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DOVER BUS CANOPY SOLAR PANELS PSE SUBMISSION

CONTRACT NO. T202153104

AGREEMENT 1911F – ARCHITECTURAL AND ENGINEERING SERVICES (FEDERAL)
TASK 26A

Submitted to:
DELAWARE TRANSIT CORPORATION

DOVER BUS CANOPY SOLAR PANELS BID PACKAGE DEVELOPMENT

This specification is for the work associated with the Dover Bus Canopy Solar Panels Bid Package Development.

SECTION

SECTION TITLE

DIVISION 03

CONCRETE

031000

Concrete Forming and Accessories

032000

Concrete Reinforcing

033000

Cast-in-Place Concrete

DIVISION 13

SPECIAL CONSTRUCTION

133000

Fabricated Steel Canopy

DIVISION 26

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Low-Voltage Electrical Power Conductors and Cables

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Low Voltage Microgrid Energy Management System (MEMS)

265600

Exterior Lighting

SECTION 031000

CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Shoring, bracing, and anchoring.

1.3 DEFINITIONS

- A. Formwork: The total system of support of freshly placed concrete, including the mold or sheathing that contacts the concrete, as well as supporting members, hardware, and necessary bracing.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction, movement, contraction, and isolation joints
 - c. Forms and form-removal limitations.
 - d. Shoring and reshoring procedures.
 - e. Anchor rod and anchorage device installation tolerances.

1.5 ACTION SUBMITTALS

- A. Product Data: For each of the following:
 - 1. Forms for cylindrical columns.
 - 2. Form ties.
 - 3. Waterstops.
 - 4. Form-release agent.
- B. Shop Drawings: Prepared by a qualified professional engineer responsible for their preparation, detailing fabrication, assembly, and support of forms.

1. For exposed vertical concrete walls, indicate dimensions and form tie locations.
2. Indicate dimension and locations of construction and movement joints required to construct the structure in accordance with ACI 301 (ACI 301M).
 - a. Location of construction joints is subject to approval of the Architect.
3. Indicate location of waterstops.
4. Indicate proposed schedule and sequence of stripping of forms, shoring removal, and reshoring installation and removal.

C. Samples:

1. For waterstops.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing and inspection agency.
- B. Research Reports: For insulating concrete forms indicating compliance with International Code Council Acceptance Criteria AC308.
- C. Field quality-control reports.
- D. Minutes of preinstallation conference.

1.7 QUALITY ASSURANCE

- A. Testing and Inspection Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Concrete Formwork: Design, engineer, erect, shore, brace, and maintain formwork, shores, and reshores in accordance with ACI 301 (ACI 301M), to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.
 1. Design wood panel forms in accordance with APA's "Concrete Forming Design/Construction Guide."

2. Design formwork to limit deflection of form-facing material to 1/240 of center-to-center spacing of supports.
- B. Design, engineer, erect, shore, brace, and maintain insulating concrete forms in accordance with ACI 301 (ACI 301M), to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.
1. Design cross ties to transfer the effects of the following loads to the cast-in-place concrete core:

2.2 FORM-FACING MATERIALS

- A. As-Cast Surface Form-Facing Material:
1. Provide continuous, true, and smooth concrete surfaces.
 2. Furnish in largest practicable sizes to minimize number of joints.
 3. Acceptable Materials: As required to comply with Surface Finish designations specified in Section 033000 "Cast-In-Place Concrete, and as follows:
 - a. Plywood, metal, or other approved panel materials.
 - b. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
- B. Concealed Surface Form-Facing Material: Lumber, plywood, metal, plastic, or another approved material.
1. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class.
1. Provide forms with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

2.3 RELATED MATERIALS

- A. Dovetail Anchor Slots: Hot-dip galvanized-steel sheet, not less than 0.034 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.
- B. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.
- C. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

- D. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
 - 2. Form release agent for form liners shall be acceptable to form liner manufacturer.
- E. Form Ties: Factory-fabricated, removable or snap-off, glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

PART 3 - EXECUTION

3.1 INSTALLATION OF FORMWORK

- A. Comply with ACI 301 (ACI 301M).
- B. Construct formwork, so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117 (ACI 117M) and to comply with the Surface Finish designations specified in Section 033000 "Cast-In-Place Concrete" for as-cast finishes.
- C. Limit concrete surface irregularities as follows:
 - 1. Surface Finish-1.0: ACI 117 Class D, 1 inch (25 mm).
- D. Construct forms tight enough to prevent loss of concrete mortar.
 - 1. Minimize joints.
 - 2. Exposed Concrete: Symmetrically align joints in forms.
- E. Construct removable forms for easy removal without hammering or prying against concrete surfaces.
 - 1. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces.
 - 2. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - 3. Install keyways, reglets, recesses, and other accessories, for easy removal.
- F. Do not use rust-stained, steel, form-facing material.
- G. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces.
 - 1. Provide and secure units to support screed strips
 - 2. Use strike-off templates or compacting-type screeds.

- H. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible.
 - 1. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar.
 - 2. Locate temporary openings in forms at inconspicuous locations.
- I. Chamfer exterior corners and edges of permanently exposed concrete.
- J. At construction joints, overlap forms onto previously placed concrete not less than 12 inches (305 mm).
- K. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work.
 - 1. Determine sizes and locations from trades providing such items.
 - 2. Obtain written approval of Architect prior to forming openings not indicated on Drawings.
- L. Construction and Movement Joints:
 - 1. Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 2. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 3. Place joints perpendicular to main reinforcement.
 - 4. Locate joints for beams, slabs, joists, and girders in the middle third of spans.
 - a. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
- M. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection.
 - 1. Locate ports and openings in bottom of vertical forms, in inconspicuous location, to allow flushing water to drain.
 - 2. Close temporary ports and openings with tight-fitting panels, flush with inside face of form and neatly fitted so joints will not be apparent in exposed concrete surfaces.
- N. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- O. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- P. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 INSTALLATION OF EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
 - 3. Clean embedded items immediately prior to concrete placement.

3.3 REMOVING AND REUSING FORMS

- A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.
- B. Clean and repair surfaces of forms to be reused in the Work.
 - 1. Split, frayed, delaminated, or otherwise damaged form-facing material are unacceptable for exposed surfaces.
 - 2. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints.
 - 1. Align and secure joints to avoid offsets.
 - 2. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a **special inspector** to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- C. Inspections:
 - 1. Inspect formwork for shape, location, and dimensions of the concrete member being formed.

END OF SECTION

SECTION 032000
CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Steel reinforcement bars.
 - 2. Welded-wire reinforcement.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction contraction and isolation joints.
 - c. Steel-reinforcement installation.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Each type of steel reinforcement.
 - 2. Bar supports.
- B. Shop Drawings: Comply with ACI SP-066:
 - 1. Include placing drawings that detail fabrication, bending, and placement.
 - 2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.
- C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.
 - 1. Location of construction joints is subject to approval of Architect.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Statements: For delegated design engineer and testing and inspection agency.

- B. Delegated Design Engineer Qualifications: Include the following:
 - 1. Experience providing delegated design engineering services of the type indicated.
 - 2. Documentation that delegated design engineer is licensed in the state in which Project is located.
- C. Material Certificates: For each of the following, signed by manufacturers:
- D. Material Test Reports: For the following, from a qualified testing agency:
 - 1. Steel Reinforcement:
 - a. For reinforcement to be welded, mill test analysis for chemical composition and carbon equivalent of the steel in accordance with ASTM A706/A706M.
- E. Field quality-control reports.
- F. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage and to avoid damaging coatings on steel reinforcement
 - 1. Store reinforcement to avoid contact with earth.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design structural foundation system, including attachment to building construction.
- B. Structural Performance of Structural foundation System: Structural foundation system to withstand the following loads and stresses:
 - 1. Dead Loads: As indicated on Drawings.
 - a. Shear Load: As indicated on shop Drawings.
 - b. Bending Moment: As indicated on shop Drawings.

2. Live Loads: As indicated on Drawings.
 - a. Shear Load: As indicated on shop Drawings.
 - b. Bending Moment: As indicated on shop Drawings.
- C. Lateral Performance of Structural foundation system: Structural thermal break Insulated connection system to withstand the effects of earthquake motions determined according to ASCE-7 latest edition

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60, deformed.
- B. Headed-Steel Reinforcing Bars: ASTM A970/A970M.
- C. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

2.3 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A615/A615M, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.
- B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.
 1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
- C. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch (1.2908 mm) in diameter.

2.4 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection of In-Place Conditions:
 1. Do not cut or puncture vapor retarder.
 2. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

3.2 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.
- B. Accurately position, support, and secure reinforcement against displacement.
 - 1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
 - 2. Do not tack weld crossing reinforcing bars.
- C. Preserve clearance between bars of not less than 1 inch (25 mm), not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.
- D. Provide concrete coverage in accordance with ACI 318 (ACI 318M).
- E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- F. Splices: Lap splices as indicated on Drawings.
 - 1. Bars indicated to be continuous, and all vertical bars to be lapped not less than 36 bar diameters at splices, or 24 inches (610 mm), whichever is greater.
 - 2. Stagger splices in accordance with ACI 318 (ACI 318M).
 - 3. Mechanical Splice Couplers: Install in accordance with manufacturer's instructions.
- G. Install welded-wire reinforcement in longest practicable lengths.
 - 1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."
 - a. For reinforcement less than W4.0 or D4.0, continuous support spacing to not exceed 12 inches (305 mm).
 - 2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches (50 mm) for plain wire and 8 inches (200 mm) for deformed wire.
 - 3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
 - 4. Lace overlaps with wire.

3.3 JOINTS

- A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 1. Place joints perpendicular to main reinforcement.
 - 2. Continue reinforcement across construction joints unless otherwise indicated.
 - 3. Do not continue reinforcement through sides of strip placements of floors and slabs.

- B. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length, to prevent concrete bonding to one side of joint.

3.4 INSTALLATION TOLERANCES

- A. Comply with ACI 117 (ACI 117M).

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- C. Inspections:
 - 1. Steel-reinforcement placement.

END OF SECTION

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SECTION 033000
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cast-in-place concrete, including concrete materials, mixture design, placement procedures, and finishes.
- B. Related Requirements:
 - 1. Section 031000 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
 - 2. Section 032000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- B. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Concrete Subcontractor.
 - 2. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction joints, control joints, isolation joints, and joint-filler strips.
 - c. Anchor rod and anchorage device installation tolerances.
 - d. Cold and hot weather concreting procedures.
 - e. Concrete finishes and finishing.

- f. Curing procedures.
- g. Forms and form-removal limitations.
- h. Shoring and reshoring procedures.
- i. Concrete repair procedures.
- j. Concrete protection.
- k. Initial curing and field curing of field test cylinders (ASTM C31/C31M.)
- l. Protection of field cured field test cylinders.

1.4 ACTION SUBMITTALS

A. Product Data: For each of the following.

- 1. Portland cement.
- 2. Fly ash.
- 3. Slag cement.
- 4. Blended hydraulic cement.
- 5. Silica fume.
- 6. Performance-based hydraulic cement
- 7. Aggregates.
- 8. Admixtures:
 - a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
- 9. Curing materials
- 10. Repair materials.

B. Design Mixtures: For each concrete mixture, include the following:

- 1. Mixture identification.
- 2. Minimum 28-day compressive strength.
- 3. Durability exposure class.
- 4. Maximum w/cm.
- 5. Calculated equilibrium unit weight, for lightweight concrete.
- 6. Slump limit.
- 7. Air content.
- 8. Nominal maximum aggregate size.
- 9. Steel-fiber reinforcement content.
- 10. Synthetic micro-fiber content.
- 11. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.
- 12. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Shop Drawings:

D. Concrete Schedule: For each location of each Class of concrete indicated in "Concrete Mixtures" Article, including the following:

1. Concrete Class designation.
2. Location within Project.
3. Exposure Class designation.
4. Curing process.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Installer: Include copies of applicable ACI certificates.
2. Ready-mixed concrete manufacturer.
3. Testing agency: Include copies of applicable ACI certificates.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Curing compounds.
4. Bonding agents.
5. Adhesives.
6. Repair materials.

C. Material Test Reports: For the following, from a qualified testing agency:

1. Portland cement.
2. Fly ash.
3. Slag cement.
4. Blended hydraulic cement.
5. Silica fume.
6. Performance-based hydraulic cement.
7. Aggregates.
8. Admixtures:

D. Research Reports:

1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
2. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.

E. Preconstruction Test Reports: For each mix design.

F. Field quality-control reports.

G. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified installer who employs Project personnel qualified as an ACI-certified Flatwork Technician and Finisher and a supervisor who is a certified ACI Flatwork Concrete Finisher/Technician.
 - 1. Post-Installed Concrete Anchors Installers: ACI-certified Adhesive Anchor Installer.
- B. Ready-Mixed Concrete Manufacturer Qualifications: A firm that is experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
 - 1. Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- C. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Control Technical Manager.
 - 1. Personnel performing laboratory tests to be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor to be an ACI-certified Concrete Laboratory Testing Technician, Grade II.
- D. Field Quality-Control Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.
 - 1. Personnel conducting field tests to be qualified as an ACI Concrete Field-Testing Technician, Grade 1, in accordance with ACI CPP 610.1 or an equivalent certification program.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.
 - 1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301 (ACI 301M).

1.9 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 306.1 and as follows.
1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 2. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301 (ACI 301M).
 3. Do not use frozen materials or materials containing ice or snow.
 4. Do not place concrete in contact with surfaces less than 35 deg F (1.7 deg C), other than reinforcing steel.
 5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M), and as follows:
1. Maintain concrete temperature at time of discharge to not exceed 95 deg F (35 deg C).
 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder/termite barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.
1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents.

2.2 CONCRETE MATERIALS

- A. Source Limitations:
1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.

2. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
 3. Obtain aggregate from single source.
 4. Obtain each type of admixture from single source from single manufacturer.
- B. Cementitious Materials:
1. Portland Cement: ASTM C150/C150M, Type I gray.
 2. Fly Ash: ASTM C618, Class C or F.
 3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 4. Silica Fume: ASTM C1240 amorphous silica.
- C. Normal-Weight Aggregates: ASTM C33/C33M, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source.
1. Alkali-Silica Reaction: Comply with one of the following:
 - a. Expansion Result of Aggregate: Not more than 0.04 percent at one-year when tested in accordance with ASTM C1293.
 - b. Expansion Results of Aggregate and Cementitious Materials in Combination: Not more than 0.10 percent at an age of 16 days when tested in accordance with ASTM C1567.
 - c. Alkali Content in Concrete: Not more than 4 lb./cu. yd. (2.37 kg/cu. m) for moderately reactive aggregate or 3 lb./cu. yd. (1.78 kg/cu. m) for highly reactive aggregate, when tested in accordance with ASTM C1293 and categorized in accordance with ASTM C1778, based on alkali content being calculated in accordance with ACI 301 (ACI 301M).
 2. Maximum Coarse-Aggregate Size: 1-1/2 inches (38 mm) nominal.
 3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Air-Entraining Admixture: ASTM C260/C260M.
- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride in steel-reinforced concrete.
1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 2. Retarding Admixture: ASTM C494/C494M, Type B.
 3. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 5. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
- F. Water and Water Used to Make Ice: ASTM C94/C94M, potable

2.3 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.
 - 1. Color:
 - a. Ambient Temperature Below 50 deg F (10 deg C): Black.
 - b. Ambient Temperature between 50 deg F (10 deg C) and 85 deg F (29 deg C): Any color.
 - c. Ambient Temperature Above 85 deg F (29 deg C): White.
- D. Curing Paper: 8-foot- (2438-mm-) wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.
- E. Water: Potable or complying with ASTM C1602/C1602M.

2.4 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber.
- B. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade and class to suit requirements, and as follows:

2.5 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301 (ACI 301M).
 - 1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Fly Ash or Other Pozzolans: 25 percent by mass.
 - 2. Slag Cement: 50 percent by mass.
 - 3. Silica Fume: 10 percent by mass.

4. Total of Fly Ash or Other Pozzolans, Slag Cement, and Silica Fume: 50 percent by mass, with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
 5. Total of Fly Ash or Other Pozzolans and Silica Fume: 35 percent by mass with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
- C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.
1. Use water-reducing, high-range water-reducing, or plasticizing admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

2.6 CONCRETE MIXTURES

- A. Class A: Normal-weight concrete used for footings, grade beams, and tie beams.
1. Minimum Compressive Strength: 3000 psi (20.7 MPa) at 28 days.
 2. Maximum w/cm: 0.50.
 3. Slump Limit: 8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm) before adding high-range water-reducing admixture or plasticizing admixture at Project site.
 4. Air Content:
 - a. Exposure Classes F2 and F3: 6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size.
 5. Limit water-soluble, chloride-ion content in hardened concrete to 1.00 percent by weight of cement.

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M[and ASTM C1116/C1116M] and furnish batch ticket information.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete in accordance with ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
 2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time,

quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:

1. Daily access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 INSTALLATION OF EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.

1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303.
3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

B. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.

2. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface, where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

C. Doweled Joints:

1. Install dowel bars and support assemblies at joints where indicated on Drawings.
2. Lubricate or asphalt coat one-half of dowel bar length to prevent concrete bonding to one side of joint.

3.4 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.
1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
 2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
- B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.
- C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect in writing, but not to exceed the amount indicated on the concrete delivery ticket.
1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301 (ACI 301M), but not to exceed the amount indicated on the concrete delivery ticket.
1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
1. If a section cannot be placed continuously, provide construction joints as indicated.
 2. Deposit concrete to avoid segregation.
 3. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.

4. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301 (ACI 301M).
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer.
 - c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
 - d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

3.5 FINISHING FORMED SURFACES

A. As-Cast Surface Finishes:

1. ACI 301 (ACI 301M) Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches (38 mm) wide or 1/2 inch (13 mm) deep.
 - b. Remove projections larger than 1 inch (25 mm).
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117 (ACI 117M) Class D.
 - e. Apply to concrete surfaces not exposed to public view.

3.6 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling In:

1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
2. Mix, place, and cure concrete, as specified, to blend with in-place construction.
3. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 6 inches (150 mm) high unless otherwise indicated on Drawings and extend base not less than 6 inches (150 mm) in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.

3. Minimum Compressive Strength: 4000 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
6. Prior to pouring concrete, place and secure anchorage devices.
 - a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Cast anchor-bolt insert into bases.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.7 CONCRETE CURING

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
 1. Comply with ACI 301 (ACI 301M) and ACI 306.1 for cold weather protection during curing.
 2. Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M) for hot-weather protection during curing.
 3. Maintain moisture loss no more than 0.2 lb./sq. ft. x h (1 kg/sq. m x h), calculated in accordance with ACI 305.1, before and during finishing operations.
- B. Curing Unformed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:
 1. Begin curing immediately after finishing concrete.

3.8 TOLERANCES

- A. Conform to ACI 117 (ACI 117M).

3.9 JOINT FILLING

- A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Overfill joint, and trim joint filler flush with top of joint after hardening.

3.10 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 1. Repair and patch defective areas when approved by Architect.

2. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1-part portland cement to 2-1/2 parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling, and placing.
 - C. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.
 - D. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.11 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform field tests and inspections and prepare testing and inspection reports.
- B. Testing Agency: owner will engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 1. Testing agency to be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 2. Testing agency to immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 3. Testing agency to report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports to include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.
 - 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.

- 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.
- C. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- D. Inspections:
1. Headed bolts and studs.
 2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.
 6. Batch Plant Inspections: On a random basis, as determined by Architect.
- E. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M to be performed in accordance with the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F (4.4 deg C) and below or 80 deg F (27 deg C) and above, and one test for each composite sample.

5. Unit Weight: ASTM C567/C567M fresh unit weight of structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
6. Compression Test Specimens: ASTM C31/C31M:
 - a. Cast and laboratory cure two sets of three 6-inch (150 mm) by 12-inch (300 mm) or 4-inch (100 mm) by 8-inch (200 mm) cylinder specimens for each composite sample.
 - b. Cast, initial cure, and field cure two sets of four standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one set of two laboratory-cured specimens at seven days and one set of two specimens at 28 days.
 - b. Test one set of two field-cured specimens at seven days and one set of two specimens at 28 days.
 - c. A compressive-strength test to be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor to evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa) if specified compressive strength is 5000 psi (34.5 MPa), or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi (34.5 MPa).
10. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
11. Additional Tests:
 - a. Testing and inspecting agency to make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
 - 1) Acceptance criteria for concrete strength to be in accordance with ACI 301 (ACI 301M), Section 1.6.6.3.

12. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
13. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

3.12 PROTECTION

A. Protect concrete surfaces as follows:

1. Protect from petroleum stains.
2. Diaper hydraulic equipment used over concrete surfaces.
3. Prohibit vehicles from interior concrete slabs.
4. Prohibit use of pipe-cutting machinery over concrete surfaces.
5. Prohibit placement of steel items on concrete surfaces.
6. Prohibit use of acids or acidic detergents over concrete surfaces.
7. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.
8. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab Protective Covering.

END OF SECTION

SECTION 133000
FABRICATED STEEL CANOPY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, shall apply this section.

1.2 SUMMARY

- A. Section includes:

- 1. Design, fabrication, and installation of a complete pitched structural steel canopy system in accordance with the drawings and this specification.

- B. Related Requirements:

- 1. Section 031000 "Concrete Forming and Accessories".
- 2. Section 032000 "Concrete Reinforcing".
- 3. Section 033000 "Cast in Place Concrete".
- 4. Section 263100 "Photovoltaic System".

1.3 REFERENCES

- A. American Institute of Steel Construction
- B. ASCE 7, Minimum Design Loads for Buildings and Other Structures.
- C. American Society for Testing and Materials (ASTM).
- D. National Association of Architectural Metal Manufacturers (NAAMM): NAAMM MFM - Metal Finishes Manual.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of canopy component.

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

- B. Shop Drawings: Include the following:

- 1. Complete erection drawings showing attachment system, column and gutter beam framing, transverse cross sections, covering and trim details, and any

optional installation details to clearly indicate proper assembly of components. Drawings shall be sealed by a State Registered Structural Engineer in the state of Delaware.

2. Anchor-Rod Plans: Submit anchor-rod plans and templates before foundation work begins. Include location, diameter, and minimum required projection of anchor rods required to attach canopy to foundation. Indicate column reactions at each location.
- C. Certificates: Submit product certificates signed by the manufacturer certifying material compliance with specified performance characteristics and criteria, and physical requirements.
- D. Delegated-Design Submittal: For pre-engineered canopy. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.
- E. Certification: Submit written Certification prepared and signed by a Delaware Registered Structural Engineer verifying that framing design will safely withstand the following loading conditions from international building Code current edition and American Society of Civil Engineers (ASCE-7), see paragraph 2.03.1
- F. Buy America Certification: Provide written and signed certification by the manufacturer/contractor that manufactured products meet FTA Buy America requirements of 49 U.S.C. 5323(j)(1) and the applicable regulations in 49 C.F.R. Part 661.5.
- G. Warranty Data: Submit warranty documents specified herein.

1.5 QUALITY ASSURANCE

- A. Codes and standards: Comply with provisions of the following except as otherwise indicated: Standard building code, latest addition with amendments, if any. AWS (American Welding Society) standards for structural aluminum welding.
- B. Manufacturer Qualifications: Company specializing in engineering and manufacturing canopies with a minimum documented experience of ten (10) years and with a quality assurance program utilizing a quality inspection for each system.
- C. Erector Qualifications: An experienced firm, with not less than five (5) years' experience in installation of steel canopy of type, quantity, and installation methods similar to work of this section, and who is acceptable to the manufacturer.
- D. Welding: Qualify procedures and personnel according to the following:
 1. Welding shall be in accordance with AWS D1.1 (with E70XX electrodes).
 2. Steel shop connections shall be welded, and field connections shall be bolted (unless otherwise noted on the Drawings). Shop welds may be changed to field welds with approval.
 3. Slag shall be cleaned from welds and inspected.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver components, sheets, panels, and other manufactured items so as not to be damaged or deformed. Package metal for protection during transportation and handling.
- B. Protect components and accessories from corrosion, deformation, damage, and deterioration when stored at job site. Keep materials free from dirt and foreign matter.
- C. Unload, store, and metal components in a manner to prevent bending, warping, twisting, and surface damage.
- D. Stack metal components horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal components to ensure dryness, with positive slope for drainage of water. Do not store metal components in contact with other materials that might cause staining, denting, or other surface damage.

1.7 PROJECT CONDITIONS

- A. Field Measurements: The Contractor shall verify location and elevation of footings relative to finished grade, columns, and other construction contiguous with metal canopies by field measurements before fabrication and indicate measurements on shop drawings.
- B. Coordination: Coordinate work of this section with work of other sections which interface with canopy (sidewalk, curbs, building fascia's, etc.).

1.8 WARRANTY

- A. Provide manufactures standard one-year warranty that shall include, but not limited to, coverage for structural and finish beginning the day of Substantial Completion of Installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Structural Solar LLC
 - 2. Nucor Buildings Group
 - 3. CBC Steel Buildings
 - 4. Austin Mohawk and Company
 - 5. DeIDOT Approved Equal.
- B. Source Limitations: Obtain canopy system components, from single source from single manufacturer.

2.2 SYSTEM DESCRIPTION

- A. Provide a complete, integrated set of mutually dependent components and assemblies that form a fabricated steel canopy capable of withstanding structural and other loads, thermally induced movement, and exposure to weather without failure. Canopies shall cover at minimum the area of bus parking indicated on drawings. Canopy shall include a watertight roof deck, gutter, and downspout system. Refer to electrical drawings and specifications for lighting and photovoltaic requirements.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer licensed in the state of Delaware to design pre-engineered canopy.
- B. Structural Performance: Pre-engineered canopies shall withstand the effects of gravity loads and the following loads and stresses within limits:

	<u>Project Loads:</u>	
	Roof Live Load	20 PSF
	Dead Load	Self-Weight
	<u>Wind Load per ASCE 7-16:</u>	
	Wind Born Debris	Applicable
	Building Risk Category	I
	Design Wind Speed Ultimate (Vult)	106 MPH
	Directionality Factor (Kd)	0.85
	Wind Exposure Category	C
	Topography Factor (Kzt)	1.00
	Gust Effect factor (Gf)	0.85
	Enclosure Classification	Open
	Internal Pressure Coefficient	0.00
	MWFRS Design Procedure	Directional

<u>MWFRS (Ultimate)</u>	
Design By PEMB Manufacturer	
<u>Seismic Design Criteria:</u>	
Risk Category	I
Seismic Importance Factor (Ie)	
Mapped Spectral Response Acc'l	Ss = 0.13 S1 = 0.014
Site Class	D (Assumed) Sds = 0.138 Sd1 = 0.066
Seismic Design Category	A
<u>Seismic Design Factors:</u>	
Design By PEMB Manufacturer	
<u>Snow Loads</u>	
Ground Snow Load	25 LB/FT
Flat Roof Snow Load	17.5
Snow Exposure Factor	1.0
Snow Load Importance Factor	1.0

1. Deflection and Drift Limits: No greater than the following:
 - a. Steel Framing: Vertical deflection of 1/240 of the span.
 - b. Design secondary-framing system to accommodate deflection of primary framing and construction tolerances, and to maintain clearances at openings.
 - c. Lateral Drift: Maximum of 1/50 of the structure height for seismic. Maximum of 1/200 of the structure height for wind.

2. Critical dimensions:
 - a. Column line spacing: 33'-0" on center and 35'-0" on center and 40'-0" on center, as indicated on drawings.
 - 1) Maximum cantilever: beams and secondary framing supporting PV array shall not extend beyond the solar array roof deck or dimensions on plans, into the drive aisles without design approval from Owner.
 - b. Minimum height to underside of structure (low side): 24'-0"
 - c. Minimum slope: ½" per foot (2.4 degrees) sloping up from west to east.
- C. Thermal Movements: Allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 1. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.

2.4 SYSTEM DESCRIPTION

- A. General: System shall consist of structural steel primary framing and secondary framing as required to support a weathertight steel roof deck, and a photovoltaic array and racking system to cover the bus parking configuration provided in the plans. Structural system shall be designed to resist gravity and lateral loads as indicated in this specification and serviceability requirements. The design calculation shall be submitted with the shop drawings bearing a seal of the professional engineer in the project state.
- B. Columns: Columns shall be wide flange structural steel A992 with steel base plates A36 and anchor rods attached to footing. Columns shall be welded to baseplates to resist the controlling load combinations.
- C. Beams: Shall be wide flange structural steel A992 shall be equally spaced to support the photovoltaic array and racking system. Delegated structural design shall coordinate with photovoltaic layout and rack system for location and dimensions of support. The beams shall be supported by steel wide flange girders that span from columns. Any cantilever beams or girder shall be constructed with complete penetration welds through the supporting girder or columns. Beam cantilevers shall not extend past concrete curbs into the drive aisle without design approval from Owner. Miscellaneous pieces such as bent plates, connection material and bracing are to be included in the system as required.
- D. Roof Deck: Shall be galvanized structural steel roof deck, assembled on support steel with no gaps to create a weathertight deck. Standing seams of deck shall be oriented with roof slope to allow for drainage to gutter system in canopy.

- E. Foundation: Foundation system shall be shallow spread footing or drilled piers. Footings shall be reinforced concrete bearing at the frost line minimum within the safe bearing capacity of 2000 psf under the controlling loading conditions. Drilled piers shall be reinforced concrete piers bearing at substrate elevation indicated in geotechnical report.

2.5 MATERIALS

- A. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings."
- B. Bolted Connections: Comply with RCDC's "Specification for Structural Joints Using High-Strength Bolts."
- C. Steel W-shapes: ASTM A992/A992M.
- D. Steel Plates, Channels, Angles, Bar: ASTM A36/A36M.
- E. Steel tubular Members: ASTM A500 Grade B structural tubing
- F. Galvanized-Steel Sheet: ASTM A653/A653M, Structural Steel (SS), G90 zinc coating.
- G. High Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325, type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH, heavy-hex carbon-steel nuts, and ASTM F436/F436M, Type 1, hardened carbon-steel washers.
 - 1. Finish: Hot-dip zinc coating, ASTM F2329, Class C.
- H. Headed Anchor Rods: ASTM F1554, Grade 36.
 - 1. Configuration: Straight.
 - 2. Nuts: ASTM A563 heavy-hex carbon steel.
 - 3. Plate Washers: ASTM A36/A36M carbon steel.
 - 4. Washers: ASTM F436 hardened carbon steel.
 - 5. Finish: Hot-dip zinc coating, ASTM F2329, Class C.
- I. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel in accordance with ASTM A123/A123M.
 - 1. Fill vent and drain holes that are exposed in the finish Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
- J. Accessories: Provide accessories as standard with pre-engineered steel canopy manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and dimensional and structural requirements.
 - 1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

2. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.6 FABRICATION

- A. General: Design components and field connections required for erection to permit easy assembly.
 1. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.
 2. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members shall be free of cracks, tears, and ruptures.
- B. Canopy Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.
- C. Drainage: Built-in Gutters where indicated on plans.
 1. Fabricate to cross section required, with riveted and soldered joints, complete with end pieces, outlet tubes, and other special accessories as required.
 2. Fabricate in minimum 96-inch-long sections. Fabricate expansion joints and accessories from same metal as gutters unless otherwise indicated.
 3. Fabricate gutters with built-in expansion joints.
 4. Accessories: Wire-ball downspout strainer.
- D. Downspouts: Fabricate rectangular downspouts to dimensions indicated below, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors.
 1. Size: 3 inch by 4 inch.
 2. Fabricate from the following materials:
 - a. Galvanized Steel: 0.022 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

1. Examine supporting foundations for compliance with manufacturer's requirements, including installation tolerances and other conditions affecting performance of supporting members.
 2. Verify the rough-in of electrical services prior to placement of the structure.
- B. Proceed with erection only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition.
- B. Provide temporary shores, guys, braces, and other supports during erection to keep structural framing secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural framing, connections, and bracing are in place unless otherwise indicated.

3.3 INSTALLATION

- A. Erect pre-engineered canopy according to manufacturer's written instructions and drawings.
- B. Do not field cut, drill, or alter structural members without written approval from canopy manufacturer's professional engineer.
- C. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.
- D. Base and Bearing Plates: Clean concrete-bearing surfaces of bond-reducing materials and roughen surfaces prior to setting plates. Clean bottom surface of plates.
1. Set plates for structural members on wedges, shims, or setting nuts as required.
 2. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- E. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
1. Level and plumb individual members of structure.
 2. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.

- F. Canopy Framing: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.
 - 1. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt type and joint type specified.
 - a. Joint Type: Snug tightened or pretensioned as required by manufacturer.
- G. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

3.4 ACCESSORY INSTALLATION

- A. General: Install accessories with positive anchorage to structure and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
- B. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.
- C. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible and set units true to line and level. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - 1. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 - 2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

3.5 INSTALLATION OF ROOF-DRAINAGE SYSTEM

- A. Install sheet metal roof-drainage items to produce complete roof-drainage system in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.
- B. Built-in Gutters:
 - 1. Join sections with riveted and soldered joints or joints sealed with sealant.

2. Provide for thermal expansion.
3. Slope to downspouts.
4. Provide end closures and seal watertight with sealant.
5. Install underlayment layer in built-in gutter trough and extend to drip edge at eaves and under underlayment on roof sheathing.
 - a. Lap sides minimum of 2 inches over underlying course.
 - b. Lap ends minimum of 4 inches.
 - c. Stagger end laps between succeeding courses at least 72 inches.
 - d. Fasten with roofing nails.
6. Install gutter with expansion joints at locations indicated on Drawings, but not exceeding, 50 feet apart. Install expansion-joint caps.

C. Downspouts:

1. Join sections with 1-1/2-inch telescoping joints.
2. Provide hangers with fasteners designed to hold downspouts securely to walls.
3. Locate hangers at top and bottom and at approximately 60 inches o.c.
4. Provide elbows at base of downspout to direct water away from building.
5. Connect downspouts to underground drainage system.

3.6 ADJUSTING AND CLEANING

- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A780/A780M and manufacture's written instructions.

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SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper building wire.
 - 2. Connectors and splices.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated, and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alpha Wire Company.
 - 2. Cerro Wire LLC.
 - 3. Encore Wire Corporation.
 - 4. Okonite Company (The).
 - 5. Southwire Company, LLC.
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

- E. Conductor Insulation:
 - 1. Type THWN-2: Comply with UL 83.
 - 2. Type XHHW-2: Comply with UL 44.

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M Electrical Products.
 - 2. ABB, Electrification Business.
 - 3. AFC Cable Systems; Atkore International.
 - 4. Hubbell Utility Solutions; Hubbell Incorporated.
 - 5. ILSCO.
 - 6. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Copper.
 - 2. Type: Two hole with standard barrels.
 - 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
 - 1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Above Ground: Type THHN/THWN-2, single conductors in raceway
- B. Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

3.3 INSTALLATION, GENERAL

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

- A. Comply with NFPA 72.
- B. Wiring Method: Install wiring in metal pathway according to Section 260529 "Hangers and Supports for Electrical Systems":
 - 1. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
 - a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to

system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.
- E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.
- D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.9 FIELD QUALITY CONTROL

- A. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 1. Procedures used.
 2. Results that comply with requirements.
 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

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SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Delegated-Design Submittal: For PV System grounding system. Include analysis data indicating compliance with performance requirements and the NEC signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. Include plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - a. Ground rods.
 - b. Grounding arrangements and connections for separately derived systems.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 2. ERICO; brand of nVent Electrical PLC.
 3. Harger Lightning & Grounding; business of Harger, Inc.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
1. Solid Conductors: ASTM B3.
 2. Stranded Conductors: ASTM B8.
 3. Tinned Conductors: ASTM B33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inch in cross section, with 9/32-inch holes spaced 1-1/8 inch apart. Stand-off insulators for mounting must comply with UL 891 for use in switchboards, 600 V and must be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Mechanical-Type Bus-Bar Connectors: Cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper, or copper alloy.

- F. Conduit Hubs: Mechanical type, terminal with threaded hub.
- G. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- H. Straps: Solid copper, copper lugs. Rated for 600 A.
- I. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- J. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless steel bolts.
 - a. Material: Die-cast zinc alloy.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 ft..

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 30 inch below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
- C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. Use exothermic welds for all below-grade connections.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft. apart.
- G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- B. Grounding system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA to 1000kVA: 5 ohms.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 260533

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT-S raceways and elbows.
2. Type ERMC-S raceways, elbows, couplings, and nipples.
3. Type FMC-S.
4. Type LFMC raceways.
5. Fittings for conduit, tubing, and cable.
6. Threaded metal joint compound.
7. Solvent cements.
8. Metallic outlet boxes, device boxes, rings, and covers.
9. Termination boxes.
10. Cabinets, cutout boxes, junction boxes, pull boxes, and miscellaneous enclosures.
11. Cover plates for device boxes.
12. Hoods for outlet boxes.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Raceways
2. Cabinets, cutout boxes, and miscellaneous enclosures.

PART 2 - PRODUCTS

2.1 TYPE EMT-S RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797 and UL Category Control Number FJMX.

B. Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - c. Western Tube; Zekelman Industries.
 - d. Wheatland Tube; Zekelman Industries.
2. Material: Steel.
3. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size: ¾”.
 - d. Colors: As indicated on Drawings.

2.2 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL Category Control Number DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - c. Western Tube; Zekelman Industries.
 - d. Wheatland Tube; Zekelman Industries.
2. Exterior Coating: Zinc.
3. Options:
 - a. Interior Coating: Zinc with organic top coating.
 - b. Minimum Trade Size: ¾”.
 - c. Colors: As indicated on Drawings.

2.3 TYPE FMC-S AND TYPE FMC-A RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1 and UL Category Control Number DXUZ.

B. Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Anaconda Sealtite; Anamet Electrical, Inc.
 - c. Penn Aluminum Conduit & EMT.
2. Material: Steel.
3. Options:
 - a. Minimum Trade Size: ¾”.
 - b. Colors: As indicated on Drawings.

2.4 TYPE LFMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Anaconda Sealtite; Anamet Electrical, Inc.
 - c. Electri-Flex Company.
 - d. International Metal Hose Co.
2. Material: Steel.
3. Options:
 - a. Minimum Trade Size: ¾”

2.5 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Fittings for Type ERMC:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - b. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Inc.
 - d. Southwire Company, LLC.
- 2. General Characteristics: UL 514B and UL Category Control Number DWTT.
 - 3. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.
- C. Fittings for Type EMT Raceways:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - d. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Inc.
 - 2. General Characteristics: UL 514B and UL Category Control Number FKAV.
 - 3. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.
- D. Fittings for Type FMC Raceways:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Fittings Corp. (AMFICO).
 - b. Liquid Tight Connector Co.
 - c. Southwire Company, LLC.
 - 2. General Characteristics: UL 514B and UL Category Control Number ILNR.
- E. Fittings for Type LFMC and Type LFNC Raceways:
- 1. Manufacturers: Subject to compliance with requirements, provide products by

one of the following:

a. Liquid Tight Connector Co.

2. General Characteristics: UL 514B and UL Category Control Number DXAS.

2.6 TERMINATION BOXES

A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

2. General Characteristics: UL 1773 and UL Category Control Number XCKT.

2.7 CABINETS, CUTOFF BOXES, JUNCTION BOXES, PULL BOXES, AND MISCELLANEOUS ENCLOSURES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

2. General Characteristics:

a. Non-Environmental Characteristics: UL 50.

b. Environmental Characteristics: UL 50E.

B. Indoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crouse-Hinds; brand of Eaton, Electrical Sector.

b. Hoffman; brand of nVent Electrical plc.

c. Milbank Manufacturing Co.

3. Additional Characteristics: UL Category Control Number CYIV.

4. Options:

a. Degree of Protection: Type 1.

C. Indoor Sheet Metal Cutout Boxes:

1. Description: Enclosure that has swinging doors or covers secured directly to and

telescoping with walls of enclosure.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Crouse-Hinds; brand of Eaton, Electrical Sector.
- b. Hoffman; brand of nVent Electrical plc.
- c. Milbank Manufacturing Co.

3. Additional Characteristics: UL Category Control Number CYIV.

4. Options:

- a. Degree of Protection: Type 1.

D. Indoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Hoffman; brand of nVent Electrical plc.
- b. Milbank Manufacturing Co.
- c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

3. Additional Characteristics: UL Category Control Number BGUZ.

4. Options:

- a. Degree of Protection: Type 1.

E. Indoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Hoffman; brand of nVent Electrical plc.
- b. Milbank Manufacturing Co.

2. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.

3. Options:

- a. Degree of Protection: Type 1.

F. Outdoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Crouse-Hinds; brand of Eaton, Electrical Sector.
- b. Hoffman; brand of nVent Electrical plc.
- c. Milbank Manufacturing Co.

3. Additional Characteristics: UL Category Control Number CYIV.

4. Options:

- a. Degree of Protection: Type 4X.

G. Outdoor Sheet Metal Cutout Boxes:

1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Crouse-Hinds; brand of Eaton, Electrical Sector.
- b. Hoffman; brand of nVent Electrical plc.
- c. Milbank Manufacturing Co.

3. Additional Characteristics: UL Category Control Number CYIV.

4. Options:

- a. Degree of Protection: Type 4X.

H. Outdoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Hoffman; brand of nVent Electrical plc.
- b. Milbank Manufacturing Co.

3. Additional Characteristics: UL Category Control Number BGUZ.

4. Options:

- a. Degree of Protection: Type 4X.

I. Outdoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Hoffman; brand of nVent Electrical plc.
- b. Milbank Manufacturing Co.

2. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.

3. Options:
 - a. Degree of Protection: Type 4X.

2.8 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Reference Standards: UL 514D and UL Category Control Numbers QCIT and QCMZ.
 - b. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Metallic Cover Plates for Device Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - b. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.040-inch-thick aluminum, anodized or lacquered to prevent corrosion.

2.9 HOODS FOR OUTLET BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Reference Standards:
 - 1) UL 514D and UL Category Control Numbers QCIT and QCMZ.
 - 2) Receptacle, hood, cover plate, gaskets, and seals comply with UL 498 Supplement SA when mated with box or enclosure

complying with UL 514A, UL 514C, or UL 50E.

- b. Mounts to box using fasteners different from wiring device.
- B. Extra-Duty, While-in-Use Hoods for Outlet Boxes:
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - c. Intermatic, Inc.
 - d. Leviton Manufacturing Co., Inc.
 - e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - 2. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
 - 3. Options:
 - a. Provides gray, weatherproof, "while-in-use" cover.
 - b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 SELECTION OF RACEWAYS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.
- B. Outdoors:
 - 1. Exposed and Subject to Severe Physical Damage: ERMC.
 - 2. Exposed and Subject to Physical Damage: ERMC.
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - 3. Exposed and Not Subject to Physical Damage: Corrosion-resistant ERMC.
 - 4. Concealed Aboveground: ERMC.
 - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- C. Indoors:
 - 1. Hazardous Classified Locations: ERMC.
 - 2. Exposed and Subject to Severe Physical Damage: ERMC.

3. Exposed and Subject to Physical Damage: ERMC. Subject to physical damage includes the following locations:
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 4. Exposed and Not Subject to Physical Damage: EMT.
 5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 6. Damp or Wet Locations: ERMC.
 7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC.
- D. Raceway Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMC: Provide threaded type fittings unless otherwise indicated.

3.2 SELECTION OF BOXES AND ENCLOSURES

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
1. Outdoors:
 - a. Type 4X unless otherwise indicated.
 - b. Locations Exposed to Hosedown: Type 4X.
 2. Indoors:
 - a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 12.
 - c. Locations Exposed to Hosedown: Type 4X.
- C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
1. Provide Boxes with knockouts or unprotected openings are prohibited.
 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.3 INSTALLATION OF RACEWAYS

- A. Installation Standards:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for installation of raceways. Consult Architect for resolution of conflicting requirements.
 2. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

3. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
4. Comply with NECA NEIS 101 for installation of steel raceways.
5. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
6. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts.
7. Raceway Terminations at Locations Subject to Moisture or Vibration:
 - a. Provide insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

B. General Requirements for Installation of Raceways:

1. Complete raceway installation before starting conductor installation.
2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
3. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
6. Support conduit within 12 inch of enclosures to which attached.
7. Install raceway sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with NFPA 70.
8. Do not install raceways or electrical items on "explosion-relief" walls or rotating equipment.
9. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
10. Keep raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
11. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
12. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
13. Install conduit more than 24" below ceiling.

C. Requirements for Installation of Specific Raceway Types:

1. Types ERM C:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
2. Types FMC and LFMC:
 - a. Comply with NEMA RV 3. Provide a maximum of 36 inch of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

D. Raceways Embedded in Slabs:

1. Run raceways larger than 1" below concrete slab.
2. Arrange raceways to cross building expansion joints with expansion fittings at right angles to the joint.
3. Arrange raceways to ensure that each is surrounded by a minimum of 2 inch of concrete without voids.
4. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
5. Change from ENT to ERM C before rising above floor.

E. Stub-ups to Above Recessed Ceilings:

1. Provide EMT for raceways.
2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

F. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

1. ERM C-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
2. EMT: Provide compression steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

G. Expansion-Joint Fittings:

1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERM C conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.

2. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 4. Install expansion fittings at locations where conduits cross building or structure expansion joints.
 5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- H. Raceways Penetrating Rooms or Walls with Acoustical Requirements:
1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty.

3.4 INSTALLATION OF BOXES AND ENCLOSURES

- A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
- B. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- C. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
- D. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- E. Locate boxes so that cover or plate will not span different building finishes.
- F. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.

- G. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
- H. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
- I. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
- J. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
- K. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 - 1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 - 2. Provide gaskets for wallplates and covers.

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.7 CLEANING

- A. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION

SECTION 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Rigid nonmetallic duct.
 - 2. Duct accessories.
 - 3. Polymer concrete handholes and boxes with polymer concrete cover.

1.3 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
 - 1. Two or more ducts installed in parallel, with or without additional casing materials.
 - 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include duct-bank materials, including spacers and miscellaneous components.
 - 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Include underground-line warning tape.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- B. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C858.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

1.7 FIELD CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Owner's written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.
- C. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Allied Tube & Conduit; Atkore International.
 - 2. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ARNCO Corp.
 - 2. Cantex Inc.
 - 3. Condux International, Inc.
 - 4. National Pipe & Plastics.
 - 5. Spiraduct/AFC Cable Systems, Inc.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.3 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Cantex Inc.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
- C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
 - 1. Color: Red dye added to concrete during batching.
 - 2. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.4 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - 2. Oldcastle Infrastructure Inc.; CRH Americas.
 - 3. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC."
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- C. Stub-ups: Concrete-encased GRC.

3.3 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.4 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
 - 1. Duct shall have maximum of three 90-degree bends, or the total of all bends shall be no more than 270 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
 - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

- I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- J. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.
- K. Concrete-Encased Ducts and Duct Bank:
 - 1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
 - 2. Width: Excavate trench 12 inches wider than duct on each side.
 - 3. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 - 4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - 5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - 6. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
 - 7. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
 - 8. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
 - a. Couple RNC duct to GRC with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 - b. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
 - 9. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - 10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

11. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
 12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
 13. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
- L. Underground-Line Warning Tape: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.5 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.7 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump.
 - 1. Sweep floor, removing dirt and debris.
 - 2. Remove foreign material.

END OF SECTION

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SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Color and legend requirements for raceways, conductors, and warning labels and signs.
 - 2. Labels.
 - 3. Bands and tubes.
 - 4. Tapes and stencils.
 - 5. Tags.
 - 6. Signs.
 - 7. Cable ties.
 - 8. Paint for identification.
 - 9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.

- E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - 3. Colors for 240-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - 4. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - 5. Color for Neutral: White.
 - 6. Color for Equipment Grounds: Green.
 - 7. Colors for Isolated Grounds: Green with two or more yellow stripes.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.
- E. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
- F. Equipment Identification Labels:
1. Black letters on a white field.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Emedco.
 - c. Panduit Corp.
- B. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Emedco.
 - c. Marking Services, Inc.
 - d. Panduit Corp.
 2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- C. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Emedco.
 - c. Ideal Industries, Inc.
 - d. Marking Services, Inc.
 - e. Panduit Corp.
2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Ideal Industries, Inc.
 - c. Marking Services, Inc.
 - d. Panduit Corp.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.
- C. Underground-Line Warning Tape:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. Marking Services, Inc.
 2. Tape:

- a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
- b. Printing on tape shall be permanent and shall not be damaged by burial operations.
- c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

- a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
- b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"
- c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Warning tape shall have the following characteristics:

- a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
- b. Width: 3 inches.
- c. Thickness: 12 mils.
- d. Weight: 36.1 lb./1000 sq. ft..
- e. Tensile according to ASTM D882: 400 lbf and 11,500 psi.

D. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.5 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Marking Services, Inc.
 - d. Panduit Corp.

2.6 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Emedco.
 - d. Marking Services, Inc.
2. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches.

B. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.
2. Engraved legend.
3. Thickness:
 - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. in., 1/8 inch thick.
 - c. Engraved legend with white letters on a dark gray background.
 - d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. HellermannTyton.
 2. Ideal Industries, Inc.
 3. Marking Services, Inc.
 4. Panduit Corp.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws, or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
 - K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
 - L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
 - M. Vinyl Wraparound Labels:
 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
 - O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
 - P. Self-Adhesive Labels:
 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
 - Q. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
 - R. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceed 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

T. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

U. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

V. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

W. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.
- D. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Vinyl wraparound labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive raceway labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
- G. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- H. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- I. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.
- J. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.
- K. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- L. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- M. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
1. Apply to exterior of door, cover, or other access.
 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- P. Arc Flash Warning Labeling: Self-adhesive labels.
- Q. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.
- R. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
- S. Equipment Identification Labels:
1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
 2. Outdoor Equipment: Laminated acrylic or melamine sign.
 3. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of an engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.

- d. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- e. Emergency system boxes and enclosures.
- f. Enclosed switches.
- g. Enclosed circuit breakers.
- h. Enclosed controllers.
- i. Variable-speed controllers.
- j. Push-button stations.
- k. Power-transfer equipment.
- l. Contactors.
- m. Remote-controlled switches, dimmer modules, and control devices.
- n. Power-generating units.
- o. UPS equipment.

END OF SECTION

SECTION 262813

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Enclosed controllers.
 - c. Enclosed switches.
 - 2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Bussmann; Eaton, Electrical Sector.
 2. Littelfuse, Inc.
 3. Mersen USA.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 1. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
 3. Type T: 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Motor Branch Circuits: Class RK5, time delay.
 - 2. Power Electronics Circuits: Class T, fast acting.
 - 3. Control Transformer Circuits: Class CC, time delay, control transformer duty.
 - 4. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

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SECTION 262816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs)
 - 4. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; Schneider Electric USA.
 - 2. Eaton.
- B. Type HD, Heavy Duty:
 - 1. Single throw.
 - 2. Three pole.
 - 3. 600-V ac.
 - 4. 1200 A and smaller.
 - 5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
 - 6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
 - 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 6. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 7. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; Schneider Electric USA.
 - 2. Eaton.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
 - 3. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 4. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 5. Service-Rated Switches: Labeled for use as service equipment.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
 - 1. Square D; Schneider Electric USA.
 - 2. Eaton.
- B. Circuit breakers must be constructed using glass-reinforced insulating material. Current carrying components must be completely isolated from handle and accessory mounting area.
- C. Circuit breakers must have toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. Circuit-breaker handle must be over center, be trip free, and reside in tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon must be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with push-to-trip button, located on face of circuit breaker to mechanically operate circuit-breaker tripping mechanism for maintenance and testing purposes.
- D. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings must be clearly marked on face of circuit breaker.
- E. MCCBs must be equipped with device for locking in isolated position.

- F. Lugs must be suitable for 75 deg C rated wire.
- G. Standard: Comply with UL 489 with required interrupting capacity for available fault currents.
- H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, RMS sensing, with the following field-adjustable settings:
 - 1. Instantaneous trip.
 - 2. Long- and short-time pickup levels.
 - 3. Long- and short-time time adjustments.
 - 4. Ground-fault pickup level, time delay, and I-squared t response.
- K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- M. GFLS Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6 mA trip).
- N. GFEP Circuit Breakers: With Class B ground-fault protection (30 mA trip).
- O. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- E. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.
 - 3. Do not proceed with interruption of electric service without Owner's written permission.
 - 4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 12.
 - 2. Outdoor Locations: NEMA 250, Type 4X.
 - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.

3.4 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.

- a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
 - h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
 - i. Verify correct phase barrier installation.
 - j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
- 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
 - 1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

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SECTION 262913
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes AC, enclosed controllers rated 600 V and less, of the following types:
 - 1. Across-the-line, manual and magnetic controllers.
 - 2. Multispeed controllers.
- B. Related Sections include the following:
 - 1. Division 26 Section "Surge Protective Devices" for low-voltage power, control, and communication surge suppressors.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships

between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

- D. Qualification Data: For manufacturer and testing agency.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.

- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.6 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- C. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- D. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
 - 2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D.
2. General Electric Company; GE Consumer & Industrial-Electrical Division.
3. Eaton Corporation; Cutler-Hammer Products.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.
1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer source of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. Control power transformers shall have primary and secondary fuse protection.
 2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
- C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
1. Non-fusible Disconnecting Means: NEMA KS 1, heavy-duty, non-fusible switch.

2.3 MULTISPEED ENCLOSED CONTROLLERS

- A. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
1. Compelling relay to ensure that motor will start only at low speed.
 2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
 3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.4 ENCLOSURES

- A. Description: Surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Push-to-Test Red “Power Available” and Green “Running” non-incandescent, Pilot Lights, and Hand-Off-Automatic Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Control Relays: Two (2) NO/NC auxiliary contacts and adjustable time-delay relays as required by automatic control sequence.
- D. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting and automatic reset for single phase protection.

2.6 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."
- C. Install Power Factor Correction Capacitors furnished under Mechanical Divisions with disconnects, overcurrent protection, wire, conduit, and ground for capacitor enclosure, all in accordance with the recommendations of the capacitor manufacturer and the National Electric Code.

3.4 IDENTIFICATION

- A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
 3. Report results in writing.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, "Motor Control - Motor Starters." Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.8 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers. Refer to Division 01 Section "Demonstration and Training."

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SECTION 263100
PHOTOVOLTAIC SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. PV modules.
- 2. Inverters.
- 3. System overcurrent protection.
- 4. Mounting structures.
- 5. Monitoring software
- 6. Ancillary equipment.

- B. Related Requirements:

- 1. Section 133000 "Fabricated Steel Canopy".

1.3 DEFINITIONS

- A. ETFE: Ethylene tetrafluoroethylene.
- B. FEP: Fluorinated ethylene propylene.
- C. IP Code: Required ingress protection to comply with IEC 60529.
- D. MPPT: Maximum power point tracking.
- E. PV: Photovoltaic.
- F. STC: Standard Test Conditions defined in IEC 61215.
- G. Voc: Open circuit voltage at STC.
- H. Isc: Short circuit current at STC.
- I. Vmpp: Maximum power point voltage.
- J. Impp: Maximum power point current.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. For PV modules.
 - a. Include plans, elevations, sections, and mounting details.
 - b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Detail fabrication and assembly.
 - d. Include diagrams for power, signal, and control wiring.
 - 2. For PV solar panel standing seam mounting system.
 - a. Include material and design for PV solar panel standing seam mounting system with quantity of ballasted paver blocks per area.
 - 3. For PV inverter.
 - a. Include material and design for PV inverter sizing.
- C. Calculations (applies to AC and DC system):
 - 1. Voltage drop.
 - 2. Conductor ampacity.
 - 3. Conduit size and fill.
- D. Certificates: Submit product certificates signed by the manufacturer certifying material compliance with specified performance characteristics and criteria, and physical requirements.
- E. Delegated-Design Submittal: For PV System. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Buy America Certification: Provide written and signed certification by the manufacturer/contractor that manufactured products meet FTA Buy America requirements of 49 U.S.C. 5323(j)(1) and the applicable regulations in 49 C.F.R. Part 661.5.

- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For all system components. Provide three (3) copies to engineer for distribution. Include as built source circuit string diagrams showing string locations and polarity. Include as built inverter locations and ancillary equipment locations. Include third party testing and field reports.

1.7 WARRANTY

- A. Special Warranty: Contractor shall warrant the system for proper operation and against defects in material and workmanship for a period of two (2) years from date of startup.
- B. Solar Module: Manufacture agrees to repair or replace components of PV modules that fail in materials or workmanship within the specified warranty period.
 - 1. Solar Module Manufacturer's materials and workmanship warranties include, but are not limited to the following:
 - a. Repair, replacement, or refund warranty due to defects in materials or workmanship in normal application, installation, use, and service conditions.
 - 2. Warranty Period: Five years from date of delivery.
- C. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, on a prorated basis, for period specified.
 - 1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:
 - a. 10-year limited power warranty for modules exhibiting a power output less than 90% of minimum peak power as specified at date of delivery by the manufacturer if such loss is determined to be caused by a defect in materials or workmanship.
 - b. 25-year limited power warranty for modules exhibiting a power output less than 80% of minimum peak power as specified at the date of delivery by the manufacturer if such loss is determined to be caused by a defect in materials or workmanship.
- D. Inverters

1. Manufacturer's special materials and workmanship warranty: Manufacturer agrees to repair or replace components of combiner boxes that fail in materials or workmanship within specified warranty period.
 2. Inverter Manufacturer's materials and workmanship warranties include, but are not limited to, the following:
 - a. Repair, replacement, or refund warranty due to defects in materials or workmanship in normal application, installation, use, and service conditions.
 3. Warranty Period: Base warranty of 10 years from date of delivery.
 - a. Contractor to purchase and supply to the owner an additional extended Manufacturer's Warranty to increase the total warranty period to twenty (20) years.
- E. Ancillary Equipment
1. Ancillary Equipment such as disconnect switches, cable, wire, conduit, fittings, etc. shall carry the standard warranty as supplied by the equipment manufacturer.
- F. Support Structure (Steel Canopy mounted)
1. System Warranty: Contractor shall warrant the system for proper operation and against defects in material and workmanship for a period of twenty (20) years from date of startup.

1.8 CONTRACTOR QUALIFICATIONS

- A. Contractors and all employees working with/for the contractor on this project shall have NABCEP Certification.
- B. Engage an installer having skilled craftsmen or individuals with a minimum of seven (7) years' experience who has successfully completed installations similar in material, design, and extent to that indicated for project.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. The Solar Array Equipment and all components shall be designed, manufactured, installed, and tested in accordance with the latest editions of the following codes and standards:
 1. NFPA 70, National Electrical Code (NEC)
 2. National Electrical Manufacturers Association (NEMA)
 3. Institute of Electrical and Electronics Engineers (IEEE)

- a. IEEE 1547
 - b. IEEE 1547.1
 - c. IEEE C62.41.2
 - d. IEEE C62.45
 - e. IEEE 519-1992
4. Underwriters Laboratory (UL) listed and labeled.
 5. American National Standards Institute (ANSI)
 6. Uniform Solar Energy Code (ICC)
 7. UL Standard 1741

2.2 PERFORMANCE REQUIREMENTS

- A. NRTL (Nationally Recognized Testing Laboratory) Listing: Entire assembly shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety, Class C according to UL 1703.

2.3 PV SYSTEMS DESCRIPTION

- A. Hybrid PV System: PV modules connected to provide power to dc and ac loads, connected to utility through interactive inverters or meters, and connected to energy storage. Refer to PV system one-line diagram on electrical drawings.
 1. Number of strings per array as required per contractor's design.
 2. PV Equipment quantity and layout as required per contractor's design.
 3. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Charge Controller
 - d. Energy Storage
 - e. System Controller
 - f. Utility-interactive inverter.
 - g. Overcurrent protection, disconnect, and rapid shutdown devices.
 - h. Mounting structure.
 - i. PV Cell Materials.

2.4 MANUFACTURED PV UNITS

- A. Cell Materials: Thin Film, Cadmium Telluride (CdTe).
- B. Basis of Design: First Solar Series 6
- C. Module Construction:
 1. Nominal Size: 49 inches wide by 79 inches long.
 2. Weight: 34.5 lb.
 3. Front Panel: Fully tempered glass.

4. Front Panel: Antireflective coating glass.
5. Bypass Diode Protection: N/A.
6. Junction Box:
 - a. Size: 1.56 by 3.96 by 0.52 inch.
 - b. IP Code: IP68.
- c. Flammability Test: UL 1703.
7. Output Cabling:
 - a. Quick, multiconnect, polarized connectors.
 - b. Length: 47 inches
8. Series Fuse Rating: 5A.
9. Minimum Capacities and characteristics
 - a. Rated Open Circuit Voltage (Voc): 219.2 Vdc
 - b. Maximum System Voltage: 1500 Vdc UL
 - c. Rated Short-Circuit Current (Isc): 2.54 A
 - d. Rated Power Point Current (Imp): 2.36 A
 - e. Maximum Power at STC (Pmax): 430 W
 - f. Module efficiency: 17.4 % (minimum)
 - g. Hail Safety Impact Velocity: 25 mm at 23 m/s
10. Temperature Coefficients
 - a. Normal Operating Cell Temperature (NOCT): 45 deg. C
 - b. Temperature Coefficient of Pmax: -0.32 %/deg C
 - c. Temperature Coefficient of Voc: -0.28 %/deg. C
 - d. Temperature Coefficient of Isc: 0.04 %/deg C
11. Module Framing: Anodized Aluminum.

2.5 PV ARRAY CONSTRUCTION

A. Framing:

1. Material: G235 Steel.
2. Maximum System Weight: Less than 4 lb./sq. ft.
3. Raceway Cover Plates: Galvanized steel.

B. Steel Support Canopy Mounting:

1. Racking systems attached to standing seams of steel support canopy.
2. 2-inch row spacing.
3. Meeting ASCE 7-98 wind loading criteria for 90 – 120 MPH with proper ballast design and installation.
4. Supply wire tray within PV array.

2.6 INVERTER

- A. Inverter Type: String.
- B. Basis of Design: Sunny HighPower
- C. Control Type: Maximum power point tracker control.
- D. Inverter Electrical Characteristics:
 - 1. Maximum Recommended PV Input Power: As required based upon system design.
 - 2. PV Start Voltage: 188 Vdc.
 - 3. Maximum DC voltage: 1500 Vdc.
 - 4. MPPT Voltage Range: 684 – 1500 Vdc
 - 5. Maximum Input Current: 180A.
 - 6. Number of Independent MPPT Circuits: 2.
 - 7. Nominal Output Voltage: 480/277 V
 - 8. Maximum Output Current: As required based upon system design.
 - 9. Peak Efficiency: 98.5 percent.
 - 10. Communications Interface: Ethernet, MODBUS TCP
 - 11. Utility Interface: Utility-interactive inverter.
 - 12. Topology: Transformer less
- E. Operating Conditions:
 - 1. Operating Ambient Temperatures: Minus -13 to plus 140 deg F.
- F. Protection Devices:
 - 1. DC reverse polarity protection.
 - 2. Ground fault monitoring.
 - 3. DC AFCI compliant to UL 1699B
 - 4. AC short circuit protection.
- G. Enclosure:
 - 1. NEMA 250, Type 4X.
 - 2. Cooling Methods:
 - a. Fan convection cooling.
 - 3. Mounting location: Canopy Supports; under structural mounting equipment.
 - 4. Nominal Size: 31 inches wide by 33 inches long by 18 inches thick.
- H. Characteristics:
 - 1. Inverter Weight: 121 lbs.

I. Communication:

1. Provide and install communication wiring to allow internet access. Coordinate with owner to determine best method of connection.

2.7 INVERTER MOUNTING

- A. On canopy supports, under solar panel canopy structural mounting.
- B. Corrosion resistant Steel rack structure.
- C. Stainless steel mounting hardware for mounting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until mounting surfaces have been properly prepared.
- B. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- C. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
- D. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to:
 1. Test and inspect components, assemblies, and equipment installations, including connections.
 2. Perform phase rotation test prior to connecting power to the inverter output per the manufacturer's recommendations.
 3. Equipment and components will be considered defective if they do not pass tests and inspections.
 4. Prepare test and inspection reports.
- B. Third Party Testing Agency: Engage a third-party testing agency. Testing agency shall have qualified NABCEP Certified individuals to perform these tests.
 1. Perform meter trending on the output of each inverter for a duration of one week with sampling points at 15-minute intervals. These sampling points shall be compared to the PV monitoring software trending points. PV inverters will be

- considered functional if sampling points are within +/- 5% of PV monitoring software trending points.
2. Perform an additional follow-up meter trending on the output of each inverter for a duration of one week with sampling points at 15-minute intervals, 11 months after date of Substantial Completion. These sampling points shall be compared to the PV monitoring software trending points. PV inverters will be considered functional if sampling points are within +/- 5% of PV monitoring software trending points.
 3. Perform meter trending at the main circuit breaker of Panel SL and SR for a duration of one week with sampling points at 15-minute intervals. Perform meter trending at Panel SL and SR feeder circuit breaker at existing switchgear for a duration of one week with sampling points at 15-minute intervals. These sampling points shall be compared and must be within +/- 5% of each other.
 4. Perform an additional follow-up meter trending at the main circuit breaker of Panel SL and SR for a duration of one week with sampling points at 15-minute intervals, 11 months after date of Substantial Completion. Perform meter trending at Panel SL and SR feeder circuit breaker at existing switchgear for a duration of one week with sampling points at 15-minute intervals. These sampling points shall be compared and must be within +/- 5% of each other.
 5. PV system will be considered defective if it does not pass tests. Contractor shall investigate and replace defective equipment and components and retest.
 6. Prepare test reports.
- C. When the installation is reported in writing by the Contractor to be complete and ready for acceptance, an inspection shall be made by the Contractor in the presence of the Engineer to ascertain whether it complies with the contract documents. If in the opinion of the Engineer it fails to do so, the Contractor shall at once remedy all defects and shortcomings. Any additional tests that may be required shall be entirely at the Contractor's expense. All the testing work shall be done when and as directed by the Engineer.
- D. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of applicable ANSI and NEMA standards.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of PV panels with support assembly and other construction.
- C. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.
- D. Install PV inverters, energy storage, charge controller, and system control in locations indicated on Drawings.
- E. Wiring Method: Install cables in raceways.

- F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.4 CONNECTIONS

- A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.5 TRAINING

- A. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training material as required.
 - 2. Training session shall be recorded and provided digitally to Owner.
 - 3. Provide minimum of eight hours of training.
 - 4. Instructor: Manufacturer's authorized representative.
 - 5. Location: At project site.

END OF SECTION

SECTION 263713

LOW VOLTAGE MICROGRID ENERGY MANAGEMENT SYSTEM (MEMS)

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for low voltage Microgrid Energy Management System (also identified as MEMS, Microgrid EMS, Energy Control Center, ECC, Microgrid PCS, Microgrid Power Control System, Distributed Energy Resources Power Control System or DER PCS) as required for the complete performance of the Work, as shown on the Drawings and as specified herein.
- B. The low voltage Microgrid Energy Management System shall be provided by a qualified MEMS system supplier. The Contractor shall ultimately be responsible for the MEMS and shall supplement the system supplier's Work as necessary to provide a complete and operable system. The Contractor shall coordinate the equipment and systems provided by others that interface with the MEMS to ensure necessary interconnections and compatibility are provided for the required functionality of the MEMS.
- C. Related Sections: Related sections include, but shall not be limited to, the following:
 - 1. Drawings and general provisions of the contract, including general and supplementary conditions and division 01 specification sections, apply to this section.
 - 2. Applicable general requirements for electrical work specified within division 26 specification sections apply to this section.
 - 3. Refer to the following specifications for additional requirements.
 - a. Section 262416 Panelboards

1.2 REFERENCES

- A. General Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
 - 1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. IEEE 1547, "IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces"
 - b. IEEE 2030.7, "Standard for the Specification of Microgrid Controllers"

- c. IEEE 2030.8, “Standard for the Testing of Microgrid Controllers”
- 2. International Organization for Standardization (ISO):
 - a. ISO 9001, “Quality Management Systems - Requirements”
- 3. National Fire Protection Agency (NFPA)
 - a. NFPA 70, “National Electrical Code (NEC)”
 - b. NFPA 70B, “Electrical Equipment Maintenance”
 - c. NFPA 70E, “Standard for Electrical Safety in the Workplace.”
- 4. Underwriters Laboratories, Inc. (UL):
 - a. UL67, “Standard for panelboards”
 - b. UL 98, "Standard for Enclosed and Dead Front Switches"
 - c. UL 489, "Standard for Molded Case Circuit Breakers and Circuit Breaker Enclosures."
 - d. UL 891, "Standard for Dead Front Switchboards"
 - e. UL 943, "Standard for Ground Fault Circuit Interrupters"
 - f. UL 1283, “Standard for Safety for Electro Magnetic Interference Filters”
 - g. UL 1449, "Standard for Surge Protective Devices."
 - h. UL 1741, “Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources.”
 - i. UL 1741 SA (Supplement A), “Advanced Inverter Testing.”
- 5. International Electrotechnical Commission (IEC):
 - a. IEC 61850, “Power Utility Automation”

1.3 DEFINITIONS

- A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
 - 1. BESS: Battery Energy Storage System
 - 2. DER: Distributed Energy Resource (e.g. generators, PV arrays, BESS, etc.)
 - 3. ECC: Energy Control Center
 - 4. HMI: Human Machine Interface
 - 5. MEMS: Microgrid Energy Management System
 - 6. PV: Photovoltaic (e.g. solar electric)

1.4 SUBMITTALS

- A. General: Submittals shall be in accordance with the requirements of Section 013300 Submittals, in addition to those specified herein.

1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

B. Action Submittals

1. Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information:
 - a. System Architecture Diagram, including but not limited to solar panels, inverters, MEMS, and battery storage system, and utility connection.
 - b. MEMS Sequence of Operations
 - c. Unwitnessed Factory Acceptance Test report submitted prior to shipment.

C. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified in Section 017823 Operation and Maintenance Data, and additional requirements specified herein.

1. Submit required Operations & Maintenance data specific to each product and accessory proposed.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 4 years.

1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.

B. Installer Qualifications: Installer shall be a firm that shall have a minimum of 10 years of successful installation experience with projects utilizing equipment similar in type and scope to that required for this Project.

C. All work performed and all materials used shall be in accordance with the National Electrical Code and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's

Laboratories or by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer-stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.7 WARRANTY

- A. General: Refer to Section 017700 - Closeout Procedures.
- B. The manufacturer shall warrant products against defects in material and workmanship for 24 months from the date of commissioning or 36 months from the date of shipment, whichever comes first, provided that the manufacturer performs functional testing, commissioning and first parameter adjusting of equipment. During the warranty period the manufacturer shall repair or replace defective products. This warranty shall be in addition to any provided by the Contractor. The warranty shall exclude normal wear and tear under normal usage and any damage caused by abuse, modification, or improper maintenance by entities other than the manufacturer or its approved representative.
- C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D Energy Control Center (ECC) by Schneider Electric.
- B. Acceptable Products: The LV Microgrid Energy Management System (MEMS) specified herein shall be the product of a single manufacturer. Products and manufacturers

specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for compliance with requirements. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:

1. Square D Energy Control Center by Schneider Electric
2. Eaton's Power Xpert Microgrid Controller
3. Approved Equal.

2.2 GENERAL REQUIREMENTS

- A. LV Microgrid Energy Management System (MEMS) shall consist of one or more of integrated power distribution equipment (e.g. power panels, switchboards) items with the required HMI interface(s), microgrid controller(s), communications interfaces, electrically operated circuit breakers, etc. to perform the required functionality, such as the control and operation of DERs per a sequence of operations, as specified herein.
- B. MEMS Integrated power distribution equipment shall be provided by same manufacturer as the MEMS.
- C. The integrated power distribution equipment bus shall be rated as shown on the Drawings.
- D. The MEMS manufacturer can provide systems custom engineered to be larger than 2500 amps. Coordinate with manufacturer for availability and options.
- E. MEMS integrated power distribution equipment shall be constructed in accordance with UL891.
- F. The enclosure rating of the MEMS integrated power distribution equipment shall be NEMA 3R.
- G. The equipment shall have separate sections for power and controls with a minimum of one for power distribution (e.g. breakers) and one for control hardware, HMI, and auxiliaries (e.g. 24 Vdc power supplies).
- H. All circuit breakers utilized within the MEMS for control shall be electrically operated and capable of being opened and closed by commands over the MEMS Ethernet network.
- I. All circuit breakers as shown on the Drawings or required for MEMS specified functionality shall have electronic trip units capable of reporting real power (P), reactive power (Q), voltage, frequency, and current over the MEMS Ethernet network.

2.3 SERVICE ENTRANCE REQUIREMENTS

- A. When the MEMS is serving as the utility service entrance, the system shall include the following:

1. The MEMS shall provide utility pull section(s) within the integrated power distribution equipment.
2. The MEMS shall include protective relaying to comply with local utility requirements.

2.4 SYSTEM REQUIREMENTS

- A. Communications: The MEMs shall provide an Ethernet Modbus TCP interface for communications to DERs, circuit breakers, inverters, meters, etc. as needed for monitoring and control. The Ethernet network shall be a secure private network or VPN dedicated to the Electrical Power Management System.
- B. The MEMS shall include a touchscreen HMI display, a white indicator light and an AUTO-MANUAL selector switch for operator interface of the system. These interfaces shall provide the following:
 1. Status indicator light: ON = ready and ok, BLINKING = not ready action required.
 2. One-line diagram showing circuit breaker arrangement, service, and status.
 3. Power, reactive power, voltage, frequency, and current measured by each breaker or meter.
 4. The relative priority of each load breaker.
 5. Key information available from DERs, such as power output and status.
 6. Pertinent alarms, such as breakers tripped for overcurrent.
 7. Pertinent events, such as breakers opened or closed by commands from the touchscreen.
 8. Trends of key measurements, such as power measured by a breaker vs time.
- C. The MEMS shall be able to comply with a utility requirement for minimum import power or zero export power. To achieve this compliance, the system shall send commands to decrease the power output from DERs, including curtailing output of PV inverters, and/or send commands to increase the power flowing into energy storage devices.
- D. In the event of a utility grid power outage, the MEMS shall automatically restore power when placed in automatic mode by utilizing local Distributed Energy Resources (DERs) as follows.
 1. The system shall detect a utility grid power outage using a circuit breaker electronic trip unit.
 2. The system shall open its main breaker to establish an isolated electrical bus.
 3. The system shall open its load breakers to prepare for restoring power to them sequentially, rather than simultaneously.
 4. The system shall initialize an anchor resource, such as a generator or BESS, capable of being a grid-forming voltage source.
 5. The system shall use the anchor resource to energize its bus as an intentional island, and the anchor resource shall regulate the bus to the desired voltage and frequency (e.g. 480 V, 60 Hz).
 6. The system shall sequentially restore power to critical and essential loads.

7. The system shall restore power to additional loads if enough capacity is available from the anchor resource.
 8. The system shall allow the operation of additional DERs, such as solar PV, in parallel with the anchor resource.
 9. The system shall manage the connected DERs to avoid unacceptable operating conditions, such as back-feeding a generator or attempts to charge a BESS that is fully charged. The System may send commands to decrease the power output from DERs, including curtailing output of PV inverters, and/or send commands to increase the power flowing into energy storage devices.
 10. The system shall restore power to additional loads if enough capacity is available from the parallel combination of connected DERs (e.g. generator and PV).
 11. The system shall reduce load (e.g. by opening electrically operated breakers for lower priority loads) if insufficient capacity is available from the parallel combination of connected DERs.
- E. Upon the return of utility grid power, the MEMS, when placed in automatic mode, shall automatically reconnect to utility grid power either by open transition or closed transition as specified.
1. MEMS shall provide an open transition back to utility grid power as follows: The system shall detect return of utility grid power using a circuit breaker electronic trip unit at the main breaker.
 - a. The system shall verify that utility grid power remains within the required range for voltage and frequency for a minimum required amount of time prior to reconnecting to utility grid power.
 - b. The system shall open its anchor resource breaker to establish an isolated electrical bus.
 - c. The system shall open its load breakers to prepare for restoring power to them sequentially, rather than simultaneously.
 - d. The system shall wait for a predetermined amount of time to allow all loads to de-energize.
 - e. The system shall close its main breaker to energize the bus from utility grid power.
 - f. The system shall sequentially restore power to all loads.
- F. During Normal operation, the solar panels should charge the battery system during the day. At night, the batteries should be used to power the vehicle chargers, with Utility help on any additional required energy. Utility contribution shall only be allowed to be used during battery discharge, and not battery charging scenarios.
- G. Control power within the MEMS shall be uninterruptible with a minimum runtime of 5 minutes.
1. When a battery within the control power subsystem needs to be replaced (e.g. due to end of life), the HMI shall display an alarm.
 2. In the event of a power outage, the system shall automatically switch the source of control power from the utility to the anchor resource once it is available. When

utility power is restored, the System shall automatically switch the source of control power back to the utility.

3. The system shall provide electrical isolation between the source (e.g. utility) and the control power subsystem.

2.5 REMOTE NOTIFICATION OF ALARMS

- A. The MEMS shall offer at least one of the following options for remote notification of alarms (e.g. breaker tripped due to overcurrent):
 1. Email: The MEMS shall send an email to designated recipients in the event of an alarm.
 2. SMS: The MEMS shall send an SMS to designated recipients in the event of an alarm.
 3. Push Notifications: The MEMS shall use a push notification on a mobile app in the event of an alarm.

2.6 ELECTRICAL POWER MANAGEMENT SYSTEM

- A. The equipment specified herein shall provide the necessary communications connectivity and functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:
 1. Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected devices and equipment necessary to provide functionality. Devices may be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment. Equipment sections with multiple connected devices and assemblies of bolted adjacent bays shall include an internal inter-wired communications network for a single connection to the EPMS network for power monitoring, equipment status and alarms.
 2. Compliance with Cyber security requirements.
 3. Remote EPMS application functionality for equipment configuration; electrical power monitoring; power quality monitoring, compliance, and correction; and alarm monitoring with event log.
- B. Native software compatibility shall be fully factory-tested and shall include the following characteristics.
 1. Pre-mapping of Capability for pre-engineered, interactive graphical display screens to view and analyze real-time device data.
 2. Registers to standard measurement names without the need for additional configuration or internal device registers.
 3. Automatic collection and logging of device data by EPMS software without additional configuration.

2.7 MARKINGS AND LABELING

- A. All identification and warning labels and nameplates exterior to the equipment shall be resistant to weather, UV, and their intended installation environment.
- B. Each integrated power distribution equipment shall be provided with an engraved nameplate identifying the project specific equipment tag and service description.
- C. Warning labels and nameplates shall be present at access locations to advise personnel of possible hazards. The integrated power distribution equipment shall be marked in accordance with UL, NFPA 70 NEC, NFPA 70E, and other applicable standards.
- D. QR code shall be required on 1st section of line-up, which, when scanned, will provide owner with database of information specific to the product with drawings, one-lines, instruction bulletins, field services startup reports, warranty information, and other documentation related to the equipment.

2.8 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. General Electric Company; G.E. Consumer & Industrial-Electrical Distribution.
 - 3. Eaton Electrical Inc.; Cutler-Hammer Products.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only, as indicated.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.9 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Siemens Energy & Automation, Inc.
 - 3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

- B. All circuit breakers shall be electrically operable.
- C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100A to 225A, field-adjustable short-time and continuous current settings for frame sizes 250A and larger.
 - 2. GFCI Circuit Breakers: Single-and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 3. Ground Fault Equipment Protection (GFEP) Circuit Breakers; Class B Ground Fault Protection (30-mA trip).
 - 4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - g. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - j. Handle Clamp: Loose attachment for holding circuit breaker handle in ON position for breakers serving clocks, telephone, and communications equipment, refrigerators, exit signs, fire alarm systems, controls, etc., to prevent accidental operation.

PART 3 - EXECUTION

3.1 GENERAL

- A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of the Drawings.
- B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

- C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- D. Pre-Installation Conference: Prior to commencing the installation, an onsite pre-installation conference shall review the material selections, installation procedures, and coordination with other trades. Attendees shall include, but shall not be limited to, the Contractor, the Installer, manufacturer's representatives, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Engineer
- E. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.
- F. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 FACTORY ACCEPTANCE TESTING

- A. The manufacturer shall perform an unwitnessed factory acceptance test prior to shipment. A test report shall be generated documenting the tests performed, assumptions, corrective actions, and results. The test shall include the manufacturer's standard test procedures but shall include the following as a minimum:
 - 1. Inspection and proper energization of components
 - 2. Operational
 - a. Transition from utility grid to islanded operation and return to utility grid operation.

3.3 FIELD QUALITY CONTROL

- A. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory-trained manufacturer's field service representative. This manufacturer's field service technician shall provide all material, equipment, labor, and technical supervision to perform inspection, testing and adjustments to ensure equipment is installed, adjusted, and tested in accordance with the manufacturer's recommendations and is ready for operation. The manufacturer's field service technician shall replace damaged or malfunctioning equipment and report to the Engineer any discrepancies or issues with the installation.

- B. The manufacturer's representative shall, upon satisfactory completion of inspection and testing, attach a label to all serviced devices indicating the date serviced and testing company responsible.

3.4 FIELD TESTING AND COMMISSIONING

A. Operational Readiness Testing

1. The Contractor shall inspect and test furnished equipment and associated systems for conformance to the contract documents, including equipment manufacturer's recommendations, and readiness for operation. The test shall include the following as a minimum:
 - a. Visually inspect for physical damage and proper installation
 - b. Perform tests in accordance with manufacturer's instructions
 - c. Perform tests to ensure compliance with Contract Documents
 - d. Perform tests that equipment is ready for operation
 - e. Touch-up paint all chips and scratches with manufacturer-supplied paint and transfer remaining paint to Owner
2. Contractor shall submit an operational readiness test report documenting all test results, including all assumptions, conditions, allowances, and corrections made during the test. The report shall provide a listing of all modifications and adjustments made onsite to include any settings / parameters not identified as factory defaults within the equipment's O&M documentation. The test report shall include a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

B. Functional Demonstration Testing

1. Prior to scheduling functional demonstration testing the Contractor shall submit a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.
2. The Contractor shall completely demonstrate the functionality and performance of the equipment and associated systems in the presence of Owner and Engineer, observing and documenting complete compliance with the Contract Documents.
3. The Contractor shall submit a written report documenting successful completion of functional demonstrating testing including all assumptions, conditions, allowances, and corrections made during the test.

3.5 TRAINING

- A. O&M Training: Onsite training specific to the equipment furnished shall be provided to the Owner's staff by a factory-trained manufacturer's representative. Training duration shall be sufficiently adequate to cover the operation and maintenance of the equipment and shall consist of not less than [1][2 repeated] session(s) with [4] hours of onsite classroom and hands-on instruction for a minimum of [4] attendees per session.
1. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:
 - a. Theory of operation
 - b. Major components of equipment
 - c. Operation of equipment
 - d. Configurations of equipment
 - e. Maintenance, troubleshooting and repair
 - f. Replacement of component level parts
 2. The submitted O&M manuals shall be used for training.

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SECTION 265600

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Extent of exterior lighting fixture work is indicated on Drawings and schedules.
- B. Types of exterior lighting fixtures in this section include the following:
 - 1. LED
- C. Applications of exterior lighting fixtures required for the project include the following:
 - 1. Outdoor area lighting.

1.2 SUBMITTALS:

- A. Product Data: Submit manufacturer's product data and installation instructions on each type exterior building lighting fixture and component. Data shall include all information necessary to indicate compliance with the contract documents, and shall include, but not be limited to, catalog number, certified photometrics from an independent source, driver information, and lamp information.
- B. Shop Drawings: Submit fixture shop drawings in booklet form with separate sheet for each fixture, assembled in "luminaire type" alphabetical and/or numerical order, with proposed fixture and accessories clearly indicated on each sheet.
- C. Wiring Diagrams: Submit wiring diagrams for exterior lighting fixtures showing connections to electrical power panels, switches, dimmers, controllers, and feeders. Differentiate between portions of wiring which are manufacturer-installed and portions which are field-installed.
- D. Samples: Submit one complete operating unit for each type of exterior lighting fixture specified.
- E. Illumination Data: Provide isofootcandle (isolux) plot diagram of footcandles on horizontal pavement surface which shows composite values of illuminance projected from the arrangement of light sources from indicated fixture locations and heights. Show on the graphic plots the locations, spacings and heights of luminaires.
 - 1. LED fixtures:
 - a. Computer generated photometric analysis of proposed DAY 1 (defined as the initial illuminance values), of the lighting installation.

- b. Computer generated photometric analysis of End-of-useful life date of the lighting installation.
- c. Provide documentation of the expected useful life including the testing and calculation of useful life and verification of site lighting performance at that life.

1.3 QUALITY ASSURANCE:

- A. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with exterior lighting fixture work similar to that required for project.
- B. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 225, 250, 410, and 501 as applicable to installation, and construction of exterior building lighting fixtures.
 - 2. NEMA Compliance: Comply with applicable requirements of NEMA Stds. Pub/ No. LE 2 pertaining to lighting equipment.
 - 3. IES Compliance: Comply with IES RP-8, 19, 20 and PB-15 pertaining to exterior, parking, and roadway lighting practices and fixtures.
 - 4. UL Compliance: Comply with requirements of UL standards, including Stds. 486A and B, pertaining to exterior lighting fixtures. Provide exterior lighting fixtures and components which are UL-listed and labeled.
 - 5. NFPA Compliance: Comply with applicable requirements of NFPA 780, "Lightning Protection Code," pertaining to installation of exterior lighting fixtures.
- C. LED:
 - 1. Site Owner may request standard production model luminaire samples identical (including LED package) to product proposed to be installed for inspection.
 - 2. If luminaires are believed to be underperforming in early life, the Site Owner may choose to take field measurements between 2,000 and 3,000 operating hours of the completion of installation to confirm that lighting levels are in accordance with the site-specific photometric requirements in this specification. If uniformity is more that 15% worse or average light levels are more than 15% below the DAY 1 submittal and the luminaire locations in the field are designed, the luminaire manufacturer must provide additional luminaires to achieve the specified light levels and uniformity. Variance from specified tolerances may be allowed provided prior approval by Owner.

1.4 DELIVERY, STORAGE AND HANDLING:

- A. Deliver exterior lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from construction debris and physical damage.
- B. Store exterior lighting fixtures in original wrappings in a clean dry space. Protect from weather, dirt, fumes, water, construction debris, and damage.
- C. Handle exterior lighting fixtures carefully to prevent damage, breaking, and scoring. Do

not install damaged fixtures or components; remove units from site and replace with new.

1.5 LED WARRANTY

A. Standard Warranty – Provide 50,000 hours or greater and:

1. A written five-year minimum on-site replacement material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty must include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
2. A written five-year replacement material warranty for defective or non-starting LED source assemblies.
3. A written five-year replacement material warranty on all power supply units (PSU's) or drivers.
4. Provide a written five-year replacement warranty for luminaires producing inadequately maintained illuminance levels at end of warranty period, as prorated from levels expected at end of useful life. For example, a luminaire expected to produce 70% of initial lumens at 100,000 hours would be expected to last over 11 years (continuous operation), so levels would be expected to be at 87% of initial at end of five-year warranty period. Warranty must cover all light sources (LED package, LED array, or LED module) including, but not limited to the LED die, encapsulate, and phosphor. If the expected useful life of the luminaire system is not maintained, then the manufacturer must replace the light source(s) or luminaire as needed.
5. Warranty period will begin on date of final acceptance. The supplier will provide the site Owner with appropriate signed and dated warranty certificates at the completion of the project and included into the Record and Information Booklet.

1.6 SEQUENCING AND SCHEDULING:

- A. Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of exterior lighting fixtures with other work.
- B. Sequence exterior lighting installation with other work to reduce possibility of damage and soiling of fixtures during remainder of construction period.

1.7 MAINTENANCE:

- A. Maintenance Data: Submit maintenance data and parts list for each exterior lighting fixture and accessory; including "trouble-shooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual; in accordance with requirements of Division 1.
- B. Extra Stock:
 1. Furnish stock or replacement LED boards/cards in the amount of 3 or a minimum of 12 individual LED lamps. Also, provide 3 spare drivers.

PART 2 - PRODUCTS

2.1 FIXTURES:

A. General:

1. Provide lighting fixtures, of sizes, types and ratings indicated on Drawings; complete with, but not limited to, housings, lamps, lamp holders, reflectors, drivers, and wiring. Ship fixtures factory-assembled, with those components required for a complete installation.
2. Provide required dimensional thickness of metal so that all fixtures are rigid, stable and will resist deflection, twisting, warping under normal installation procedures, loading, relamping, etc.
3. All cast parts, including die-cast members, shall be of uniform quality, free from blow holes, pores, hard spots, shrinkage defects, cracks or other imperfections that affect strength and appearance, or are indicative of inferior metals or alloys.
4. Reflectors, cones, or baffles shall be absolutely free of spinning lines, ripples or any marks or indentations caused by riveting or other assembly techniques. No rivets or hardware shall be visible after installation.
5. Prior to finishing, all metal surfaces shall be hot cleaned by chemical means and shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
6. Where modified fixtures are specified, fixtures shall be modified as required with lamp sockets positioned to provide desired photometric performance.
7. Where custom color is indicated on the schedule, a color other than the manufacturer's standard will be required for all parts and components visible after installation. The finish material will be of the same type and process as applied to the standard catalogued item.
8. All castings and extrusions shall be machined, sanded, or similarly treated, and given minimum one coat of baked-on clear methacrylate lacquer, unless a painted finish is specified.
9. Aluminum surfaces exposed to corrosive atmospheres shall receive a Duranodic or polyester powder paint finish for corrosion resistance.

B. Acceptable Manufacturers:

1. HOLOPHANE – MONGOOSE LED
2. As specified in the lighting fixture schedule and drawings

2.2 LAMPS:

A. LED

1. Luminaires must be rated for -40°C to +50°C operation.
2. Correlated Color Temperature (CCT) shall be one Nominal CCT: 4000 K .
3. Duv tolerance of 0.001 ± 0.006 .
4. Color Rendering Index (CRI): ≥ 70 .
5. Luminaire manufacturer must submit reliability reports indicating that the manufacturer of the LED (chip, diode, or package) has performed JEDEC (Joint

Electron Devices Engineering Council) reliability tests on the LEDs as follows:

- a. High Temperature Operating Life (HTOL)
- b. Room Temperature Operating Life (RTOL)
- c. Low Temperature Operating Life (LTOL)
- d. Powered Temperature Cycle (PTMCL)
- e. Non-Operating Thermal Shock (TMSK)
- f. Mechanical Shock
- g. Variable Vibration Frequency
- h. Solder Heat Resistance (SHR)

2.3 LED DRIVERS

A. Power supply Units (PSUs) including drivers must meet the following requirements:

1. Must have a minimum efficiency of 85%.
2. Must be rated to operate between -40°C to +50°C.
3. Input Voltage: capable of 120 (±10%) volt, single phase as required by the site.
4. Power supplies can be UL Class I or II output.
5. Operating frequency must be 50/60 Hz.
6. Drivers must have a Power Factor (PF) of: > 0.90.
7. Drivers must have a Total Harmonic Distortion (THD) of: ≤ 20%.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which lighting fixtures are to be installed, and substrate which will support lighting fixtures. Notify Contractor in writing of conditions detrimental to proper completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF EXTERIOR LIGHTING FIXTURES:

- A. Install exterior lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A-1991 and B, and the National Electrical Code.
- C. Fasten electrical lighting fixtures and brackets securely to indicated structural supports, including poles/standards; and ensure that installed fixtures are plum and level.

- D. Make installation such that the fixture is free of finger marks, flaws, scratches, dents or other imperfections.
- E. Arrangement
 - 1. Align edges of fixtures with walls or other building elements. Where indicated by dimensions or indicated on Drawings, maintain indicated arrangement.

3.3 GROUNDING:

- A. Provide equipment grounding connections for exterior lighting fixtures as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

3.4 FIELD QUALITY CONTROL:

- A. Lamps
 - 1. Install lamps in all light fixtures.
 - 2. All lamps shall be new and unused. If permanent lighting system is used for temporary construction lighting, lamps shall be replaced upon turn over to Owner.
 - 3. Furnish stock or replacement lamps amounting to 15%, but not less than 4 lamps in each case, of each type and size lamp used in each type fixture. Deliver replacement stock as directed to Owner's storage space.
- B. Extra Stock:
 - 1. Furnish stock or replacement LED boards/cards in the amount of 3 or a minimum of 12 individual LED lamps. Also provide 3 spare drivers.

3.5 ADJUSTING AND CLEANING:

- A. Aim adjustable lighting fixtures and lamps in night test of system. Verify that measured illuminance values comply with isolux plot diagram values.
- B. Clean lighting fixtures of dirt and debris upon completion of installation.
- C. Protect installed fixtures from damage during construction period.

3.6 DEMONSTRATION

- A. Upon completion of installation of exterior lighting fixtures, and associated electrical supply circuitry, apply electrical energy to circuitry to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION