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Preparing Activity: NASA Superseding
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 9 October 2006

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COMMON WORK RESULTS FOR ELECTRICAL 10/06

NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This broadscope section covers requirements common to all electrical sections.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's

Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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) Standard for Safety Color Code

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480 (1981) Toggle Switches

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 (2003 R 2004) Standard 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 (2003) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable

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

NEMA OS 1 (2003) Standard for Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

NEMA OS 2 (2003) Standard for Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

NEMA PB 1 (2000; R 2001) Standard for Panelboards

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

NEMA TC 13 (2005) Standard for Electrical Nonmetallic Tubing (ENT)

NEMA VE 1 (2003) Standard for Metallic Cable Tray

Systems

NEMA WD 1 (1999) Standard for General Requirements for Wiring Devices

NEMA WD 6 (2002) Standard for Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1 (2004; Rev 2) Standard for Flexible Metal Conduit

UL 1242 (2003; R 2005) Standard for Electrical Intermediate Metal Conduit - Steel

UL 489 (2004) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 506 (2005) Standard for Specialty Transformers

UL 6 (2004e13) Standard for Electrical Rigid Metal Conduit-Steel

UL 797 (2000e8) Standard for Electrical Metallic Tubing

UL 870 (2003e7) Standard for Wireways, Auxiliary Gutters, and Associated Fittings

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 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 01 33 00 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

Submit manufacturer's catalog data 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 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 09 96 00 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).

Protect metallic materials against corrosion. Provide equipment enclosures with 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 09 96 00 HIGH-PERFORMANCE COATINGS. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect 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 must be hot-dip galvanized except where other equivalent protective treatment is specifically approved in writing.

1.4 GENERAL REQUIREMENTS

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

Submit Manufacturer's Instructions 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 must be the standard cataloged products of manufacturers regularly engaged in the manufacture of the products.

2.1.1 Rigid Steel Conduit

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

Fittings for rigid steel conduit must be threaded.

Gaskets must be solid. Conduit fittings with blank covers must have

gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

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

2.1.1.2 Electrical Metallic Tubing (EMT)

EMT must be in accordance with [UL 797](#) and must be zinc coated steel. Couplings and connectors must be zinc-coated, raintight, gland compression with insulation throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Flexible metallic conduit must comply with [UL 1](#) and be galvanized steel.

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

Liquidtight flexible metallic conduit must 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 must be specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Intermediate metal conduit must comply with [UL 1242](#) and be galvanized.

2.1.1.5 Rigid Nonmetallic Conduit

Rigid nonmetallic conduit must comply with [NEMA TC 13](#) and shall be PVC with wall thickness not less than Schedule 40.

2.1.1.6 Wireways and Auxiliary Gutters

Wireway and auxiliary gutters must be a minimum 100 by 100 millimeter 4- by 4 inch trade size conforming to [UL 870](#).

2.1.1.7 Surface Raceways and Assemblies

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

2.1.1.8 Cable Trays

Provide ladder type cable trays conforming to [NEMA VE 1](#).

2.2 WIRE AND CABLE

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

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

Conductors installed in plenums must be marked plenum rated.

2.3 SPLICES AND CONNECTORS

Make all splices in 3.15 millimeter diameter (AWG No. 8) AWG No. 8 and smaller with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Make all splices in 4.1 millimeter diameter (AWG No. 6) AWG No. 6 and larger with [indentor crimp-type connectors and compression tools] [bolted clamp-type connectors]. Joints must 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 must comply with NEMA KS 1, and be the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated. Switch construction must be such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device must be coinproof and be so constructed that an external tool must be used to open the cover. Provisions must be made to lock the handle in the "OFF" position, but the switch must not be capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type. Terminal lugs must be approved for use with copper conductors.

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

2.4.2 Toggle Switches

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

Toggle switches must 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 must be products of the same manufacturer.

2.5 RECEPTACLES

Receptacles must 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 must be in accordance with NEMA FB 1 and [NEMA OS 1] [NEMA OS 2] and be not less than 40 millimeter 1-1/2 inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.7 PANELBOARDS

Lighting and appliance branch circuit panelboards must be the circuit-breaker type in accordance with NEMA PB 1. Bolt circuit breakers to the bus. Plug-in circuit breakers are not acceptable. Buses must be copper of the rating indicated, with main lugs or main circuit breaker as indicated. Provide all panelboards for use on grounded ac systems with a full-capacity isolated neutral bus and a separate grounding bus bonded to the panelboard enclosure. Panelboard enclosures must be NEMA 250, Type 1, in accordance with NEMA PB 1. Provide enclosure fronts with latchable hinged doors.

2.8 CIRCUIT BREAKERS

Circuit-breaker interrupting rating must 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 must be the common-trip type with a single handle. Molded case circuit breakers must 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, are acceptable. Provide lamps of the proper type and wattage for each fixture.

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

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

2.10 DRY-TYPE DISTRIBUTION TRANSFORMERS

General purpose dry-type transformers with windings 600 volts or less must be two-winding, 60 hertz, self-cooled in accordance with UL 506. Windings must 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 must not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Care must be taken to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course

of construction. Clogged conduit must be cleared of obstructions or 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 must be made with approved hickey or conduit bending machine. Conduit elbows larger than 65 millimeter 2-1/2 inches must be long radius.

Provide all 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, with a flush coupling when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. Conduits installed for future use must be terminated with a coupling and plug set flush with the floor.

3.1.2 Electrical Metallic Tubing (EMT)

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

3.1.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

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

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

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

3.1.4 Intermediate Conduit

Make all field-made bends and offsets with approved hickey or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.1.5 Rigid Nonmetallic Conduit

Rigid PVC conduit must be direct buried.

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

3.1.6 Wireway and Auxiliary Gutter

Straight sections and fittings must be bolted together to provide a rigid, mechanical connection and electrical continuity. Dead ends of wireways and auxiliary gutters must be closed. Plug all unused conduit openings.

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

Auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure must contain no switches, overcurrent devices, appliances, or apparatus and be not more than [_____] [9000] millimeter [30] feet long.

3.1.7 Surface Raceways and Assemblies

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

3.1.8 Cable Trays

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

3.2 WIRING

Feeder and branch circuit conductors must 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 must be manufactured with colored insulating materials. Conductors larger than 6.5 millimeter diameter (AWG No. 2) AWG No. 2 must have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Conductor identification must 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 must match as indicated.

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

3.3 SAFETY SWITCHES

Securely fasten switches to the supporting structure or wall, utilizing a minimum of [four] [_____] 6 millimeter 1/4 inch bolts. Do not use sheet

metal screws and small machine screws for mounting. Switches must not be mounted in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height must be [_____] [1500] millimeter [5] feet above floor level, when possible.

3.4 WIRING DEVICES

3.4.1 Wall Switches and Receptacles

Install wall switches and receptacles so 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 must 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 must 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 must be suitably marked, showing the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Required marking must consist of a self-adhesive label having [_____] [6] millimeter [1/4] inch embossed letters.

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

3.5 BOXES AND FITTINGS

Furnish and install pullboxes 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 must have a pullbox installed at a convenient intermediate location.

Securely mount boxes and enclosures 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, must 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

Install new lamps of the proper type and wattage in each fixture. Securely fasten fixtures and supports to structural members and install 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.

Securely mount panelboards so that the top operating handle does not exceed [_____] [1800] millimeter [72]-inches above the finished floor. Do not mount equipment within 914 millimeter 36 inches of the front of the panel. Directory card information must be complete and legible.

3.8 DRY-TYPE DISTRIBUTION TRANSFORMERS

Connect dry-type transformers with flexible metallic conduit.

[Mount all dry-type transformers on vibration isolators in accordance with Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.]

3.9 IDENTIFICATION PLATES AND WARNINGS

Furnish and install identification plates 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 must have identification plates.

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

3.10 PAINTING

Exposed conduit, supports, fittings, cabinets, pull boxes, and racks must be thoroughly cleaned and painted as specified in Section 09 90 00.00 40 PAINTING AND COATING or Section 09 96 00 HIGH-PERFORMANCE COATINGS.

3.11 FIELD TESTING

Submit Test Reports in accordance with referenced standards in this section.

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Contractor must provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices must be used to isolate the circuits under test.

Perform [Insulation-Resistance Test](#) on each field-installed conductor with respect to ground and adjacent conductors. Applied potential must be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values must not be less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes 8AWG and smaller insulation resistance testing is not required.

Perform [Continuity Test](#) to insure correct cable connection (i.e correct phase conductor, grounded conductor, and grounding conductor wiring) end-to-end. Any damages to existing or new electrical equipment resulting from contractor mis-wiring will be repaired and re-verified at contractor's expense. All repairs must be approved by the CO prior to acceptance of the repair.

Conduct [Phase-Rotation Tests](#) on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source.

Final acceptance will depend upon the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved by the CO.

-- End of Section --