breaker interrupting rating shall be not less than those indicated and in no event less than [10,000] [20,000] amperes root-mean-square (rms) symmetrical at [208] [240] volts, respectively. Multipole circuit breakers shall be the common-trip type with a single handle. Molded case circuit breakers shall be bolt-on type conforming to UL 489.

2.9 LAMPS AND LIGHTING FIXTURES

Manufacturers and catalog numbers shown are indicative of the general type desired and are not intended to restrict the selection to fixtures of any particular manufacturer. Fixtures with the same salient features and equivalent light distribution and brightness characteristics, of equal finish and quality, will be acceptable. Lamps of the proper type and wattage shall be provided for each fixture.

Ballasts shall be high power factor and be energy efficient. Ballasts shall have a Class P terminal protective device for [120] [277]-volt operation as indicated and shall be rapid-start fluorescent. Ballasts shall be "A" sound rated. Fluorescent lamps shall be standard reduced wattage type.

High intensity discharge (HID) lighting fixtures shall have prewired integral ballasts and cast aluminum housings complete with tempered glass lenses suitable for installation in damp or wet locations. Fixtures and lamps shall be provided.

2.10 DRY-TYPE DISTRIBUTION TRANSFORMERS

General purpose dry-type transformers with windings 600 volts or less shall be two-winding, 60 hertz, self-cooled in accordance with UL 506. Windings shall have a minimum of two 2-1/2-percent taps above and below nominal voltage.

PART 3 EXECUTION

3.1 CONDUITS, RACEWAYS AND FITTINGS

Conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting shall contain not more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Crushed or deformed conduit shall not be installed. Trapped conduit runs shall be avoided where possible. Care shall be taken to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clogged conduit shall be cleared of obstructions or shall be replaced.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 1470 millimeter 5 feet or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

3.1.1 Rigid Steel Conduit

Field-made bends and offsets shall be made with approved hickey or conduit bending machine. Conduit elbows larger than 65 millimeter 2-1/2 inches shall be long radius.

Conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, shall be provided with a flush coupling when the floor slab is of sufficient thickness. Otherwise, a floor box shall be provided and set flush with the finished floor. Conduits installed for future use shall be terminated with a coupling and plug set flush with the floor.

3.1.2 Electrical Metallic Tubing (EMT)

EMT shall be grounded in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.1.3 Flexible Metallic Conduit

Flexible metallic conduit shall be used to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Bonding wires shall be used in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit shall not be considered a ground conductor.

Electrical connections to vibration-isolated equipment shall be made with flexible metallic conduit.

Liquidtight flexible metallic conduit shall be used in wet and oily locations and to complete the connection to motor-driven equipment.

3.1.4 Intermediate Conduit

Field-made bends and offsets shall be made with approved hickey or conduit bending machine. Intermediate metal conduit shall be used only for indoor installations.

3.1.5 Rigid Nonmetallic Conduit

Rigid PVC conduit shall be direct buried.

A green insulated copper grounding conductor shall be in conduit with conductors and shall be solidly connected to ground at each end. Grounding wires shall be sized in accordance with NFPA 70.

3.1.6 Wireway and Auxiliary Gutter

Straight sections and fittings shall be bolted together to provide a rigid, mechanical connection and electrical continuity. Dead ends of wireways and auxiliary gutters shall be closed. Unused conduit openings shall be plugged.

Wireways for overhead distribution and control circuits shall be supported at maximum [_____] [1500] millimeter [5]-foot intervals.

Auxiliary gutters used to supplement wiring spaces for equipment not

contained in a single enclosure shall contain no switches, overcurrent devices, appliances, or apparatus and shall be not more than [_____] [9000] millimeter [30] feet long.

3.1.7 Surface Raceways and Assemblies

Surface raceways shall be mounted plumb and level, with the base and cover secured. Minimum circuit run shall be three-wire with one wire designated as ground.

3.1.8 Cable Trays

Cable trays shall be supported from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Support shall be provided when the free end extends beyond [_____] [900] millimeter [3] feet. Maximum support spacing shall be [_____] [1800] millimeter [6] feet. Trays 250 millimeter 10-inches wide or less shall be supported by [one] [_____] hanger. Trays greater than 250 millimeter 10-inches wide shall be supported by [two] [_____] hangers. Cable trays shall be bonded at splices.

3.2 WIRING

Feeder and branch circuit conductors shall be color coded as follows:

<u>CONDUCTOR</u>	<u>COLOR AC</u>
Phase A	[_____]
Phase B	[_____]
Phase C	[_____]
Neutral	[White] [Natural Gray]
Equipment Grounds	[Green] [Green with Yellow Stripe] [Bare]

Conductors up to and including 6.5 millimeter diameter (AWG No. 2) AWG No. 2 shall be manufactured with colored insulating materials. Conductors larger than 6.5 millimeter diameter (AWG No. 2) AWG No. 2 shall have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splices shall be in accordance with the NFPA 70. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Terminal and conductor identification shall match as indicated.

Where several feeders pass through a common pullbox, the feeders shall be tagged to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.3 SAFETY SWITCHES

Switches shall be securely fastened to the supporting structure or wall, utilizing a minimum of [four] [_____] 6 millimeter 1/4 inch bolts. Sheet metal screws and small machine screws shall not be used for mounting. Switches shall not be mounted in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height shall be [_____] [1500] millimeter [5] feet above floor level, when possible.

3.4 WIRING DEVICES

3.4.1 Wall Switches and Receptacles

Wall switches and receptacles shall be so installed that when device plates are applied, the plates will be aligned vertically to within [_____] [2] millimeter [1/16] inch.

Ground terminal of each flush-mounted receptacle shall be bonded to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.4.2 Device Plates

Device plates for switches that are not within sight of the loads controlled shall be suitably engraved with a description of the loads.

Device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets shall be suitably marked, showing the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Required marking shall consist of a self-adhesive label having [_____] [6] millimeter [1/4] inch embossed letters.

Device plates for convenience outlets shall be similarly marked indicating the supply panel and circuit number.

3.5 BOXES AND FITTINGS

Pullboxes shall be furnished and installed where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than [_____] [30] meter [100] feet or with more than three right-angle bends shall have a pullbox installed at a convenient intermediate location.

Boxes and enclosures shall be securely mounted to the building structure with supporting facilities independent of the conduit entering or leaving the boxes.

Mounting height of wall-mounted outlet and switch boxes, measured between the bottom of the box and the finished floor, shall be in accordance with ICC A117.1 and as follows:

<u>LOCATION</u>	<u>MOUNTING HEIGHT</u>
Receptacles in offices	450 millimeter18 inches
Receptacles in corridors	450 millimeter18 inches
Receptacles in shops & laboratories	1200 millimeter48 inches
Receptacles in rest rooms	1200 millimeter48 inches
Switches for light control	1200 millimeter48 inches

3.6 LAMPS AND LIGHTING FIXTURES

New lamps of the proper type and wattage shall be installed in each fixture. Fixtures and supports shall be securely fastened to structural

members and shall be installed parallel and perpendicular to major axes of structures.

3.7 PANELBOARDS

NOTE: Ability to remove access covers is required for maintenance activities. In addition, access may be required to inspect this device while circuits are energized (for example, using infrared imaging). Minimum distances to energized circuits is specified in OSHA Standards Part 1910.333 (Electrical - Safety-Related work practices). OSHA Standards are available on the internet.

Panelboards shall be securely mounted so that the top operating handle does not exceed [_____] [1800] millimeter [72]-inches above the finished floor. No equipment shall be mounted within 914 millimeter 36 inches of the front of the panel. Directory card information shall be complete and legible.

3.8 DRY-TYPE DISTRIBUTION TRANSFORMERS

Dry-type transformers shall be connected with flexible metallic conduit.

[All dry-type transformers shall be mounted on vibration isolators in accordance with Section 15072S VIBRATION ISOLATION FOR AIR CONDITIONING SYSTEMS.]

3.9 IDENTIFICATION PLATES AND WARNINGS

Identification plates shall be furnished for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Process control devices and pilot lights shall have identification plates.

Identification plates shall be furnished for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. Circuits 480 volts and above shall have conspicuously located warning signs in accordance with OSHA requirements.

3.10 PAINTING

Exposed conduit, supports, fittings, cabinets, pull boxes, and racks shall be thoroughly cleaned and painted as specified in Section 09920S ARCHITECTURAL PAINTING or Section 09960 HIGH-PERFORMANCE COATINGS.

3.11 FIELD TESTING

After the installation is complete wire and cable shall be given a continuity and insulation resistance test. Insulation resistance test shall be with a [250] [500] [1000] - volt insulation test set. Readings shall be recorded after a minimum of 3 minutes and until the reading is constant for 1 minute. Resistance between phase conductors and ground shall be no less than 25 megohms.

Phase-rotation tests shall be conducted on three-phase circuits using a

phase-rotation indicating instrument. Phase rotation of electrical connections to connected equipment shall be A, B, C left to right, or top to bottom facing the equipment.

Transformers shall be given an insulation resistance test. Resistance between each phase and ground shall be not less than 25 megohms.

Final acceptance will depend upon the satisfactory performance of the equipment under test. No conductor or circuit shall be energized until the installation has been approved by the Contracting Officer. Final test data shall be provided to the Contracting Officer. Data shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Data - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --