The Engineer of Record for Division 26, 27, and 28 of the Specifications, including:

260010	GENERAL ELECTRICAL REQUIREMENTS
260500	COMMON WORK RESULTS FOR ELECTRICAL
260502	EQUIPMENT WIRING SYSTEMS
260504	PROVISIONS FOR ELECTRIC UTILITY SERVICE
260519	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
260526	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
260529	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
260533	RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
260543	UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
260553	IDENTIFICATION FOR ELECTRICAL SYSTEMS
260573	OVERCURRENT PROTECTIVE DEVICE COORDINATION
260800	COMMISSIONING ELECTRICAL SYSTEMS
260923	LIGHTING CONTROL DEVICES
262200	LOW-VOLTAGE TRANSFORMERS
262413	SWITCHBOARDS
262416	PANELBOARDS
262726	WIRING DEVICES
262813	FUSES
262816	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
262913	ENCLOSED CONTROLLERS
263213	ENGINE DRIVEN GENERATORS
263600	TRANFER SWITCHES
264313	SURGE PROTECTIVE DEVICES
265100	INTERIOR LIGHTING
265600	EXTERIOR LIGHTING
270010	GENERAL COMMUNICATIONS REQUIREMENTS
270500	COMMON WORK RESULTS FOR COMMUNICATIONS
270543	UNDERGROUND DUCTS AND RACEWAYS FOR COMMUNICATIONS SYSTEMS
271000	STRUCTURED CABLING SYSTEM
271100	TELECOMMUNICATIONS EQUIPMENT ROOM FITTINGS
271300	COMMUNICATIONS BACKBONE CABLING
271500	COMMUNICATIONS HORIZONTAL CABLING
274100	AUDIO VIDEO SYSTEMS
274116	AUDIO VIDEO SYSTEMS EQUIPMENT
275129.13	RESCUE ASSISTANCE SIGNAL SYSTEMS
275300	DISTRIBUTED ANTENNA SYSTEM
280010	GENERAL ELECTRONIC SAFETY AND SECURITY REQUIREMENTS
280501	COMMON WORK RESULTS FOR ELECTRONIC SECURITY
281010	CONDUCTORS AND CABLES FOR ELECTRONIC SECURITY
281300	ACCESS CONTROL
282000	VIDEO SURVEILLANCE

for the AWSOM, Bentonville, AR Project No. 993A is:

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PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and to all following sections within Division 26.

1.02 SECTION INCLUDES

- A. This Division requires providing complete functioning systems, and each element thereof, as specified, indicated, or reasonably inferred, on the Drawings and in these Specifications, including every article, device, or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the Work include, but are not limited to, materials, labor, supervision, supplies, tools, equipment, transportation and utilities.
- B. Division 26 of these Specifications, and Drawings numbered with prefixes E generally describe these systems, but the scope of the electrical work includes all such work indicated in all of the Contract Documents, including, but not limited to: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.
- C. Drawings are graphic representations of the Work upon which the Contract is based. They show the materials and their relationship to one another, including sizes, shapes, locations, and connections. They also convey the scope of work, indicating the intended general arrangement of the equipment, fixtures, outlets and circuits without showing all of the exact details as to elevations, offsets, control lines, and other installation requirements. Use the Drawings as a guide when laying out the Work and to verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers' requirements, will ensure a complete, coordinated, satisfactory and properly operating system.
- D. Specifications define the qualitative requirements for products, materials, and workmanship upon which the Contract is based.

1.03 DEFINITIONS

- A. Whenever used in these Specifications or Drawings, the following terms shall have the indicated meanings:
 - 1. Furnish: "To supply and deliver to the project site, ready for unloading, unpacking, assembling, installing, and similar operations."
 - 2. Install: "To perform all operations at the project site, including, but not limited to, and as required: unloading, unpacking, assembling, erecting,

placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, testing, commissioning, starting up and similar operations, complete, and ready for the intended use."

- 3. Provide: "To furnish and install complete, and ready for the intended use."
- 4. Furnished by Owner (or Owner-Furnished) or Furnished by Others: "An item furnished by the Owner or under other Divisions or Contracts, and installed under the requirements of this Division, complete, and ready for the intended use, including all items and services incidental to the Work necessary for proper installation and operation. Include the installation under the warranty required by this Division.
- 5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division.
 - a) A Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Architect".
- 6. Contract Administrator: Where referenced in this Division, "Contract Administrator" is the primary liaison between the Owner and the Contractor. Specifically, for this project this is the "Construction Manager"
- 7. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
- 8. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other NRTLs that are acceptable to the AHJ, and standards that meet the specified criteria.
- 9. Substitution: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Substitutions include Value Engineering proposals.
 - a) Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
 - b) Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.
- 10. Value Engineering: A systematic method to improve the "value" of goods and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. The goal of VE is to achieve the desired function at the lowest overall cost consistent with required performance.

- 11. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified
- B. When 'furnish', 'install', 'perform', or 'provide' is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, "provide" is implied.
- C. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.
- D. Manufacturers: The listing of specific manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 3. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference, unless otherwise noted.
- E. The following definitions apply to excavation operations:
 - 1. Additional Excavation: Where excavation has reached indicated sub-grade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
 - 2. Sub-base: as used in this section refers to the compacted soil layer used in pavement systems between the sub-grade and the pavement base course material.
 - 3. Sub-grade: as used in this section refers to the compacted soil immediately below the slab or pavement system.
 - 4. Unauthorized excavation consists of removal of materials beyond indicated sub-grade elevations or dimensions without specific direction from the Contract Administrator.

1.04 REFERENCE STANDARDS

A. Execute all work in accordance with, and comply at a minimum with, National Fire Protection Association (NFPA) codes, state and local building codes, and all other applicable codes and ordinances in force, governing the particular class of work involved, for performance, workmanship, equipment, and materials. Additionally, comply with rules and regulations of public utilities and municipal departments affected by connection of services. Where conflicts between various codes, ordinances, rules, and regulations exist, comply with the most stringent. Wherever requirements of these Specifications, Drawings, or both, exceed those of the above items, the requirements of these Specifications, Drawings, or both, shall govern. Code compliance, at a minimum, is mandatory. Construe nothing in these Construction Documents as permitting work not in compliance, at a minimum, with these codes. Bring all conflicts observed between codes, ordinances, rules, regulations and these documents to the Contract Administrator's and Engineer's attention in sufficient time, prior to the opening of bids, to prepare the Supplementary Drawings and Specifications Addenda required to resolve the conflict.

- B. If the conflict is not reported timely, prior to the opening of bids, resolve the conflict and provide the installation in accordance with the governing codes and to the satisfaction of the Contract Administrator and Engineer, without additional compensation. Contractor will be held responsible for any violation of the law.
- C. Obtain timely inspections by the constituted authorities having jurisdiction; and, upon final completion of the Work, obtain and deliver to the Owner executed final certificates of acceptance from these authorities having jurisdiction.
- D. All material, manufacturing methods, handling, dimensions, methods of installation, and test procedures shall conform to industry standards, acts, and codes, including, but not limited to the following, except where these Drawings and Specifications exceed them:

IBC ADA AIA AEIC ANSI ASTM AWS AWWA ICEA IEEE IES NBFU NEC NECA NECA NETA NFPA OSHA	International Building Code Americans with Disabilities Act Guidelines for Design and Construction of Hospital and Healthcare Facilities Association of Edison Illuminating Companies American National Standards Institute American Society of Testing Materials American Welding Society American Water Works Association Insulated Conductors Engineers Association Institute of Electrical and Electronics Engineers Illuminating Engineering Society National Board of Fire Underwriters National Electrical Code, NFPA 70 National Electrical Contractors Association InterNational Electrical Testing Association InterNational Electrical Testing Association National Fire Protection Association Occumational Safety and Health Act
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
UL	Underwriter's Laboratories

E. Comply with rules and regulations of public utilities and municipal departments affected by connections of services.

- F. Perform all electrical work in compliance with applicable safety regulations, including OSHA regulations. All safety lights, guards, and warning signs required for the performance of the electrical work shall be provided by the Contractor.
- G. Obtain and pay for all permits, licenses and fees that are required by the governing authorities for the performance of the electrical work.

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate with other divisions for electrical work included in them but not listed in Division 26 or indicated on electrical Drawings.
- B. Visit the site and ascertain the conditions to be encountered in installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provisions for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, and incorrect or faulty installation of any of the Work under this Division or for additional compensation for any work covered by this Division.
- C. Refer to Drawings and divisions of the other trades and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. Make all offsets required to clear equipment, beams and other structural members, and to facilitate concealing conduit in the manner anticipated in the design.
- D. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
- E. Provide materials with trim that will fit properly the types of ceiling, wall, or floor finishes installed.
- F. Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.
- G. Maintain an electrical foreman on the jobsite at all times to coordinate this work with other trades so that various components of the electrical systems is installed at the proper time, fits the available space, and allows proper service access to all equipment. Carry on the Work in such a manner that the Work of the other trades will not be handicapped, hindered, or delayed at any time.
- H. Work of this Division shall progress according to the "Construction Schedule" as described in Division 01 and as approved by the Contract Administrator. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of all schedule dates.

I. Measurements and Layouts: The Drawings are schematic in nature but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the Work. Figured dimensions take precedence to scaled dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing all Contract Documents. Correct, at no additional costs to the Owner, errors that could have been avoided by proper checking and inspection.

1.06 COORDINATION DRAWINGS

- A. Coordination Drawings, General: Prepare coordination drawings according to the requirements of individual Sections. Additionally, prepare coordination drawings as required scope of installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one trade.
 - 1. Information shall be project specific and drawn accurately to a scale large enough to resolve conflicts. Do not base coordination drawings on standard dimensional data.
 - 2. Prepare floorplans, sections, elevations, and details as needed to adequately describe relationship of various systems and components.
 - 3. Clearly indicate functional and spatial relationships of components of all systems specified in the Contract Documents, including but not limited to: architectural, structural, civil, mechanical, electrical, fire protection, and specialty systems.
 - 4. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
 - 5. Show location and size of access doors required for access to concealed equipment, fittings, controls, terminations, and cabling.
 - 6. Indicate required installation sequence to minimize conflicts between entities.
 - 7. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Contract Administrator indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
 - 8. The details of the coordination are the responsibility of the Contractor and, where indicated on the Drawings, minor adjustments in raceway routing, device placement, device type, or equipment arrangement are not to be considered changes to the Contract.
- B. Equipment Room Coordination Drawings: In accordance with the submittal procedures outlined within these Specifications, provide dimensioned layouts of electrical equipment locations within electrical rooms/closets, mechanical rooms and generator rooms with equipment drawn to scale and identified therein.

- 1. Clearly identify all required working clearances and access provisions required for installation and maintenance.
- 2. Equipment layouts should be arranged accounting for considerations for required door openings and the clearances required by the equipment manufacturer.
- 3. Indicate path to allow for the future removal of each large piece of equipment (up to and including generators and unit sub-station transformers) without removal of non-related equipment or architectural elements.
- 4. Include work provided by others routed through the equipment rooms.
- C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:
 - 1. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.
 - 2. BIM File Incorporation: Develop and incorporate coordination drawing files into Building Information Model established for Project.
 - a) Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Contract Administrator.
 - 3. Where the Engineer's digital data files are provided to the Contractor for use in preparing coordination digital data files, the Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to the Drawings or Specifications.
 - 4. Submit coordination drawings in accordance with the submittal procedures outlined within these Specifications.

1.07 SUBMITTALS

- A. Refer to Division 01 and General Conditions for submittal requirements in addition to requirements specified herein.
- B. Refer to Division 01 for acceptance of electronic submittals. If not specified by Division 01, provide electronic submittals. If Division 01 requires paper submittals, provide the quantity of submittals required, but no fewer than seven (7) sets.
- C. For electronic submittals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Architect and Engineer that the submittals have been posted. If electronic submittal procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the submittals. For submittals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representatives. Contractor shall allow for the Engineer Review Time as specified. Contractor shall submit only the documents required to purchase the materials and/or equipment in the submittal.

- D. Engineer Review Time: Transmit submittals as early as required to support the project schedule. Allow two weeks for Engineer review time plus to/from mailing time via the Architect, plus a duplication of this time for resubmittal if required. Transmit submittals as soon as possible after Notice to Proceed and before Mechanical construction starts.
- E. Submittals and shop drawings shall not contain the firm name, logo, seal, or signature of the Engineer. They shall not be copies of the work product of the Engineer. If the Contractor desires to use elements of such product, the license agreement for transfer of information obtained from the Engineer must be used.
- F. Assemble and submit for review manufacturer product literature for material and equipment to be furnished and/or installed under this Division. Literature shall include shop drawings, manufacturer product data, performance sheets, samples, and other submittals required by this Division as noted in each individual Section. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.
- G. Separate submittals according to individual specification sections. Only resubmit those sections requested for resubmittal.
- H. Provide submittals in sufficient detail so as to demonstrate compliance with these Contract Documents and the design concept. Highlight, mark, list or indicate the materials, performance criteria and accessories that are being proposed. Illegible submittals will be rejected and returned without review.
- I. Refer to individual Sections for additional submittal requirements.
- J. Before transmitting submittals and material lists, verify that the equipment submitted is mutually compatible with and suitable for the intended use. Verify that the equipment will fit the available space and maintain manufacturer recommended service clearances. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.
- K. Submittals shall contain the following information:
 - 1. The project name.
 - 2. The applicable specification section and paragraph.
 - 3. Equipment identification acronym as used on the drawings.
 - 4. The submittal date.
 - 5. The Contractor's stamp, which shall certify that the stamped drawings have been checked by the Contractor, comply with the Drawings and Specifications, and have been coordinated with other trades.
 - 6. Submittals not so identified will be returned to the Contractor without action.

L. The checking and subsequent acceptance by the Engineer and/or Architect of submittals shall not relieve responsibility from the Contractor for (1) deviations from Drawings and Specifications; (2) errors in dimensions, details, sizes of equipment, or quantities; (3) omissions of components or fittings; and (4) not coordinating items with actual building conditions and adjacent work. Contractor shall request and secure written acceptance from the Engineer and Architect prior to implementing any deviation.

1.08 SUBSTITUTIONS

- A. Refer to Division 01 and General Conditions for substitutions in addition to requirements specified herein.
- B. Materials, products, equipment, and systems described in the Bidding Documents establish a standard of required function, dimension, appearance and quality to be met by the proposed substitution.
- C. The base bid shall include only the products from manufacturers specifically named in the drawings and specifications.
- D. Request for Substitution:
 - 1. Complete and send the Substitution Request Form attached at the end of this section for each material, product, equipment, or system that is proposed to be substituted.
 - 2. The burden of proof of the merit of the proposed substitution is upon the proposer.
 - 3. Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, Construction Manager, and Owner the following:
 - a) Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
 - b) Proposed substitution is consistent with the Contract Documents and will produce indicated results, including functional clearances, maintenance service, and sourcing of replacement parts.
 - c) Proposed substitution has received necessary approvals of the Authorities Having Jurisdiction.
 - d) Same warranty will be furnished for proposed substitution as for specified Work.
 - e) If accepted substitution fails to perform as required, Contractor shall replace substitute material or system with that originally specified and bear costs incurred thereby.
 - f) Coordination, installation and changes in the Work as necessary for accepted substitution will be complete in all respects.
- E. Substitution Consideration:

- 1. No substitutions will be considered unless the Substitution Request Form is completed and attached with the appropriate substitution documentation.
- 2. Prior to receipt of Bids: No substitutions will be considered prior to receipt of bids unless written request for approval to bid has been received by the Engineer at least ten (10) calendar days prior to the date for receipt of bids.
 - a) If the proposed substitution is approved prior to receipt of bids, such approval will be stated in an addendum. Bidders shall not rely upon approvals made in any other manner. Verbal approval will not be given.
- 3. After receipt of Bids: No substitutions will be considered after receipt of Bids and before award of the Contract.
- 4. After award of Contract: No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.09 ELECTRONIC DRAWING FILES

- A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF format from the Engineer for a shipping and handling fee of \$200 for a drawing set up to 12 sheets and \$15 per sheet for each additional sheet.
- B. Contractor shall request and complete the Electronic File Release Agreement form from the Engineer. Send the form along with a check made payable to Henderson Engineers, Inc. Contractor shall indicate the desired shipping method and drawing format on the attached form.
- C. Contact the Contract Administrator for written authorization.
- D. The following must be received before electronic drawing files will be sent:
 - 1. Contract Administrator's written authorization
 - 2. Engineer's release agreement form
 - 3. Payment

1.010 QUALITY ASSURANCE

- A. Execute all work under this Division in a thorough and professional manner by competent and experienced workmen duly trained to perform the work specified.
- B. Install all work in strict conformance with all manufacturers' requirements and recommendations, unless these Documents exceed those requirements. Install all equipment and materials in a neat and professional manner, aligned, leveled, and adjusted for satisfactory operation, in accordance with NECA guidelines.
- C. Unless indicated otherwise on the Drawings, provide all material and equipment new, of the best quality and design, free from defects and imperfections and with

markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Provide all material and equipment of the same type from the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items of the same types specified within this Division shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this Project.

1.011 OPERATION AND MAINTENANCE MANUALS

- A. Refer to Division 01 and General Conditions for Operation and Maintenance Manuals in addition to requirements specified herein.
- B. Submit manuals prior to requesting the final punch list and before all requests for Substantial Completion.
- C. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.
- D. Prior to Substantial Completion of the project, furnish to the Contract Administrator, for Engineer's review, and for the Owner's use, four (4) copies of Operation and Maintenance Manuals in labeled, hard-back three-ring binders, with cover, binding label, tabbed dividers and plastic insert folders for Record Drawings. Include local contacts, complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.
- E. Each manual shall contain equipment data, approved submittals, shop drawings, diagrams, capacities, spare part numbers, manufacturer service and maintenance data, warranties and guarantees.
- F. Refer to Division 01 for acceptance of electronic manuals for this project. For electronic manuals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Contract Administrator and Engineer that the manuals have been posted. If electronic manual procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the manuals. For manuals sent by e-mail, Contractor shall copy the Contract Administrator's and Engineer's designated representatives.

1.012 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections of this Division

1.013 RECORD DRAWINGS

- A. Refer to Division 01 and General Conditions for Record Drawings in addition to requirements specified herein.
- B. A set of work prints of the Contract Documents shall be kept on the jobsite during construction for the purpose of noting changes. During the course of construction, the Contractor shall indicate on these Documents changes made from the original Contract Documents. Particular attention shall be paid to those items which need to be located for servicing. Underground utilities shall be located by dimension from column lines.
- C. At the completion of the project, the Contractor shall obtain, at their expense, reproducible copies of the final drawings and incorporate changes noted on the jobsite work prints onto these drawings. These changes shall be done by a skilled drafter. Each sheet shall be marked "Record Drawing", along with the date. These drawings shall be delivered to the Contract Administrator.

1.014 DELIVERY, STORAGE AND HANDLING

- A. Refer to Division 01 and General Conditions for Delivery, Storage and Handling in addition to requirements specified herein.
- B. Deliver equipment and material to the job site in their original containers with labels intact, fully identified with manufacturer's name, make, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.
- C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, including the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which becomes rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Contract Administrator.
- D. Be responsible for the safe storage of tools, material and equipment.

1.015 WARRANTIES

- A. Refer to Division 01 and General Conditions for Warranties in addition to requirements specified herein.
- B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.

- C. Warrant each system and each element thereof against all defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific items are noted to carry a longer warranty in these Construction Documents or manufacturer's standard warranty exceeds 12 months. Remedy all defects, occurring within the warranty period(s), as stated in the General Conditions and Division 01.
- D. Also warrant the following additional items:
 - 1. All raceways are free from obstructions, holes, crushing, or breaks of any nature.
 - 2. All raceway seals are effective.
 - 3. The entire electrical system is free from all short circuits and unwanted open circuits and grounds.
- E. The above warranties shall include labor and material. Make repairs or replacements without any additional costs to the Owner.
- F. Perform the remedial work promptly, upon written notice from the Contract Administrator or Owner.
- G. At the time of Substantial Completion, deliver to the Owner all warranties, in writing and properly executed, including term limits for warranties extending beyond the one year period, each warranty instrument being addressed to the Owner and stating the commencement date and term.

1.016 TEMPORARY FACILITIES

- A. Refer to Division 01 and General Conditions for Temporary Facilities requirements in addition to requirements specified herein.
- B. Temporary Utilities: The types of services required include, but are not limited to, electricity, telephone, and internet. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.
- C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.
 - 1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.
 - 2. Heating: Provide heat, as necessary, to protect work, materials and equipment from damage due to dampness and cold. In areas where building

is occupied, maintain a temperature not less than 65 degrees F. Use steam, hot water, or gas from piped distribution system where available. Where steam, hot water or piped gas are not available, heat with self-contained LP gas or fuel oil heaters, bearing UL, FM or other approval labels appropriate for application. Use electric-resistance space heaters only where no other, more energy-efficient, type of heater is available and allowable.

- a) Vent and exhaust fuel-burning heaters per SMACNA Guidelines for Source Control and equip units with individual-space thermostatic controls.
- b) If permanent HVAC systems are used during construction, provide HVAC Protection and replace all filtration prior to occupancy in accordance with SMACNA Guidelines.

1.017 FIELD CONDITIONS

- A. Conditions Affecting Excavations: The following project conditions apply:
 - 1. Maintain and protect existing building services that transit the area affected by selective demolition.
 - 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
- B. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.
- C. Use of explosives is not permitted.
- D. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits specified by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

(Not Used)

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.02 PERMITS

A. Secure and pay for all permits required in connection with the installation of the Electrical Work. Arrange with the various utility companies for the installation and connection of all required utilities for this facility and pay all charges associated therewith including connection charges and inspection fees, except where these services or fees are designated to be provided by others.

3.03 TEMPORARY ELECTRICAL SERVICE AND WIRING

- A. Provide 208Y/120 volt, three-phase, four-wire, temporary electrical service and temporary lighting system to facilitate construction.
- B. Pay all charges made by the Electric Utility, with respect to installation and energy charges for temporary services.
- C. Work for the temporary power shall consist of all labor and materials, including, but not limited to conduit, wiring, panelboards, fuse blocks, fused disconnecting switches, fuses, pigtails, receptacles, wood panel switch supports, and other miscellaneous materials required to complete the power system.
- D. Install all temporary wiring in accordance with applicable codes, and maintain in an OSHA-approved manner.
- E. Provide an adequate number of GFCI type power distribution centers, rated 208Y/120V, four-wire, and not less than 60A, with sufficient fuse blocks or breakers for lighting and hand tool circuits, 60A four-wire feeders, all mounted within pre-fabricated enclosures UL listed for this application or on suitable wood panels bolted to columns or upright wood supports as required.
- F. Install circuits to points on each level of each building so that service outlets can be reached by a 50-foot extension cord for 120V power and a 100-foot extension cord for 208V power (or as required by OSHA or local authorities).
- G. Provide one lighting outlet per 30 linear feet of corridor and at least one light in each room and for every 800 square feet of floor area. Temporary lighting shall comply with OSHA requirements.
- H. If additional service is required for cranes, electrical welders or for electric motors over 1/2 HP per unit, such additional service shall become the responsibility of the trade involved.
- I. When the permanent wiring for lighting and power is installed, with approval of the Contract Administrator and Owner, the permanent system may be used, provided the Contractor assumes full responsibility for all electrical material, equipment, and devices contained in the systems and provided that roof drainage system and roofing are complete.

J. When directed by the Contract Administrator, remove all temporary services, lighting, wiring and devices from the property.

3.04 ACCESS TO EQUIPMENT

- A. Locate all pull boxes, junction boxes and controls to provide easy access for operation, service inspection and maintenance. Provide an access door where equipment or devices are located above inaccessible ceilings. Refer to Division 26 Section "Common Work Results for Electrical".
- B. Maintain all code required clearances and clearances required by manufacturers.

3.05 **PENETRATIONS**

- A. Unless otherwise noted as being provided under other divisions, provide sleeves, box frames, or both, for openings in floors, walls, partitions and ceilings for all electrical work that passes through construction. Refer to Division 26 Section "Common Work Results for Electrical".
- B. Provide sleeves, box frames, or both, for all conduit, cable, and busways that pass through masonry, concrete or block walls.
- C. The cutting of new and/or existing construction will not be permitted except by written approval of the Contract Administrator.

3.06 EXCAVATION AND BACKFILLING

- A. Refer to Division 01, Division 02 and General Conditions for Excavation and Backfilling in addition to the requirements specified herein.
- B. Perform excavation of every description, of whatever substance encountered and to the depth required in connection with the installation of the work under this division. Excavation shall be in conformance with applicable Divisions and sections of the Specifications.
- C. Restore roads, alleys, streets and sidewalks damaged during this work to the satisfaction of Authorities Having Jurisdiction.
- D. Do not excavate trenches close to walks or columns without prior consultation with the Contract Administrator.
- E. Erect barricades around excavations, for safety, and place an adequate number of amber lights on or near the work and keep those burning from dusk to dawn. Be responsible for all damage that any parties may sustain in consequence of neglecting the necessary precautions in prosecuting the work.
- F. Slope sides of excavations to comply with local, state, and federal codes and ordinances. Shore and brace as required for stability of excavation.

- G. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local, state, and federal codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
 - 1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.
- H. Install sediment and erosion control measures in accordance with local codes and ordinances.
- I. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
 - 1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
 - 2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches. In no case shall sewers be used as drains for such water.
- J. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.
 - 1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
 - 2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.
- K. Excavation for Underground Tanks and Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
 - 1. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of one inch in diameter and larger with emulsified asphalt tree paint.
 - 2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.
- L. Trenching: Excavate trenches for electrical installations as follows:
 - 1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of six to nine inches clearance on both sides of raceway and cables.
 - 2. Excavate trenches to depth indicated or required for raceway and cables to establish slope, away from buildings and indicated elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.

- 3. Limit the length of open trench to that in which raceway and cables can be installed, tested, and the trench backfilled within the same day.
- 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceway and cables. Provide a minimum of six inches of stone or gravel cushion between rock bearing surface and raceway and cables.
- 5. Excavate trenches for raceway, cables, and equipment with bottoms of trench to accurate elevations for support of raceway and cables on undisturbed soil.
- M. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.
- N. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.
 - 1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
 - 2. Under building slabs, use drainage fill materials.
 - 3. Under raceway and cables, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
 - 4. For raceway and cables less than 30 inches below surface of roadways, provide 4-inch-thick concrete base slab support. After installation and testing of raceway and cables, provide a 4-inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
 - 5. Other areas use excavated or borrowed materials.
- O. Backfill excavations as promptly as work permits, but not until completion of the following:
 - 1. Inspection, testing, approval, and locations of underground utilities have been recorded.
 - 2. Removal of concrete formwork.
 - 3. Removal of shoring and bracing, and backfilling of voids.
 - 4. Removal of trash and debris.
- P. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
 - 1. For vertical and diagonal raceway installations, thoroughly support raceways from permanent structures or undisturbed earth at no less that 10-foot intervals, while placing backfill materials, so that raceways are not deflected, crushed, broken, or otherwise damaged by the backfill placement.
- Q. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry

density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

- R. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.
- S. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below:
 - 1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).
 - a) Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - b) Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - c) Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.
 - 2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.
- T. Subsidence: Where subsidence occurs at mechanical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.07 CUTTING AND PATCHING

A. Cut walls, floors, ceilings, and other portions of the facility as required to install work under this Division.

- B. Obtain permission from the Architect prior to cutting. Do not cut or disturb structural members without prior approval from the Architect and Structural Engineer.
- C. For post-tension slabs, x-ray slab and closely coordinate all core drill locations with Architect and Structural Engineer prior to performing any work. Obtain approval from Architect and Structural Engineer for all core drills and penetrations at least four days prior to performing work.
- D. Penetrations shall be made as small as possible while maintaining required clearances between the building element penetrated and the system component.
- E. Patch around openings to match adjacent construction, including fire ratings, if applicable.
- F. Repair and refinish areas disturbed by work to the condition of adjoining surfaces in a manner satisfactory to the Architect.

3.08 PAINTING

- A. Refer to Division 09 Section "Painting" for painting requirements.
- B. Paint exposed ferrous surfaces, including, but not limited to, hangers, equipment stands and supports using materials and methods as specified under individual sections and Division 09 of the Specifications; colors shall be as selected by the Contract Administrator.
- C. Re-finish all field-threaded ends of galvanized conduits and field-cut ends of galvanized supports with a cold-galvanizing compound approved for use on conductive surfaces. Follow closely manufacturer's instructions for pre-cleaning surfaces and application.
- D. Factory finishes and shop priming and special finishes are specified in the individual equipment Specification sections.
- E. Where factory finishes are provided and no additional field painting is specified, touch up or refinish, as required by, and to the acceptance of, the Contract Administrator, marred or damaged surfaces so as to leave a smooth, uniform finish. If, in the opinion of the Contract Administrator, the finish is too badly damaged to be properly re-finished, replace the damaged equipment or materials at no additional costs to the Owner.

3.09 CLEANING

A. Remove dirt and refuse, resulting from the performance of the Work, from the premises as required to prevent accumulation. Cooperate in maintaining reasonably clean premises at all times.

- B. Immediately prior to the final inspection, the Electrical Contractor shall clean material and equipment installed under the Electrical Contract. Dirt, dust, plaster, stains, and foreign matter shall be removed from surfaces including components internal to equipment.
- C. Damaged finishes shall be touched-up and restored to their original condition

3.010 ADJUSTING, ALIGNING AND TESTING

- A. Adjust, align and test all electrical equipment furnished and/or installed under this Division.
- B. Check motors for alignment with drive and proper rotation, and adjust as required.
- C. Check and test protective devices for specified and required application, and adjust as required.
- D. Check, test and adjust adjustable parts of all light fixtures and electrical equipment as required to produce the intended performance.
- E. Verify that completed wiring system is free from short circuits, unintentional grounds, low insulation impedances, and unintentional open circuits.
- F. After completion, perform tests for continuity, unwanted grounds, and insulation resistance in accordance with the requirements of NFPA 70 and NETA.
- G. Be responsible for the operation, service and maintenance of all new electrical equipment during construction and prior to acceptance by the Owner of the complete project under this Contract. Maintain all electrical equipment in the best operating condition including proper lubrication.
- H. Notify the Contract Administrator immediately of all operational failures caused by defective material, labor or both.
- I. Maintain service and equipment for all testing of electrical equipment and systems until all work is approved and accepted by the Owner.
- J. Keep a calibrated voltmeter and ammeter (true RMS type) available at all times. Provide service for test readings when and as required.
- K. Refer to individual sections for additional and specific requirements.

3.011 START-UP OF SYSTEMS

A. Prior to start-up of electrical systems, check all components and devices, lubricate items appropriately, and tighten all screwed and bolted connections to manufacturers' recommended torque values using appropriate torque tools.

- B. Each power, lighting and control circuit shall be energized, tested and proved free of breaks, short-circuits and unwanted grounds.
- C. Adjust taps on each transformer for rated secondary voltages.
- D. Balance all single phase loads at each panelboard, redistributing branch circuit connections until balance is achieved to plus or minus 10 percent.
- E. After all systems have been inspected and adjusted, confirm all operating features required by the Drawings and Specifications and make final adjustments as necessary.
- F. Demonstrate that all equipment and systems perform properly as designed per Drawings and Specifications.
- G. At the time of final review and tests of the power and lighting systems, all equipment and system components shall be in place and all connections at panelboards, switches, circuit breakers, and the like, shall be complete. All fuses shall be in place, and all circuits shall be continuous from point of service connections to all switches, receptacles, outlets, and the like.

3.012 TEST REPORTS

- A. Perform tests as required by these Specifications and submit the results to the Contract Administrator, for Engineer's review. Record the results, date and time of each test and the conditions under which the test was conducted. Include a copy of the finalized test results, with corrections made, in the operations and maintenance manuals. The tests shall establish the adequacy, quality, safety, and reliability for each electrical system installed. Notify the Contract Administrator and Engineer two working days prior to each test.
- B. For specific testing requirements of special systems, refer to the Specification section that describes that system. The Contractor shall provide the following to facilitate the testing of the electrical systems:
 - 1. Perform tests as described in the individual sections;
- C. Upon completing each test, record the results, date and time of each test and the conditions under which the test was conducted. Submit to the Contract Administrator, for Engineer's review, in duplicate, the test results for the following electrical items:
 - 1. Building service entrance voltage and amperes at each phase.
 - 2. Electrical service grounding conditions and grounding resistance.
 - 3. Proper phasing throughout the entire system.
 - 4. Voltages (phase-to-phase and phase-to-neutral) and amperes at each phase for each panelboard, switchboard, and the like.
 - 5. Phase voltages and amperes at each three-phase motor.

- 6. Test all wiring devices for electrical continuity and proper polarity of connections.
- D. Promptly correct all failures or deficiencies revealed by these tests in accordance with the manufacturer's recommendations and as determined by the Engineer.

3.013 SUBSTANTIAL COMPLETION REVIEW

- A. Prior to requesting a site observation for "CERTIFICATION OF SUBSTANTIAL COMPLETION", complete the following items:
 - 1. Submit complete Operation and Maintenance Data.
 - 2. Submit complete Record Drawings.
 - 3. Perform all required training of Owner's personnel.
 - 4. Turn over all spares and extra materials to the Owner, along with a complete inventory of spares and extra materials being turned over.
 - 5. Perform start-up tests of all systems.
 - 6. Remove all temporary facilities from the site.
 - 7. Comply with all requirements for Substantial Completion in the Division 01 and General Conditions.
- B. Request in writing a review for Substantial Completion. Give the Contract Administrator at least seven (7) days notice prior to the review.
- C. State in the written request that the Contractor has complied with the requirements for Substantial Completion.
- D. Upon receipt of a request for review, the Contract Administrator will either proceed with the review or advise the Contractor of unfilled requirements.
- E. If the Contractor requests a site visit for Substantial Completion review prior to completing the above-mentioned items, he shall reimburse the Contract Administrator and Engineer for time and expenses incurred for the visit.
- F. Upon completion of the review, the Contract Administrator will prepare a "final list" of outstanding items to be completed or corrected for final acceptance.
- G. Omissions on the "final list" shall not relieve the Contractor from the requirements of the Contract Documents.
- H. Prior to requesting a final review, submit a copy of the final list of items to be completed or corrected. State in writing that each item has been completed, resolved for acceptance or the reason it has not been completed.

END OF SECTION

SUBSTITUTION REQUEST FORM

Request # (GC Determined):							
Date:							
: Article/Paragraph:							
Model No.:							
Phone:							
History: 🗌 New product 🔲 1-4 years old 🔲 5-10 years old 🔲 More than 10 years old							
Differences between proposed substitution and specified Work:							
Point-by-point comparative data attached – REQUIRED BY ENGINEER Comparative data may include but not be limited to performance, certifications, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements. Include all information necessary for an evaluation.							
Product Data Samples Reports Other:							
Reason for not providing specified item:							
Architect:							
Owner:							
Date Installed:							
□ No □ Yes; explain:							

Substitution Certification Statement:

Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner that the:

- A. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
 - B. Proposed substitution is consistent with the Contract Documents and will produce indicated results.
 - C. Proposed substitution does not affect dimensions and functional clearances.
 - D. Proposed substitution has received necessary approvals of authorities having jurisdiction.
 - E. Same warranty will be furnished for proposed substitution as for specified Work.
 - F. Same maintenance service and source of replacement parts, as applicable, is available.
 - G. Proposed substitution will not adversely affect other trades or delay construction schedule.
 - H. Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitting Contractor

Date

Company

Manufacturer's Certification of Equal Quality:

I ______ represent the manufacturer of the Proposed Substitution item and hereby certify and warrant to Architect, Engineer, and Owner that the function and quality of the Proposed Substitution meets or exceeds the Specified Item.

	Manufacturer's Representative		Date	Company
Engine	er Review and Recommendat	ion Section		
	Recommend Acceptance	🗌 Yes	🗌 No	
	Additional Comments:	Attached	🗌 None	
Acceptance Section:		Date	Company	
	Owner Acceptance Signature		Date	Company
	Architect Acceptance Signature		Date	Company
	Engineer Acceptance Signature		Date	Company

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PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes limited scope general construction materials and methods, electrical equipment coordination, and common electrical installation requirements as follows:
 - 1. Access doors in walls, ceilings, and floors for access to electrical materials and equipment.
 - 2. Sleeves and seals for electrical penetrations.
 - 3. Joint sealers for sealing around electrical materials and equipment, and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 4. Sealing penetrations through noise critical spaces.
 - 5. Fire protective wrap for use as a listed fire rated electrical circuit protective system.

1.02 DEFINITIONS

- A. The following abbreviations apply to this and other Sections of these Specifications:
 - 1. AHJ: Authority(ies) having Jurisdiction
 - 2. ATS: Acceptance Testing Specifications
 - 3. EPDM: Ethylene-propylene-diene monomer rubber
 - 4. MC: Metal Clad
 - 5. N/A: Not Available or Not Applicable
 - 6. NBR: Acrylonitrile-butadiene rubber
 - 7. NRTL: Nationally Recognized Testing Laboratory
 - 8. PCF: Pounds per Cubic Foot
- B. The following definitions apply to this and other Sections of these Specifications:
 - 1. Homerun: That portion of an electrical circuit originating at a junction box, termination box, receptacle or switch with termination at an electrical panelboard. Note: Where MC Cable is utilized for receptacle and/or lighting branch circuiting loads, the originating point of the homerun shall be at the first load in the circuit or at a junction box in an accessible ceiling space immediately above the first load.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

- 3. To allow right of way for piping, ducts, and other systems installed at required slopes and/or elevations.
- 4. So connecting raceways, cables, and wireways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.
- D. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Product data for the following products:
 - a) Sleeve seals.
 - b) Through and membrane penetration firestopping systems.
 - c) Joint sealers
 - d) Acoustical sealers
 - e) Endothermic wrap
 - 2. Shop drawings for:
 - a) Detailed fabrication drawings of access panels and doors.
 - 3. Through and Membrane Penetration Firestopping Systems Product Schedule: Provide UL listing, location, wall or floor rating and installation drawing for each penetration fire stop system.
 - a) Where Project conditions require modification to qualified testing and inspecting agency's illustrations for a particular firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.
 - b) Qualifications data for testing agency.
 - 4. Endothermic Wrap drawings and system details: Provide UL listing, assembly rating and installation drawing for each case specific installation. Include installation instructions indicating layers of wrap required and securing method.
 - a) Where Project conditions require modifications to qualified testing and inspecting agency's installation requirements for a particular listed fire rated electrical circuit protective system, submit

illustration with modifications marked and approved by Endothermic Wrap manufacturer's fire protection engineer as an engineering judgement or equivalent fire-resistive-rated assembly.

- 5. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26
 - a) Accurately record actual locations of firestopped penetrations and access panel/door locations. Indicate dimensions from fixed structural elements.

1.05 NOISE CRITICAL SPACES

- A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces that will require application of sound attenuating measures and acoustical sealants.
 - 1. Theatre
 - 2. Offices
 - 3. Study Areas
 - 4. Open Offices
 - 5. Conference Rooms
 - 6. Teleconference Rooms
 - 7. Meeting Rooms
 - 8. A/V Spaces
 - 9. Patient Care Areas
 - 10. Clinic Exam Rooms
 - 11. Classrooms
 - 12. Library
 - 13. Operating and Simulation Rooms

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCESS TO EQUIPMENT

- A. Available Manufacturers:
 - 1. Bar-Co., Inc.
 - 2. Elmdor Stoneman.

- 3. JL Industries
- 4. Jay R. Smith Mfg. Co.
- 5. Karp Associates, Inc.
- 6. Milcor
- 7. Nystrom Building Products
- 8. Wade
- 9. Zurn
- B. Access Doors:
 - 1. Provide access doors for all concealed equipment, except where above layin ceilings. Refer to Section "Identification for Electrical Systems" for labeling of access doors.
 - 2. Access doors shall be adequately sized for the devices served with a minimum size of 18 inches x 18 inches, furnished by the respective Contractor or Subcontractor and installed by the General Contractor.
 - 3. Access doors must be of the proper construction for type of construction where installed.
 - 4. The exact location of all access doors shall be verified with the Contract Administrator and Architect prior to installation.
 - 5. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
 - 6. Frames: 16-gauge steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.
 - a) For installation in masonry, concrete, ceramic tile, or wood paneling: 1-inch-wide exposed perimeter flange and adjustable metal masonry anchors.
 - b) For installation in gypsum wallboard or plaster: perforated flanges with wallboard bead.
 - c) For installation in full-bed plaster applications: galvanized, expanded metal lath and exposed casing bead, welded to perimeter of frame.
 - 7. Flush Panel Doors: 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.
 - a) Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
 - 8. Locking Devices:
 - a) Flush, screwdriver-operated cam locks.
 - b) Where indicated on the drawings or where access panels are installed in locations accessible to the public, provide 5-pin or 5-disc

type cylinder locks, [individually keyed][all access panels keyed alike]; provide 2 keys per access panel.

2.02 SLEEVES

- A. Steel sleeves for raceways and cables:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends and drip rings.
- B. Cast iron wall pipe sleeves for raceways and cables:
 - 1. Manufacturers
 - a) Josam Mfg. Co.
 - b) Smith (Jay R) Mfg. Co.
 - c) Tyler Pipe/Wade Div.; Subs of Tyler Corp.
 - d) Watts Industries, Inc.
 - e) Zurn Industries, Inc.; Hydromechanics Div.
 - 2. Cast-iron sleeve with integral clamping flange with clamping ring, and nuts for membrane flashing.
 - a) Underdeck Clamp: Clamping ring with setscrews.
 - 3. Sleeves for rectangular openings: Galvanized sheet steel with minimum 0.052- or 0.138- inch thickness as indicated and of length to suit application.
 - 4. Coordinate sleeve selection and application with selection and application of firestopping to be used.

2.03 SEALANTS

- A. SLEEVE SEALS
 - 1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 2. Available Manufacturers:
 - a) Advance Products & Systems, Inc.
 - b) Calpico, Inc.
 - c) Metraflex Co.
 - d) O-Z/Gedney
 - e) Pipeline Seal and Insulator, Inc.
 - 3. Sealing Elements: Interlocking or solid sealing links shaped or pre-drilled to fit surface of cable or raceway. Include type and number required for material and size of raceway or cable.
 - a) EPDM
 - b) NBR
 - c) Neoprene

- 4. Pressure Plates: Include two for each sealing element. For multi-phase circuits, use slotted pressure plates if metal.
 - a) Carbon steel
 - b) Stainless steel
 - c) PVC-coated steel
- 5. Connecting Bolts and Nuts: Provide bolts of length required to secure pressure plates to sealing elements. Include one for each sealing element.
 - a) Carbon steel with corrosion-resistant coating
 - b) Stainless steel

B. JOINT SEALERS

- 1. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- 2. Colors: As selected by the Contract Administrator from manufacturer's standard colors.
- 3. Elastomeric Joint Sealers: Provide the following types:
 - a) Silicone Joint Sealants, One-part nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer. Provide one of the following:
 - 1) Dow Corning, Dowsil 790
 - 2) Dow Corning, Dowsil 795
 - 3) GE, Silglaze II SCS 2350
 - 4) GE, Silpruf SCS 2000
 - 5) Owens Corning, Energy Complete
 - 6) Pecora, 864 NST
 - 7) Tremco, Spectrem 1
 - 8) Tremco, Spectrem 2
 - b) Mildew Resistant Sealants, one-part mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, metal or porcelain plumbing fixtures and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes. Provide one of the following:
 - 1) Dow Corning, Dowsil 786
 - 2) GE, Momentum SCS 1700
 - 3) Pecora, 898 Silicone NST
 - c) Hybrid Joint Sealants: One-part, nonsag, paintable complying with ASTM C 920, Type S, Grade NS, Class 50 recommended for exposed applications on interior and exterior locations involving

joint movement of not more than plus or minus 50 percent. Subject to compliance with requirements, provide one of the following:

- 1) BASF, MasterSeal NP 100
- 2) Pecora, DyanTrol I-XL
- 3) Tremco, Dymonic FC

C. FIRESTOPPING

- 1. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E 814, by Underwriters' Laboratories, Inc., or other NRTL acceptable to AHJ. Subject to compliance with requirements, provide one of the following:
 - a) Available Manufacturers:
 - 1) 3M Corp., Fire Barrier Sealant
 - 2) Hilti, Inc.
 - 3) Tremco, Tremstop Fyre-Sil
 - 4) Pecora, AC-20 FTR
 - 5) RectorSeal
 - 6) Specified Technologies Inc. Firestop
 - 7) USG, SHEETROCK Firecode Compound
 - 8) Owens Corning Firestopping Insulation

D. ACOUSTICAL SEALANTS

- 1. General: Penetrations by conduit through surfaces that are around and between noise critical spaces shall be sleeved, packed and sealed airtight with foam rod, non-hardening sealant and/or packing material as described herein.
- 2. Foam Backer Rod: Closed cell polyethylene suitable for use as a backing for non-hardening sealant.
- 3. Non-Hardening Sealant: Sealant for penetrations shall be non-hardening, permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.
- 4. Packing Material: Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 PCF (40 kg/m3).
- 5. Acoustical Joint Sealant: Manufacturer's standard non-sag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90. Meeting ASTM E 84 for a smoke flame spread index of less than 25 / 50. Subject to compliance with requirements, provide one of the following:
 - 1) Pecora, AC-20 FTR

- 2) Pecora, AIS-919
- 3) USG, SHEETROCK Acoustical Sealant.

2.04 FIRE RATED PROTECTIVE WRAPS

- A. Endothermic Wrap
 - 1. General: Protective wrap, designed to provide fire protection of critical feeders and circuits in accordance with ASTM E1725. Subject to compliance with requirements, provide one of the following:
 - 1) 3M Corp., Interam Endothermic Mat
 - 2) Specified Technologies Inc., E-Wrap

PART 3 - EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
- C. Coordinate seals with wall, ceiling, roof or floor materials and rating of the surface (sound, fire, waterproofing, etc.)
- D. Comply with NECA 1.
- E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless indicated otherwise.
- F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- G. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- H. Right of Way: Yield to raceways and piping systems installed at a required slope.

3.02 ACCESS DOORS

- A. Verify the exact location, sizes, and types of all access doors with the Contract Administrator prior to purchase.
- B. Provide access doors for all concealed electrical equipment, except where above lay-in ceilings.

- C. Coordinate with architectural finishes to set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- D. Adjust hardware and panels after installation for proper operation.
- E. Label all access doors with a nameplate as described in Division 26 Section "Identification for Electrical Systems".

3.03 SLEEVES AND SLEEVE SEALS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Provide sleeves for required openings in all concrete and masonry construction and fire, smoke, or both, partitions, for all electrical work that passes through such construction. Coordinate with all other trades and divisions to dimension and lay out all such openings.
- C. Only those openings specifically indicated on the Architectural or Structural Drawings will be provided under other divisions.
- D. New Construction:
 - 1. Coordinate with Divisions 03 and 04 for installation of sleeves and sleeve seals integrally in cast-in-place, precast, and masonry walls and horizontal slabs where indicated on the Drawings or as required to support raceway penetrations.
- E. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls. Do not cut or core drill new construction without written approval from the Contract Administrator and Structural Engineer.
- F. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- G. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- H. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- I. Install pipe and rectangular sleeves in above-grade walls and slabs, where penetrations are not subject to hydrostatic water pressures. Ensure that drip ring is fully encased and sealed within the wall or slab.
- J. Sleeve Length:
 - 1. Sleeves through walls: Cut sleeves to length for mounting flush with both surfaces of walls.
 - 2. Sleeves through floors: Extend sleeves 2 inches above finished floor level.
- K. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed[or as required to meet seismic criteria]; in which case, size sleeves as recommended by the seal manufacturer[or per seismic criteria, or both].
- L. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- M. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint
- N. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.
- O. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- P. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (or larger, if required by the seal manufacturer) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- Q. Above Grade Concrete or Masonry Penetrations
 - 1. Provide sleeves for cables or raceways passing through above grade concrete or masonry walls, concrete floor or roof slabs. Sleeves are not required for core drilled holes in existing masonry walls, concrete floors or roofs. Provide sleeves as follows:
 - a) Install schedule 40 galvanized steel pipe for sleeves smaller than 6 inches in diameter.
 - b) Install galvanized sheet metal for sleeves 6 inches in diameter and larger, thickness shall be 0.138 inches.
 - c) Install galvanized sheet metal for rectangular sleeves
 - d) Schedule 40 PVC pipe sleeves are acceptable for use in areas without return air plenums.

- 2. Seal elevated floor, exterior wall and roof penetrations watertight and weather tight with non-shrink, non-hardening commercial sealant. Pack with mineral wool and seal both ends with minimum of $\frac{1}{2}$ " of sealant.
- R. Underground, Exterior-Wall Penetrations: Install cast-iron wall pipes for sleeves. Size sleeves to allow for 1-inch (or larger, if required by the mechanical sleeve manufacturer) annular clear space between sleeve and cable or raceway. Provide mechanical sleeve seal.
 - 1. Use type and number of sealing elements recommended by manufacturer for pipe material and size. Position pipe in center of sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 - 2. Inspect installed sleeve and sleeve-seal installation for damage and faulty work. Verify watertight integrity of sleeves and seals installed below grade to seal against hydrostatic pressure.
- S. Concrete Slab on Grade Penetrations:
 - 1. Provide ¹/₂" thick cellular foam insulation around perimeter of raceway passing through concrete foundation. Installation shall extend to 2" above and below the concrete slab.
- T. Elevated Floor Penetrations of waterproof membrane:
 - 1. Provide cast-iron wall pipes for sleeves. Size wall pipe for minimum ¹/₂" annular space between wall pipe and cable or raceway.
 - 2. Pack with mineral wool and seal both ends with minimum of ¹/₂" of waterproof sealant.
 - 3. Secure waterproof membrane flashing between clamping flange and clamping ring.
 - 4. Extend bottom of wall pipe below floor slab as required and secure underdeck clamp to hold wall pipe rigidly in place.
- U. Interior Foundation Penetration: Provide sleeves for horizontal raceway passing through or under foundation. Sleeves shall be cast iron soil pipe two normal pipe sizes larger than the pipe served.
- V. Interior Penetrations of Non-Fire-Rated Walls: Seal annular space between sleeve and cable or raceway, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ½" of sealant.
- W. Exterior Wall Penetrations: Seal annular space between sleeve and raceway or duct, using joint sealant for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ¹/₂" of waterproof sealant.
- X. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- Y. Sleeve-Seal Installation
 - 1. Install sleeve seals for all underground raceway penetrations through walls at elevations below finished grade. Additionally, install seals inside raceways, after conductors or cables have been installed, in all raceway penetrations through walls at elevations below finished grade.
 - 2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- Z. Inspect installed sleeve and sleeve-seal installations for damage and faulty work. Verify watertight integrity of sleeves and seals installed below grade and above grade where installed to seal against hydrostatic pressure.
- AA. Sleeves shall be protected throughout the course of construction, and when damaged shall be replace and/or repaired to a satisfactory condition.

3.04 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire/smoke-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.05 JOINT SEALERS

- A. Preparation for Joint Sealers
 - 1. Clean surfaces of penetrations, sleeves, or both, immediately before applying joint sealers, to comply with recommendations of joint sealer manufacturer.
 - 2. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.
- B. Application of Joint Sealers
 - 1. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
 - a) Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
 - b) Comply with recommendations of ASTM C 790 for use of acrylicemulsion joint sealants.

- 2. Tooling: Immediately after sealant application and prior to time shining or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
- C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical raceways penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.06 ACOUSTICAL PENETRATIONS

- A. Do not allow direct contact of raceways with shaft walls, floor slabs and/or partitions. Sleeve, pack and seal airtight with foam rod, non-hardening sealant and/or packing material, as described herein, for all penetrations by raceway, through surfaces that encompass or are between noise critical spaces. Seal and pack with caulking for the full depth of the penetration all openings around raceways in the structure surrounding the electrical equipment and surrounding noise-critical spaces. This includes all slab penetrations and penetrations of noise critical walls.
- B. Where a raceway passes through a wall, ceiling or floor slab of a noise critical space, cast or grout a metal sleeve into the structure. The internal diameter or dimensions of the sleeve shall be 2 inches larger than the external diameter or dimensions of the raceway passing through it. After all of the raceways are installed in that area, check the clearances and correct, if necessary, to within 1/2-inch. Pack the voids full depth with packing material sealed at both ends, 1-inch deep, with non-hardening sealant backed by foam rod.

3.07 FIRE RATED PROTECTIVE WRAP

- A. Where indicated on the Drawings or required by code, provide fire rated protective wrap around raceways and equipment.
- B. Install and secure fire protective wrap per manufacturer's written installation documents. Wrap shall be layered as required by the manufacturer to provide 1-, 2-, or 3-hour fire rating required by code for the application.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes limited scope for electrical connections to equipment specified under other sections or divisions, or furnished under separate contracts or by the Owner.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Unless otherwise noted, perform all electrical work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this contract.
- B. Coordinate with work described in Division 11 Sections for equipment requiring electrical connection.
- C. Coordinate with work described in Division 23 Section "Common Work Results for HVAC".
- D. Coordinate with work described in Division 23 Section "Direct-Digital Control for HVAC".
- E. Obtain and review shop drawings, product data, and manufacturer's instructions for equipment furnished under other sections.
- F. Determine connection locations and rough-in requirements based on shop drawings.
- G. Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.
- H. Sequence electrical connections to coordinate with start-up schedule for equipment.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product data for the following products for:
 - 1. Special connectors
 - 2. Special conductors or cable assemblies.
- C. Shop drawings for:

3. Detailing electrical characteristics, wiring diagrams, fabrication and installation for wiring systems.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories:
- 4. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Authorities Having Jurisdiction.
- 5. Marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.01 CORDS AND CAPS

- A. Attachment Plugs: Conform to NEMA WD 1.
- B. Configuration: NEMA WD 6, matching receptacle configuration at outlet provided for equipment, or as required by the equipment manufacturer.
- C. Cord: See Paragraph "Flexible Cords" in Division 26 Section "Low-voltage Electrical Power Conductors and Cables".
- D. Provide cord size suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify conditions of equipment and installation prior to beginning work.
- B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 INSTALLATION, GENERAL

- B. Install in accordance with manufacturer's instructions.
 - A. Provide fire-resistive protective assembly or an electrical circuit protective system for feeders and control circuit conductors and cables having a fire-resistance rating of not less than 2 hours where required by NFPA or local building codes. Types of systems requiring a fire-resistive protective assembly include, but are not limited to:
 - 1. Feeders for Emergency Power systems

- 2. Smoke Removal systems
- 3. Fire service and Occupant Evacuation Elevator systems

3.03 ELECTRICAL DEVICES

A. Install disconnect switches, controllers, control stations, and control devices (other than temperature control devices) as indicated, specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.

3.04 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturers' instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquid tight flexible conduit with watertight connectors in damp or wet locations.
- C. Make wiring connections using conductors and cable with insulation suitable for temperatures encountered in heat producing equipment.
- D. Provide receptacle outlet where connection with attachment plug is indicated. Provide cord and cap where field-supplied attachment plug is indicated on the Drawings.
- E. Provide suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- F. Provide interconnecting conduit and wiring between devices and equipment where indicated on the Drawings.

3.05 EQUIPMENT

- A. When equipment is delivered in separate parts and field assembled, internal wiring, indicated on Shop Drawings as field wiring, will be provided by the equipment supplier, unless otherwise noted.
- B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.
- C. Provide all control and interlock wiring for all equipment that is not included within the responsibility of Division 22 or 23.
- D. Motorized Damper: Provide lockable toggle, pilot lighted disconnect switch in an accessible location at each motor actuator, or group of motor actuators.

3.06 FOOD SERVICE (SERVERY) (KITCHEN) (CAFÉ) EQUIPMENT

- A. Provide power connection to all equipment as indicated or as otherwise required to accommodate the equipment indicated in the food service equipment drawings and specifications.
- B. Coordinate and provide the appropriate receptacle for equipment being installed as required for proper operation. Coordinate the required quantity of conductors prior to pulling wire to outlet box.
- C. Provide a local recessed non-fused equipment disconnect for kitchen equipment as required by the applicable codes and jurisdictions. Coordinate exact location prior to rough-in and maintain all code required clearances.
- D. Provide control wiring and conduit for all equipment that is not indicated as being within the responsibility of the equipment manufacturer or installer.
- E. When equipment is delivered in separate parts and field assembled, internal wiring, indicated on Shop Drawings as field wiring, shall be provided by the equipment installer, unless otherwise noted.
- F. Coolers and Freezers: Cut conduit openings in freezer and cooler walls, floor, and ceilings, in accordance with manufacturers' instructions, when openings are not provided by the manufacturers. Seal around conduit penetrations air tight with an approved pliable material suitable for low temperatures. Effectively seal interiors of conduits, by installing a conduit fitting at the boundary of the two spaces, and filling it with an approved pliable material, after conductors or cables have been installed and tested.
- G. Provide all grounding systems as required by the equipment supplier.

3.07 DOOR OPERATORS AND HARDWARE

- A. Provide electrical connections to automatic entry doors, automatic corridor doors, electrically held door latches, remote release doors, and all other required electrical connections for door systems included in other sections of these specifications.
- B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.
- C. Provide all control wiring and conduit for all equipment that is not included within the responsibility of the door hardware installer. Provide connection from junction boxes to the door operators or hardware and from door operators to actuation devices as required. Install key operated switches, push pad switches, and other electrically controlled door operation devices furnished by other divisions within this contract.
- D. Provide fire alarm devices and wiring as required for proper operation of door systems in accordance with the NFPA codes.

3.08 SIGNAGE AND WAYFINDING

- A. Provide junction boxes, disconnect switches and grounding per manufacturer's installation drawings.
- B. Coordinate rough-in requirements with signage installation instructions.
- C. Coordinate box locations and conduit routing with parapets and roof elevations.
- D. Provide labelling on all junction boxes and disconnects in accordance with Division 26 section "Identification for Electrical Systems"

3.09 MEDICAL AND SIMULATION EQUIPMENT

- A. Provide all work related to Division 26 required for the Owner furnished medical equipment. Note that this work has not been entirely duplicated and indicated on the sheets with E prefixes, rather only a minimum amount as required for coordination with other systems, and as required to comply with local codes. The medical equipment planner has prepared a complete manual including all the equipment intended to be purchased general electrical requirements and associated cut sheets. Review the medical equipment manual prior to bid. Prior to rough-in and final connection coordinate with final equipment installation diagrams, drawings, manuals, and specifications. Such equipment, surgical or exam lights, articulating arms, equipment booms, headwalls, patient beds, patient lift systems, processors, sterilizers, warming cabinets, refrigerators, freezers, blood bank equipment, laboratory equipment, x-ray film view boxes, digital x-ray viewing systems, or bio-medical patient monitoring systems.
- B. Provide power connection to all equipment as indicated or as otherwise required to accommodate the medical equipment.
- C. Provide all grounding systems as required by the equipment supplier.
- D. Provide wireways, cable trays, trench duct, wall duct, conduit and all other raceways and boxes as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.
- E. Provide all other equipment, wiring, connections, emergency power off stations, warning lights, interlocks, controls, etc. as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.

END OF SECTION

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PART 1 - GENERAL

1.01 SUMMARY

A. Provisions for Underground Secondary Electrical Service.

1.02 GENERAL REQUIREMENTS

- A. Utility service voltage:
 - 1. As indicated on the Drawings.
- B. Utility service ampacity: As indicated on the Drawings.
- C. The extent of Work for the secondary electrical service includes providing the following:
 - 1. Raceways
 - 2. Provisions for Metering
 - 3. Grounding and Bonding
 - 4. Concrete pad for service transformer
 - 5. Primary raceways

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product Data: For the following products:
 - a) Meter bases
 - b) Current transformer cabinets
- C. Shop Drawings: For the following:
 - a) Utility Company prepared installation drawings
 - b) Cast-in-place concrete pads
- D. Field quality-control test reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
 - 4. Utility voltage adjustment request.
- E. Where equipment or materials are specified to comply with utility standards and are listed above as required submittals, obtain approval from the serving utility before submitting to the Contract Administrator.

- F. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Accurately record actual routing of interior conduits two-inch and larger trade size and all exterior buried raceway, including coordination with other surrounding utilities and underground structures. Provide scaled plans and sections that Indicate dimensions from finished grade or other fixed structural elements.

1.04 QUALITY ASSURANCE

- A. Perform all work in accordance with Utility Company installation drawings and service standards.
- B. Maintain one copy of Utility Company installation drawings and service standards at the site.
- C. Prior to commencing work in this Section, meet with the Utility Company representative to review service entrance requirements and details.
- D. Verify that field measurements are as indicated on Utility Company drawings.
- E. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that are acceptable to authorities having jurisdiction.
 - 2. Marked for intended use.
- F. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

(Not Used)

PART 3 - EXECUTION

3.01 SECONDARY SERVICE ENTRANCE UNDERGROUND

- A. Provide an underground secondary service lateral from the pad mounted transformer in accordance with NFPA 70 Article 230 and the Utility Company standards. Reference the Drawings for service lateral conductor and raceway quantities, sizes, and types.
- B. The Utility Company will provide the service transformer.
- C. Provide a concrete pad, complying with the Utility Company standards, for transformer mounting, and set conduit elbows and riser(s), with grounding bushing(s), to receive primary and secondary raceways. Where direct burial

primary is used, set elbow(s) and riser(s), with grounding bushing(s), to receive primary cables.

- D. Make connections to the secondary terminals of the transformer as required and in conformance with Utility Company requirements. Utility Company will provide primary conductors and terminal connections unless otherwise directed by the Utility Company.
- E. Provide underground raceways for primary cables from the transformer pad to the property line, and provide pull cord, per Utility Company standards, for the Utility Company's use in pulling primary conductors. Install raceways a minimum of 24 inches below finished grade line unless otherwise indicated on the Drawings or directed by the Utility Company. Provide excavation and backfill as required to accomplish the installation.

3.02 METERING

A. The Utility Company will provide the meter and meter wiring.

3.03 UTILITY SERVICE CHARGES

- A. It shall be the responsibility of the Division 26 contractor to apply for the electrical service, including the preparation and completion of all forms. Submit the completed application along with all other required documentation for the new or modified service.
- B. Pay all Utility Company charges for providing electric service, including all charges for bringing primary service conductors to the site.

3.04 FIELD QUALITY CONTROL

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a) Rebalance loads.
 - b) Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained. Submit results in writing.

END OF SECTION

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Conductors, cables, and cords rated 600V and less.
- B. Connectors and terminations rated 600V and less.

1.02 DEFINITIONS

- A. The following abbreviations apply to this and other Sections of these specifications:
 - 1. MC: Metal Clad
 - 2. NBR: Acrylonitrile-butadiene rubber
 - 3. NETA ATS: Acceptance Testing Specification.
- B. The following definitions apply to this and other Sections of these Specifications:
 - 1. HOMERUN: That portion of an electrical circuit beginning at a junction box, termination box, receptacle or switch with termination at an electrical panelboard.
 - a) Note: Where MC Cable is allowed to be utilized for receptacle and/or lighting branch circuiting loads, the originating point of the homerun shall be at the first load in the circuit or at a junction box in an accessible ceiling space immediately above the first (most upstream) load.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop and temperature deration.
 - 2. Coordinate routing of power, low-voltage, and control conduits requiring fire-resistive protective assembly or electrical circuit protective system. Fire-resistive protective assembly or electrical circuit protective system for power, low-voltage, and control circuit conductors and cables shall have a fire-resistance rating of not less than 2 hours and shall be provided where required by NFPA or local building codes. Types of systems requiring a fire-resistive protective assembly include, but are not limited to:
 - a) Feeders for Emergency Power systems
 - 3. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.

- 4. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.
- B. Notify Contract Administrator of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Product data for the following products:
 - a) Conductors, cables, and cords rated 600V and less.
 - b) Metal Clad (MC) cable and fittings.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports in accordance with NETA ATS:
 - 1. Submit all system and component test results.
- F. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.
- G. Operation and Maintenance Data: For cable and all accessories to include in operation and maintenance manuals.
- H. Follow-up service reports.

1.05 QUALITY ASSURANCE

- A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.
- B. Provide products listed and classified by Underwriters Laboratories, Inc (UL) as suitable for the purpose specified and indicated.
- C. 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.

- D. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with NFPA 70.

1.06 PROJECT CONDITIONS

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Contract Administrator and obtain direction before proceeding with work.
- B. 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 Contract Administrator and the Owner no fewer than 7 days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Contract Administrator and the Owner's written permission.
 - 3. Owner reserves the right to require Contractor to cease work in any area Owner requires access to on an emergency basis.
- C. Make every effort to schedule outages during non-business or off-peak business hours to minimize disruptions to business operations.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

PART 2 - PRODUCTS AND MATERIALS

2.01 CONDUCTORS AND CABLES - GENERAL

- A. Available Manufacturers, unless noted otherwise:
 - 1. AFC Cable Systems, Inc.
 - 2. Alan Wire
 - 3. Cerrowire

- 4. Colonial Wire & Cable
- 5. Encore Wire Corporation
- 6. General Cable
- 7. Northern Cables Inc.
- 8. Okonite Company
- 9. Southwire Company
- B. Conductor Material: Annealed (soft) copper complying with ICEA S-95-658/NEMA WC70 and UL Standards 44 or 83, as applicable.
 - 1. Solid conductors for No. 10 AWG and smaller; concentric, compressed stranded for No. 8 AWG and larger
 - 2. Stranded conductors
 - 3. Stranded for all flexible cords, cables, and control wiring.
 - 4. As noted otherwise below.
- C. Aluminum conductors are not allowed.
- D. Conductor Insulation: Type THHN/THWN-2 or XHHW-2 complying with ICEA S-95-658/NEMA WC70.
- E. Sizes of conductors and cables indicated or specified are American Wire Gage (Brown and Sharpe).
- F. Unless indicated otherwise, special purpose conductors and cables, such as low voltage control and shielded instrument wiring, shall be as recommended by the system equipment manufacturer.
- G. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

2.02 SINGLE CONDUCTORS

A. 600V, insulated conductors as noted above shall be color-coded as follows, unless noted otherwise:

PHASE	208Y/120V	480Y/277V
A	Black	Brown
В	Red	Orange
С	Blue	Yellow
Neutral	White	Gray**
Equipment Ground	Green	Green
Isolated Ground	Green/Yellow Stripe	Green/Yellow Stripe
**Except as provided in N	FPA 70.	•

B. Conductors shall not be smaller than No. 12 AWG, with the exception of wiring for signal and pilot control circuits; and pre-manufactured whips for light fixtures which may be No. 14 AWG.

C. Conductors installed for site electrical work shall be no smaller than No. 10 AWG CU. All site electrical branch circuit wiring shall be sized such that the maximum branch circuit voltage drop is less than 3 percent.

2.03 METAL CLAD CABLE; TYPE MC

- A. General:
 - 1. For use in non-patient care areas only.
 - 2. Shall not be used for life safety or critical systems.
- B. MC Cable (with insulated green grounding conductor, no bonding conductor):
 - 1. Manufacturers:
 - a) AFC Cable Systems, Inc. (MC Lite)
 - b) Encore Wire Corporation (MC)
 - c) Kaf-Tech
 - d) Southwire Company (Amorlite)
 - 2. 600V, Unjacketed and/or PVC-jacketed UL Standard 83, UL Standard 1569 for Type MC, UL Standard 1685, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. Type MC Cable shall be listed for use in UL 1, 2, and 3 Hour Through-Penetration Firestop Systems.
 - 3. Armor Assembly: Aluminum interlocked armor (aluminum color).
 - 4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
 - 5. Grounding Conductor: Solid soft-drawn copper, THHN/THWN-2 green insulated grounding conductor sized per NFPA 70.
 - 6. Marking: Cable markings shall comply with the requirements of NFPA 70.
- C. MC Cable (with 0-10V dimming control wiring):
 - 1. Manufacturers:
 - a) AFC Cable Systems, Inc. (MC- PCS)
 - b) Encore Wire Corporation (MC- LED)
 - c) Southwire Company (MC PCS Duo)
 - 600V, Unjacketed and/or PVC-jacketed UL Standard 83, UL Standard 1569 for Type MC, UL Standard 1685, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. Type MC Cable shall be listed for use in UL 1, 2, and 3 Hour Through-Penetration Firestop Systems.
 - 3. Armor Assembly: Aluminum interlocked armor (aluminum color).
 - 4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
 - 5. Grounding Conductor: Solid soft-drawn copper, THHN/THWN-2 green insulated grounding conductor sized per NFPA 70.
 - 6. Control Conductors: Color-coded Class 2/Class 3 twisted jacketed pairs

- 7. Marking: Cable markings shall comply with the requirements of NFPA 70.
- D. MC Cable Fittings:
 - 1. Manufacturer & Model:
 - a) Arlington (4010 AST snap-in type): (SG38 saddle type)
 - b) Crouse-Hinds (QLK Quick-Lok Series, Saddle type); ACB Series; set-screw, saddle type)
 - c) O-Z Gedney (AMC-50 speed-lok, saddle type)
 - d) Thomas & Betts (XC-730 Series cable-lok, saddle type); 3110 Series Tite-Bite)
 - 2. Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be UL listed and identified for such use with an MCI-A marking on the fitting carton or package.
 - 3. Fittings shall be insulated type not requiring the use of anti-short bushings.
 - 4. Romex style, clamp type fittings are not acceptable.

2.04 METAL CLAD CABLE – HEALTH CARE FACILITY RATED; TYPE MC- HCF

- A. General:
 - 1. Use allowed for normal power circuits in general patient care areas.
 - 2. Do not use for life safety or critical systems.
- B. MC HCF Cable:
 - 1. Manufacturers:
 - a) AFC Cable Systems, Inc. (MC- Stat)
 - b) Encore Wire Corporation (MC- MCMP)
 - c) Southwire Company (HCF MCAP)
 - 600V, Unjacketed and/or PVC-jacketed UL Standard 1569 for Metal-Clad cables, UL Standard 83, UL Standard 1063, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. MC cable shall be listed for use in UL 1, 2, and 3 Hour through-Penetration Firestop Systems.
 - 3. Armor Assembly: Aluminum interlocked armor and full-sized solid bare aluminum grounding/bonding conductor in intimate and continuous contact with armor recognized as equipment ground per NFPA 70.
 - 4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
 - 5. Grounding Conductor: Solid, soft-drawn copper, THHN green insulated grounding conductor sized per NFPA 70.
 - 6. Type MC-HCF Cable shall be "Hospital Care Facility" type in accordance with NFPA 70 with raceway system listed as an equipment ground return path.

- 7. Marking: Cable markings shall comply with the requirements of NFPA 70. Outer armor shall have green-color for easy identification as hospital patient care rated.
- C. MC HCF Cable (with 0-10V dimming control wiring):
 - 1. Manufacturers:
 - a) AFC Cable Systems, Inc. (MC- HCF-PCS)
 - b) Encore Wire Corporation (MC- HCF-PCS)
 - c) Southwire Company (MC-HCF-PCS Duo)
 - 2. 600V, Unjacketed and/or PVC-jacketed UL Standard 1569 for Metal-Clad cables, UL Standard 83, UL Standard 1063, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. MC cable shall be listed for use in UL 1, 2, and 3 Hour through-Penetration Firestop Systems.
 - 3. Armor Assembly: Aluminum interlocked armor and full-sized solid bare aluminum grounding/bonding conductor in intimate and continuous contact with armor recognized as equipment ground per NFPA 70.
 - 4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
 - 5. Control Conductors: Color-coded Class 2/Class 3 twisted jacketed pairs
 - 6. Grounding Conductor: Solid, soft-drawn copper, THHN green insulated grounding conductor sized per NFPA 70.
 - 7. Type MC-HCF Cable shall be "Hospital Care Facility" type in accordance with NFPA 70 with raceway system listed as an equipment ground return path.
 - 8. Marking: Cable markings shall comply with the requirements of NFPA 70. Outer armor shall have green-color for easy identification as hospital patient care rated.
- D. MC Cable Fittings:
 - 1. Manufacturer & Model:
 - a) Arlington (4010 AST snap-in type): (SG38 saddle type)
 - b) Crouse-Hinds (QLK Quick-Lok Series, Saddle type); ACB Series; set-screw, saddle type)
 - c) O-Z Gedney (AMC-50 speed-lok, saddle type)
 - d) Thomas & Betts (XC-730 Series cable-lok, saddle type); 300 Series Tite-Bite).
 - 2. Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be UL listed and identified for such use with an MCI-A marking on the fitting carton or package.
 - 3. Fittings shall be insulated type not requiring the use of anti-short bushings.
 - 4. Romex style, clamp type fittings are not acceptable.

2.05 FLEXIBLE CORDS

- A. 600V, multi-conductor (2, 3, or 4 as indicated on the Drawings), oil-resistant black jacket, extra-hard-usage; Type SEO or SO for indoor dry and damp locations; SEOW or SOW for damp, wet, and outdoor locations; or as required by the manufacturer of the equipment to which the cords are connected.
- B. 300V, multi-conductor (2, 3, or 4 as indicated on the Drawings), oil-resistant black jacket, hard-usage; Type SJEO or SJO for indoor dry locations; SJEOW or SJOW for damp, wet, and outdoor locations; or as required by the manufacturer of the equipment to which the cords are connected.

2.06 CONTROL WIRING

- A. Refer to Division 23 Section "Direct-Digital Control for HVAC"
- B. Unless otherwise noted, all control wiring will be the responsibility of the Section or Division in which the control system is specified. Provide all conduits and boxes required for installation of control wiring.

2.07 CONNECTORS

- A. Available Manufacturers:
 - 1. AMP; Tyco
 - 2. FCI-Burndy
 - 3. Gould
 - 4. Ideal Industries, Inc.
 - 5. Ilsco
 - 6. NSi Industries, Inc.
 - 7. O-Z/Gedney
 - 8. Panduit
 - 9. Thomas and Betts
 - 10. 3-M Electrical Products Division
- B. Compression connectors for conductors No. 8 AWG and larger: Long-barreled, UL 486-listed, circumferential compression type (Burndy "Hylug", or equal), insulated with clamp-on, cold-shrink, or molded covers, or wrapped with multiple over-lapping layers of 3-M Scotch electrical tape.
 - 1. Termination fittings for copper conductors: Bare copper, 1-hole pad and inspection port.
- C. Mechanical connections for conductors No. 8 AWG and larger: UL-listed, dualrated, mechanical type, insulated with clamp-on, cold-shrink, or molded covers, or wrapped with multiple over-lapping layers of 3-M Scotch electrical tape.
 - 1. Termination fittings: Bare copper, 1-hole pad and inspection port.

- D. Connectors for solid conductors No. 10 AWG and smaller: Insulated winged wire nuts. Color-coded for size, except use green only for grounding connections.
- E. Connectors for stranded conductors No. 10 AWG and smaller: Tinned copper, insulated-sleeve, compression type, UL-listed, with wire insulation grip. Terminations: ring-tongue type.
- F. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- G. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

PART 3 - EXECUTION

3.01 **PREPERATION**

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
- B. Coordinate seals with wall, ceiling, roof or floor materials and rating of the surface (sound, fire, waterproofing, etc.)
- C. Electrical conductor and cable work is schematically represented on the Drawings. Unless otherwise indicated, conductor sizes shown on the Drawings are based on not more than three single current-carrying conductors in a raceway in free air. Current ratings are based on copper at 75 degrees C temperature rating for all power circuits. Modify raceway and conductor sizing as may be necessitated by any deviation from these conditions. Do not decrease the indicated conductor size due to the use of conductors having a temperature rating of 90 degrees C.
- D. Conductor sizes shown are minimum based on code requirements, voltage drop, and/or other considerations. Where approved by the Engineer and at no extra cost to the Owner, larger conductor sizes may be installed at Contractor's option in order to utilize stock sizes, provided raceway sizes are increased where necessary to conform with NFPA 70 (determine the effect of the use of larger conductors on the short circuit current ratings of the electrical equipment, and provide increased short circuit current rated equipment as required).
- E. Where anticipated conductor installed lengths exceed the lengths indicated on the Drawings, notify Contract Administrator. Provide tabulated list of exceeded lengths for review. Increase conductor size, circuit ground size, and conduit size accordingly to meet maximum voltage drop indicated within the calculations.

3.02 INSTALLATION

A. General

- 1. Unless otherwise indicated on the Drawings on in other Sections, install all conductors in raceway. Install continuous conductors between outlets, devices and boxes without splices or taps. Do not pull connections into raceways. Leave at least 12 inches of conductor at outlets for fixture or device connections.
- 2. Install in accordance with manufacturer's instructions.
- 3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used shall not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- 4. Use pulling means, including fish tape, cable, rope, and basket weave conductor/cable grips that will not damage conductors/cables or raceway.
- 5. Where parallel conductors are shown, install each set of conductors in separate raceways of essentially the same length.
- 6. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping".
- 7. Wiring at Outlets: Install conductors at each outlet with at least 12 inches of slack.
- 8. Common or Shared Neutrals are not allowed unless shown on the plans or specifically noted to be allowed.
- 9. Multi-wire branch circuits are not allowed unless noted otherwise on the drawings.
- 10. Where multi-wire branch circuits are utilized (i.e., shared neutral), shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point the branch circuit originates. Multi-pole breakers or 3 single pole breakers with a handle tie are two examples.
- 11. When multiple home runs are combined into a single raceway such that the number of conductors exceeds four (conductor count is made up of any combination of phase and neutral conductors), the following restrictions apply, which are in addition to those in NFPA 70:
 - a) Emergency Power Circuits includes all circuits covered under Articles 700, 701 and 702.
 - Maximum of eight conductors in a single raceway. Minimum raceway size: ³/₄-inch. Do not install any other type of circuit in this raceway.
 - 2) Only 15A and 20A branch circuit homeruns may be combined into one raceway.
 - b) Normal or Non-Essential circuits.
 - Maximum of 16 conductors in a single raceway. For up to eight conductors in a raceway, minimum raceway size: 3/4 inch. For greater than eight conductors, minimum raceway size: 1 inch. Do not install any other type of circuit in this raceway.
 - 2) The minimum wire size for all conductors in this raceway: No. 10 AWG.

- 3) Only 15A and 20A branch circuit homeruns may be combined into one raceway.
- c) GFCI-protected circuits.
 - 1) Do not use multi-conductor circuits, with a shared neutral, for any GFCI circuit breaker or receptacle circuit.
- d) Isolated Ground (IG) Circuits:
 - 1) Do not use multi-conductor or MC cables.
 - 2) Do not share neutrals between separate circuits.
 - 3) Do not share the isolated grounding conductor with more than one device (i.e., each device on an IG circuit shall have its own dedicated IG conductor back to the branch panelboard IG bus).
 - 4) The equipment grounding conductor may be shared between IG circuits sharing a common raceway.
- 12. For branch circuits fed from GFCI circuit breakers, limit the one-way conductor length to 100 feet between the panelboard and the most remote receptacle or load on the GFCI circuit.
- 13. Where the number of conductors for branch circuits is not shown on the Drawings, determine the number of conductors in accordance with NFPA 70. Provide adequate conductors so as to allow performance of all functions of the device.
- 14. Branch circuit conductors shall be copper.
- 15. All essential power systems circuits shall be copper.
- 16. Provide all conductors with 600V insulation of the following types, unless otherwise noted on the Drawings or in these Specifications:
 - a) Wet or dry locations, in raceways:
 - 1) Service entrance: Type THWN,
 - 2) THHN/THWN-2, or XHHW.
 - Feeders and branch circuits: Type THWN, THHN/THWN-2, or XHHW.
 - 4) Conductors No. 6 AWG and smaller: Types THWN or THHN/THWN-2.
 - b) Light fixtures or conductors within three feet of high temperature equipment such as heaters: Type THHN, XHHW, or higher temperature insulation as required for the use.
- B. Metal Clad Type MC and/or Metal Clad Health Care Facility type MC-HFC Cable:
 - 1. Securing and Supporting:
 - a) Support per NFPA 70 for MC cable
 - b) Secure cable within 12 inches of every box or fitting.
 - c) Secure/supporting intervals shall not exceed six (6) feet for MC cable.

- d) Utilize steel cable hangers, Arlington SMC series or equivalent, for MC cable support wherever possible so as to provide for cable routing in a neat and workmanship like manner.
- 2. Type MC and/or MC-HCF cable may only be used:
 - a) In lieu of flexible conduit and wiring from light fixtures in accessible ceilings to junction boxes (attached to building structure) above the ceiling. Provide cable whips of sufficient lengths to allow for relocating each light fixture within a 5-foot radius of its installed location, but not exceeding 6 feet in unsupported lengths.
 - b) For horizontal wiring in stud walls.
- 3. MC and/or MC-HCF cable shall not be used for any use not listed in the paragraph above. Examples of those uses include, but are not limited to:
 - a) Unjacketed MC or MC-HCF:
 - 1) In locations not permitted by NFPA 70.
 - 2) When specifically not allowed by the local AHJ and/or Owner.
 - 3) Homeruns to panelboards.
 - 4) Where exposed to view.
 - 5) Where subject to physical damage.
 - 6) Corrosive or Hazardous locations.
 - 7) Wet locations.
 - 8) Branch circuits serving HVAC, elevator/escalator, medical and kitchen equipment loads.
 - 9) Within mechanical, electrical or telecommunication equipment rooms.
 - 10) Emergency circuits covered by NFPA 70.
- 4. Type MC- HCF cable shall have an outer metal armor or sheath in accordance with NFPA 70. This requirement applies to MC- HCF cable installations for non-emergency (non-life safety & non-critical) circuits in General Patient Areas i.e. Patient bedrooms, examining rooms, treatment rooms, clinics, and similar areas within health care facilities including but not limited to, hospitals, nursing homes, limited care facilities, clinics, medical and dental offices, and ambulatory care centers, whether permanent or movable.
 - a) This further applies to any area where it is intended that the patient will come in contact with ordinary appliances such as a nurse call system, electric instrument, cord connected equipment, electric beds, examining lamps, telephones, and entertainment devices.
 - b) Type MC- HCF Health Care Facility cable is permitted for use in general patient care areas of health care facilities. The use of standard/non-health care facility type MC or AC cable is not permitted in patient care areas.

- c) The HCF length for power circuits shall be limited to 30 feet from the junction box to the wiring device located in the wall. If the circuit continues outside the wall, the circuit shall immediately transition to conduit.
- d) The HCF length for lighting circuits shall be limited to 30 feet from the junction box to the first fixture and from that point only those fixtures above the enclosed space/room shall be served by this HCF circuit.
- C. Flexible Cords
 - 1. Refer to Division 26 Section, "Equipment Wiring Systems", for electrical connections to equipment.
- D. Control Wiring
 - 1. Unless otherwise indicated on the Drawings or in other sections, install all control wiring in raceway, regardless of voltage. A qualified Electrician shall install all control wire operating at 120V nominal and above. Control wiring operating at less than 120V (e.g., 12V and 24V) may be installed under the Division furnishing it.
 - 2. Open wiring in air-handling plenums: UL listed and classified for use in air plenums without raceway. Where indicated on the Drawings or otherwise specified, and permitted by local codes, only cable for communication or fire alarm systems and low voltage control wiring may be installed without raceways.
 - a) Low voltage wiring not routed in a race way shall be supported by cable tray or j-hooks secured independently of ceiling supports. Cabling shall not be supported directly by the ceiling system.
- E. Connections:
 - 1. Apply a zinc based, anti-oxidizing compound to connections.
 - 2. 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 and UL 486B.
 - 3. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 4. Use only resin pressure splices and splicing kits that totally encapsulate the splice for splices in underground junction boxes. Arrange the splicing kit to minimize the effects of moisture.
 - 5. Use connectors as indicated in equipment schedules. Where not indicated use connections as noted below.
 - a) Compression Conductors No. 8 AWG and larger to panelboards, switchboards and apparatus
 - b) Compression splices, terminals
 - c) Mechanical where temporary removal is required

6. Do not use terminals on wiring devices to feed through to the next device.

3.03 IDENTIFICATION

- A. General: Provide all identification per Division 26 "Identification for Electrical Systems".
- B. Single Conductors: Identify and color-code conductors to indicate voltage and phase according to Part 2 of this Section. Identification method shall be either:
 - 1. Factory provided colored insulation
 - 2. Color-Coding Conductor Tape.
 - 3. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
- C. Power-Circuit Conductor Identification: For primary and secondary conductors 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes identify voltage, source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
- D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in the same junction or pull box identify each ungrounded conductor according to voltage, source and circuit number.
- E. Conductors to Be Extended in the Future: Attach identification device to conductors and list source and circuit number.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- G. Conductors for controls (lighting, controls): Label each conductor with Markers for Conductor and Control Cables. – identify conductors using method as noted in Division 26 Section "Identification for Electrical Systems". Note conductor identification on record Drawings.
- H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
- I. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

- J. Low voltage cable sheath labels and related manufacturer information shall remain apparent in all exposed applications.
 - 1. Protect exposed cabling labels from painting and overspray (this includes protection of cables in cable tray)

3.04 FIELD QUALITY CONTROL

- A. Do not perform insulation resistance tests of the distribution wiring to equipment with the surge protective devices installed. Disconnect surge protective device before conducting insulation resistance tests and reconnect immediately after the testing is over.
- B. Testing: Perform the following field quality-control testing:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements. Test all wiring prior to energizing to ensure that it is free from unintentional grounds and shorts, is properly phased, and that all connectors are tight.
 - 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3. Certify compliance with test parameters.
- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION

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GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.
- B. This Section includes:
 - 1. Grounding Electrodes
 - 2. Ground Bars
 - 3. Grounding Conductors
 - 4. Connector Products
 - 5. Miscellaneous Grounding Materials and Products

1.2 DEFINITIONS

- A. The following apply to this and other Sections of these Specifications:
 - 1. Ground ring: Bare underground grounding conductor encircling the building or structure.
 - 2. NETA ATS: Acceptance Testing Specification.
 - 3. PSF: Pounds per Square Foot
 - 4. EMT: Electrical metallic tubing.
 - 5. ENT: Electrical nonmetallic tubing.
 - 6. FMC: Flexible metal conduit.
 - 7. GRS: Galvanized Rigid Steel Conduit
 - 8. IMC: Intermediate metal conduit.
 - 9. LFMC: Liquidtight flexible metal conduit.
 - 10. LFNC: Liquidtight flexible nonmetallic conduit.
 - 11. RAC: Rigid Aluminum Conduit
 - 12. RMC: Rigid Metal Conduit
 - 13. RNC: Rigid nonmetallic conduit.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Product data for the following products:
 - a. Electrodes, mechanical and compression connectors, and exothermic connectors
 - 2. Shop drawings for:
 - a. Pool Grounding and Bonding Systems.

- B. Quality-Control Test Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Accurately record actual locations of all buried electrodes, bonding conductors and ground rings. Indicate dimensions from fixed structural elements.

1.4 QUALITY ASSURANCE

- A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.
- B. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- C. Testing Agency Qualifications: An independent testing 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.
- D. Electrical Components, Devices, and Accessories:
 - Listed and labeled as defined in NFPA 70, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 2. Marked for intended use.
 - 3. Comply with UL 467.
- E. Comply with NFPA 780, UL 96 and all manufacturer requirements when interconnecting with lightning protection system.
- F. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.1 GROUNDING CONDUCTORS, CONNECTORS, AND ELECTRODES:

- A. Available Manufacturers:
 - 1. ABB, Inc.

- 2. Advanced Lightning Technology (ALT)
- 3. AFL Global
- 4. Boggs, Inc.
- 5. Burndy; Hubbell.
- 6. Cooper Power; Eaton.
- 7. Copperweld Corp.
- 8. ECN/Korns; Division of Robroy Industries.
- 9. Erico; nVent.
- 10. Galvan Industries, Inc.
- 11. Greaves Corp.
- 12. Harger.
- 13. Hastings Fiber Glass Products, Inc.
- 14. Heary Brothers Lightning Protection Co.
- 15. Ideal Industries, Inc.
- 16. ILSCO.
- 17. Lightning Master Corp.
- 18. Lyncole XIT Grounding; Division of VFC.
- 19. O-Z/Gedney Co.; Emerson.
- 20. Panduit, Inc
- 21. RACO; Hubbell, Inc.
- 22. Robbins Lightning, Inc.
- 23. Superior Grounding Systems, Inc.

2.2 GROUNDING ELECTRODES

- A. Ground Rods: UL-listed:
 - 1. Copper-clad steel; bonded copper electrolytically-applied to minimum thickness of 10 mils.
 - 2. Size: 3/4 inch by 10 feet. Provide sectional types when longer rods are indicated.
- B. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a bare conductor sized, at a minimum, for the size of the connecting grounding electrode conductor.
- C. Ground Plates: UL-listed, rectangular, bare solid copper plate; minimum 0.032-inch thick.
- D. Ground Ring:
 - 1. Bare copper grounding conductor, size as noted on Drawings but not less than #2/0 AWG.

2.3 GROUND BARS

A. General

- 1. Ground bars described in this section are intended to be wall mounted bars used for grounding and bonding. Equipment ground buses for switchboards, panelboards and miscellaneous equipment are described in the individual equipment sections.
- 2. Supports: Minimum of two each 1-1/2-inch insulators and 1-inch stainless steel offset mounting brackets.
- B. Electrical Room Ground Bars
 - 1. Rectangluar Ground Bars: bare, ¹/₄ inch thick, electrolytic, tough pitch copper bar, 4 inches wide. Length as indicated on the Drawings but not less 24 inches long. Hole spacing as required for conductor lugs.

2.4 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
- B. Material:
 - 2. Copper.
- C. Equipment Grounding Conductors: Insulated and identified as indicated in Part 3 of this section.
- D. Isolated Ground Conductors: Insulated and identified as indicated in Part 3 of this section.
- E. Grounding Electrode Conductors: Bare, stranded, unless otherwise indicated.
- F. Underground Conductors:
 - 1. Bare-copper conductor.
 - 2. No. 3/0 AWG minimum
- G. Bare Copper Conductors:
 - 1. Solid Conductors: Comply with Conductors: ASTM B 8.
- H. Copper Bonding Conductors:
 - 1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
 - 2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
 - 3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- I. Ground Ring:
 - 1. Bare copper grounding conductor, size as noted on Drawings but not less than #2/0 AWG.

2.5 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure-type connectors.
- C. Compression Connectors: Burndy Hyground, or equal, permanent, pure, wrought copper, meeting ASTM 8 1 87, essentially the same as the conductors being connected; clearly and permanently marked with the information listed below:
 - 2. Company symbol and/or logo.
 - 3. Catalog number.
 - 4. Conductors accommodated.
 - 5. Installation die index number or die catalog number is required.
 - 6. Underwriters Laboratories "Listing Mark:".
 - 7. The words "Suitable for Direct Burial" or, where space is limited, "Direct Burial" or "Burial" per UL Standard ANSI/UL467.
- D. Cast connectors: copper base alloy according to ASTM B 30.
- E. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.6 MISCELLANEOUS

- A. Test Wells:
 - 1. Traffic Areas: Polymer concrete reinforced with heavy weave fiberglass; H-20 load rating; minimum 24 inches deep.
 - 2. Non-traffic Areas: High density polyethylene; 350 PSF minimum load rating; minimum 10.25 inches deep.
 - 3. Cover: Factory-identified by permanent means with word "GROUND".
- B. Ground Enhancing Backfill: Provide low-resistivity, ground-enhancing backfill material recommended by the electrode manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine areas and conditions under which electrical grounding connections are to be made and notify the Contract Administrator and the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with Work until unsatisfactory conditions have been corrected.
3.2 INSTALLATION

- A. General:
 - 1. Provide all materials, labor and equipment for an electrical grounding system in accordance with applicable portions of NFPA 70 and NECA. Coordinate electrical work as necessary to interface installation of electrical grounding systems with other work.
 - 2. Accomplish grounding and bonding of electrical installations and specific requirements for systems, circuits and equipment required to be grounded for both temporary and permanent construction.
 - 3. Where the size of the grounding conductors are not shown, size in accordance with NFPA 70 Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Application:
 - 1. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
 - 2. Underground Grounding Conductors: Unless noted otherwise, bury at least 24 inches below grade, or 6 inches below the official frost line, whichever is greater, or when crossing a duct bank, bury 12 inches above duct bank.
 - B. Grounding Electrode System: Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - 1. Provide continuous grounding electrode conductors without splice or joint.
 - 2. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
 - 3. Ground Rod Electrodes:
 - a) Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
 - b) Unless otherwise indicated, install ground rod electrodes vertically.
 - 1) Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
 - 2) Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.
 - c) Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70. If depth is unachievable, notify Contract Administrator and Engineer.
 - d) Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated.

Make connections without exposing steel or damaging copper coating.

- e) Verify that final backfill and compaction has been completed before driving rod electrodes.
- f) Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade, pavement, or floor.
- 4. Ground Plate Electrodes: Unless otherwise indicated, install ground plate electrodes at a depth of not less than 30 inches. Use exothermic weld to secure grounding electrode conductor.
- 5. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare, tinned copper conductor not smaller than No. 4 AWG. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor above footer and foundation and connect to building structural steel or other grounding electrode external to concrete.
- 6. Metal Water Service Pipe: Provide 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 by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conductor steeve to conductor at each end.
- 7. Ground Ring Electrode (Counterpoise):
 - a) Provide a ground ring encircling the building or structure, in direct contact with earth., installed at a depth of not less than 18 inches or 6 inches below the official frost line, whichever is greater.
 - b) Locate ground ring conductor at least 24 inches outside building perimeter foundation, unless noted otherwise on the Drawings.
 - c) Provide ground enhancement material around conductor where indicated.
- 8. Metal In-Ground Support Structures: Provide connection to metal inground support structure that is in direct contact with earth in accordance with NFPA 70.
- 9. Metal Poles Supporting Outdoor Luminaires: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.
- C. Equipment Grounding Conductors:
 - 1. Comply with NFPA 70, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
 - 2. Install equipment grounding conductors in all feeders and branch circuits.

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- 3. Install equipment grounding conductor with circuit conductors for the following items, in addition to those required by NFPA 70:
 - a) Feeders and branch circuits.
 - b) Lighting circuits.
 - c) Receptacle circuits.
 - d) Single-phase motor and appliance branch circuits.
 - e) Three-phase motor and appliance branch circuits.
 - f) Flexible raceway runs.
 - g) Armored and metal-clad cable runs.
 - h) Feeders and branch circuits installed in non-metallic raceways.
- 4. In branch circuit and feeder raceways, use insulated equipment grounding conductors.
- 5. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- 6. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components. On water heaters, bond metal hot and cold water pipes together, across the heater tank.
- 7. Busway Supply Circuits: Install an insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panelboard to the equipment grounding bar terminal on the busway, if a direct bus-to-bus connection is not factory provided.
- 8. Metallic Cable Tray Systems: Install equipment grounding conductor in each cable tray. Do not use metal cable tray system as sole equipment grounding conductor.
 - a) Equipment Grounding Conductor for Steel Cable Tray: Use bare or insulated copper conductor.
 - b) Equipment Grounding Conductor for Aluminum Cable Tray: Use insulated copper conductor only; do not use bare copper conductor.
 - c) Minimum Equipment Grounding Conductor Size: 6 AWG copper.
- 9. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- D. Ground Bars:
 - 1. Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.
 - a) Use insulated spacers and mounting brackets, and support from wall
 2 feet above finished floor, unless otherwise indicated.
- C. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 AWG minimum insulated grounding conductor

in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

- 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a ground bar.
- 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- D. Separately Derived Systems: Bond the derived neutral (grounded) conductor of all separately derived system (e.g., transformers, generators, UPS) to the nearest available grounding electrode, or back to the service grounding electrode if no approved electrodes are readily available. Size the grounding electrode conductor and bonding jumpers as indicated on the Drawings or as required by NFPA 70, whichever is larger.
 - E. Bonding: Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70:
 - 1. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
 - 2. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.
 - 3. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
 - 4. Bond metallic elements likely to become energized or where indicated on the Drawings, including but not limited to fences around electrical equipment and metal drain bodies near pools or electrical equipment.
 - 5. Bond raised flooring systems and static control flooring.
 - 6. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
 - 7. Common Ground Bonding with Lightning Protection System: Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in PVC conduit.
 - 8. Pole Mounted Luminaires: Bond metal enclosures and components of pole mounted luminaires to the grounding system per the Manufacturer's requirements.
 - 9. Bond the components within the following systems to the building grounding system:

- a) Metallic Cable Tray Systems.
- E. Isolated Ground (IG) Receptacle Circuits:
 - 10. Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
 - 11. Do not use multi-conductor or MC cables.
 - 12. Do not share neutrals between separate circuits.
 - 13. Do not share the isolated grounding conductor with more than one device (i.e., each device on an IG circuit shall have its own dedicated IG conductor back to the branch panelboard IG bus).
 - 14. The equipment grounding conductor may be shared between IG circuits sharing a common raceway
 - F. Isolated Equipment Enclosure Circuits:
 - 1. For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

1.02 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible. Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by the manufacturers for indicated applications. Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, and bonding straps as recommended by the manufacturers for types of service indicated.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to 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.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Replace welds that are puffed up or that show convex surfaces

indicating improper cleaning. Use exothermic welded connections for the following:

- 1. Connecting conductors together.
- 2. Connecting conductors to ground rods, except at test wells.
- 3. Connecting conductors to building steel.
- 4. Connecting conductors to plates.
- C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
 - 1. Compression Fittings: Permanent compression-type fittings may be used for the following rather than exothermic connections:
 - a) Connecting conductors together.
 - b) Connecting conductors to building steel.
 - c) Connecting conductors to ground rods, except at test wells.
- D. Mechanical Pressure-Type Connections: Tighten screws and bolts for grounding and bonding 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.
 - 1. Mechanical Pressure Fittings: Use bolted mechanical (removable) pressure-type clamps for the following:
 - a) Connecting conductors to ground rods at test wells.
 - b) Connecting conductors to pipes.
- E. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- F. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- G. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.
- H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

1.03 GROUND RING

A. Ground the steel framework of the building with a buried electrode at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Protect taps for steel framing connections from physical damage at foundations and transitions to steel columns.

1.04 POOL GROUNDING AND BONDING

- F. Grounding: Provide copper equipment grounding conductors for all pool equipment and electrical equipment within corrosive environments as defined by and in accordance with NFPA 70, including but not limited to the following:
 - 1. Pool pumps.
 - 2. Motors.
 - 3. Flexible cord connections.
 - 4. Through-wall assemblies, unless noted otherwise.
 - 5. Luminaire circuits.
 - 6. Panelboard Feeders.
 - 7. Audio equipment exceeding the low voltage contact limits as defined in NFPA 70.
 - B. Bonding: Bond all metal parts, fittings, piping, and raceway associated with pool construction per NFPA 70.
 - 1. Equipotential Bonding: Where practicable, bond conductive pool shell utilizing the structural steel reinforcing per NFPA 70. Otherwise, provide a copper grid for equipotential bonding consisting of No. 8 AWG solid copper and arranged in accordance with NFPA 70. Bond all metallic components, underwater lighting, metallic raceways and piping, through-wall assemblies, metal fittings, metallic anchors, electrical equipment, all fixed metal parts, and controls within 5'-0" (1.5m) of the pool, pool lifts and all specialized pool equipment.
 - 2. Provide an equipotential bonding ring within pool equipment space with solid bare copper conductor. Bonding ring shall be sized equivalent to the largest phase conductor serving the pool equipment but shall not be less than 8 AWG.
 - C. Grounding terminals for pool equipment or electrical equipment located within located within the pool area and pool corrosive environments, as defined in NFPA 70, shall be copper, copper or stainless steel and listed for wet location and direct burial. The equipment grounding conductor shall be connected to the fixed portion of an assembly. Ensure removable parts of an assembly are bonded appropriately in accordance with the Manufacturer's written instructions.

1.05 FOUNTAIN GROUNDING AND BONDING

- G. Grounding: Provide copper equipment grounding conductors for all fountain circulation equipment, and luminaires and electrical equipment within the fountain or within 5'-0" (1.5 m) of the fountain edge, in accordance with NFPA 70.
 - A. Bonding: Bond for all metal parts, fittings, piping, and raceway associated with the fountain per NFPA 70.
 - B. Grounding terminals for fountain equipment or electrical equipment located within located within the pool area and pool corrosive environments, as defined in NFPA 70, shall be copper, copper or stainless steel and listed for wet location and direct burial. The equipment grounding conductor shall be connected to the fixed portion of an assembly. Ensure removable parts of an assembly are bonded appropriately in accordance with the Manufacturer's written instructions.

1.06 GROUNDING AND BONDING FOR BODIES OF WATER

- H. Grounding: Provide insulated copper equipment grounding conductor for feeders and branch circuits serving equipment and devices within or adjacent to natural and artificially made bodies of water in accordance with NFPA 70.
 - A. Bonding: Bond all non-current carrying metal enclosures, parts, fittings, tanks and piping in contact with the water. Bond associated structures or equipment located within or adjacent to natural and artificially made bodies of water in accordance with NFPA 70. Use solid copper conductor not less than No. 10 AWG for bonding conductors.
 - B. Equipotential Plane: Install equipotential planes as indicated on the plans. Bond outdoor service equipment to equipotential plane per NFPA 70.

1.07 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- B. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 6 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

C. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise encircling the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade, or 6 inches below the official frost line, whichever is greater, and 6 inches from the foundation.

3.3 IDENTIFICATION

A. Provide identification as specified in Division 26 "Low-Voltage Electrical Power Conductors and Cables" and "Identification for Electrical Systems".

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
 - 1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
 - 2. Test completed grounding system at each location where a maximum groundresistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the 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. Perform tests by the fall-of-potential method according to IEEE 81.
 - 3. Provide drawings locating each 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.
 - 4. Inspect and test in accordance with NETA ATS, except Section 4.
 - 5. Perform inspections and tests listed in NETA ATS, Section 7.13.
 - 6. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
 - 7. Perform point-to-point megohmmeter tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
 - 8. Test Values:
 - a. The resistance between the main grounding electrode and earth ground shall be no greater than 5 ohms.
 - b. Equipment Rated 500 kVA and Less: 10 ohms.
 - c. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - d. Equipment Rated More Than 1000 kVA: 3 ohms.
 - e. Substations and Pad-Mounted Switching Equipment: 5 ohms.
 - f. Manhole Grounds: 10 ohms.

- 9. Minimum system neutral-to-ground insulation resistance: one megohm.
- 10. Investigate point-to-point resistance values that exceed 0.5 ohms.
 - a. Check for loose connections.
 - b. Check for absent or broken connections.
 - c. Check for poor quality welds.
 - d. Consider other reasons.
- 11. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements
- 12. Excessive Grounding Electrode Resistance: If measured resistance to earth ground value exceeds specified values, add grounding electrodes and additional conductors as required to obtain the specified value.
- 13. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.5 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 31 and 32. Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION

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HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.02 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

- 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
- 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
- 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
- 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
- 5. Notify Contract Administrator of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- 6. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- 7. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members in path of conduit groups with supports or individual conduits larger than 3-inches in diameter.
 - 2. HVAC items, plumbing items and architectural features in the paths of conduit groups with common supports or individual conduits larger than 3-inches in diameter.

- C. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.04 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Submit fabrication drawings and product literature.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.05 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Rooftop support systems.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates.

1.06 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70 and applicable building code.
- C. Installer Qualifications for Powder-Actuated Fasteners: Certified by fastener system manufacturer with current operator's license.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. General:

- 1. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
- B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly. Use corrosion resistant materials suitable for the environment where installed.
 - 1. Available Manufacturers:
 - a) Allied Tube & Conduit; Atkore International.
 - b) Eaton
 - c) Erico; nVent.
 - d) GS Metals Corp.
 - e) Thomas & Betts Corporation.
 - f) Unistrut; Atkore International.
 - g) Wesanco, Inc.
 - 2. Metallic Coatings:
 - a) Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
 - 3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 4. Channel Dimensions: Selected for applicable load criteria.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
 - 1. Conduit Straps: One-hole or two-hole type.
 - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a) Available Manufacturers:

- 1) Hilti Inc.
- 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
- 3) MKT Fastening, LLC.
- 4) Powers Fasteners, Inc;
- 5) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
- 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a) Available Manufacturers:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
- 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
- 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
- 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
- 6. Toggle Bolts: All-steel springhead type.
- 7. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.

2.02 FABRICATED METAL CONDUIT OR EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.
- C. Rooftop support assemblies: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane.
 - 1. Conduit supports: Unless noted otherwise, surface mounted fittings not requiring any attachment to the roof structure and not penetrating the roofing assembly with support fixtures.
 - 2. Equipment supports: Attachment fittings for connection to roof structure.
- D. Base Sizes: As required to prevent overturning and to distribute load sufficiently to prevent indentation of roofing assembly.

E. Mounting Height: Provide minimum clearance of 6 inches under supported components to top of roofing.

PART 3 - EXECUTION

3.01 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Unless specifically indicated or approved by the Contract Administrator and Structural Engineer, do not support from roof deck.
- C. Where support wires are permitted, identify independent electrical component support wires above accessible ceilings with color distinguishable from ceiling support wires in accordance with NFPA 70.
- D. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - 1. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - 2. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
- E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway:
 - 1. Minimum rod size shall be 1/4 inch (6 mm) in diameter, unless otherwise indicated.
 - a) Equipment Supports: 1/2 inch diameter minimum.
 - b) Busway Supports: 1/2 inch diameter minimum.
 - c) Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter minimum.
 - d) Trapeze Support for Multiple Conduits: 3/8 inch diameter minimum.
 - 2. Space supports for EMT, IMC, and RMC as required by NFPA 70.
- F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 20 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with:
 - a) two-bolt conduit clamps
 - b) single-bolt conduit clamps

3.02 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Install in accordance with manufacturer's instructions.
- E. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- F. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
 - 1. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 1.5. Include consideration for vibration, equipment operation, and shock loads where applicable.
- G. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
- H. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- I. Remove temporary supports when no longer required.
- J. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- K. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Steel:

- a) Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
- b) Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
- 5. To Light Steel: Sheet metal screws.
- 6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- L. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.
- D. Minimize overhanging materials and protrusions, and provide protective caps and fittings on exposed material ends where:
 - 1. Accessible to untrained personnel.
 - 2. Located within confined spaces.
- E. Rooftop support assemblies:
 - 1. Conduit supports: Unless noted otherwise, coordinate installation of support system after roofing materials are complete. Provide adhesive materials to secure conduit supports where required. Where attachment to roof structure is required or otherwise specified, coordinate installation of supports with roofing material installation.
 - 2. Equipment supports: Coordinate installation of supports with roofing material installation.

3.04 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 "Concrete"."

- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Comply with requirements in Division 09 "Finishes" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- D. Inspect support and attachment components for damage and defects. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 260533

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUREMENTS

1.01 SECTION INCLUDES

- A. This Section includes:
 - 1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.02 DEFINITIONS

- A. Terminology used in this specification is as defined below:
 - 1. EMT: Electrical Metallic Tubing
 - 2. FMC: Flexible Metal Conduit
 - 3. GRS: Galvanized Rigid Steel Conduit
 - 4. IMC: Intermediate Metal Conduit
 - 5. LFMC: Liquidtight Flexible Metal Conduit
 - 6. LFNC: Liquidtight Flexible Nonmetallic Conduit
 - 7. RAC: Rigid Aluminum Conduit
 - 8. RMC: Rigid Metal Conduit
 - 9. RNC: Rigid Nonmetallic Conduit

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of raceway, boxes, or other potential obstructions within the dedicated equipment spaces and working clearances for equipment installed by other trades in accordance with the codes and manufacturer requirements.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
 - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
 - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
 - 6. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated. Coordinate the work with other trades to preserve insulation integrity.
 - 7. Coordinate routing of power, low-voltage, and control conduits requiring fire-resistive protective assembly or electrical circuit protective system. Fire-resistive protective assembly or electrical circuit protective system for power, low-voltage, and control circuit conductors and cables shall have a fire-resistance rating of not less than 2 hours and shall be provided where

required by NFPA or local building codes. Types of systems requiring a fire-resistive protective assembly include, but are not limited to:

a) Feeders for Emergency Power systems

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product data for the following products:
 - 1. Floor boxes
 - 2. Poke-Through Outlets
 - 3. Floor mounted raceway systems
- C. Shop drawings for:
 - 1. Detailing fabrication and installation for custom enclosures.
 - 2. Floor mounted raceway systems
- D. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members in path of conduit groups with supports.
 - 2. HVAC items, plumbing items and architectural features in the paths of conduit groups with common supports.
- E. Samples:
 - 1. Finishes:
 - a) Submit sample chips, illustrating range of colors available for enclosure manufacturer finish products for approval by the Contract Administrator.
 - b) Submit floorbox cover sample in finishes requested by the Contract Administrator for approval prior to purchasing boxes.
 - c) Submit poke-through outlet cover sample in finishes requested by the Contract Administrator for approval prior to purchasing devices.
- F. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Accurately record actual routing of all exterior buried raceway and all interior raceways three inches and larger. Indicate dimensions from fixed structural elements.

1.05 QUALITY ASSURANCE

- A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.
- B. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to AHJ.
 - 2. Marked for intended use.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.01 CONDUITS, SURFACE MOUNTED RACEWAYS AND ACCESSORIES

- A. Metal Conduit and Tubing
 - 1. Available Manufacturers:
 - a) ABB, Inc.
 - b) AFC Cable Systems, Inc.; a division of Atkore International
 - c) Allied Tube and Conduit
 - d) American Conduit
 - e) Anamet Electrical, Inc.
 - f) Electri-Flex Co.
 - g) Nucor Tubular Products.
 - h) O-Z/Gedney Co.; Emerson.
 - i) Republic Raceway.
 - j) Southwire Company, LLC
 - k) Western Tube and Conduit Corporation.
 - l) Wheatland Tube Co.
 - 2. RMC:
 - a) GRS: Hot-dip galvanized: ANSI C80.1, UL 6.
 - 1) Plastic-Coated GRS and Fittings: NEMA RN 1, UL-listed. Coating thickness of 0.04 inches (1mm), minimum.
 - b) RAC: ANSI C80.5, UL6A.
 - 3. IMC: ANSI C80.6, UL 1242.
 - a) Plastic-Coated IMC and Fittings: NEMA RN 1, UL-listed.
 - 4. EMT and Fittings: ANSI C80.3, UL 797. Only steel products allowed. Reduced wall EMT is not allowed.
 - a) Fittings: Set-screw or Compression type.
 - 5. FMC: Aluminum UL 1. Reduced wall FMC is not allowed.
 - 6. LFMC: Flexible steel raceway with PVC jacket: UL 360.

- a) Fittings: NEMA FB 1; compatible with raceway and tubing materials.
- B. Nonmetallic Raceway
 - 1. Available Manufacturers:
 - a) ABB, Inc.
 - b) AFC Cable Systems, Inc. (Tubing); a division of Atkore International
 - c) Allied Tube and Conduit
 - d) American Pipe and Plastics, Inc.
 - e) Anamet Electrical, Inc.
 - f) Arnco Corp.
 - g) Cantex Inc.
 - h) Champion Fiberglass, Inc.
 - i) Electri-Flex Co.
 - j) FRE Composites.
 - k) Hubbell Inc. (Fittings)
 - l) IPEX USA, LLC.
 - m) Phoenix Contact.
 - n) Prime Conduit.
 - o) Southwire Corporation.
 - p) Superflex Ltd.
 - q) United Fiberglass of America, Inc.
 - 2. RNC: Schedule 40 and 80 PVC: NEMA TC 2, UL 651.
 - a) Fittings: match to raceway and tubing type and material: NEMA TC 3, NEMA TC 6, UL 651, as applicable.
- C. Metal Wireways
 - 1. Available Manufacturers:
 - a) BEL Products, Inc.
 - b) Cooper B-Line; Eaton.
 - c) EPI-Electrical Enclosures
 - d) Hoffman.
 - e) Square D.
 - 2. Material and Construction: 14 gauge (minimum) sheet steel, sized and shaped as indicated, NEMA 1, 3R, or 4X.
 - 3. Fittings and Accessories: Include couplings, offsets, elbows, expansion/deflection joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70. Where indicated, provide a barrier to divide wireway into compartments.
 - 4. Wireway Covers:

- a) Hinged type
- b) Flanged-and-gasketed type
- 5. Finish: Manufacturer's standard phosphate pre-treatment and baked enamel finish.
- D. Surface Metal Raceways
 - 1. Available Manufacturers:
 - a) ABB, Inc.
 - b) Hubbell, Inc.
 - c) Legrand.
 - d) Mono-Systems; Niedax Group
 - e) Panduit Inc.
 - 2. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating.
 - 3. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.02 BOXES, ENCLOSURES AND CABINETS

- A. General
 - 1. Available Manufacturers:
 - a) ABB, Inc.
 - b) American Midwest Power
 - c) Appleton/O-Z Gedney Co.; Emerson.
 - d) BEL Products, Inc.
 - e) Cooper Crouse-Hinds; Eaton.
 - f) Erickson Electrical Equipment Co.
 - g) FSR, Inc.
 - h) Hoffman.
 - i) Hubbell, Inc.
 - j) Legrand.
 - k) Molex; Koch Industries.
 - 1) Robroy Industries, Inc.; Enclosure Division.
 - m) Spring City Electrical Manufacturing Co.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 - 3. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 - 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
 - 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
 - 1. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
 - 2. Cast Metal Boxes: Comply with NEMA FB 1, Type FD, with gasketed cover. Furnish with threaded hubs.
 - a) List and label as complying with UL 514A for non-hazardous locations;.
 - b) List and label as complying with UL 886 for hazardous locations, where required.
 - 3. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
 - 4. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes.
 - 5. Minimum Box Size, Unless Otherwise Indicated:
 - a) Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-7/8 inch deep trade size.
 - b) Communications Systems Outlets: Comply with Division 27 specifications.
 - c) Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
 - 6. Do not use "through-wall" boxes designed for access from both sides of wall.
 - 7. Wall Plates: Comply with Division 26 Section "Wiring Devices".
- C. Boxes for telephone, data, telecommunications and audio-video outlets, refer to:
 - 1. Division 27 Section "Common Work Results for Communications"
- D. Junction and Pull Boxes Larger Than 100 cubic inches:
 - 1. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, and list and label as complying with UL 514A.
 - 2. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast iron or aluminum with gasketed cover.
 - 3. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - 4. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.
 - 5. Terminal Blocks: Where indicated on the Drawings, provide terminal blocks with voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.
- E. Floor Boxes
 - 1. General:

- a) Floor Box Schedule on drawings: Where titles in this section are column or row headings that introduce lists, the requirements listed for that title apply to product selection.
- b) Provide a complete Floor Box Assembly.
- c) Floor boxes shall be concealed service with flush coverplate.
- d) UL514A listed for scrub water exclusion for all floor types.
- e) Receptacles:
 - 1) Provide receptacles complying with requirement of Division 26 "

Wiring Devices"

- 2) Include a minimum of one convenience duplex receptacle, or quantity as indicated on schedule, with features as noted on schedule.
- 3) GFCI: Include quantity of GFCI Receptacles as indicated on schedule, with features as noted on schedule.
- 4) Special: Include quantity of Special/Miscellaneous Devices as indicated on schedule, with features as noted on schedule.
- f) Communications:
 - 1) Provide dedicated mounting space (gang) for each communication device type indicated on schedule. Include provisions for mounting devices in accordance with the requirements of the communication systems provider.
 - 2) In floor boxes with unused spare gang locations, provide one spare gang with 1" conduit from gang up in nearest adjacent wall to above accessible ceiling for low voltage cabling.
 - 3) The following items are not provided per this specification section:
 - a) Telecommunications outlet termination plate and termination connectors shall be provided per Division 27 Section "Communications Horizontal Cabling". Coordinate all other Assembly components to ensure compatibility.
 - b) Audio Video custom termination plates and connectors shall be provided per Division 27 Section "Audio Video Systems" and/or "Audio Video Systems Equipment". Coordinate all other assembly components to ensure compatibility.
- 2. For Multi-service Floor Boxes, see Division 27 Section "Common Work Results for Communications".
- F. Poke-Through Outlets
 - 1. General:

- a) Poke-Through Schedule on drawings: Where titles in this section are column or row headings that introduce lists, the requirements listed for that title apply to product selection.
- b) Provide a complete Poke through assembly with concealed service.
- c) Assembly shall be UL listed and UL Fire Classified, with one- to two-hour fire rating, as required by floor rating and type.
- d) The following items are not provided per this specification section:
 - 1) Include provisions for mounting communications faceplate and connectors in accordance with the requirements of the communications systems provider. Telecommunications outlet termination plate and termination connectors shall be provided per Division 27 Section "Communications Horizontal Cabling". Coordinate all other Assembly components to ensure compatibility.
 - Audio Video custom termination plates and connectors shall be provided per Division 27 Section "Audio Video Systems" and/or "Audio Video Systems Equipment". Coordinate all other assembly components to ensure compatibility.
- e) UL514A listed for scrub water exclusion for all floor types.
- f) Provide with flush cover plate, with individual device covers, and floor flange for specific floor material for all types. Provide color as directed by the Architect.
- 2. Receptacles:
 - a) Provide receptacles complying with requirement of Division 26 section "

Wiring Devices"

- b) Include a minimum of one Duplex Receptacle, or quantity as indicated on schedule, with features as noted on schedule.
- c) GFCI: Include quantity of GFCI Receptacles as indicated on schedule, with features as noted on schedule.
- d) Special: Include quantity of Special/Miscellaneous Devices as indicated on schedule, with features as noted on schedule.
- 3. Communications:
 - a) Provide dedicated mounting space (gang) for each communication device type indicated on schedule. Include provisions for mounting devices in accordance with the requirements of the communication systems provider. Communication devices to be defined and provided under specification of other divisions.
- 4. Manufacturers:
 - a) Legrand/Wiremold ATC series
 - b) FSR SmartFit SF Series
 - c) Hubbell FRPT series

- 5. For additional multi-service poke-through types, see Division 27 Section "Common Work Results for Communications".
- G. Cabinets and Enclosures:
 - 1. General:
 - a) Compliance: NEMA 250, and list and label as complying with UL 50 and UL50E or 508A, as applicable.
 - b) Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes: Shall be keyed. Provide 2 keys for each enclosure.
 - 1) All locks shall be keyed alike.
 - c) NEMA 250 Environment ratings:
 - 1) NEMA Type 1: Code-gauge phosphatized steel with continuously welded seams; non-gasketed removable hinged front cover, with flush latch and concealed hinge; collar studs.
 - 2) NEMA Type 3R: Code-gauge galvanized steel with drip shield top, seam-free front, side, and back; non-gasketed continuous-hinged door, with stainless steel pin; captive, plated steel cover screws; hasp and staple for padlocking; collar studs.
 - 3) NEMA Type 4X: External wall-mounting brackets; rolled flanges on door and door opening; continuous-hinged door, with removable stainless steel pin; seamless continuous gasket; stainless steel hasp and staple for padlocking; collar studs; captive, stainless steel door clamps on 3 sides of door; interior data pocket:
 - a) Metal: Code-gauge Type 304 stainless steel with continuously welded seams.
 - d) Provide enclosures wider than 36 inches with double doors; removable center posts; internal bracing, supports, or both, as required to maintain their structural integrity; and, accessory feet where required for freestanding equipment.
 - e) Provide clamps, grids, slotted wireways, or similar devices to which or by which wiring may be secured. Provide DIN-rail mounted terminal strips for terminating all incoming and outgoing control wiring, and power terminal blocks for incoming/outgoing power wiring. Provide wire management troughs where practicable.
 - f) Provide metal barriers to separate compartments containing control wiring operating at less than 50 volts from power and higher-voltage control wiring.

2.03 FACTORY FINISHES

- A. Interior Finish: All interior components shall be factory finished; manufacturer's standard grey unless otherwise noted.
- B. Exterior Finish (Finished Areas exposed to public): For metal wireway and surface raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.
- C. Exterior Finish (Unfinished Areas): For metal wireway and surface raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled metal wireway and surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General
 - 1. Install in accordance with manufacturer's instructions

3.02 RACEWAYS

- A. General
 - 1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this article are stricter.
 - 2. Provide sizes and types of raceways as indicated on the Drawings. Sizes are based on THWN insulated copper conductors, except where noted otherwise. Where sizes are not shown on the Drawings or in the Specifications, size raceways in accordance with NFPA 70 requirements for the number, size and type of conductors installed. Minimum raceway size: 1/2 inch (concealed and exposed); 1 inch (underground, concealed in slab and under slab on grade).
 - a) 1/2 inch conduit shall contain maximum (5) #12AWG conductors or (3) #10AWG conductors.
 - b) 3/8 inch flexible conduit may be used for light fixture whips.
 - 3. Provide all raceways, fittings, supports, and miscellaneous hardware required for a complete electrical system as described by the Drawings and Specifications.
 - 4. Install a green-insulated, equipment-grounding conductor, which is bonded to the electrical system ground, in all raceways, with the exception of Service Entrance raceways.
 - 5. Install grounding bushings on all conduit terminations and bond to the enclosure, equipment grounding conductor, and electrical system ground.

- 6. Install raceways concealed in walls or above suspended ceilings in finished areas. When approved by the Contract Administrator, raceways may be installed concealed in elevated floor slabs. Do not install raceways horizontally within slabs on grade.
- 7. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
- 8. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- 9. Make bends and offsets so inside diameters are not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- 10. Install raceways:
 - a) To meet the requirements of the structure and the requirements of all other Work on the Project.
 - b) To clear all openings, depressions, ducts, pipes, reinforcing steel, and so on.
 - c) Within or passing through the concrete structure in such a manner so as not to adversely affect the integrity of the structure. Become familiar with the Architectural and the Structural Drawings and their requirements affecting the raceway installation. If necessary, consult with the Contract Administrator.
 - d) Parallel or perpendicular to building lines or column lines.
 - e) Tight to structure.
 - f) When concealed, with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
- 11. Raceways Embedded in Slabs:
 - a) Raceways may only be embedded in concrete slabs with written permission from, and only where directed, by the Structural Engineer.
 - b) Install in middle 1/3 of slab thickness, where practical. At a minimum, concrete shall provide at least 2 inches of concrete cover for raceways.
 - c) Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 - d) Space raceways laterally to prevent voids in concrete.
 - e) Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
- 12. Where masonry walls are left unfinished, coordinate raceway installations with other trades so that the raceways and boxes are concealed and the wall will have a neat and smooth appearance.
- 13. Support raceways from structural elements of the building as required by NFPA 70, Division 26 Section "Hangers and Supports for Electrical

Systems". Do not support raceways by hangers used for any other systems foreign to the electrical systems; and, do not attach to other foreign systems. Do not lay raceways on top of the ceiling system.

- a) Raceways on roof shall be supported from structure not from the roof deck.
- 14. Provide support spacing in accordance with NFPA 70 requirements, and at a minimum in accordance with NEMA standards. Support by the following methods:
 - a) Attach single raceway directly to structural steel with beam clamps.
 - b) Attach single raceway directly to concrete with one-hole clamps or clips and anchors. Outdoors and wherever subject to dampness or moisture, offset raceways from the surface by using galvanized clamps and clamp backs, to mitigate moisture entrapment between raceways and surfaces.
 - c) Attach groups of raceway to structural steel with slotted support system attached with beam clamps. Attach raceway to slotted channel with approved raceway clamps.
 - d) Attach groups of raceway to concrete with cast-in-place steel slotted channel fabricated specifically for concrete embedment. Attach raceway to steel slotted channel with approved raceway clamps.
 - e) Hang plumb horizontally suspended single raceway using a threaded rod. Attach threaded rods to concrete with anchors and to structural steel with beam clamps. Attach raceway to threaded rod with approved raceway clamps.
 - f) Hang horizontally suspended groups of raceway using steel slotted support system suspended from threaded rods. Attach threaded rods to concrete with anchors and to structural steel with beam clamps. Attach raceway to steel slotted channel with approved raceway clamps.
 - g) Support conductors in vertical raceway in accordance with NFPA 70 requirements.
 - h) Cross-brace suspended raceway to prevent lateral movement during seismic activity.
 - i) Use pre-fabricated non-metallic spacers for parallel runs of underground or under-slab conduits, either direct buried or encased in concrete.
- 15. Install electrically- and physically-continuous raceways between connections to outlets, boxes, panelboards, cabinets, and other electrical equipment with a minimum possible number of bends and not more than the equivalent of four 90-degree bends between boxes. Make bends smooth and even, without flattening raceway or flaking the finish.
- 16. Protect all electrical Work against damage during construction. Repair all Work damaged or moved out of line after rough-in, to meet the Contract Administrator's approval, without additional cost to the Owner. Cover or temporarily plug openings in boxes or raceways to keep raceways clean

during construction. Clean all raceways prior to pulling conductors or cables.

- 17. Align and install raceway terminations true and plumb.
- 18. Complete raceway installation before starting conductor installation.
- 19. Install a pull cord in each empty raceway that is left empty for installation of wires or cables by other trades or under separate contracts. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull cord.
- 20. Install approved expansion/deflection fittings where raceways pass through or over building expansion joints; or where structures providing a means of support are subject to relative movement greater than acceptable by the raceway manufacturer.
- 21. Route raceway through roof openings for piping and ductwork or through roof seals approved by the Contract Administrator, the roofing contractor, or both. Obtain approval for all roof penetrations and seal types from the Contract Administrator, Owner, roofing contractor, or all three as required to maintain new or existing roofing warranties.
- 22. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - a) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces or from building exterior to building interior.
 - b) Where otherwise required by NFPA 70.
- 23. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment as required by other requirements of the construction documents.; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- 24. Maintain 2" minimum spacing from bottom of roof deck to prevent raceway penetrations from above
- 25. Do not route conduits across skylights, access panels, hatched tiles, HVAC diffusers, or equipment working space.
- 26. Route conduits serving rooftop equipment concealed inside the equipment curb and minimize roof penetrations and exterior conduit runs where practicable.
- 27. Install all underground conduits/raceways a minimum of 24" below the bottom of slab/paving/grade, unless noted otherwise, where practicable.
- 28. Provide boxes and raceways for the fire protection system low voltage wiring as required. This includes low voltage wiring exposed less than 96" AFF.

- a) At a minimum, provide 3/4" conduit.
- b) Coordinate requirements and locations with system installer and fire alarm specifications.
- B. RMC
 - 1. Use GRS or IMC in the following areas:
 - a) Where indicated.
 - b) For Emergency Feeders.
 - c) Exterior applications where above grade and exposed.
 - d) Below grade when concrete-encased, plastic-coated, or provided with a corrosion resistant approved mastic coating.
 - e) All raceways penetrating slabs on grade (use plastic-coated raceway or provide with a corrosion resistant approved mastic coating). This shall include the 90-degree elbow below grade and the entire vertical transition to above grade.
 - f) Exposed, in parking garages:
 - 1) GRS: vertical risers below 7 feet AFF, when exposed to vehicular traffic.
 - g) Concealed within masonry walls.
 - h) Damp or wet locations.
 - i) Elevator pits.
 - 2. Use RAC in the following areas:
 - a) Indoors above grade.
 - b) Interior wet or damp locations.
 - c) For circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
 - 3. Do not use RAC:
 - a) Below grade.
 - b) Imbedded in concrete or other areas corrosive to RAC.
- C. EMT
 - 1. Use EMT in the following areas:
 - a) Where indicated.
 - b) Interior concealed locations for:
 - 1) Branch circuits.
 - 2) Feeders.
 - 3) Emergency branch circuits.
 - 4) Low-voltage control, security, and fire alarm circuits
 - c) Exposed where not subject to physical damage
 - 1) Mechanical rooms

- 2. Do not use EMT:
 - a) Below grade.
 - b) In exterior applications when exposed.
- D. FMC and LFMC
 - 1. Use FMC or LFMC:
 - a) For the final 24 inches of raceway to all motors, transformers, and other equipment subject to vibration or movement.
 - b) From outlet boxes (attached to building structure) to recessed light fixtures. Install sufficient length to allow for relocating each light fixture within a 5-foot radius of its installed location.
 - c) Use FMC only in dry locations
 - d) Use LFMC in damp, wet, corrosive, outdoor locations, and food service and kitchen areas.
 - 2. Do not use FMC or LFMC:
 - a) For branch circuits, homeruns or feeders.
 - b) In lengths exceeding 6 feet.
- E. RNC
 - 1. Solvent-weld RNC fittings and raceway couplings per the manufacturer's instructions and make all connections watertight. Use solvent of the same manufacturer as the raceway.
 - 2. Where installed exposed outdoors or other areas subject to temperature variations, install expansion fittings per NFPA 70, to accommodate thermal expansion in straight runs.
 - 3. RNC is only allowed to be used in the following locations:
 - a) Where specifically indicated.
 - 1) If an adopted code prevents use of RNC in a location where the contract documents specifically allows its use, contractor shall utilize other types of conduit allowed by the specification.
 - 2) Allowed does not mean required.
 - b) Underground, single and grouped, in lieu of GRS or IMC, when indicated.
 - 1) Direct buried
 - 2) Concrete-encased (use approved rigid PVC interlocking spacers, selected to provide minimum duct spacing and cover depths indicated while supporting ducts during concreting and backfilling; produced by the same manufacturer as the ducts).

3.03 RACEWAY FITTINGS:

- A. Compatible with raceways and suitable for use and location.
- B. RMC and IMC: Use threaded rigid steel conduit fittings, unless otherwise indicated.
- C. PVC Externally Coated, Rigid Steel Conduits: Use only fittings and installation tools approved by the manufacturer for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits. Replace all fittings and conduits that have any portion of the coating scraped off to bare metal, at no additional cost to the Owner.
- D. Join raceways with fittings designed and approved for that purpose and make joints tight.
- E. Use insulating bushings to protect conductors at raceway terminations:
 - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

3.04 WIREWAYS:

- A. Use flat head screws, clips and straps to fasten wireways to surfaces. Mount plumb and level.
- B. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
- C. Close ends of wireway and unused raceway openings.

3.05 BOXES:

- A. General
 - 1. Verify locations of device boxes prior to rough in.
 - 2. Set boxes at elevations to accommodate mounting heights as specified or indicated on the Drawings.
 - 3. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Adjust box locations to accommodate intended purpose.
 - 4. Install boxes to preserve fire ratings of walls, floors, and ceilings.
 - 5. Install flush wall-mounted boxes without damaging wall insulation or reducing its effectiveness.
 - 6. Support boxes independently of raceway.

- 7. Clean the interior of boxes to remove dust, debris, and other material. Clean exposed surfaces and restore finish.
- 8. Adjust flush-mounted boxes to make front edges flush with finished wall material.
- 9. Provide boxes of the depth required for the service, device and the application, and with raised covers set flush with the finished wall surface for boxes concealed in plaster finishes. Select covers with the proper openings for the devices being installed in the boxes. Install boxes flush unless otherwise indicated.
- 10. Install outlet boxes in firewalls complying with UL requirements, with box surface area not exceeding 16 square inches; and, when installed on opposite sides of the wall, separate by a distance of at least 24 inches.
- B. NEMA Enclosure ratings: Suitable for the environment in which it is installed. At a minimum, provide the following ratings:
 - 1. NEMA 250, type 3R
 - a) Provide at exterior locations
 - 2. NEMA 250, type 1
 - a) Provide at interior and dry locations
 - 3. NEMA 250 type 4 stainless steel
 - a) Provide at interior damp or wet locations
 - 4. NEMA 250 type 4X
 - a) Provide at interior locations subject to corrosion, including, but not limited to:
 - 1) Water Fountain equipment room.
- C. Outlet Boxes
 - 1. Locations of outlets on Drawings are approximate; and, except where dimensions are shown, determine exact dimensions for locations of outlets from plans, details, sections, or elevations on Drawings, or as directed by Contract Administrator. Locate outlets generally from column centers and finish wall lines or to centers or joints of wall or ceiling panels.
 - 2. Locate outlet boxes so they are not placed back-to-back in the same wall, and in metal stud walls, so they are separated by at least one stud space, to limit sound transmission from room to room. Install outlet boxes in accessible locations and do not install outlets above ducts or behind furring.
 - 3. Install all electrical devices, such as plug receptacles, lamp receptacles, light switches, and light fixtures in or on outlet boxes Use sheet-steel boxes for dry locations unless otherwise indicated or required.
 - 4. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
- 5. Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
- 6. Use cast aluminum boxes where aluminum rigid metal conduit is used.
- 7. Use suitable concrete type boxes where flush-mounted in concrete.
- 8. Use suitable masonry type boxes where flush-mounted in masonry walls.
- 9. Use raised covers suitable for the type of wall construction and device configuration where required.
- 10. Use shallow boxes where required by the type of wall construction.
- 11. Install extension and plaster rings as required by NFPA 70.
- 12. Carefully set outlet boxes concealed in non-plastered block walls so as to line up with wall joints. Coordinate the box and raceway installation with the wall construction as required for a flush and neat appearing installation. Outlet box extensions may be used where necessary.
- 13. Do not exceed allowable fill per NFPA 70.
- 14. Where multiple devices are shown grouped together, gang mount with a common cover plate.
- D. Junction and Pull Boxes
 - 1. Install junction and pull boxes above accessible ceilings and in unfinished areas.
 - 2. Provide boxes set flush in painted walls or ceilings with primer coated cover.
 - 3. Where junction and pull boxes are installed above an inaccessible ceiling, locate so as to be easily accessible from a ceiling access panel.
 - 4. Boxes for exterior use for individual raceway application shall be:
 - a) PVC with a UV-stabilized PVC cover sealed and gasketed watertight.
 - b) Cast aluminum with a cast aluminum cover sealed and gasketed watertight where used in pathway used for foot traffic.
 - c) Cast iron with cast iron cover sealed and gasketed watertight in vehicular traffic areas. Provide box and cover UL listed for use in vehicular traffic areas.
 - d) Install buried boxes so that box covers are flush with grade, unless indicated otherwise.
- E. Floor Boxes
 - 1. Use cast or coated steel floor boxes for installations in slab on grade. Unless otherwise indicated, formed steel boxes are acceptable for slabs above grade.
 - 2. Set metal floor boxes level and flush with finished floor surface.

3.06 CABINETS AND ENCLOSURES:

- A. Unless otherwise indicated on the Drawings, provide
 - 1. NEMA 1 construction for indoor, dry locations

- 2. NEMA 12 for indoor, damp and dusty locations
- 3. NEMA 3R for outdoor locations
- 4. NEMA 4X for indoor wet and corrosive locations
- B. Install flush mounted in the wall in finished spaces, with the top 78 inches above finished floor. The front shall be approximately 3/4-inch larger than the box all around.
- C. Install surface mounted in unfinished spaces, with the top 78 inches above finished floor. The front shall be the same height and width as the box.
- D. Electrically ground all metallic cabinets and enclosures. Where wiring to cabinet or enclosure includes a grounding conductor, provide a grounding lug in the interior of the cabinet or enclosure. Cabinets and enclosures specified in this Section are intended to house miscellaneous electrical components assembled in a custom arrangement, such as contactors and relays.
- E. All components that are specified or indicated for assembly in cabinets and enclosures shall each be individually UL listed and labeled. Arrange wiring so that it can be readily identified. Support wiring no less than every 3 inches. Install gauges, meters, pilot lights and controls on the face of the door.
- F. Do not provide cabinets and enclosures smaller than the sizes indicated. Where sizes and types are not indicated, provide cabinets and enclosures of the size, type and classes appropriate for the use and location per the guidelines of the NEC. Provide all items complete with covers and accessories required for the intended use.

3.07 IDENTIFICATION

- A. Refer to Division 26 Section "Identification for Electrical Systems" for identification materials.
- B. Raceway Identification:
 - 1. Conduit and raceways are to be color coded for ease of identification. Where a facility standard already exists, that shall be followed. Where no standard exists for color-coding, provide in accordance with table below.
 - a) Conduit shall be color-coded from the factory. Junction boxes, fittings, and connectors are not required to be painted to match.
 - b) As an alternative, submit deduct to omit use of factory-painted conduit. Tape or paint are to be used to identify conduits and junction boxes and/or fittings are to be painted in accordance with facility standard or color table.

Color Description
Blue
Red

Emergency Lighting conduit downstream of Battery Inverter	Orange
Generator Power Distribution Not Listed Above	Yellow

- 2. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size. Use the following means of identification:
 - a) Self-Adhesive Vinyl Labels
 - b) Snap-Around Labels
 - c) Snap-Around, Color-Coding Bands
 - d) Self-Adhesive Vinyl Tape
- 3. Color for Printed Legend:
 - a) Power Circuits: Black letters on an orange field.
 - b) Legend: Indicate system or service and voltage, if applicable
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identification device shall be:
 - 1. Self-adhesive vinyl label
 - 2. Snap around label
 - 3. Self-adhesive vinyl tape applied in bands.
- D. Accessible Raceways of Auxiliary Systems: Identify the following systems using the same identification device as other accessible raceways 600V or less, and with the indicated color scheme for each system:
 - 1. Fire Alarm System: Red.
 - 2. Fire-Suppression Supervisory and Control System: Red and yellow.
 - 3. Combined Fire Alarm and Security System: Red and blue.
 - 4. Security System: Blue and yellow.
 - 5. Mechanical and Electrical Supervisory System: Green and blue.
 - 6. Telecommunication System: Green and yellow.
 - 7. Control Wiring: Green and red.
- E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
- F. Junction Boxes and Pull Boxes:
 - 1. Junction box and pull box covers shall be spray painted to identify the voltage and system. Circuit numbers and the panel they originate from shall be listed on the cover using permanent, waterproof, black ink marker.

END OF SECTION

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

- A. This Section includes:
 - 1. Raceways, fittings, boxes and handholes for direct buried and concreteencased electrical distribution.

1.02 RELATED SECTIONS INCLUDE THE FOLLOWING:

- A. Division 26 Section "General Electrical Requirements" for general requirements and related documents that apply to this Section.
- B. Division 26 Section "Common Work Results for Electrical" for limited scope general construction materials and methods.
- C. Division 26 Section "Grounding and bonding"
- D. Division 26 Section "Identification for Electrical Systems"

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Product data for the following products:
 - a) Raceways, Raceway fittings, separators, duct-bank materials, handholes, boxes, solvent cement, warning tape and warning planks.
- B. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Accurately record actual routing of all exterior buried raceway including coordination with other surrounding utilities and underground structures. Provide scaled plans and sections that Indicate dimensions from finished grade or other fixed structural elements.

1.04 DEFINITIONS

- A. Terminology used in this specification is as defined below:
 - 1. GRS: Galvanized Rigid Steel Conduit
 - 2. RMC: Rigid Metal Conduit
 - 3. RNC: Rigid Nonmetallic Conduit

1.05 QUALITY ASSURANCE

- A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.
- B. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to AHJ.
 - 2. Marked for intended use.
- C. Comply with NFPA 70 and ANSI C2.
- D. Test and inspect pre-cast concrete utility structures according to ASTM C 1037.
- E. Non-concrete Handhold and Pull-Box Prototype Test: Test prototypes of 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 a independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the 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.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to project site with ends capped and store nonmetallic ducts with supports to prevent bending, warping, and deformation.
- B. Store pre-cast and other factory –fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings, if present, are visible.
- C. Lift and support pre-cast concrete units only at designated lifting or supporting points.

1.07 COORDINATION

- A. Coordinate layout and installation of ducts, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field

conditions and to ensure that duct runs drain to handholes, and as approved by the Architect.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
- B. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 RACEWAYS AND FITTINGS

- A. Metal Conduit
 - 1. Available Manufacturers:
 - a) AFC Cable Systems, Inc.
 - b) Alflex Corporation, a Southwire Company
 - c) Anamet Electrical, Inc.; Anaconda Metal Hose.
 - d) Electri-Flex Co.
 - e) Indalex
 - f) Manhattan/CDT/Cole-Flex
 - g) O-Z/Gedney; Unit of General Signal (Fittings)
 - h) Republic Raceway
 - i) Tyco International; Allied Tube & Conduit Div.
 - j) Wheatland Tube Co.
 - 2. RMC:
 - a) GRS: Hot-dip galvanized: ANSI C80.1, UL 6
 - 3. Plastic-Coated GRS and Fittings: NEMA RN 1, UL-listed. Coating thickness of 0.40 inches (1 mm), minimum.
 - 4. Fittings: NEMA FB 1; compatible with raceway and tubing materials.
- B. Nonmetallic Raceway
 - 1. Available Manufacturers:
 - a) AFC Cable Systems, Inc. (Tubing)
 - b) American International.
 - c) Anamet Electrical, Inc.; Anaconda Metal Hose.
 - d) Arnco Corp.
 - e) Cantex Inc.

- f) Certainteed Corp.; Pipe & Plastics Group.
- g) Condux International.
- h) ElecSYS, Inc.
- i) Electri-Flex Co.
- j) Lamson & Sessions; Carlon Electrical Products.
- k) Manhattan/CDT/Cole-Flex.
- 1) RACO; Division of Hubbell, Inc.
- m) Spiralduct, Inc./AFC Cable Systems, Inc.
- n) Superflex Ltd.
- o) Thomas & Betts Corporation.
- 2. RNC: Schedule 40 (type EPC-40-PVC) and 80 (type EPC-80-PVC) PVC: NEMA TC 2, UL 651.
 - a) a. Fittings: match to raceway type and material: NEMA TC 3, NEMA TC 6, UL 651, as applicable.

C. DUCT ACCESSORIES

- 1. Duct Separators shall be factory-fabricated rigid interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
- 2. Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
- 3. Concrete warning planks shall be nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
 - a) Color: Red dye added to concrete during batching.
 - b) Labeling: Mark each plank with "ELECTRICAL" in 2-inch high, 3/8-inch deep letters.

2.03 PRE-CAST CONCRETE HANDHOLES AND BOXES

- A. General
 - 1. Available Manufacturers:
 - a) Carder Concrete Products.
 - b) Christy Concrete Products
 - c) Elmhurst-Chicago Stone Co.
 - d) Oldcastle Pre-cast Group
 - e) Riverton Concrete Products; a division of Cretex Companies, Inc.
 - f) Utility Concrete Products, LLC
 - g) Utility Vault Co.
 - h) Wausau Title, Inc.
- B. Comply with ASTM C858 for design and manufacturing process.

- C. Pre-cast concrete handholes and boxes shall be factory-fabricated, reinforcedconcrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of the handhole or box.
 - 1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - 2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - 3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a) Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b) Cover Handle: Recessed.
 - 4. Frame and Cover: Weatherproof aluminum frame, with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a) Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b) Cover Handle: Recessed.
 - 5. The cover finish shall be a nonskid finish with a minimum coefficient of friction of 0.50.
 - 6. The cover shall have the following legend lettering molded into the cover:
 - a) "COMMUNICATIONS"
 - b) "CONTROLS"
 - c) "ELECTRICAL"
 - d) "LIGHTING"
 - 7. Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
 - 8. Extensions and slabs shall be designed to mate with bottom of enclosure and shall be same material as enclosure.
 - a) Extension shall provide increased depth of 12 inches
 - b) Slab shall be same dimensions as bottom of enclosure, and arranged to provide closure.
 - 9. Duct entrances into handhole walls shall have cast end-bell or ductterminating fittings in the wall for each entering duct.
 - a) Type and size shall match fittings to duct or conduit to be terminated.
 - b) Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
 - 10. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.04 HANDHOLES AND BOXES OTHER THAN PRE-CAST CONCRETE

A. General

- 1. Description: Comply with SCTE 77.
- 2. Color of Frame and Cover: Gray where installed in concrete or other paved area; Green where installed in grass area.
- 3. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
- 4. Load Ratings:
 - a) Boxes and covers installed in sidewalks and other areas not subject to normal vehicular traffic shall be rated for a design load of 8,000 lbs. minimum.
 - b) Boxes and covers installed in driveways, parking lots, and other offroadway applications shall be rated for a design load of 15,000 lbs. minimum.
 - c) Boxes and covers installed in roadways and other high vehicular traffic areas shall be rated for a design load of 28,800 lbs.
- 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 7. Cover Legend: Molded lettering, applicable logo from the following:
 - a) "COMMUNICATIONS"
 - b) "CONTROLS"
 - c) "ELECTRICAL"
 - d) "LIGHTING"
- 8. Duct Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 9. Handholes 12 inches wide by 24 inches long and larger shall have factoryinstalled inserts for cable racks and pulling-in irons.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a) Armorcast Products Company.
 - b) Carson Industries LLC.
 - c) CDR Systems Corporation.
 - d) NewBasis.
 - e) Strongwell

- C. Fiberglass Handholes and Boxes with Polymer-Concrete frame and cover: Sheetmolded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a) Armorcast Products Company.
 - b) Carson Industries LLC.
 - c) Christy Concrete Products.
 - d) Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

PART 3 - EXECUTION

3.01 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600 volts and Less: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.
- B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40 PVC, in directburied duct bank, unless otherwise indicated.
- C. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: Refer to division 27 specifications
- D. Underground Ducts Crossing Paved Paths and Driveways RNC, NEMA Type EPC-40 PVC, encased in reinforced concrete.

3.02 UNDERGROUND ENCLOSURE INSTALLATION

- A. Handholes and Boxes for 600 volts and Less:
 - 1. Units in roadways, driveways and Other Deliberate Traffic Paths: Pre-cast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Parking Lot, and Off-Roadway paved Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Pre-cast Concrete, AASHTO HB 17, H-20 structural load rating.
 - 3. Units in Sidewalk, Plaza and Similar Applications with a Safety Factor for Non-deliberate loading by Vehicles:
 - a) Pre-cast Concrete, AASHTO HB 17, H-10 structural load rating
 - b) Polymer Concrete Units, SCTE 77, Tier 8 structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic in un-paved locations Only: Fiberglass-reinforced Polyester resin structurally tested according to SCTE 77 with 3000-lbf vertical loading.

3.03 EARTHWORK

- A. Excavation and Backfilling: Comply with Division 31 Section "Earth Moving" but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling and compaction is complete.
- C. 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 Division 32 Sections "Turf and Grasses and "Plants"
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.04 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope ducts from a high point in runs between two handholes to drain in both directions.
- B. 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.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
- D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10-inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell with out reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to handhole.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- E. Building Wall Penetrations: Sleeve all wall penetrations. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."

- F. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- G. Pulling Cord: Install 100-lbf test nylon cord in ducts, including spares.
- H. Concrete-Encased Ducts: Support ducts on duct separators.
 - 1. Separator installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and ducts to prevent floating during concreting. Stagger separators approximately 6-inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around the ducts or duct group.
 - 2. Concreting Sequence: Pour each run of envelope between other terminations in one continuous operation.
 - a) Start at one end finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to the manufacturer's written recommendations, 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 18-inches into concrete on both sides of joint near corners of envelope.
 - 3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
 - 4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - 5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured with out soil inclusions; otherwise, use forms.
 - 6. Minimum Space between Ducts: 3-inches between ducts and exterior envelope wall, 2-inches between ducts for like services, and 4-inches between power and signal ducts.
 - 7. Depth: Install top of duct bank 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 of vehicles, unless otherwise indicated.
 - 8. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

- a) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3-inches of concrete.
- b) Stub-ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60-inches from edge of base. Install insulated grounding bushings on terminations at equipment.
- 9. Warning Tape: Bury warning tape approximately 12 inches above all concrete–encased ducts and duct banks. Align tape parallel to and within 3-inches of the 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.
- I. Direct-Buried Duct Banks:
 - 1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6-inches between tiers.
 - 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6-inches in nominal diameter.
 - 4. Install backfill as specified in Division 31 Section "Earth Moving."
 - 5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4-inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
 - 6. Install ducts with a minimum of 3-inches between ducts for like services and 6-inches between power and signal ducts.
 - 7. Depth: Install top of duct bank at least 36-inches below finished grade, unless otherwise indicated.
 - 8. Set elevation of bottom of duct bank below the frost line.
 - 9. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3-inches of concrete.
 - b) For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60-inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Warning Planks: Bury warning planks approximately 12 inches above all direct-buried ducts an duct banks placing them 24-inches 0.c.. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18-inches. Space additional planks 12-inches apart, horizontally.

3.05 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

- A. Precast Concrete Handhole Installation:
 - 1. Comply with ASTM C891, unless otherwise indicated.
 - 2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 - 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- B. Elevations:
 - 1. Install handholes with bottom below the frost line, 24-inches below grade.
 - 2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1-inch above grade.
 - 3. Where indicated, cast handhole cover frame integrally with handhole structure.
- C. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section for waterproofing. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars.
- D. Dampproofing: Apply dampproofing to exterior surfaces of handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing"." After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars.
- E. Hardware: Install removable hardware, including pulling eye, cable stanchions, and cable arms, as required for installation and support of cable and conductors and as indicated.
- F. Field-Installed Bolting Anchors in Concrete Handholes: Do not drill deeper than 2inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.06 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRE-CAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below the frost line, 24-inches below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000psi, 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: Extend concrete 6-inches past enclosure opening and 12-inches deep

3.07 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.08 INSTALLATION ACCEPTANCE

A. Prior to final acceptance of the duct bank and associated structures, pull an aluminum of wood test mandrel through the duct to prove joint integrity and to verify ducts have not been deformed. Provide mandrel equal to 80 percent fill of

the duct. Test duct bank and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems." Correct any deficiencies and retest as specified above. Clean internal surfaces of handholes and remove foreign materials.

END OF SECTION

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IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes the following:
 - 1. Nameplates.
 - 2. Labels for raceways and metal-clad cable.
 - 3. Labels for junction boxes and pull boxes.
 - 4. Labels for wiring devices and lighting control devices.
 - 5. Markers for conductors, and control cables.
 - 6. Tags.
 - 7. Underground-line warning tape.
 - 8. Warning labels and signs.
 - 9. Arc Flash Warning Labels.
 - 10. Instruction signs.
 - 11. Miscellaneous identification products.
 - 12. Painted Identification.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Where a facility identification standard already exists, that standard shall be continued. Where an identification standard does not exist, color-coding and identification shall be as described herein.
- B. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- C. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- D. Coordinate installation of identifying devices with location of access panels and doors.
- E. Install identifying devices before installing acoustical ceilings and similar concealment.

1.03 SUBMITTALS

Product Data: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements" for each electrical identification product indicated:

- 1. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- 2. For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.04 QUALITY ASSURANCE

- A. Electrical Equipment, Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, by an NRTL as defined by OSHA in 29 CFR 1910.7 and that are acceptable to authorities having jurisdiction.
 - 2. Marked for intended use.
- B. Comply with ANSI A13.1 and ANSI C2.
- C. Comply with requirements of NFPA 70.
- D. Comply with 29 CFR 1910.145.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL

A. Location, text, and method of identification to be used is noted in individual sections. Refer to other sections for additional identification requirements.

2.02 NAMEPLATES

- A. Comply with UL RP 9691, Recommended Practice for Nameplates for Use in Electrical Installations.
- B. Engraved, Laminated Acrylic or Melamine Label: Non-conductive phenolic with beveled edges.
 - 1. Adhesive backed.
 - 2. Minimum 1/16 inch (1.6 mm) thick for nameplates with both dimension 4 inches (102 mm) or less and 1/8 inch (3.2 mm) thick for larger sizes.
- C. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laseretched text.
- D. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text
- E. Text: Minimum text height shall be 1/8 inch (3.2 mm) unless otherwise required by local jurisdiction or owner standards. For elevated components, increase sizes of labels and letters to those appropriate for viewing from the floor.

- F. Colors:
 - 1. Normal systems white letters on a black background.
 - 2. Generator systems white letters on a red background.
- G. Label Requirements:
 - 1. Service Equipment Label

LINE 1: NOMINAL VOLTAGE AND FREQUENCY IN HERTZ LINE 2: SERVICE EQUIPMENT BUS RATING IN AMPS LINE 3: SCCR OF SERVICE EQUIPMENT IN AMPS LINE 4: MAXIMUM AVAILABLE FAULT CURRENT IN AMPS LINE 5: DATE CALCULATED

EXAMPLE:



2. Panelboard/Switchboard Label:

LINE 1: PANELBOARD/SWITCHBOARD DESIGNATION LINE 2: VOLTAGE, PHASE, WIRES, AMPS LINE 3: FED FROM "

EXAMPLES:



3. Transformer Label:

LINE 1: TRANSFORMER DESIGNATION LINE 2: FED FROM "" LINE 3: SUPPLIES ""

EXAMPLE:



4. Disconnect Switch Label:

LINE 1: DESIGNATION OF EQUIPMENT SERVED BY DISCONNECT LINE 2: VOLTAGE, PHASE, WIRES, AMPS LINE 3: FED FROM " "

EXAMPLES:

WATER HEATER WH1

260553-3

480V, 3PH, 3W, 100A FED FROM MDB

2.03 LABELS FOR RACEWAYS AND METAL-CLAD CABLE

- A. Factory Painted Raceways:
 - 1. Metal Raceways: Continuous, rust-inhibiting paint factory applied.
 - 2. Non-Metallic Raceways: Factory dyed or colored PVC sleeve.
- B. Factory Painted Metal-Clad Cable: 2-inch wide, factory painted bands at a maximum of 6-foot on center spacing.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.04 LABELS FOR JUNCTION BOXES AND PULL BOXES

A. Junction box and pull box covers shall be spray painted to identify the voltage and system. Circuit numbers and the panel they originate from shall be listed on the cover using permanent, waterproof, black ink marker.

2.05 LABELS FOR WIRING DEVICES AND LIGHTING CONTROL DEVICES

- A. Self-laminating Computer Printable Labels: Clear over-laminate to protect legend for permanent, clean identification. Self-laminating Polyester material with clear print-on area.
- B. Engraved cover plates: Provide with white letters. White or ivory cover plates shall have black letters.

2.06 MARKERS FOR CONDUCTOR AND CONTROL CABLES

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Self-laminating Computer Printable Labels: Clear over-laminate to protect legend for permanent, clean identification. Self-laminating Polyester material with white print-on area.
- D. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- (0.35-mm-) thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking nylon tie fastener.

2.07 TAGS

- A. Write-On Tags: Polyester tag, .015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.08 UNDERGROUND-LINE WARNING TAPE

- A. Materials: Use foil-backed detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- B. Foil-backed Detectable Type Tape: 6 inches (152 mm) wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
- C. Legend: Type of service, continuously repeated over full length of tape.
- D. Color: Tape for Buried Power Lines: Black text on red background.

2.09 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145. Attachment method shall be acceptable to the manufacturers of the equipment to which the nameplates are being applied and shall not compromise any NRTL listing or labeling criteria.
- B. Self-Adhesive Warning Labels: Factory pre-printed or machine-printed multicolor self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
 - 1. Use thermal transfer process printing machines and accessories recommended by label manufacturer.

- 2. Do not use labels designed to be completed using handwritten text.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 1. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
 - 1. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign 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 (208 Volts): "WARNING OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
 - 3. Workspace Clearance Warning (480 Volts): "WARNING OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (915 MM)."

2.010 ARC FLASH WARNING LABELS

- A. General: All labels will be based on recommended overcurrent device settings and will be printed after the results of the analysis have been presented and after any system changes, upgrades, or modifications have been incorporated in the system. Refer to Division 26 section "Overcurrent Protective Device Study" for additional requirements.
- B. Materials: Use machine-printed, high adhesion, polyester label; UV, chemical, water, heat, and abrasion resistant, for each work location analyzed.
- C. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer. Labels shall be machine printed, with no field markings. Provide warning labels complying with ANSI Z535.4 to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.
- D. Minimum Size: 3.5 inch by 5 inch (89 mm by 127 mm), unless otherwise noted by Owner.
- E. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment. The label shall include the following information, at a minimum:

- 1. Location designation
- 2. Nominal voltage
- 3. Available fault current
- 4. Limited approach boundary
- 5. Arc flash boundary
- 6. Restricted approach boundary
- 7. Hazard risk category
- 8. Incident energy
- 9. Working distance
- 10. Site-specific PPE (personnel protective equipment) requirements.
- 11. Date calculations were performed.
- 12. Engineering report number, revision number and issue date.

2.011 INSTRUCTION SIGNS

- A. Engraved, Laminated Acrylic or Melamine plastic: Non-conductive phenolic. Unless indicated otherwise, provide with minimum 3/8-inch- (10-mm-) high letters. For elevated components, increase sizes of labels and letters to those appropriate for viewing from the floor.
 - 1. Minimum 1/16 inch (1.6 mm) thick for nameplates with either dimension greater than 4 inches (102 mm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
 - 4. Normal systems: Engraved legend with white letters on black face.
 - 5. Generator Systems: Engraved legend with white letters on red face.
- B. Colors:
 - 1. General Information and Operating Instructions Black letters on white background.
 - 2. Normal systems white letters on a black background.
 - 3. Generator systems white letters on a red background.

2.012 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength: 50 lb (22.6 kg), minimum.
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black, except where used for color-coding.
- B. Fasteners for Nameplates, Labels and Signs

- 1. Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat lock washers unless otherwise noted.
- C. Floor Marking Tape for Equipment Working Clearance Identification: Selfadhesive vinyl or polyester tape with overlaminate, 3 inches wide, with alternating black and white stripes.
- D. Painted identification. Paint materials and application requirements are specified in Division 09 painting Sections.
 - 1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
 - a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior concrete and masonry primer.
 - 2) Finish Coats: Exterior semi-gloss acrylic enamel.
 - 2. Exterior Concrete Unit Masonry:
 - a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Exterior semi-gloss acrylic enamel.
 - 3. Exterior Ferrous Metal:
 - a) Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior ferrous-metal primer.
 - 2) Finish Coats: Exterior semi-gloss alkyd enamel.
 - 4. Exterior Zinc-Coated Metal (Except Raceways):
 - a) Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior zinc-coated metal primer.
 - 2) Finish Coats: Exterior semi-gloss alkyd enamel.
 - 5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
 - a) Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Interior concrete and masonry primer.
 - 2) Finish Coats: Interior semi-gloss alkyd enamel.
 - 6. Interior Concrete Unit Masonry:
 - a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Interior semi-gloss acrylic enamel.
 - 7. Interior Gypsum Board:

- a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Interior gypsum board primer.
 - 2) Finish Coats: Interior semi-gloss acrylic enamel.
- 8. Interior Ferrous Metal:
 - a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Interior ferrous-metal primer.
 - 2) Finish Coats: Interior semi-gloss acrylic enamel.
- 9. Interior Zinc-Coated Metal (Except Raceways):
 - a) Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Interior zinc-coated metal primer.
 - 2) Finish Coats: Interior semi-gloss acrylic enamel.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Verify identity of each item before installing identification products.
- B. Do not install adhesive products when ambient temperature is lower or higher than recommended by manufacturer.
- C. Provide identification product listed for the location in which it is to be installed.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Painted Identification: Prepare surface and apply paint according to Division 09 painting sections.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. For surfaces that require finish work, apply identification devices after completing finish work. Do not install identification products until final surface finishes and painting are complete.
- C. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed. Replace labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

- D. Location: Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance without interference with operation and maintenance of equipment. Unless otherwise indicated, locate products as follows:
 - 1. Surface-Mounted Equipment: Enclosure front.
 - 2. Flush-Mounted Equipment: Inside of equipment door.
 - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 - 4. Elevated Equipment: Legible from the floor or working platform.
 - 5. Branch Devices: Adjacent to device.
 - 6. Interior Components: Legible from the point of access.
 - 7. Conduits: Legible from the floor.
 - 8. Boxes: Outside face of cover.
 - 9. Conductors and Cables: Legible from the point of access.
 - 10. Devices: Outside face of cover.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
 - 1. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
- G. Equipment Nameplates and Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual.
 - 1. Indoor Clean, Dry Locations: Use plastic nameplates, unless noted otherwise.
 - 2. Outdoor Locations: Use stainless steel, or aluminum nameplates suitable for exterior use.
- H. Install identification products centered, level, and parallel with lines of item being identified.
- I. Mark all handwritten text, where permitted, to be neat and legible.
- J. For refrigeration systems: Neatly bundle circuits and clearly tag and label each circuit with panelboard, branch circuit designation and refrigeration system number at each termination.

END OF SECTION

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes computer-based studies for the following:
 - 1. Short-circuit analysis.
 - 2. Protective device coordination study.
 - 3. Arc flash and shock risk assessment, including arc flash hazard labels.
- B. Criteria for selection and adjustment of equipment and associated protective devices not specified in this section, as determined by the studies performed.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. The AIC ratings indicated on the Drawings are preliminary and will be finalized based on the results of the short-circuit study. Device ratings for furnished equipment shall be as required by the results of the short-circuit study at no additional cost.
- B. Coordination:
 - 1. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
 - 2. Notify Contract Administrator of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- C. Sequencing:
 - 1. Initial Study:
 - a) Study must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. Do not order equipment until matching study reports and product submittals have both been evaluated by the Contract Administrator.
 - b) If study has not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the Contractor at no additional cost to the project.
 - 2. Final Study:
 - a) Study must be completed and submitted for review prior to substantial completion. Do not print arc flash labels until final study has been evaluated by the Contract Administrator.

- b) Verify naming convention for equipment identification prior to creation of final drawings, reports, and arc flash hazard warning labels.
- D. Scheduling:
 - 1. Arrange access to existing facility for data collection with Owner.
 - 2. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner. Refer to Division 26 section "General Electrical Requirements" for additional requirements.

1.03 SUBMITTALS

- A. Product Data: In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.
 - 1. Product data for computer software program to be used for studies.
 - 2. Include characteristic time-current trip curves for protective devices.
 - 3. Include impedance data for engine generators.
 - 4. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 - 5. Include documentation of listed series ratings upon request.
 - 6. Identify modifications made in accordance with studies to meet the results of the study.
- B. Product Certificates: For coordination-study and short-circuit-study computer software programs, certifying compliance with IEEE 399.
- C. Qualification Data:
 - 1. Study Preparer Specialist qualifications.
 - 2. Field Testing Agency qualifications.
- D. Arc Flash Hazard Warning Label Samples: One of each type and legend specified.
- E. Other Action Submittals:
 - 1. Initial Study report, stamped or sealed and signed by study preparer, including:
 - a) Cover page including date of study, study methodology, assumptions made and software products used.
 - b) Study input data, including completed computer program input data sheets.
 - c) Short-circuit study report.
 - d) Equipment evaluation report.
 - e) Coordination-study report.
 - f) Settings report.

- 2. Final Study report, stamped or sealed and signed by study preparer, including:
 - a) Cover page including date of study, study methodology, assumptions made, software products used, and summary of changes between initial and final studies.
 - b) Study input data, including completed computer program input data sheets.
 - Short circuit study report. c)
 - Equipment evaluation report. d)
 - Coordination-study report. e)
 - Settings report. f)
 - Arc-Flash Hazard Analysis, including labels. **g**)
- 3. Certification that field adjustable protective devices have been set in accordance with requirements of studies.
- F. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":
 - 1. Accurately record on the One-Line Diagram actual ratings and settings for all overcurrent devices, both adjustable and non-adjustable, including all changes made during construction, due to the study, or both.
 - Include computer software files used to prepare studies with file name(s) 2. cross-referenced to specific pieces of equipment and systems.
 - Include copies of previous studies and existing drawings that were obtained 3. during the data collection phase of the study.

1.04 **QUALITY ASSURANCE**

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B. Study Preparer Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - Professional engineer, licensed in the state in which the Project is located, 1. shall be responsible for the study and with a minimum five years experience in the preparation of studies of similar type and complexity using the specified computer software. All elements of the study shall be performed under the direct supervision and control of engineer.

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- C. Comply with IEEE 399 for general study procedures.
- Comply with IEEE 141, 242 and 551 for short-circuit currents and coordination D. time intervals.

- E. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard calculations.
- F. Studies shall include coordination of series-rated devices where series rating is specified in other sections and where indicated on Drawings.
- G. Field Testing Agency Qualifications: Independent testing organization specializing in testing, analysis, and maintenance of electrical systems with minimum five years experience; NETA Accredited Company.
 - 1. Field Supervisor: Certified electrical testing technician; NETA ETT Level III.

PART 2 - PRODUCTS AND MATERIALS

2.01 COMPUTER SOFTWARE DEVELOPERS

- A. Computer Software Developers: Subject to compliance with requirements, use the latest commercially available computer software programs utilizing the specified methodologies developed by one of the following:
 - 1. CYME International, Inc.
 - 2. EDSA Micro Corporation.
 - 3. Electrical Systems Analysis, Inc.
 - 4. SKM Systems Analysis, Inc.
 - 5. Operation Technology, Inc.

2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399.
- B. Analytical features of short-circuit-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.
- C. Computer software program shall be capable of plotting and diagramming timecurrent-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.
 - 1. Zero-Sequence current.
 - 2. Arcing faults.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

- B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.
- C. Short-circuit study and coordination study to be performed prior to the final submittals for any piece of electrical equipment which has an AIC rating or an overcurrent protective device so that correct equipment gets ordered for the project conditions.
- D. Arc Flash Study must be performed after conductors and equipment have been installed and after the project's utility company confirms the available fault current. A final short-circuit and coordination study with all device settings shall be submitted with the Arc Flash Study. The goal of the revised settings is to minimize the arc flash hazard while maintaining reasonable coordination and selectivity. For the components of emergency and legally required standby system components, full selectivity must be maintained.

3.02 SYSTEM COMPONENTS TO BE INCLUDED IN STUDIES

- A. Study shall begin with the utility and each alternate power source overcurrent device(s) serving the Project and end at the last branch circuit overcurrent protective device. This includes studies of the complete paths and operating modes on both sides of any transfer switch, contactor or circuit breaker.
- B. Operating modes shall include, where applicable:
 - 1. Utility as a source.
 - 2. Generator as a source.
 - 3. Maintenance settings.
- C. Components include, but are not limited to:
 - 1. Switchgear
 - 2. Switchboards
 - 3. Distribution Panelboards
 - 4. Panelboards
 - 5. Chiller Controllers
 - 6. Pump VFDs
 - 7. Air Handling Equipment
 - 8. Roof Top HVAC equipment
 - 9. Elevator controllers

3.03 POWER SYSTEM DATA FOR STUDIES

A. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling. Gather and tabulate the following input data to support studies:

- 1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
- 2. Impedance of utility service entrance.
- 3. Electrical distribution system diagram showing the following:
 - a) Indicate load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
 - b) Protective Devices: Include circuit-breaker and fuse-current ratings and types;
 - c) Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
 - d) Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio. kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
 - e) Generators: Include manufacturer/model, kilovolt amperes, size, voltage, and source impedance.
 - f) Cables: Indicate conduit material, sizes of conductors, conductor insulation, and length.
 - g) Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.
- 4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:
 - a) Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b) Magnetic inrush current overload capabilities of transformers.
 - c) Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d) Ratings, types, and settings of utility company's overcurrent protective devices.
 - e) Special overcurrent protective device settings or types stipulated by utility company.
 - f) Protective Devices:
 - 1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
 - Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).

- g) Time-current-characteristic curves of devices indicated to be coordinated.
- h) Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
- i) Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
- j) Panelboards, switchboards, motor-control center ampacity, and interrupting ratings in amperes rms symmetrical.
- 5. Existing Installations:
 - a) Provide the services of field testing agency or equipment manufacturer's representative to perform field data collection.
 - b) Collect data on existing electrical distribution system necessary for completion of studies, including field verification of available existing data (e.g. construction documents, previous studies). Include actual settings for field-adjustable devices.

3.04 SHORT-CIRCUIT STUDY

- A. Source Impedance: Utility company's fault current contribution as indicated.
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operation modes that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Comply with IEEE 241 recommendations for fault currents and time intervals.
- E. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:
 - 1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
 - 2. Low-Voltage Fuses: IEEE C37.46.
 - 3. Circuit Breakers: IEEE C37.13.
- F. Study Report:
 - 1. Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report.

- 2. List other output values from computer analysis, including momentary (1/2cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.
- G. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing short-circuit current ratings of these devices with calculated short-circuit current momentary and interrupting duties. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.

3.05 COORDINATION STUDY

- A. Perform coordination study and prepare a written report using the results of the short-circuit study and approved computer software program. Comply with IEEE 399.
- B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.
- C. Comply with IEEE 241 recommendations for fault currents and time intervals.
- D. Analyze alternate scenarios considering known operating modes.
- E. Transformer Primary Overcurrent Protective Devices:
 - 1. Device shall not operate in response to the following:
 - a) Inrush current when first energized.
 - b) Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c) Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.
- F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.
- G. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
 - 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a) Device tag.
 - b) Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.

- c) Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
- d) Fuse-current rating and type.
- e) Ground-fault relay-pickup and time-delay settings.
- 2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve the level of selective coordination required in the contract documents or by the edition of the National Electrical Code (including any local jurisdiction amendments) the project must comply with. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:
 - a) For protective Devices:
 - 1) Device tags.
 - 2) Circuit Breakers: Include long time pickup and delay, short time pickup and delay, and instantaneous pickup.
 - 3) Protective Relays: Include current/potential transformer ratios, tap, time dial, and instantaneous pickup.
 - 4) Include ground fault pickup and delay.
 - 5) Include fuse ratings.
 - b) Voltage and current ratio for curves.
 - c) Three-phase and single-phase damage points for each transformer.
 - d) No damage, melting, and clearing curves for fuses.
 - e) Cable damage curves.
 - f) Generator full load current, overload curves, decrement curves and short-circuit withstand points.
 - g) Transformer inrush points.
 - h) Maximum fault current cutoff point.
 - i) Capacitor full load current and damage curves.
- 3. Include conclusions and recommendations.
- 4. Completed data sheets for setting of overcurrent protective devices.
- 5. Power systems must selectively coordinate to the values indicated below unless local amendments to the National Electrical Code require a different value.
 - a) Elevator Systems (NEC article 620) 0.01 seconds

3.06 ARC-FLASH HAZARD ANALYSIS

A. Determine arc-flash incident energy levels and flash protection boundary distances based on the results of the Short-Circuit and Coordination studies in accordance with IEEE 1584. Perform the analysis under worst-case arc-flash conditions for all modes of operation.
- B. In addition to the requirements outlined in IEEE 1584, the study shall include all equipment rated less than 240 Volts fed by transformers less than 125 kVA in the calculations.
 - 1. Where reasonable, study preparer may assume a maximum clearing time of two seconds in accordance with IEEE 1584, provided that the conditions are such that a worker's egress from an arc flash event would not be inhibited.
 - 2. For single-phase systems, the calculations may be performed assuming a three-phase system in accordance with IEEE 1584, yielding conservative results.
- C. For equipment with main devices mounted in separate compartmentalized sections, perform calculations on both the line and load side of the main device.
- D. Identify all locations and equipment to be included in the arc-flash hazard analysis:
 - 1. Include a copy of the facility one-line in the report.
 - 2. Identify the possible system operating modes including tie-breaker positions, and parallel generation.
 - 3. Calculate the arcing fault current flowing through each branch for each fault location.
 - 4. Determine the time required to clear the arcing fault current using the protective device settings and associated trip curves.
 - 5. Select the working distances based on system voltage and equipment class.
 - 6. Calculate the incident energy at each fault location at the prescribed working distance.
 - 7. Determine the hazard/risk category (HRC) for the estimated incident energy.
 - 8. Calculate the flash protection boundary at each fault location.
 - 9. Document the assessment in reports and one-line diagrams.
 - 10. Provide labels to be placed on each piece of equipment analyzed. Label shall show the calculated incident energy and hazard/risk category for the calculated incident energy.
- E. Results of the arc-flash study shall be summarized in a final report containing the following:
 - 1. Basis, method of hazard assessment, description, purpose, scope, and date of the study.
 - 2. Tabulations of the data used to model the system components and a corresponding one-line diagram.
 - 3. Descriptions of the modes of operation evaluated and identification of the worst case scenario used to evaluate equipment ratings.
 - 4. Tabulations of equipment incident energies, hazard risk categories, and flash protection boundaries. The tabulation shall identify and clearly note equipment that exceeds allowable incident energy ratings.
 - 5. Required arc-flash labeling and placement of labels.

6. Conclusions and recommendations, including recommendations for reducing incident energy at locations where calculated maximum incident energy exceeds 8 calories per sq cm.

3.07 OVERCURRENT PROTECTIVE DEVICE SETTING

- A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.
 - 1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:
 - a) Verify that overcurrent protective devices meet parameters used in studies.
 - b) Adjust devices to values listed in final study results.
 - c) Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 100.7 and 100.8 in NETA ATS.

3.08 INSTALLATION

A. Install arc flash warning labels. Refer to Division 26 section Identification for Electrical Systems for additional requirements.

3.09 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Inspect and test protective devices in accordance with the NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Overcurrent protection devices will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies protective device settings have been adjusted in accordance with the requirements of the study. Include notation of conflicts with or deviations made from the studies or the contract documents, deficiencies detected, remedial action taken, and observations after remedial action.

3.010 TRAINING

- A. Provide training for Owner's personnel on electrical safety pertaining to arc flash and shock hazards.
- B. Use site-specific arc flash and shock risk assessment report as training reference, supplemented with additional training materials as required.
- C. Provide minimum of eight hours of training performed by a representative of the entity performing the study.

END OF SECTION

PART 1 - GENERAL

1.01 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. These requirements shall be in addition to applicable Division 01, 22 and 23 Sections.
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning activities and requirements
 - 2. Division 22 Section "Commissioning of Plumbing Systems" for commissioning process activities for plumbing equipment, sub-systems, and systems.
 - 3. Division 23 Section "Commissioning of HVAC Systems" for commissioning process activities for HVAC equipment, sub-systems, and systems.

1.2 SUMMARY

- A. Commissioning is the process of ensuring that building systems operate as intended through their life cycle as defined in the Contract Documents.
- B. Commissioning during the construction phases is intended to achieve the following objectives according to the Contract Documents:
 - 1. Verify that applicable systems and equipment are installed according to the manufacturer's recommendations and to industry accepted minimum standards.
 - 2. Verify that applicable equipment receives adequate operational checkout by installing contractors.
 - 3. Verify and document proper performance of systems and equipment.
 - 4. Verify that O&M documentation provided to the Owner is complete.
 - 5. Verify that the Owner's operating personnel are adequately trained.
- C. General commissioning requirements and coordination are detailed in Division 01. Division 26 shall execute all commissioning responsibilities assigned to them in the Contract Documents and include the cost of commissioning in the Contract Sum.

1.3 ABBREVIATIONS & DEFINITIONS

A. Refer to Division 01 Section 019113 "General Commissioning Requirements" for abbreviations and definitions.

1.4 COMMISSIONING TEAM

A. Refer to Division 01 Section 019113 "General Commissioning Requirements" for the commissioning team members and responsibilities anticipated for this project.

1.5 COMMISSIONING DOCUMENTATION

- A. The responsible Sub-Contractor(s) shall provide the following information to the CA for inclusion in the commissioning final report:
 - 1. Copies of completed Plan and Documentation Requirements for Start-up and Initial Checkout (as applicable).
 - 2. Copies of completed Commissioning Corrective Action Reports.
 - 3. Building operations and maintenance information documents shall be provided and consist of manufacturers' information specifications, recommendations; programming procedures and data points; narratives and other means of illustrating to the owner how the building, equipment and systems are intended to be installed, maintained, and operated. Required regular maintenance actions for equipment and systems shall be clearly stated on a ready visible label.

1.6 SUBMITTALS

A. Refer to Division 01 Section 019113 "General Commissioning Requirements" for submittal requirements.

1.7 ELECTRICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

- A. The following equipment and systems shall be commissioned within the scope of this project. All general references to equipment and systems in this document refer only to the listed equipment and systems.
 - 1. Interior Lighting Controls Including Daylighting Controls and AV integration.
 - 2. Exterior and Parking Garage Lighting Controls
 - 3. Standby Generator
 - 4. Electrical Metering system
- B. The CxA will coordinate and execute FPTs for 100% of the primary commissioned systems (emergency power, networked and automated lighting controls, etc). For standalone lighting controls (occupancy sensors, switches, etc), the CxA will direct testing of 10% (or minimum of one) of each type.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified elsewhere in the Contract Documents.

- B. Include special tools and instruments (only available from equipment manufacturer, specific to a piece of equipment) required for testing equipment in the base bid price to the CA.
- C. Contractors shall comply with test equipment manufacturers calibration procedures and intervals. Recalibrate test equipment immediately after equipment has been repaired resulting from being dropped or damaged. Affix calibration tags to test equipment. Furnish calibration records to the CxA upon request.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCESS OVERVIEW

- A. The following narrative provides a brief overview of the typical commissioning tasks during the construction, acceptance, and post-occupancy phases and the general order in which they occur.
 - 1. Construction-related submittals for all commissioned equipment are provided to the CxA during the normal submittal process.
 - 2. Early during construction, the CxA conducts a kick-off meeting and presents the commissioning process for the project. Additional meetings with the commissioning team will occur throughout the project as required.
 - 3. The CA and responsible Sub-Contractors shall document equipment start-up and initial checkout with assistance from manufacturer's technicians. The CxA may request copies of the manufacturer's or contractor's field start-up reports.
 - 4. The CxA develops specific FPT plans for review by the A/E, CA, and responsible Sub-Contractors.
 - 5. The CA and responsible Sub-Contractors complete installation and checkout of all building electrical systems.
 - 6. The CxA coordinates and executes FPTs with the assistance of responsible Subcontractors. The CxA reports on the testing process including all observed deficiencies.
 - 7. Testing of other commissioned systems not requiring formal functional testing is completed.
 - 8. The CxA may review close-out documentation and schedule deferred testing.
 - 9. The CxA submits a final commissioning report.

3.2 COORDINATION

- A. Sub-Contractors shall provide sufficient notice to the CA regarding their completion schedule for start-up of all equipment and systems. Sub-Contractors shall transmit completed checklists and start-up documentation to the CxA without delay.
- B. The CxA will finalize scheduling of functional tests through the CA and responsible Sub-Contractors only upon completion of all checklists and start-up activities related to the equipment or systems and receipt of a completed FPT Readiness Checklist from the CA.

- C. Individual Sub-Contractor's shall be responsible for notifying the CA if commissioning activities involving a CxA site visit require rescheduling due to insufficient system completion. A Sub-Contractor's failure to notify the CA or the CA's failure to notify the CxA five (5) business days in advance of a scheduled CxA site visit shall result in back-charges to the CA for all reasonable travel expenses and lost time.
 - 1. At the direction of the CxA, the CA and responsible Sub-Contractors shall participate in a meeting prior to functional testing. The meeting shall be used to verify that all commissioned systems are properly installed, functional and are ready for functional testing. Any known problems that may impact or prevent functional testing shall be discussed during the meeting. Based on the outcome of the meeting a date to commence functional testing will be determined.

3.3 TESTING PREPARATION

- A. Certify in writing to the CxA that electrical equipment and systems have passed start-up and controls checkout.
 - 1. The equipment has passed start-up in accordance with the manufacturer's recommendations and the start-up has been documented. All start-up reports as applicable shall be submitted to the CxA.
 - 2. The electrical control systems have been completed and calibrated, and are operating according to the Contract Documents, and the pretest setpoints have been recorded.

3. The CA has submitted a completed FPT Readiness Checklist to the CxA.

- B. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- C. Inspect and verify the position of each device and interlocks identified on checklists.
- D. Check safety kill switches, alarms, and interlocks (as applicable) during each mode of operation.
- E. Install measuring instruments and logging devices to record test data as directed by the CxA.

3.4 FUNCTIONAL PERFORMANCE TESTING

A. Scope

- 1. The following procedures apply to all commissioning FPTs for this division.
- B. Purpose

- 1. The objective of the FPTs is to demonstrate that each commissioned system is operating according to the documented design intent and Contract Documents.
- C. Execution
 - 1. Each commissioned system shall be tested through its approved sequence of operation including all specified modes of operation.
 - 2. Before test procedures are written, the CxA will be provided all requested documentation including the most currently approved controls submittals and any device parameters that could impact testing. The CxA will develop specific test procedures and forms to verify and document proper system operation. The CA shall authorize the required Sub-Contractors and equipment manufacturers to assist in developing the test procedures if requested by the CxA.
 - 3. The CxA will submit the test procedures to the Sub-Contractors and equipment manufacturers for review for feasibility, safety, equipment, and warranty protection. The CxA will also submit the test procedures to the A/E for confirmation that the functionality matches the design intent. All review comments shall be submitted to the CxA and if necessary, the CxA will revise the test procedures per the submitted review comments prior to scheduling functional testing.
 - a. The time required for the CxA to coordinate and execute any retesting due to a Sub-Contractor's failure to disclose during this review that test procedures are not feasible within the context of the control system installed, shall be back-charged on an hourly basis to the CA. Any required retesting shall not be considered justification for a claim of delay or request for time extension by the CA.
 - 4. All training documentation, test reports, O&Ms, and submittals shall be at the jobsite before functional testing commences.
 - 5. The Sub-Contractors shall have trained technicians available to assist in the execution of the functional testing and/or coordinate with equipment manufacturers to make authorized technicians available. The CxA will coordinate and execute the testing and document the testing results.
- D. Documentation, Deficiencies and Approval of Tests
 - 1. The CxA will document the results of the FPTs using the specific procedural forms developed for that purpose.
 - 2. All deficiencies shall be noted and reported to the CA by the CxA within five (5) business days of test completion. The CxA may recommend corrective actions to deficiencies found, however the burden of responsibility to clear any deficiency is with the CA and A/E.
 - 3. Corrections of minor deficiencies identified may be made during testing at the discretion of the CxA. In such cases the deficiency and resolution shall be documented in the functional test plan.
 - 4. As testing progresses and deficiencies are identified, the CxA will discuss the deficiencies with the responsible Sub-Contractor(s).
 - a. When there is no dispute regarding the deficiency and the Sub-Contractor(s) accepts responsibility to perform the approved corrective action:

- 1) The CxA documents the deficiency and the Sub-Contractor(s) response and the testing proceeds. At the discretion of the CxA retesting of the corrected deficiency is rescheduled and the test is repeated.
- b. If there is a dispute about a deficiency, regarding whether a deficiency exists or who is responsible for corrections:
 - 1) The CxA documents the deficiency and the Sub-Contractor(s) response and reports to the CA within five (5) business days.
 - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Owner. The CxA documents the resolution process.
 - 3) The appropriate party performs the approved corrective actions. The CxA reschedules the test and testing is repeated until the deficiency is cleared.
 - 4) Any deficiencies accepted by the Owner as found, or not corrected prior to submission of the final commissioning report, shall be marked as a non-conforming item for the purpose of the final report.
- c. The CxA notes each accepted functional test on the test plan. Formal approval of the completed FPTs is contingent on the final review by the CxA and the A/E. The CxA recommends acceptance of each completed test to the Commissioning Team.

3.5 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Manufacturer's or independent testing requirements are specified in individual Division 26 sections. Provide test reports and certifications to the CxA.
- B. Provide technicians, load banks, infrared cameras, instrumentation, tools, and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA will determine the sequence of testing and testing procedures for each equipment item.

3.6 **DEFERRED TESTING**

A. If any FPT cannot be completed due to an unforeseen condition not within control of the CA, execution of the FPT shall be deferred based on the recommendation of the CxA and approval of the Owner. The affected testing shall be completed as soon as practical.

3.7 TRAINING OF OWNER PERSONNEL

A. The CA shall be responsible for training coordination, scheduling and for ensuring training is completed in accordance with the Contract Documents.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes the following lighting control devices:
 - 1. Line-voltage wall switch occupancy sensors.
 - 2. Line-voltage photoelectric switches.
 - 3. Low-voltage occupancy sensors.
 - 4. Low-voltage photoelectric switches.
 - 5. Low-voltage power packs.
 - 6. Low-voltage switches.
 - 7. Outdoor motion sensors.
 - 8. Automatic load control relays.
 - 9. Branch circuit transfer switches.
 - 10. Conductors and Cables for Lighting Control Devices.

1.02 DEFINITIONS

- A. Acoustic Type: Occupancy sensor detection type that detects occupancy by listening for acoustic noises.
- B. Closed loop: Photosensor control algorithm designed for influence by both daylight and electric light in a space or area.
- C. Dual-Technology Type: Occupancy sensor detection type that detects occupancy by using a combination of PIR and ultrasonic or acoustic detection technologies.
- D. LED: Light-emitting diode.
- E. Open loop: Photosensor control algorithm designed for influence by daylight entering in a space or area.
- F. PIR Type: Passive infrared. Occupancy sensor detection type that detects occupancy by sensing a combination of infrared heat and movement.
- G. SPST: Single pole, single throw.
- H. Ultrasonic Type: Occupancy sensor detection type that detects occupancy by sensing a change in pattern of reflected ultrasonic energy.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.04 SUBMITTALS

- A. Product data for the following products:
 - 1. Catalog cut sheets, including major and minor motion coverage patterns sensors, time delay and sensitivity adjustability settings, load restrictions, and performance specification items indicating compliance with this specification for all lighting control devices.
- B. Shop Drawings:
 - 1. Occupancy sensors and photoelectric switches
 - a) Show installation details.
 - b) Lighting plan showing location, mounting height, orientation and coverage area of each sensor and coordination with other trades.
 - c) Interconnection diagrams showing field-installed wiring.
 - d) Include diagrams for power, signal, and control wiring.
 - e) For any manufacturer submitted other than that listed as the Basis of Design, provide the following information for Engineer review:
 - Factory-generated occupancy sensor and photoelectric switch layouts on project lighting plans with sensor location, orientation and product type clearly marked on plans. Sensor placement shall be coordinated with project reflected ceiling plan layout, ceiling heights, lights, diffusers, and any other ceiling devices and equipment.
 - 2) List of any deviations to this specification or Basis of Design products.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
 - 1. Occupancy sensors and photoelectric switches:
 - a) Manufacturer's installation instructions, including instructions for storage, handling, protection, examination, preparation, start-up calibration and installation.
 - b) Product data clearly showing sensor field adjustments, including dip switch setting definitions and location of settings within sensors.
 - c) Manufacturer's maintenance, including operating and adjustment instructions.
 - 2. Timeclocks
 - a) Description of programmed timeclock settings at time of substantial completion.

1.05 QUALITY ASSURANCE

- A. 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.
- B. Occupancy sensors and photoelectric switches
 - 1. Products supplied shall be from a single manufacturer that has been continuously involved in the manufacturing of occupancy sensors for a minimum of 5 years.
 - 2. Products shall be manufactured by an ISO 9001 certified manufacturing facility.
 - 3. Manufacturer shall test all equipment prior to shipment.

1.06 WARRANTY

A. Manufacturers shall provide a five (5) year warranty for sensors and accessories from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL INFORMATION

- A. PIR type requirements:
 - 1. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
 - 2. Sensor shall utilize pulse count processing and digital signature analysis to respond only to those signals caused by human motion.
 - 3. Sensor shall provide high immunity to false triggering from RFI and EMI.
 - 4. Sensor shall have a multiple-segmented fresnel lens in a multiple-tier configuration, with grooves to eliminate dust and residue buildup. Sensor shall be capable of accepting mask inserts to mask specific portions of the lens to prevent false triggering.
- B. Ultrasonic type requirements:
 - 1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 - 2. Detection Frequency (Small Area 500 sq ft and less): Ultrasonic operating frequency shall be crystal controlled at 40 kHZ within +/- 0.005% tolerance to assure reliable performance and eliminate sensor cross-talk.
 - 3. Detection Frequency (Medium and Large Areas greater than 500 sq ft): Ultrasonic operating frequency shall be crystal controlled at 32 kHz within +/- 0.005% tolerance, to assure reliable performance and eliminate sensor cross-talk.

- 4. Sensors shall be capable of automatically adapting to airflow conditions or filtering frequency spectrum related to air movement.
- C. Dual-Technology type requirements:
 - 1. Dual-Technology sensors using ultrasonic technology shall have fieldselectable controls on unit to determine if a particular technology or combination of technologies controls the on-off function.
 - 2. Dual-Technology sensors using acoustic technology shall have the PIR technology initially detect motion and a combination of PIR and acoustic technologies shall keep the load on.
 - 3. Sensitivity Adjustment: Separate for each sensing technology.
 - 4. Different LED indicator colors for each sensing technology
 - 5. PIR sensor component shall comply with all requirements listed under PIR type requirements.
 - 6. Ultrasonic sensor component shall comply with all requirements listed under Ultrasonic Type requirements.
 - 7. Acoustic sensor component shall comply with all requirements listed under Acoustic Type requirements.

2.02 LINE VOLTAGE WALL SWITCH OCCUPANCY SENSORS

- A. General Requirements for Sensors:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C), unless indicated elsewhere for specific model and application.
 - 3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.
 - 4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply.
 - a) Occupancy Sensor (auto-on): Upon occupancy of space, loads shall be energized. If occupancy is not detected within the time delay period, loads shall be de-energized.
 - b) Vacancy Sensor (manual-on): Upon occupancy of space, loads are enabled such that manual operation of the switch shall energize loads. If occupancy is not detected within the time delay period, loads shall be de-energized.
 - 5. Operation adjustment: Concealed, field-adjustable for auto-on or manualon operation.
 - 6. Time Delay adjustment:
 - a) Concealed, field-adjustable.
 - b) Time delay for de-energizing loads shall be adjustable with multiple increments from 30 seconds up to 30 minutes.

- 7. Adaptive technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
- 8. Mounting: Single-gang wall box switch
- 9. Finish: Sensor finish shall be As directed by the Architect.
- 10. Sensor:
 - a) Vandal-resistant lens
 - b) Integral sliding blinders or pre-cut tape strips to block sensor views
 - c) Protrudes no greater than 0.50 inches from wall.
 - d) 180-degree field of view
 - e) Major and minor motion coverage patterns confirmed per Nema WD7 guidelines.
 - f) Detection types: Provide type or types indicated in Lighting Control Device Schedule. Refer to Section 2.1 General Information above for more information.
- 11. Indicators:
 - a) LED indicator for visual detection of motion
 - b) audible and/or visual alerts for pending shut-off
- 12. Suitable for switching load types used, including LED, fluorescent, incandescent, magnetic and electronic low voltage and motor load types. UL listed and labeled, zero-cross relay, no minimum load requirement, ground wire.
- 13. Wall switch shall have no leakage of current to load and integral service switch to permit a maintained off for servicing of lamps for safety purposes
- 14. Buttons/Relays: Provide control relay and push button quantities as indicated by model listed in Lighting Control Device Schedule.
- 15. Restriction on leakage to grounding conductor.
 - a) For new construction: Dual-technology wall switch sensor shall have not more than 0.5ma leakage of current to ground per UL requirements. Provide and connect a neutral conductor to these devices.

2.03 LINE-VOLTAGE PHOTOELECTRIC SWITCHES

- A. Outdoor:
 - 1. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
 - a) Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photoelectric switch to prevent fixed light sources from causing turn-off.
 - b) Time Delay: 15-second minimum, to prevent false operation.

- c) Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
- d) Mounting: Base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.04 LOW-VOLTAGE OCCUPANCY/VACANCY SENSORS

- A. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensor unit, for use with a separate stand-alone low-voltage power pack containing a line-voltage relay.
 - 1. Occupancy sensors and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
 - 2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. UL Listed for dry locations and complies with local codes.
 - 4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply.
 - a) Occupancy Sensor (auto-on): Upon occupancy of space, loads shall be energized. If occupancy is not detected within the time delay period, loads shall be de-energized.
 - b) Vacancy Sensor (manual-on): Upon occupancy of space, loads are enabled such that manual operation of a separate, associated switch shall energize loads. If occupancy is not detected within the time delay period, loads shall be de-energized.
 - 5. Switch Rating: As indicated in Lighting Control Device Schedule.
 - 6. Detection Coverage: As indicated in Lighting Control Device Schedule on Drawings.
 - 7. Mounting: Suitable for mounting in any position on a standard outlet box.
 - 8. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 9. Indicator: LED, to show when motion is detected during testing and normal operation of the sensor.
 - 10. Bypass Switch: Override the "on" function in case of sensor failure, concealed on unit to prevent tampering.
 - 11. Finish: Sensor finish shall be As directed by the Architect.
 - 12. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.
 - 13. Field selectable time delay and sensitivity settings or the capability for selfadjusting technologies to optimize time delay and sensitivity settings to respond to occupancy usage patterns. Occupancy usage patterns shall be saved in a non-volatile memory that retains settings in the event of a power outage.

- 14. Sensors:
 - a) Sensor shall be compatible with lighting control system.
 - b) Sensors shall be capable of being combined with additional sensors to achieve adequate coverage.
 - c) Sensor coverage pattern: AS indicated on Lighting Control Device Schedule,
 - d) Detection types: Provide type or types indicated in Lighting Control Device Schedule. Refer to Section 2.1 General Information above for more information.
- B. High-Bay Model:
 - 1. Detection type: PIR type. Refer to Section 2.1 General Information above for more information.
- C. Extreme Temperature Model:
 - 1. Detection type: PIR type. Refer to Section 2.1 General Information above for more information.
 - 2. Operating Ambient Conditions: Temperatures from minus 40 to plus 125 degree F.

2.05 LOW-VOLTAGE POWER PACKS

- A. General Requirements for power packs: Box mounted, solid-state indoor power pack/relay unit, for use with a separate stand-alone low-voltage sensor and switches.
 - 1. Power packs and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
 - 2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. UL Listed for dry locations and complies with local codes.
 - 4. Unit shall include isolated relay with NO and NC contacts to interface with BMS, HVAC and or other building monitoring systems as indicated on the Drawings
 - 5. Relay shall be compatible with the specific lighting types controlled.
 - 6. Operations: Refer to drawings for Sequence of Operations or other operational instructions. Unit operates in conjunction with other system components. Refer to operations requirements of associated devices.
 - 7. Switch Rating: As indicated in Lighting Control Device Schedule.

Mounting: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.

8. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.

2.06 LOW-VOLTAGE SWITCHES

- A. General Requirements for switches: Wall-mounted, solid-state indoor manual switch, for use with a separate stand-alone low-voltage power pack, containing a line-voltage relay.
 - 1. Switches and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
 - 2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. UL Listed for dry locations and complies with local codes.
 - 4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply. Manual push of any button shall energize or de-energize loads.
 - 5. Mounting: Suitable for mounting in any position on a standard outlet box.
 - 6. Indicator: LED, for each button to indicate when loads are energized and de-energized.
 - 7. Finish: Sensor finish shall be as directed by the Architect.
 - 8. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.

2.07 OUTDOOR MOTION SENSORS

- A. General Requirements for Sensors: Solid-state outdoor motion sensors.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Weatherproof, detection technology as indicated in the Lighting Control Device Schedule on the Drawings.
 - 3. Detection type: PIR type. Refer to Section 2.1 General Information above for more information.
 - 4. Detection Coverage: As indicated in Lighting Control Device Schedule on the Drawings.
 - 5. Switch Rating: Line Voltage: Minimum 1000-W incandescent and 500-VA ballast load at 120-V ac; 1000W ballast load at 277-V ac. Voltage as indicated on Drawings and Lighting Control Device Schedule.
 - 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 1 to 20 FC. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 - 7. Concealed, field-adjustable, "off" time-delay selector with multiple increments from 30 seconds up to 15 minutes.
 - 8. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 14 to plus 130 deg F, rated as "rain tight" according to UL 773A.
 - 9. Mounting:

- a) Sensor: Suitable for mounting in any position on a standard outdoor junction box and ½" threaded nipple for use with standard NEMA weatherproof fixture fitting.
- b) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
- 10. Bypass Switch: Override the on function in case of sensor failure.

2.08 AUTOMATIC LOAD CONTROL RELAYS

- A. Description: Normally closed, electrically held relay, arranged for wiring in parallel with automatic switching contacts; complying with UL 924.
 - 1. For control of emergency lighting circuits: Loss of normal power shall cause relay to automatically shunt emergency power to lighting circuit regardless of manual or automatic switch position. Emergency lighting circuit shall continue to operate at full power until normal power has been restored.
 - 2. Coil Rating: 120 or 277 V, as indicated on Drawings.
 - 3. Mounting: Either a 2-gang outlet box with separation barrier and plaster ring or a wall-mountable box with separate compartments. Mount per manufacturer's instructions.

2.09 BRANCH CIRCUIT TRANSFER SWITCHES

- A. Description: Normally closed, electrically held relay, arranged for wiring in parallel with automatic switching contacts; complying with UL 1008.
 - 1. For control of emergency lighting circuits: Loss of normal power shall cause relay to automatically shunt emergency power to lighting circuit regardless of manual or automatic switch position. Emergency lighting circuit shall continue to operate at full power until normal power has been restored.
 - 2. Coil Rating: 120 or 277 V as indicated on Drawings.

2.010 CONDUCTORS AND CABLES FOR LIGHTING CONROL DEVICES

- A. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables.
- B. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG.
- C. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG.
- D. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG.

E. Provide all necessary conductor and cabling required for operation of the controls and control systems specified. This includes power and control wiring required for the controls to operate as described.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. GENERAL
 - 1. Install devices and associated power packs and wiring in accordance with manufacturer's instructions and applicable codes.

B. LINE VOLTAGE WALL SWITCHES

- 1. Install dimming wall switches to achieve full rating specified on Lighting Control Device Schedule taking into account de-rating for ganging as instructed by the manufacturer.
- 2. Provide a separate grounded (neutral) conductor for each circuit controlled by a line voltage switch.
 - a) Do not share neutral conductor on load side of dimmers.
 - b) If neutral termination is not required for the device, cap conductor and tag as "Neutral for future use".

C. OCCUPANCY/VACANCY SENSORS AND PHOTOELECTRIC SWITCHES

- 1. Arrange a pre-installation meeting with manufacturer's factory authorized field representative, at Owner's facility, to verify placement of sensors and installation criteria.
- 2. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage areas specified in manufacturer's literature. The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms or areas that are to be provided with sensors. Provide additional sensors as required to properly and completely cover the respective areas.
- 3. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems and partition assemblies.
- 4. Occupancy sensors with ultrasonic or dual-technology sensing technologies shall be located not closer than 4 feet from the nearest edge of air supply devices or similar obstructions that would adversely affect the sensor performance.
- 5. Adjust time delay setting of occupancy sensors to de-energize loads after space has been unoccupied for period of time indicated on the Drawings.
- 6. Install outdoor photoelectric switches with clear view of the northern sky unless noted otherwise on the Drawings.

- 7. Adjust settings of photoelectric switches to turn on lighting at illumination level indicated on the Drawings.
- 8. Install devices and auxiliary equipment in compliance with manufacturer's instructions and recommendations.
- 9. Install relay units where concealed from view and where accessible.
- 10. 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 and UL 486B.
- 11. Install switchbox mounted occupancy sensors at same elevation as other lighting control switches.

D. AUTOMATIC LOAD CONTROL RELAYS

- 1. When used with manual controls, install emergency shunt relay in accessible ceiling near the control device or wall mounted within electrical room. Label within enclosure the connected normal and emergency circuits.
- 2. When used with automatic controls, install where concealed from view in accessible ceiling near the automatic control device or wall mounted within electrical room. Label outlet box cover with connected normal and emergency circuits.

E. BRANCH CIRCUIT TRANSFER SWITCHES

1. Install branch circuit transfer switches where concealed from view in accessible ceiling near the automatic control device or wall mounted within electrical room. Label outlet box cover with connected normal and emergency circuits.

F. WIRING

- 1. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- 3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- 4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.02 IDENTIFICATION

- A. General: Provide identification complying with requirements specified in Division 26 Section "Identification for Electrical Systems."
- B. Power and control wiring: Identify using marker tapes.

- 1. Identify controlled circuits in lighting contactors.
- 2. Identify circuits or luminaries controlled by photoelectric switches and occupancy sensors at each sensor.
- C. Components: Label each component with self-laminating computer printed labels, using a unique designation matching control drawing.
- D. Cover plates: Refer to drawings for labeling requirements of certain cover plates for manual switches, or similar devices, requiring labeling for user information.
- E. Buttons/switches:
 - 1. Engraved from manufacturer. Refer to drawings for detailed requirements and text for labeling.

3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Test all occupancy sensors in test mode to confirm sensor coverage and sensitivity of sensor per manufacturer's instructions. Upon completion of tests, set sensor time delay as indicated on Lighting Control Device Schedule. Follow testing and adjustment procedures as written in the manufacturer's installation instructions for each sensor model.
- B. Lighting control devices that fail tests and inspections are defective work. Remove, replace, and retest devices that fail tests.

3.04 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- B. Photoelectric switch Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project for this purpose.

3.05 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Lighting Control Systems."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to

Division 01 Section "Demonstration and Training" and Division 26 Section "Lighting Control Systems" for additional information

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1500 kVA:
 - 1. Distribution transformers.

1.02 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.03 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, technical certification sheets and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Transformer ratings including:
 - a) kVA
 - b) Primary and secondary voltage
 - c) Taps
 - d) Basic impulse level (BIL) for equipment over 600 volts
 - e) Design impedance
 - f) Insulation class and temperature rise
 - g) Sound level.
- C. Qualification Data: For testing agency.
- D. Source quality-control test reports.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. 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.
- B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- C. 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.
- D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."
- E. Transformers shall meet the requirements of the most current version of federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment".
- F. All transformers shall be UL listed and bear the UL label.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 2. General Electric Company.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; Schneider Electric.

2.02 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: One leg per phase. Cores shall be constructed of high grade, non-aging silicon steel. The core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The completed core and coil shall be bolted to the base of the enclosure but isolated by means of rubber, vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor or strap sized in accordance with UL and NEC requirements. The neutral shall be brought to a stud to facilitate the required external grounding of the secondary
- C. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper.
- D. Connections to transformers shall be by flexible metal conduit and using flexible couplings.
- E. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.
- F. Wiring/Terminations:
 - 1. Recommended external cable shall be rated 90 degrees C (sized at 75 degrees C ampacity) for encapsulated and 75 degrees C for ventilated designs.
 - 2. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.
 - 3. Lug kits shall be provided by the Manufacturer of the transformer.

2.03 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Enclosures: Unless otherwise specified, transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. Enclosures shall have a baked polyester powder coat finish-gray in color and suitable for interior or exterior applications. Enclosures shall be constructed so that there are no exposed live parts. Enclosures shall have a removable front cover to allow access to internal parts and wiring terminations
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

- 2. Transformer locations:
 - a) Dry locations:
 - 1) Ventilated
 - 2) NEMA 250, Type 2.
- 3. The maximum temperature of the enclosure shall not exceed 90 degrees C.
- 4. The maximum temperature of the top of the enclosure shall not exceed 50°C rise above a 40°C ambient.
- C. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: ANSI 61 gray.
- D. Taps
 - 1. Three-phase Transformers smaller than 24 kVA and all single phase transformers:
 - a) One 5 percent tap above and one 5 percent tap below normal full capacity
 - 2. Transformers 25 kVA through 500 kVA:
 - a) Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
 - 3. Transformers 501 kVA and Larger:
 - a) Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity manufacturer's standard tap configuration.
- E. Insulation Class for transformers less than 15 kVA: 185 deg C, UL-componentrecognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- F. Insulation Class for transformers 15 kVA and larger: 220 deg C, UL-componentrecognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature
- G. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with the requirements of the most current version of federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment" efficiency levels.
 - 2. Tested in accordance with federal law 10 CFR Part 431.
- H. Mounting Methods.
 - 1. Transformers 75 KVA and larger shall be floor mounted unless indicated otherwise. Transformers 45 KVA and smaller may be wall mounted where wall construction is suitable for the load. Floor mounted transformers shall be securely bolted to a 4 inch, concrete housekeeping pad with vibration

isolation pads. Wall mounted or suspended transformers shall have a means of isolating vibration from the support.

- 2. Transformers up through 1000 KVA shall be mounted on elastomeric vibration isolation pads. Pad shall be constructed of neoprene, rubber, glass fiber, or a combination thereof. Pads shall be "ribbed" or "waffled" in texture. Pads shall be selected for smallest durometer (hardness), preferably less than 50. Deflection of pad shall be .25" static minimum. Stack pads until the desired deflection is achieved.
- 3. Wall Mounting: Manufacturer's standard brackets.
- 4. Suspended Mounting: See transformer mounting detail on plans.
- I. Low-Sound-Level Requirements: Maximum sound levels (NEMA ST 20), when factory tested according to IEEE C57.12.91, as follows:
 - 1. 29 kVA and Less: 40 dBA
 - 2. 10 to 50 kVA: 45 dBA
 - 3. 51 to 150 kVA: 50 dBA
 - 4. 151 to 300 kVA: 55 dBA
 - 5. 301 to 500 kVA: 60 dBA
 - 6. 501 to 700 kVA: 62 dBA

2.04 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to ANSI C57.12.01 and IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

2.05 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
 - 1. Ratio tests at the rated voltage connection and at all tap connections
 - 2. Polarity and phase relation tests on the rated voltage connection
 - 3. Applied potential tests
 - 4. Induced potential test
 - 5. No-load and excitation current at rated voltage on the rated voltage connection

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Floor mounted transformers shall be mounted on a 4 inch concrete housekeeping pad 2 inches larger all around transformer.
- C. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
- D. Use flexible conduit under the provisions of Division 26 Section "Raceways and Boxes for Electrical Systems" for connections to transformer case. Minimum flexible conduit length shall be two (2) feet.
- E. Mount transformers on vibration isolating pads between equipment and concrete base suitable for isolating the transformer noise from the building structure.

F. CONNECTIONS

- 1. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- 2. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 IDENTIFICATION

- A. Nameplates: Label each transformer with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems." Nameplates shall be engraved with the following information
 - 1. Transformer name
 - 2. Fed from (primary source)
 - 3. Secondary voltage, phase, wires
- B. Warning Labels: Label each panelboard with a warning label indicating NFPA 70 workspace clearance requirements, complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
 - 1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
 - 3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

PART 4 - DRAWING COORDINATION – DELETE THIS PARAGRAPH WHEN DONE WITH DESIGN

4.01 TRANSFORMER TYPE

- A. Type(s) of transformers (dry type, pad mounted, etc.) if more than one type is used.
- B. Transformer rating and phases: single or three phase.
- C. Voltage ratings. For high voltage, indicate nominal system voltage, e.g., 13,800 V, rather than voltage class (15 kV). For low voltage, indicate nominal system voltage, e.g., 480/277 V.
- D. Winding connections, such as delta or grounded wye, for primary and secondary connections or diagram of transformer connections.

4.02 LOCATION

A. Locations of transformers on plans. Indicate physical size and relation to adjacent items and mounting, including clearance required for "hot-stick" operations.

4.03 ONE LINE

A. Wire sizes and types for field connections of the primary side, secondary side, bonding, and grounding of the transformer.

4.04 DETAILS

- A. Details of installation of ground bus and conductors and access for provisions for ground rods.
- B. Connections for cooling-fan power and remote alarms.
- C. Details of mountings, supports, and fastenings including seismic restraints, if required, and concrete transformer bases.
- D. Required accessory items, such as drain valves, meters, gages, and pressure relief devices.
- E. Locations of indoor units in environmentally controlled space. Include temperature regulation, freedom from excessive airborne dust, and isolation of acoustical noise generated by equipment.
- F. Curbing where required to contain fluid leakage for liquid-filled units.

4.05 ACCESSORIES

A. Fuse ratings for fuse-protected transformers.

- B. Medium-voltage-cable termination type and provision for housing the termination at the transformer.
- C. Provision for secondary metering and mounting arrangement of current and potential transformers.
- D. Arrangements and ratings of surge arresters. Provide details for arresters located outside dry-type transformer enclosures.

4.06 ENCLOSURES

- A. Designations of transformers with low-sound-level requirements.
- B. Enclosure type, cooling-system class, and temperature-rise rating if not covered by the Specifications.
- C. Basic impulse level rating, voltage tap arrangement, and impedance if not covered by the Specifications.
- D. Key interlocking of transformer compartment access doors or tap-changer handle in interlocking scheme diagram.
- E. Details of busway connections to the transformer's secondary terminals.
- F. Specific labeling requirements.

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PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes switchboards rated 600 V and less, including the following:
 - 1. Service and distribution switchboards.
 - 2. Surge Protection Devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.

1.02 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. NETA ATS: InterNational Electrical Testing Association Acceptance Testing Specification.
- C. SPD: Surge Protection Device

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Fault-Current Study, Coordination Study, and Overcurrent Protective Device Settings report must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. If studies have not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the contractor at no additional cost to the project. Refer to specification section "Overcurrent Protective Device Coordination Study"

1.04 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product Data: For each type of switchboard, switching and overcurrent protective device, instrumentation, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, weights, and finishes.
- C. Shop Drawings: For each switchboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances, service space around equipment, and attachments to other work. Show tabulations of installed devices, equipment features, and ratings.
 - a) Tabulate features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Include outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
 - 4. Detail bus configuration, current, and voltage ratings, including size and number of bus bars and current rating for each bus. Indicate mains and branches of phase, neutral, and ground buses.
 - 5. Detail short-circuit current rating of switchboard assembly and overcurrent protective devices.
 - 6. Include descriptive documentation of barriers specified for electrical insulation and isolation.
 - 7. Detail utility company's metering provisions with indication of approval by utility company.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards; include selectable ranges for each type of overcurrent protective device.
 - 10. Include schematic and wiring diagrams for power, signal, and control wiring.
 - 11. Include nameplate legends.
 - 12. Include list of materials.
- D. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
 - 1. For each equipment room, provide dimensioned layout of the electrical equipment within the space, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

- 2. Dimensioned concrete base, outline of switchboard, conduit entries, and ground rod locations; including equipment working clearances and manufacturer required access space.
- 3. Indicate structural members, light fixtures, sprinkler piping and heads, HVAC equipment, ducts and diffusers, plumbing piping and access fittings. Include maintenance access clearances.
- 4. Location of structural supports for structure-supported raceways.
- 5. Location and clearance of electrical equipment and raceways impacting equipment installation.
- 6. Proposed routing of equipment, in shipping splits, from exterior of the building to the final installed location. Include product weights, width and height restrictions encountered along the path. Include intended construction sequencing to mitigate conflicts.
- 7. Proposed routing of equipment for future removal, from within equipment room to exterior of the building without removal of non-related equipment or architectural elements.
- E. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Sample Warranty: For warranty.
- H. Project Record Documents: Record actual installed equipment and circuiting arrangements. Record actual routing for underground circuits. Record actual installed location of ground rods.
- I. Operation and Maintenance Data: For switchboards and components 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 switchboards and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 3. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
 - 4. Features and operating sequences, both automatic and manual.
 - 5. Video recording of operation training and demonstration.
- J. Follow-up service reports.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E; Employs installers and supervisors who are trained and approved by manufacturer.
- 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. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- D. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. 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.
- G. Comply with NEMA PB 2.1.
- H. Comply with NFPA 70.
- I. Comply with UL 891.

1.06 PROJECT CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- B. Environmental Limitations:
 - 1. Do not install switchboards until spaces are enclosed and weathertight. Equipment shall be protected from any remaining wet work in the space and work above secondary unit substation. Provide temporary HVAC system for maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

- 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a) Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b) Altitude: Not exceeding 6600 feet (2000 m).

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.
- B. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- C. Coordinate delivery of equipment to allow movement into designated space.
- D. Store in a clean, dry space, protected from weather and so condensation will not form on or in units. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic. Handle carefully in accordance with manufacturer's instructions to avoid damage to equipment components, enclosure, and finish. Provide temporary heating according to manufacturer's written instructions.
- E. Handle and prepare switchboard components according to NEMA PB 2.1 and manufacturer's written instructions. Use factory-installed lifting provisions.

1.08 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components and/or products of the switchboards that fail in materials or workmanship within the specified warranty period.
- B. Warranty Period: Three years from date of Substantial Completion.

1.09 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. Fuses: Refer to Division 26 section "Fuses" for spare fuse requirements. At a minimum, include spares for the following:
 - a) Primary disconnect fuses.
 - b) Potential transformer fuses.
 - c) Control power fuses.
 - d) Fuses for fusible devices.

- 2. Indicating Lights: Four of each type installed.
- 3. Primary Switch Contact Lubricant: One container.
- 4. Touchup Paint: Two containers of paint matching enclosure finish, each 0.5 pint (250 mL).
- 5. Enclosure Keys: Two for each enclosure type. All distribution equipment keyed alike.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Manufacturers:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Siemens Energy & Automation, Inc.
- B. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.

2.02 RATINGS

- A. Nominal System Voltage: As indicated on the Drawings.
- B. Main-Bus Continuous: Ampacity as indicated on the Drawings.
- C. Short-Circuit Current Rating (SCCR):
 - 1. Refer to fault-current and coordination study submittal requirements listed in other parts of this section, in addition to specification section "Overcurrent Protective Device Coordination Study".
 - 2. Rating value: Rated to interrupt symmetrical short-circuit current available at terminals. Switchgear shall be fully-rated, unless series-rated is indicated on the drawings. SCCR shall not be less than the highest AIC rating of any circuit breaker in switchgear.

2.03 FABRICATION

- A. Indoor Enclosures: Steel, NEMA 250, Type 1.
 - 1. Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- B. Front align all sections.

- C. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- D. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- E. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchgear.
- F. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- G. Barriers: Bus bars shall connect between vertical sections and between compartments. Cable connections are not permitted.
 - 1. Bus isolation barriers shall be arranged to isolate each vertical section. Where indicated, horizontal isolation barriers shall be arranged to isolate adjacent compartments within a vertical section.
 - 2. Isolation barriers shall be fabricated in a manner to permit checking of busbolt tightness.
- H. Buses: Bus bars shall connect between vertical sections and between compartments. Cable connections are not permitted.
 - 1. Main Phase Bus: Size: Ampacity as indicated on drawings, with uniform capacity for entire length of switchboard's main and distribution sections
 - 2. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors.
 - 3. Vertical Section Bus Size: Ampacity as indicated on drawings, with uniform capacity for entire length of vertical section bus.
 - 4. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - 5. Contact Surfaces of Buses: Silver plated.
 - 6. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size required by UL 891. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - 7. Supports for Buses: Adequate support for bussing material used. Include supports for bus extensions for busway feeders.
 - 8. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

- 9. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
- 10. Provide any available breaker mounting space with bussing.
- 11. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
 - a) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
- 12. Line-Side Conductor and Feeder Circuit-Breaker Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors unless otherwise indicated on Drawings, suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 section "Low-Voltage Electrical Power Conductors and Cables". Provide load terminals for future circuit-breaker positions at fullampere rating of circuit-breaker position.
- I. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- J. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.
- K. Service Equipment Equipment:
 - 1. Label: Where used as service entrance equipment, provide NRTL label for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

2.04 SURGE PROTECTION DEVICES

A. Provide surge protective devices as required by Division 26 Section "Surge Protective Devices".

2.05 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Arc Flash Mitigation
 - 1. Overcurrent devices, 1200 A and larger, shall be provided with an energyreducing active arc flash mitigation capability. The energy-reducing active arc flash mitigation system shall allow the operator to enable a maintenance mode using a switch which enables a preset accelerated instantaneous override trip to reduce arc flash energy. An LED on the trip unit shall indicate the trip unit is in the maintenance mode.
- B. Ratings:
 - 1. Continuous ampere rating: as indicated on drawings.
 - 2. Voltage and frequency rating: same as panelboard.

- 3. Short-circuit current rating (SCCR): Same as requirements for switchboard.
- 4. Ampere Interrupting Current (AIC) rating: Rated to interrupt symmetrical short-circuit current available at terminals. Panelboards shall be fully-rated, unless series-rated is indicated on the drawings.
- 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 lowlevel overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a) Instantaneous trip.
 - b) Long- and short-time time adjustments.
 - c) Ground-fault pickup level, time delay, and I^2t response.
 - 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; letthrough ratings less than NEMA FU 1, RK-5.
 - 4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a) Standard frame sizes, trip ratings, and number of poles.
 - b) Lugs: Mechanical or compression style as indicated, suitable for number, size, trip ratings, and conductor material.
 - c) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - 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) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f) Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - g) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h) Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

- i) Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- j) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.06 INSTRUMENTATION

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
 - 1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 - 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a) Phase Currents, Each Phase: Plus or minus 1 percent.
 - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d) Megawatts: Plus or minus 2 percent.
 - e) Megavars: Plus or minus 2 percent.
 - f) Power Factor: Plus or minus 2 percent.
 - g) Frequency: Plus or minus 0.5 percent.
 - h) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - 2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.
- C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
 - 1. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semi flush, with antiparallax 250-degree scales and external zero adjustment.
 - 2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

- D. Instrument Switches: Rotary type with off position.
 - 1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
 - 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- E. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- F. Watt-Hour Meters and Wattmeters:
 - 1. Comply with ANSI C12.1.
 - 2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
 - 3. Suitable for connection to three- and four-wire circuits.
 - 4. Potential indicating lamps.
 - 5. Adjustments for light and full load, phase balance, and power factor.
 - 6. Four-dial clock register.
 - 7. Ratchets to prevent reverse rotation.
 - 8. Removable meter with draw out test plug.
 - 9. Semi flush mounted case with matching cover.
 - 10. Appropriate multiplier tag.
- G. Impulse-Totalizing Demand Meter:
 - 1. Comply with ANSI C12.1.
 - 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
 - 3. Cyclometer.
 - 4. Four-dial, totalizing kilowatt-hour register.
 - 5. Positive chart drive mechanism.
 - 6. Capillary pen holding a minimum of one month's ink supply.
 - 7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
 - 8. Capable of indicating and recording 15 minute integrated demand of totalized system.

2.07 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied from remote branch circuit.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.08 ACCESSORY, COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.09 IDENTIFICATION

A. Nameplates: Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine switchboards before installation. Reject equipment that is damaged, or rusted, or have been subjected to water saturation.
- B. Examine areas, surfaces, substrates, and elements to receive switchboards with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that field measurements are as indicated.
 - 2. Verify that manufacturer's written instructions for environmental conditions have been established in spaces where equipment will be installed, before installation begins.
- C. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and manufacturer's instructions.
- B. Coordinate layout and installation of equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Equipment Mounting: Install switchboards on concrete bases.

- 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchboard unless otherwise indicated. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- 2. Anchor switchboards to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports for Electrical Systems".
- 3. 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.
- 4. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- 5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- 6. Install anchor bolts to elevations required for proper attachment to switchboards.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- E. Mount equipment plumb and rigid without distortion of enclosure.
- F. Install overcurrent protective devices, surge suppression devices and instrumentation.
- G. Install filler plates in unused spaces of panel-mounted sections.
- H. Arrange conductors in auxiliary compartments and gutters into groups and bundle and wrap with wire ties.
- I. Comply with NECA 1.

3.03 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. 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 for control wiring.

3.04 IDENTIFICATION

- A. Equipment Nameplates: Label each contiguous main, or entrance, section with equipment nameplate.
- B. Device Nameplates: Label each main, feeder and branch circuit device with a nameplate.
- C. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- D. Diagram and Instructions:
 - 1. Engraved, Laminated Acrylic or Melamine Label. Mount on front of switchboard.
 - a) Operating Instructions: Printed operating instructions for switchboard, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures.
 - b) System Power One-Line Diagrams: Provide color-coded, largeformat one-line diagram showing the new work is to be provided and installed in the associated electrical room. Depict power sources, feeders, distribution components, and major loads.
 - 2. Storage for Maintenance Instructions: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.
- E. Warning Labels: Label each panelboard with a warning label in accordance with NFPA 70 and NFPA 70E.

3.05 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Vacuum dirt and debris from interior of equipment; do not use compressed air to assist in cleaning. Remove paint splatters and other spots. Repair exposed surfaces to match original finish.

3.06 **PROTECTION**

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions throughout periods when equipment environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.07 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges and protective relay trip characteristics as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.08 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control tests and inspections:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, to assist in testing, and to assist in adjusting device settings.
- B. Acceptance Testing Preparation:
 - 1. After installing equipment but before equipment is energized, test for compliance with requirements.
 - 2. Verify that grounding system at the equipment tested at the specified value or less.
 - 3. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.
 - 4. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. After electrical circuitry has been energized, test for compliance with requirements.
 - 2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
 - 3. Complete installation and startup checks according to manufacturer's written instructions.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 6. Report results of tests and inspections in writing. Record adjustable settings and measured insulation resistances. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Assist in field commissioning of equipment including pretesting and adjusting of equipment and components.
- E. Infrared Scanning: Perform the following infrared scan tests and inspections and prepare reports:
 - 1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each

switchboard. Remove necessary panels so joints and connections are accessible to portable scanner.

- 2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
- 3. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the main incoming section of each service entrance switchboards. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a) Rebalance loads.
 - b) Prepare written request for voltage adjustment by electric utility in accordance with Division 26 section "Provisions for Electric Utility Service".
 - 3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
- G. Switchboard will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.09 **DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment, overcurrent protective devices, instrumentation, and accessories.
- B. Video record demonstrations presentation for Owner's records.

END OF SECTION

PART 1 - GENERAL

1.01 SUMMARY:

- A. This section includes panelboards rated 600 V and less, including the following:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Disconnecting and Overcurrent Protective Devices.
 - 4. Surge Protection Devices.
 - 5. Accessory Components and Features.

1.02 DEFINITIONS

- A. NETA ATS: InterNational Electrical Testing Association Acceptance Testing Specification.
- B. SVR: Suppressed voltage rating.
- C. SPD: Surge Protection Device

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Fault-Current Study, Coordination Study, and Overcurrent Protective Device Settings report must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. If studies have not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the contractor at no additional cost to the project. Refer to specification section "Overcurrent Protective Device Coordination Study"

1.04 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".

- B. Product Data: For each type of panelboard, switching and overcurrent protective device, furnished accessories and components. Include dimensions and Manufacturer's technical data on features, performance, electrical characteristics, ratings, weights, furnished options, specialties, accessories, and finishes.
- C. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances, service space around equipment, and attachments to other work. Show tabulations of installed devices, equipment features, and ratings.
 - a) Tabulate features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Detail enclosure types and details for other than NEMA 250, Type 1.
 - 3. Include general arrangement drawing showing dimensions and weights of each assembled section.
 - 4. Detail bus configuration, current, and voltage ratings, including size and number of bus bars and current rating for each bus. Indicate mains and branches of phase, neutral, and ground buses.
 - 5. Detail short-circuit current rating of panelboard assembly and overcurrent protective devices.
 - 6. Include descriptive documentation of barriers specified for electrical insulation and isolation.
 - 7. Detail utility company's metering provisions with indication of approval by utility company.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards; include selectable ranges for each type of overcurrent protective device. Submit electronic files, in an SKM-compatible format.
 - 10. Include schematic and wiring diagrams for power, signal, and control wiring.
 - 11. Include nameplate legends.
 - 12. Include list of materials.
- D. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around panelboards where pipe and ducts are prohibited. Show panelboard layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
 - 1. For each equipment room, provide dimensioned layout of the electrical equipment within the space, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

- 2. Dimensioned concrete base, outline of panelboard sections, conduit entries, and ground rod locations; including equipment working clearances and manufacturer required access space.
- 3. Indicate structural members, light fixtures, sprinkler piping and heads, HVAC equipment, ducts and diffusers, plumbing piping and access fittings. Include maintenance access clearances.
- 4. Location of structural supports for structure-supported raceways.
- 5. Location and clearance of electrical equipment and raceways impacting equipment installation.
- 6. Proposed routing of equipment for future removal, from within equipment room to exterior of the building without removal of non-related equipment or architectural elements.
- E. Qualification Data: For qualified testing agency.
- F. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Manufacturer's field service report.
- H. Sample Warranty: For warranty.
- I. Project Record Documents: Record actual installed equipment and circuiting arrangements. Record actual routing for underground circuits. Record actual installed location of ground rods.
- J. Panelboard Schedules: Submit final panelboard directories.
- K. Operation and Maintenance Data: For panelboards and components 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 panelboards and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 3. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
 - 4. Features and operating sequences, both automatic and manual.
 - 5. Video recording of operation training and demonstration.
- L. Follow-up service reports.

1.05 QUALITY ASSURANCE

- A. 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.
- B. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- C. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. 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.
- F. Comply with NEMA PB 1.
- G. Comply with NFPA 70.

1.06 PROJECT CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- B. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above equipment is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a) Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b) Altitude: Not exceeding 6600 feet (2000 m).

- C. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).
- D. Interruption of Existing Electric Service: Do not interrupt electric service to occupied facilities. Refer to Division 26 Section "General Electrical Requirements" for allowable outages.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate delivery of equipment to allow movement into designated space.
- B. Store in a clean, dry space, protected from weather and so condensation will not form on or in units. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic. Handle carefully in accordance with manufacturer's instructions to avoid damage to equipment components, enclosure, and finish. Provide temporary heating according to manufacturer's written instructions.
- C. Handle and prepare panelboards for installation according to NEMA PB 1 and manufacturer's written instructions. Use factory-installed lifting provisions.

1.08 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components and/or products of the panelboards that fail in materials or workmanship within the specified warranty period.
- B. Warranty Period: Three years from date of Substantial Completion.

1.09 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. Fuses: Refer to Division 26 section "Fuses" for spare fuse requirements. At a minimum, include spares for the following:
 - a) Primary disconnect fuses.
 - b) Potential transformer fuses.
 - c) Control power fuses.
 - d) Fuses for fusible devices.
 - 2. Indicating Lights: Four of each type installed.
 - 3. Primary Switch Contact Lubricant: One container.
 - 4. Touchup Paint: Two containers of paint matching enclosure finish, each 0.5 pint (250 mL).

5. Enclosure Keys: Two for each enclosure type. All distribution equipment keyed alike.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Manufacturers:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Siemens Energy & Automation, Inc.
- B. Enclosures: Flush- or surface-mounted cabinets as noted.
 - 1. Rated for environmental conditions at installed location.
 - a) Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b) Outdoor Locations: NEMA 250, Type 3R.
 - c) Kitchen and/or Wash-Down Areas where indicated on drawings: NEMA 250, Type 4X, stainless steel.
 - d) Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e) Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.
 - 2. Hinged Front Cover: Entire front trim hinged to box.
 - 3. Door: Standard door with concealed hinges, within hinged trim cover. Secured with vault-type latch with tumbler lock; keyed alike.
 - 4. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gauge and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Finishes:
 - a) Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b) Back Boxes: Galvanized steel.
 - 7. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top and/or bottom as required.
- D. Buses: Three phase, four wire unless otherwise indicated.
 - 1. Phase, and Neutral Buses:

- a) Material:
 - 1) Hard-drawn copper, 98 percent conductivity.
 - 2) Hard-drawn copper, 98 percent conductivity, silver-plated
- b) Size: Ampacity as indicated on drawings, with uniform capacity for entire length of panelboard's sections.
 - Neutral bus: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus
- 2. Ground Bus: Equipped with connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - a) Material: Hard-drawn copper, 98 percent conductivity
 - b) Size: Minimum-size required by UL 67
- 3. General: Provide any available breaker mounting space with bussing.
- E. Line-Side Conductor Connectors (Lugs):
 - 1. General: Suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
 - 2. Material: Same as bus material.
 - 3. Capacity rating: Same as associated bus.
 - 4. Type: Provide mechanical type unless otherwise indicated on Drawings, refer to schedules and one-line diagram.
 - 5. Provide properly sized lugs for all equipment, circuit breakers and other electrical devices to accommodate installed conductors. A larger frame, oversized lugs or non-standard product may be required in some instances.
 - a) Pin adapters may be utilized only as allowed by manufacturer and the authority having jurisdiction.
- F. Feed-Through Lugs:
 - 1. General: Suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
 - 2. Location: Locate at opposite end of bus from line side lugs or main device.
 - 3. Material: Same as line side conductor connectors.
 - 4. Capacity rating: Same as associated bus.
 - 5. Type: Same as line side conductor connectors.
- G. Subfeed lugs (Double Lugs):

- 1. General: Suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
- 2. Location: Locate at same end of bus as incoming lugs or main device.
- 3. Material: Same as line side conductor connectors.
- 4. Capacity rating: Same as associated bus.
- 5. Type: Same as line side conductor connectors.
- H. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- I. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- J. Short-Circuit Current Rating (SCCR):
 - 1. Refer to fault-current and coordination study submittal requirements listed in other parts of this section, in addition to specification section "Overcurrent Protective Device Coordination Study".
 - 2. Rating value: Rated to withstand symmetrical short-circuit current available at terminals. Panelboards shall be fully-rated, unless series-rated is indicated on the drawings. SCCR shall not be less than the highest AIC rating of any circuit breaker in panelboard.

2.02 DISTRIBUTION PANELBOARDS

- A. Panelboards: NEMA PB 1, power and feeder distribution type.
- B. Doors: For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- C. Mains: As indicated on drawings.
- D. Branch Overcurrent Protective Devices:
 - 1. Connection to bus:
 - a) For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 - b) For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
 - 2. Type: Provide types as indicated on drawings and as defined below.
- E. Device Ratings:
 - 1. Continuous ampere rating: as indicated on drawings.
 - 2. Voltage and frequency rating: same as panelboard.

- 3. Short-circuit current rating (SCCR): Same as requirements for panelboard.
- 4. Ampere Interrupting Current (AIC) rating: Rated to interrupt symmetrical short-circuit current available at terminals. Panelboards shall be fully-rated, unless series-rated is indicated on the drawings.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: Circuit breaker type: NEMA PB 1, lighting and appliance branchcircuit type.
- B. Mains: As indicated on drawings.
- C. Branch Overcurrent Protective Devices:
 - 1. Connection to bus: Plug-in circuit breakers, replaceable without disturbing adjacent units.
 - 2. Type: Provide types as indicated on drawings and as defined below.
- D. Device Ratings:
 - 1. Continuous ampere rating: as indicated on drawings.
 - 2. Voltage and frequency rating: same as panelboard.
 - 3. Short-circuit current rating (SCCR): Same as requirements for panelboard.
 - 4. Ampere Interrupting Current (AIC) rating: Rated to interrupt symmetrical short-circuit current available at terminals. Panelboards shall be fully-rated, unless series-rated is indicated on the drawings.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Arc Flash Mitigation
 - 1. Overcurrent devices, 1200 A and larger, shall be provided with an energyreducing active arc flash mitigation capability. The energy-reducing active arc flash mitigation system shall allow the operator to enable a maintenance mode using a switch which enables a preset accelerated instantaneous override trip to reduce arc flash energy. An LED on the trip unit shall indicate the trip unit is in the maintenance mode.
- B. Ratings:
 - 1. Continuous ampere rating: as indicated on drawings.
 - 2. Voltage and frequency rating: same as panelboard.
 - 3. Short-circuit current rating (SCCR): Same as requirements for panelboard.
 - 4. Ampere Interrupting Current (AIC) rating: Rated to interrupt symmetrical short-circuit current available at terminals. Panelboards shall be fully-rated, unless series-rated is indicated on the drawings.
- 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 lowlevel overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a) Instantaneous trip.
 - b) Long- and short-time time adjustments.
 - c) Ground-fault pickup level, time delay, and I^2t response.
- 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; letthrough ratings less than NEMA FU 1, RK-5.
- 5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- 6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
- 7. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a) Standard frame sizes, trip ratings, and number of poles.
 - b) Lugs: Mechanical type unless otherwise indicated on Drawings, suitable for number, size, trip ratings, and conductor materials.
 - c) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d) Ground-Fault Protection: Relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 1) Mounting: Integral
 - e) Communication Capability: Universal-mounted Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - f) Shunt Trip: 24 -V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - g) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - h) Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - i) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

- j) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
- k) Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
- 1) Handle Padlocking Device: Fixed attachment, for locking circuitbreaker handle in on or off position.
- m) Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.05 SURGE PROTECTION DEVICES

- A. Provide surge protective devices as required by Division 26 Section "Surge Protective Devices".
- B. Panelboards requiring SPD and the location of the devices shall be as indicated on the Drawings.

2.06 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

2.07 IDENTIFICATION

A. Nameplates: Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine panelboards before installation. Reject equipment that is damaged, or rusted, or have been subjected to water saturation.
- B. Examine areas, surfaces, substrates, and elements to receive panelboards with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that field measurements are as indicated.
 - 2. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.
- C. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.

- 2. Entries are within conduit-entry tolerances specified by manufacturer.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1 and manufacturer's instructions.
- B. Coordinate layout and installation of equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Wall-Mounted Panelboards: Install panelboards on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For panelboards not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- D. Floor-Mounted Panelboards: Install panelboards on concrete bases.
 - 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of panelboards unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
 - 2. Anchor panelboards to concrete bases according to manufacturer's written instructions, and requirements in Division 26 Sections "Hangers and Supports for Electrical Systems".
 - 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - 4. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 6. Install anchor bolts to elevations required for proper attachment to panelboards.
 - 7. Attach panelboards to the vertical finished or structural surface behind the panelboards.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 72 inches (1788 mm)above finished floor unless otherwise indicated.

- G. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- H. Install overcurrent protective devices and controllers not already factory installed.
- I. Install filler plates in unused spaces.
- J. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
 - 1. Empty conduits shall be provided with pull strings.
 - 2. Cap and label empty conduits for future use.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- L. Comply with NECA 1.

3.03 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. 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 for control wiring.

3.04 IDENTIFICATION

- A. Equipment Nameplates: Label each contiguous main, or entrance, section with equipment nameplate.
- B. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate.
- C. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- D. Diagram and Instructions:
 - 1. Engraved, Laminated Acrylic or Melamine Label. Mount on front of panelboard.

- a) Operating Instructions: Printed operating instructions for panelboard, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures.
- E. Warning Labels: Label each panelboard with a warning label in accordance with NFPA 70 and NFPA 70E.
 - 1. Exception: Do not install NFPA 70 working clearance requirements on flush panelboards and similar equipment in finished spaces.
- F. Panel Directories
 - 1. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
 - 2. Note the date the directory was created/updated.
 - 3. Create directory after loads have been balanced to reflect actual as-built conditions.
 - 4. Circuit descriptions shall be per code and shall be distinguishable from all others.

3.05 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Vacuum dirt and debris from interior of equipment; do not use compressed air to assist in cleaning. Remove paint splatters and other spots. Repair exposed surfaces to match original finish.

3.06 **PROTECTION**

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.07 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.08 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control tests and inspections:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, to assist in testing, and to assist in adjusting device settings.

- B. Acceptance Testing Preparation:
 - 1. After installing equipment but before equipment is energized, test for compliance with requirements.
 - 2. Verify that grounding system at the equipment tested at the specified value or less.
 - 3. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.
 - 4. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. After electrical circuitry has been energized, test for compliance with requirements.
 - 2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Report results of tests and inspections in writing. Record adjustable settings and measured insulation resistances. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Assist in field commissioning of equipment including pretesting and adjusting of equipment and components.
- E. Infrared Scanning: Perform the following infrared scan tests and inspections and prepare reports:
 - 1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - 2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - 3. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

- 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the main incoming section of each service entrance panelboard. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
- 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a) Rebalance loads.
 - b) Prepare written request for voltage adjustment by electric utility in accordance with Division 26 section "Provisions for Electric Utility Service".
- 3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
- G. Panelboards will be considered defective if they do not pass tests and inspections.
- H. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.09 **DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain panelboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.
- B. Video record demonstrations presentation for Owner's records.

END OF SECTION

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles: Single, duplex, twist-lock, ground-fault circuit interrupters (GFCI), and tamper resistant (TR).
 - 2. AC Wall Switches: Single- and double-pole, three- and four-way, maintained and momentary, pilot light and lighted toggle.
 - 3. Device Wall Plates.
 - 4. Multi-Outlet Assemblies.
 - 5. Emergency Power Off Buttons

1.02 **DEFINITIONS**

- A. GFCI: Ground-fault circuit interrupter.
- B. IG: Isolated Ground
- C. PIR: Passive Infrared.
- D. RFI: Radio Frequency Interference
- E. SPD: Surge Protective Device
- F. USB: Universal Serial Bus
- G. TR: Tamper Resistant

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product data for the following products:
 - 1. Provide manufacturer's catalog information specifically marked to indicate which devices are being furnished, and showing dimensions, colors, and configurations for all devices, including, but not limited to: Receptacles, AC wall switches, cover plates, and multi-outlet assemblies.
- C. Shop drawings for:
 - 1. List of legends and description of materials and process used for premarking wall plates.
- D. Samples:

- 1. One for each type of device and wall plate specified, in each color specified.
- 2. Samples will be returned after review, and, if accepted by the Architect and Engineer, may be installed on the Project.
- E. Field quality-control test reports.
- F. Warranty: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated cover plate from a single manufacturer and through one source. Where practical and possible, obtain all wiring devices and associated cover plates from a single manufacturer and one source.
- B. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 10 years.
- C. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that are acceptable to authorities having jurisdiction.
 - 2. Marked for intended use.
- D. Comply with NFPA 70.

1.05 COORDINATION

A. Receptacles for Equipment Furnished by Owner or Under Other Divisions or Contracts: Match plug configurations.

1.06 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. Wall Plates: One for every 50 of each type (i.e., style, size, and finish) installed, but no fewer than two of each type.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL

A. Wiring devices are defined as single discrete units of electrical distribution systems, such as convenience receptacles, switches, special purpose receptacles, and similar, which are intended to carry, but not use electrical energy. Install wiring devices as required by the Specifications and where indicated on the Drawings.

2.02 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Receptacles and Switches:
 - a) Lutron
 - b) Cooper Wiring Devices.
 - c) Hubbell Incorporated; Wiring Device-Kellems.
 - d) Leviton Mfg. Company Inc.
 - e) Pass & Seymour/Legrand; Wiring Devices Div.
 - 2. Multioutlet Assemblies:
 - a) Hubbell Incorporated; Wiring Device-Kellems.
 - b) Wiremold Company (The).
 - 3. Emergency Power Off Buttons:
 - a) GE Industrial.
 - b) Square D/Groupe Schneider NA.
 - c) Eaton.
- C. In other Part 2 articles below, where lists of manufacturers and device catalog numbers are included, the following additional requirements apply to product selection:
 - 1. Additional Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include manufacturers listed in individual articles below, in addition to those listed in Paragraph "Manufacturers" above.

2.03 FINISHES

- A. Color:
 - 1. Wiring devices connected to normal power systems: Standard white, unless otherwise indicated or required by NFPA 70 or Black where identified in "Architectural Device Color Diagrams" for exact locations of devices. Cover plates: The same color as the wiring device.
 - Wiring devices connected to generator power systems: Red. Cover plates: Same associated wiring device and labeled with "GENERATOR POWER". Label the panelboard designation and circuit number serving the emergency device into the cover plate.
 - 3. Hospital grade receptacles: As specified above, with a green dot on its face.

B. Manufacturer's model numbers listed are to establish the quality of the wiring devices. Coordinate the proper suffixes in order to provide the correct color as specified above.

2.04 CONVENIENCE RECEPTACLES:

- A. The catalog numbers listed below are generally for 20A rated devices. Where 15A rated devices are indicated on the Drawings or required for circuit rating limitations, provide receptacles equivalent to those specified for 20A, but rated for 15A.
- B. Duplex tamper resistant convenience receptacles: Commercial Specification grade, NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding, Decora/Style Line Face Style.

Manufacturer	Duplex
Cooper	TR5362
Hubbell	DR20
Leviton	8300-SGG
Pass & Seymour	TR5362

C. Duplex weather resistant convenience receptacles: Heavy Duty Specification grade, NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding.

Manufacturer	Duplex
Cooper	TWR270
Hubbell	5362WR
Leviton	WBR20
Pass & Seymour	WR5862

D. Hospital Grade straight blade safety type, tamper-resistant receptacles: NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, nylon face, side and back wired, self-grounding. Decora/Style Line Face Style.

Manufacturer	Duplex
Cooper	TR8300
Hubbell	2182TR
Leviton	8300-SG
Pass & Seymour	TR63HW

E. Twist-Locking type receptacles: NEMA L5-20R, 125V, 20A, grounding type, UL listed and labeled, nylon face, side and back wired, self-grounding.

Manufacturer	Single
Cooper	L520R
Hubbell	HBL2310
Leviton	2310
Pass & Seymour	L520-R

F. Automatically Controlled receptacles: Where indicated on drawings, provide device type from other applicable category, along with marking for controlled receptacles as required by the current version of the NEC. In the case where the NEC is not applicable to the project, the device shall still be provided with this marking. In that case, the NEC is providing the standard for the marking and this specification is requiring it to be marked above and beyond the application of the code.

2.05 GFCI RECEPTACLES

A. Ground fault circuit interrupter type receptacles: Specification Grade except where noted to be Hospital Grade on plans: UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Manufacturer	Specification Grade	Hospital Grade
Cooper	VGF2	VGFH20
Hubbell	GF20LA	GFR8300HLA
Leviton	Т7899-Н	6898-HG
Pass & Seymour	2095	2095HG

B. Ground fault circuit interrupter type weather-resistant receptacles: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Manufacturer	Specification Grade
Cooper	WRVGF20
Hubbell	GFTR20
Leviton	W7899
Pass & Seymour 2095TRWR

C. Ground fault circuit interrupter type tamper and weather-resistant receptacles: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Manufacturer	[Specification Grade]
Cooper	TWRVGF20
Hubbell	GFTR20
Leviton	W7899-T
Pass & Seymour	2095TRWR

D. Ground fault circuit interrupter with Blank Face: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Manufacturer	Specification Grade
Cooper	VGFD20
Hubbell	GFBF20
Leviton	7595
Pass & Seymour	2085

2.06 SPD RECEPTACLES

 A. SPD receptacles for 125V (150V maximum continuous operating voltage) service: NEMA 5-20R, 125V, 20A, self-grounding type, RFI/EMI noise filtering, UL listed 1449 Second Edition (1998) & 489; equipped with LED indicator(s) and audible alarm.

Manufacturer	Duplex	W/Isolated Ground
Cooper	5362BLS	IG5362BLS
Hubbell	HBL5362SA	IG5362SA
Leviton	5380	5380-IG
Pass & Seymour	5362xSP	IG5362xSP

B. Suppression module shall protect normal and common modes, with the following mode characteristics, and be suitable for ANSI/IEEE C62.41-1991 A, B installations:

Peak Energy	240 joules minimum
Peak Current	13,000A minimum
UL 6kv/3000A (8/20 micro sec. wave form) Test	400V minimum (VPR)
Response Time	Approximately 5 nano-seconds

C. Special Warranty: Manufacturer agrees to repair or replace SPD receptacles, or replaceable surge modules (if removable), that fail in materials or workmanship within 5 years from date of Substantial Completion.

2.07 SWITCHES

- A. The catalog numbers listed below are generally for 20A rated devices. Where 15A rated devices are indicated on the Drawings or required for circuit rating limitations, provide switches equivalent to those specified for 20A, but rated for 15A.
- B. Switches: Heavy Duty Specification grade, rated for 120/277V, 20A, back and side wired, and UL listed and labeled.

Manufacturer	1 Pole	2 Pole	3 Way	4 Way
Cooper	AH1221	AH2221	AH3221	AH4221
Hubbell	1221	1222	1223	1224
Leviton	1221-2	1222-2	1223-2	1224-2
Pass & Seymour	CSB20AC1	CSB20AC2	CSB20AC3	CSB20AC4

C. Switches: Commercial Specification grade, rated for 120/277V, 20A, back and side wired, and UL listed and labeled.

Manufacturer	1 Pole	2 Pole	3 Way	4 Way
Cooper	CSB120	CSB220	CSB320	CSB420
Hubbell	DS120	DS220	DS230	DS330
Leviton	CSB1-20	CSB2-20	CSB3-20	CSB4-20

Pass & Seymour	CS20AC1		CS20AC3	
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D. Pilot Light switches: 20A, single pole switch with red neon lighted handle. Toggle shall be illuminated when the switch is in the "ON" position.

Manufacturer	1 Pole	2 Pole	3 Way
Cooper	AH2221PL	AH222PL	AH2223PL
Hubbell	HBL1221PL	HPL1222PL	HBL1223PL
Leviton (120V)	1221-PLX	1222-PLX	1223-PLX
Leviton (277V)	1221-7PLX (277V)	1222-7PLX	1223-7PLX
Pass & Seymour	PS20AC1-XSL	PS20AC2-XSL	PS20AC3-XSL

E. Key operated light switches (120/277 V-ac): Same as standard light switches except toggle handle shall be operated by a factory provided key.

Manufacturer	1 Pole	2 Pole	<u>3 Way</u>	4 Wa <u>y</u>
Cooper	221L	2222L	2223L	2224L
Hubbell	HBL1221L	HBL1222L	HBL1223L	HBL1224L
Leviton	1221-2KL	122202KL	1223-2KL	1224-2KL
Pass & Seymour	PS20AC1-L	PS20AC2-L	PS20AC3-L	PS20AC4-L

F. Switches for use with mechanically-held, electrically-operated lighting contactors: Single pole, double throw, momentary, center off switch, rated for 120/277V, and UL listed and labeled.

Manufacturer	1 Pole
Cooper	1995
Hubbell	HBL1557
Leviton	1257-l
Pass & Seymour	1251

2.08 COVER PLATES

A. Wet Location Weatherproof Receptacle Cover Plates (Outlet Box Hood): While-In-Use NEMA 3R weather resistant recessed or flush mount, die cast aluminum lockable cover. Configure cover for horizontal mounting of receptacle or as indicated otherwise. Back box must be suitable for conduit connections. Coordinate back box with wall depth.

Manufacturer	Horizontal
Thomas & Betts	CKMU
Eaton	WIUMV-1
Hubbell	WP26MH
Leviton	IUM1H-GY

A. Damp and Wet Location Weatherproof switch cover plates: Fabricated of cast aluminum or cast zinc, sealed water-tight and UL listed for wet locations.

Manufacturer	1 Gang	2 Gang
Appleton	FSK	
Raco	5100 Series	
Steel City	SW Series	

- B. Other locations: Single and combination types to match corresponding wiring devices and manufacturer of wiring devices specified herein.
 - 1. Plate securing screws: Metal with head color to match finish plate.
 - 2. Material for Finished Spaces: High impact nylon, minimum 0.10-inch thick. Refer to "Finishes" above for color.
 - 3. Material for Unfinished Spaces and surface mounted wiring devices: Galvanized steel.
 - 4. Masonry walls and oversized wall openings: Jumbo size plates with same material as indicated above.

2.09 EMERGENCY POWER OFF BUTTONS

A. Push Button Operators: 30MM, watertight/oiltight, heavy duty, 600V maximum ac/dc, 10A continuous, momentary, non-illuminated, shrouded push button operator. Provide with 1 normally open and 1 normally closed contact block.

Manufacturer Red Button

Schneider 9001KR1RH13

GE Industrial CR104PBG91R3

Eaton 10250T5021

B. Push/Pull Button Operators: 30MM, watertight/oiltight, heavy duty, 600V maximum ac/dc, 10A continuous, 2 position maintained, non-illuminated, push/pull button operator. Provide with 1 normally open and 1 normally closed contact block.

Manufacturer	Red Button
Schneider	9001SKR9RH13
GE Industrial	CR104PBM91R5C
Eaton	10250T5B621

C. Break Glass Operators: 30MM, watertight/oiltight heavy duty, 600V maximum ac/dc, 10A continuous, push button operator that when disk is broken the operator is released to its open position. Provide with 1 normally closed contact block, surface or recess mounted, NEMA 1, 4, 4X enclosure with integral break glass hammer and chain.

Manufacturer	
Schneider	9001K15
Eaton	10250TBG

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install all wiring devices plumb, level, and square with building lines. Wiring device bodies shall extend to the finished surface of the walls, ceiling or floor, as applicable, without projecting beyond them.
- C. Connect wiring devices by wrapping conductors around screw terminals. 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 and UL 486B.
- D. Connect wiring device grounding terminal to branch circuit equipment grounding conductor and bond to metal outlet box. Exception: Do not bond grounding terminals of isolated ground receptacles to the outlet box.

- E. Install devices shown on wood trim, cases or other fixtures symmetrically and, where necessary, set with the long dimensions of the plate horizontal, or ganged in tandem.
- F. Unless dimensioned otherwise, install wiring devices a minimum of 24 inches from the closest edge of any sink.
- G. Install switches with OFF position down.
- H. Install cover plates on all switches, receptacles, and blank outlets.
- I. Locate wiring devices so that the cover plate does not have to be cut to be installed.
- J. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.
- K. Install cover plates after the wall has been finished (painted, wall paper, etc).
- L. Install device boxes in brick or block walls such that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
- M. Provide Hospital Grade receptacles in, patient rooms, surgery rooms, special procedure rooms, exam rooms, treatment rooms, radiology rooms and other patient care and treatment areas. Provide specification grade receptacles in all other areas unless otherwise noted.
- N. Provide safety-type, tamper-resistant receptacles in all areas where receptacles are mounted less than 5'-6" AFF and are easily accessible to children.
- O. Provide safety-type, tamper-resistant receptacles in psychiatric patient rooms. Provide tamperproof screws on faceplates of all wiring devices in psychiatric patient rooms.
- P. Provide engraved nameplate on emergency off buttons.
- Q. Provide ground fault circuit interruption capability for all 120V receptacles 50A or less and all 208/240V receptacles 100A or less in code required locations. Locations include, but are not limited to: bathrooms, kitchens/food prep areas, exterior locations and within 6' or sinks. Interruption capability can be achieved via a GFCI circuit breaker or a GFCI receptacle.
- R. Provide type and quantity of normally open and/or normally closed contacts for emergency off buttons to meet the sequence of operations shown.
- S. Install wiring devices shown back-to-back on a common wall offset a minimum of 12" horizontally to reduce sound transmission between rooms.

3.02 GENERAL

- A. Outlets are only approximately located on the small scale Drawings. Use great care in the actual location by consulting the various large scale detailed Drawings used by other Division trades, and by securing definite locations from the Architect.
- B. Do not use multi-conductor circuits, with a shared neutral, for any GFCI receptacle circuit. Provide a separate neutral conductor with all GFCI receptacle circuits.
- C. Provide twist-locking type receptacles or other special type receptacles where indicated on the Drawings.

3.03 EXAMINATION

- A. Verify existing conditions prior to beginning work.
- B. Verify that outlet boxes are installed at proper height and are flush with the finished surface.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that floor boxes are adjusted properly and are flush with the finished surface.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.04 **PREPARATION**

- A. If required, provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean debris from in and around outlet boxes.

3.05 MOUNTING HEIGHTS

- A. Coordinate locations of outlet boxes provided under Division 26 Section "Common Work Results for Electrical".
- B. Unless noted otherwise, install wiring devices at mounting heights indicated in the Electrical Symbols Legend on the construction drawings.
 - 1. Receptacles:
 - a) General:
 - 1) Unless indicated otherwise, install vertically with the ground slot mounted at the top.
 - 2) Where Installed horizontally, install neutral slot mounted at the top.

- b) Above counters:
 - 1) Mount vertically.
- c) Mechanical and electrical equipment rooms and janitors closets:
 - 1) Mount horizontally.
- d) Garages:
 - 1) Wet location: Mount horizontally.
 - 2) Other locations: Mount vertically.
- e) Weatherproof exterior receptacles:
 - 1) Mount horizontally.
- f) GFCI receptacles: Same as general receptacles.
- g) Isolated ground receptacles: Same as general receptacles.
- h) SPD receptacles: Same as general.
- i) Concrete Block Walls: Dimensions above may be adjusted slightly, as required to compensate for variable joint dimensions, such that bottom or top of boxes, as applicable, are at block joints.
- 2. Switches:
 - a) Above counters: Same as for receptacles.
 - b) Concrete Block Walls: Dimension may be adjusted slightly, as required to compensate for variable joint dimensions, such that bottom of boxes are at block joints.
 - c) Walls with wainscoting: 6 inches minimum above wainscoting, but not exceeding 48 inches above finished floor.
- 3. Telephone/Data Outlet Boxes:
 - a) General: Match mounting height of adjacent wiring device listed above.
- 4. Emergency Power Off Buttons and Break Glass Operators:
 - a) General: Match requirements of switches listed above.
 - b) Wall-mounted telephone: 40 inches above finished floor.

3.06 IDENTIFICATION

- A. Label all devices fed down stream of GFCI protected receptacles as "GFCI PROTECTED".
- B. Comply with Division 26 Section "Identification for Electrical Systems."
 - 1. Receptacles and Switches: Identify panelboard and circuit number from which served, using:
 - a) Durable wire markers or tags inside outlet boxes.
 - b) Permanent-ink marker, hand-printed legibly, inside outlet boxes.

- c) Adhesive film label, but with letter/number height of 1/4 inch, on face of plate.
- d) Adhesive Film Label with Clear Protective Overlay, but with letter/number height of 1/4 inch, on face of plate, for exterior and damp/wet locations.

3.07 FIELD QUALITY CONTROL

- A. Inspect each wiring device for defects.
- B. Operate each wall switch with circuit energized and verify proper operation.
- C. Verify that each receptacle device is energized. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
- D. Test all wiring devices for electrical continuity and proper polarity of connections.
- E. Test each GFCI receptacle device for proper operation.
- F. Correct wiring devices incorrectly installed.
- G. Repair or replace all damaged items or damaged finishes at no expense to the Owner.

3.08 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.09 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

PART 1 - GENERAL

1.01 SUMMARY

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

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, 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.
 - 3. Current-limitation curves for fuses with current-limiting characteristics.
 - 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
 - 5. Coordination charts and tables and related data.
 - 6. Fuse sizes for elevator feeders and elevator disconnect switches.
- B. Operation and Maintenance Data: For fuses 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. All items requested under "Product Data".

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

- 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. Comply with UL 248.

1.04 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C) apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.05 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.
- B. Coordinate location of and access to spare fuse cabinet(s) with final electrical equipment layouts within electrical equipment rooms.

1.06 EXTRA MATERIALS

- 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

2.01 GENERAL

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Selectivity: Where selectivity is required by the Documents, furnish products as required to achieve selective coordination.

2.02 MANUFACTURERS

A. Manufacturers:

AWSOM

- 1. ABB Ltd.
- 2. Eaton Corporation Plc
- 3. Mersen Electrical Power
- 4. Littelfuse, Inc.
- 5. Schneider Electric SE
- 6. Siemens AG

2.03 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.04 ACCESSORIES

- A. Provide the following accessories where indicated or where required to complete installation:
 - 1. Fuseholders: Compatible with indicated fuses.
 - 2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

2.05 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.01 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.

3.02 INSTALLATION

- A. Do not install fuses until circuits are ready to be energized.
- B. Install in accordance with manufacturer's instructions.
- C. Install fuses in fusible devices. Arrange fuses so manufacturer, type and rating information is readable without removing fuse.
- D. Install spare-fuse cabinet(s).

3.03 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Feeders:
 - a) Greater than 600A:
 - 1) Class L, time delay
 - b) 600A or less:
 - 1) Class RK1, time delay
 - 2. Motor Branch Circuits:
 - a) Class RK1 time delay
 - 3. Other Branch Circuits:
 - a) Class RK1, time delay
 - 4. Control Circuits:
 - a) Class CC fast acting

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes enclosed switches and circuit breakers rated 600 V and less, including the following:
 - 1. Fusible switches.
 - 2. Non-fusible switches.
 - 3. Shunt trip switches.
 - 4. Molded-case circuit breakers (MCCBs).
 - 5. Enclosures.

1.02 DEFINITIONS

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

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of enclosed switches, circuit breakers and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Fault-Current Study, Coordination Study, and Overcurrent Protective Device Settings report must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. If studies have not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the contractor at no additional cost to the project. Refer to specification section "Overcurrent Protective Device Coordination Study".

1.04 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".

- B. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensions and Manufacturer's technical data on features, performance, electrical characteristics, ratings, weights, furnished options, specialties, accessories, and finishes.
- C. Shop Drawings: For enclosed switches and circuit breakers.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances, service space around equipment, and attachments to other work. Show tabulations of installed devices, equipment features, and ratings.
 - a) Tabulate features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Detail enclosure types and details for other than NEMA 250, Type 1.
 - 3. Include general arrangement drawing showing dimensions and weights of each assembled section.
 - 4. Detail bus configuration, current, and voltage ratings, including size and number of bus bars and current rating for each bus. Indicate mains and branches of phase, neutral, and ground buses.
 - 5. Detail short-circuit current rating of enclosed switch or circuit breaker assembly and overcurrent protective devices.
 - 6. Include descriptive documentation of barriers specified for electrical insulation and isolation.
 - 7. Include time-current coordination curves for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
 - 8. Include schematic and wiring diagrams for power, signal, and control wiring.
 - 9. Include nameplate legends.
 - 10. Include list of materials.
- D. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around enclosed switches and circuit breakers where pipe and ducts are prohibited. Show enclosed switch and circuit breaker layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- E. Qualification Data: For qualified testing agency.
- F. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

- G. Manufacturer's field service report.
- H. Sample Warranty: For warranty.
- I. Project Record Documents: Record actual installed equipment and circuiting arrangements. Record actual routing for underground circuits. Record actual installed location of ground rods.
- J. Operation and Maintenance Data: For enclosed switches and circuit breakers 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 switches, circuit breakers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 3. Time-current curves; include selectable ranges for each type of overcurrent protective device.
 - 4. Features and operating sequences, both automatic and manual.
 - 5. Video recording of operation training and demonstration.
- K. Follow-up service reports.

1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- C. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- D. 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.
- E. 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.
- F. Comply with NFPA 70.

1.06 PROJECT CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- B. Environmental Limitations:
 - 1. Do not deliver or install enclosed switches and circuit breakers until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above equipment is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a) Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - b) Altitude: Not exceeding 6600 feet (2010 m).
- C. Interruption of Existing Electric Service: Refer to Division 26 section "General Electrical Requirements"

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.
- B. Deliver enclosed switches and circuit breakers in sections or lengths that can be moved past obstructions in delivery path.
- C. Coordinate delivery of equipment to allow movement into designated space.
- D. Store in a clean, dry space, protected from weather and so condensation will not form on or in units. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic. Handle carefully in accordance with manufacturer's instructions to avoid damage to equipment components, enclosure, and finish. Provide temporary heating according to manufacturer's written instructions.
- E. Handle and prepare enclosed switches and circuit breakers components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.08 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components and/or products of the enclosed switches and circuit breakers that fail in materials or workmanship within the specified warranty period.
- B. Warranty Period: Three years from date of Substantial Completion.

1.09 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. Fuses: Refer to Division 26 section "Fuses" for spare fuse requirements. At a minimum, include spares for the following:
 - a) Potential transformer fuses.
 - b) Control power fuses.
 - c) Fuses for fusible devices.
 - 2. Indicating Lights: Four of each type installed.
 - 3. Primary Switch Contact Lubricant: One container.
 - 4. Enclosure Keys: Two for each enclosure type. All distribution equipment keyed alike.

PART 2 - PRODUCTS

2.01 FUSIBLE SWITCHES

- A. Manufacturers:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Siemens Energy & Automation, Inc.
- B. Type HD, Heavy Duty, Single Throw, [240] [600]-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, 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.
- D. Accessories where indicated on drawings:
 - 1. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 2. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

- 3. Lugs: Mechanical or Compression type, suitable for number, size, and conductor material.
- 4. Service-Rated Switches: Labeled for use as service equipment.
- 5. Accessory Control Power Voltage: Remote mounted and powered.

2.02 NONFUSIBLE SWITCHES

- A. Manufacturers:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Siemens Energy & Automation, Inc.
- B. Type HD, Heavy Duty, Single Throw, [240] [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. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
- D. Accessories where noted on drawings:
 - 1. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 2. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - 3. Lugs: Mechanical or Compression type, suitable for number, size, and conductor material.
 - 4. Accessory Control Power Voltage: Remote mounted and powered;

2.03 SHUNT TRIP SWITCHES

- A. Manufacturers:
 - 1. Eaton.
 - 2. Littelfuse, Inc.
 - 3. Mersen
 - 4. Siemens Energy & Automation, Inc.
- B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200kA interrupting and short-circuit current rating when fitted with Class J fuses.
- C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

- D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
- E. Accessories:
 - 1. Oiltight key switch for key-to-test function.
 - 2. Oiltight red or green ON pilot light.
 - 3. Isolated neutral lug; 100 percent rating.
 - 4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 - 5. Form C alarm contacts that change state when switch is tripped.
 - 6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
 - 7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.04 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Siemens Energy & Automation, Inc.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. 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 250 A and larger.
- D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with frontmounted, field-adjustable trip setting.
- E. 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^2t response.
- F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- G. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

- H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- I. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical or Compression type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, selfpowered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
 - 9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 10. Electrical Operator: Provide remote control for on, off, and reset operations.
 - 11. Accessory Control Power Voltage: Integrally mounted, self-powered

2.05 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2.06 IDENTIFICATION

A. Nameplates: Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine enclosed switches and circuit breakers before installation. Reject equipment that is damaged, or rusted, or have been subjected to water saturation.
- B. Examine areas, surfaces, substrates, and elements to receive enclosed switches and circuit breakers with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that field measurements are as indicated.
 - 2. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.
- C. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install enclosed switches and circuit breakers and accessories in accordance with manufacturer's instructions.
- B. Coordinate layout and installation of equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section "Seismic Controls for Electrical Systems."
- D. Wall-Mounted Switches and Circuit Breakers: Install enclosed switches and circuit breakers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For enclosed switches and circuit breakers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Mount equipment plumb and rigid without distortion of enclosure.

- G. Install fuses in fusible devices.
- H. Comply with NECA 1.

3.03 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. 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 for control wiring.

3.04 IDENTIFICATION

- A. Equipment Nameplates: Label each section with equipment nameplate.
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- C. Diagram and Instructions:
 - 1. Engraved, Laminated Acrylic or Melamine Label. Mount on front of equipment.
 - a) Operating Instructions: Printed operating instructions for switches and circuit breakers, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures.
- D. Warning Labels: Label equipment with a warning label in accordance with NFPA 70 and NFPA 70E.
 - 1. Exception: Do not install NFPA 70 working clearance requirements on enclosed switches and circuit breakers in finished spaces.

3.05 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Vacuum dirt and debris from interior of equipment; do not use compressed air to assist in cleaning. Remove paint splatters and other spots. Repair exposed surfaces to match original finish.

3.06 **PROTECTION**

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.07 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges and protective relay trip characteristics as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.08 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control tests and inspections:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, to assist in testing, and to assist in adjusting device settings.
- B. Acceptance Testing Preparation:
 - 1. After installing equipment but before equipment is energized, test for compliance with requirements.
 - 2. Verify that grounding system at the equipment tested at the specified value or less.
 - 3. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 4. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. After electrical circuitry has been energized, test for compliance with requirements.
 - 2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Report results of tests and inspections in writing. Record adjustable settings and measured insulation resistances. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Assist in field commissioning of equipment including pretesting and adjusting of equipment and components.

- E. Infrared Scanning: Perform the following infrared scan tests and inspections and prepare reports:
 - 1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - 2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - 3. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the main incoming section of each service entrance equipment. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a) Rebalance loads.
 - b) Prepare written request for voltage adjustment by electric utility in accordance with Division 26 section "Provisions for Electric Utility Service".
- G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- H. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.09 **DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain equipment, overcurrent protective devices, instrumentation, and accessories, and to use monitoring and communication units.
- B. Video record demonstrations presentation for Owner's records.

END OF SECTION

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PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes the following enclosed controllers rated 600 V and less:
 - 1. Full-voltage manual:
 - a) Fractional Horsepower Manual Controllers:

1.02 **DEFINITIONS**

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon-controlled rectifier.

1.03 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - 1. Show tabulations of the following:
 - a) Each installed unit's type and details.
 - b) Factory-installed devices.
 - c) Nameplate legends.
 - d) Short-circuit current rating of integrated unit.
 - e) Listed and labeled for integrated short-circuit current (withstand) rating: of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - f) Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.
- C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.05 CLOSEOUT SUBMITTALS

- A. 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 installed components.
 - 2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
 - 3. Manufacturer's written instructions for setting field-adjustable overload relays.
 - 4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

1.06 MATERIALS MAINTENANCE 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 for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3.

1.07 QUALITY ASSURANCE

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- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

- 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 NFPA 70.
- D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Seismic Controls for Electrical Systems."

1.08 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.

1.09 PROJECT 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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.010 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 sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 GENERAL

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

- 1. Eaton Electrical Inc.: Cutler-Hammer Business Unit.
- 2. General Electric Company: GE Consumer & Industrial Electrical Distribution.
- 3. Rockwell Automation, Inc.: Allen-Bradley brand.
- 4. Siemens Energy & Automation, Inc:
- 5. Square D: a brand of Schneider Electric.
- B. Mounting: Controllers may be surface mounted in equipment rooms and unfinished spaces but shall be flush mounted in finished spaces or where noted on the Drawings.

2.02 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - 1. Configuration: Nonreversing.
 - 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
 - 3. Surface mounting.
 - 4. Pilot light:

2.03 ENCLOSURES

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: Type 1
 - 2. Outdoor Locations: Type 3R
 - 3. Kitchen Areas: Type 4X
 - 4. Other Wet or Damp Indoor Locations: Type 4

2.04 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - 1. Pilot Lights: Standard-duty, type.
 - a) Pilot Lights: LED types; colors as indicated.
- B. Cover gaskets: for Type 1 enclosures:

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting 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."
- C. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- D. Comply with NECA 1.

3.02 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.04 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.

- 1. Connect selector switches to bypass only those manual- and automaticcontrol devices that have no safety functions when switch is in manualcontrol position.
- 2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.05 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed controllers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 **DEMONSTRATION**

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES:

- A. Gas-engine generator sets for standby power supply with the following features and accessories:
 - 1. Engine-generator set.
 - 2. Battery charger.
 - 3. Starting battery
 - 4. Muffler/silencer.
 - 5. Generator overcurrent and fault protection.
 - 6. Outdoor enclosure.
 - 7. Vibration isolation devices.
 - 8. Remote annunciator.
 - 9. Unit-mounted cooling system.
 - 10. Unit-mounted control and monitoring.
 - 11. Remote stop switch.
 - 12. Load bank.
 - 13. Load-bank remote-control panel.

1.02 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- B. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.
- C. LP: Liquid petroleum.
- D. EPS: Emergency power supply.
- E. EPSS: Emergency power supply system.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of generators and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.04 SUBMITTALS

- A. Product Data: Include the following:
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Thermal damage curve for generator.
 - 3. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Include the following:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Dimensioned plan and elevation drawings of engine-generator set and other components specified.
 - 3. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 4. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 - 5. Diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.
- C. Coordination Drawings: For each equipment room and equipment yard, provide dimensioned layout of the electrical equipment within the space, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
 - 1. Dimensioned concrete base, outline of equipment, conduit entries, and ground rod locations; including equipment working clearances and manufacturer required access space.
 - 2. Indicate structural members, light fixtures, sprinkler piping and heads, HVAC equipment, ducts and diffusers, plumbing piping and access fittings. Include maintenance access clearances.
 - 3. Location of structural supports for structure-supported raceways and piping.
 - 4. Location and clearance of electrical equipment and raceways impacting equipment installation.
 - 5. Proposed routing of equipment, in shipping splits, from exterior of the building to the final installed location. Include product weights, width and height restrictions encountered along the path. Include intended construction sequencing to mitigate conflicts.

- 6. Proposed routing of equipment for future removal, from within equipment room to exterior of the building without removal of non-related equipment or architectural elements.
- D. Welding certificates.
- E. Qualification Data:
 - 1. For Installer.
 - 2. For manufacturer.
 - 3. For testing agency.
- F. Source Quality-Control Reports: Including, but not limited to, the following
 - 1. Certified summary of prototype-unit test report.
 - 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 - 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria.
 - 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 - 5. Report of sound generation.
 - 6. Report of exhaust emissions showing compliance with applicable regulations.
 - a) For installations where field-deployed after treatment devices are utilized to meet emission standards, provide manufacturer certification.
 - 7. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.
- G. Field quality-control test reports.
- H. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - a) List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - b) Operating instructions laminated and mounted adjacent to generator location.
 - c) Training plan.
- I. Warranty

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. 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.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged generator sets and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for generators including clearances between generators and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- G. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX for welding exhaust system piping.
- H. 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.
- I. Comply with NFPA 54
- J. Comply with NFPA 37.
- K. Comply with NFPA 70.
- L. Comply with NFPA 99.
- M. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

N. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.06 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.07 WARRANTY

- A. Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.08 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in manufacture and installation of original equipment.

1.09 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. Fuses: One for every 10 of each type and rating, but not less than one of each.
 - 2. Indicator Lamps: One for every six of each type used, but not less than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements provided in Generator Sizing Schedule on drawings, provide comparable products by one of the following, the manufacturer used as the basis of design is listed in schedule:

- 1. Caterpillar; Engine Div.
- 2. Cummins Power Generation, Inc
- 3. MTU Onsite Energy

2.02 SERVICE CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: 5 to 40 deg C
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1,500 feet (300 m)

2.03 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.
- C. Power Rating: Standby.
- D. Service Load: Generator system shall be sized to handle load scheduled on drawings on Generator Load Schedule, but shall not be less than 200 kW.
- E. Power Factor: 0.8, lagging.
- F. Frequency: 60 Hz.
- G. Voltage: 480 V ac.
- H. Phase: Three-phase, four wire, delta.
- I. Governor: Adjustable isochronous, with speed sensing.
- J. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components.
- K. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.

- 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- L. Generator-Set Performance
 - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 - 2. Transient Voltage Performance: Refer to Generator Sizing Schedule on drawings. Voltage shall recover and remain within the steady-state operating band within three seconds.
 - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - 5. Transient Frequency Performance: Refer to Generator Sizing Schedule on drawings. Frequency shall recover and remain within the steady-state operating band within five seconds.
 - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 - 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, the system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 - 8. Start Time: Refer to Generator Sizing Schedule on drawings.

2.04 ENGINE

- A. Fuel: Natural gas
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: The following items are mounted on engine or skid:
 - 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 - 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

- E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a) Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Muffler/Silencer
 - 1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a) Minimum sound attenuation of 25 dB at 500Hz.
 - b) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge shall be 85 dBA or less.
 - 2. Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a) Minimum sound attenuation 19 dB at 500 Hz.
 - b) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge shall be 95 dBA or less.
 - 3. Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a) Minimum sound attenuation 15 dB at 500 Hz.
 - b) Sound level in the 20- to 75-Hz frequency band measured at a distance of 25 feet (8 m) from exhaust discharge shall be 87 dBA or less.
- G. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dryfilter element and "blocked filter" indicator.
- H. Starting System: electric, with negative ground .

- 1. Components: Sized so they will not be damaged during a full enginecranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article.
- 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
- 3. Cranking Cycle: 60 seconds.
- 4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article to provide specified cranking cycle at least twice without recharging.
- 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
- 6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
- 7. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a) Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d) Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
- I. Installation of equipment required for emissions compliance shall include a complete manufacturer certified system, including, but not limited to any additional piping, heating and structural support.

2.05 FUEL SUPPLY SYSTEM

- A. Natural Gas Vapor-Withdrawal System:
 - 1. Comply with NFPA 54.

- 2. Carburetor.
- 3. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
- 4. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
- 5. Fuel Filters: One for each fuel type.
- 6. Manual Fuel Shutoff Valves: One for each fuel type.
- 7. Flexible Fuel Connectors: Minimum one for each fuel connection.
- 8. LP gas flow adjusting valve.
- 9. Fuel change gas pressure switch.

2.06 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of the generator set. When mode-selector switch is switched to the on position, the generator set starts. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.
- B. Configuration:
 - 1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.
 - 2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
 - 3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:
 - a) Wall-Mounted Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.
- C. Control and Monitoring Panel:
 - 1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.

- 2. Instruments: Located on the control and monitoring panel and viewable during operation.
 - a) Engine lubricating-oil pressure gage.
 - b) DC voltmeter (alternator battery charging).
 - c) Engine-coolant temperature gage.
 - d) Running-time meter.
 - e) AC voltmeter, for each phase
 - f) AC ammeter, for each phase
 - g) AC frequency meter.
 - h) Generator-voltage adjusting rheostat.
- 3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:
 - a) Cranking control equipment.
 - b) Run-Off-Auto switch.
 - c) Control switch not in automatic position alarm.
 - d) Overcrank alarm.
 - e) Overcrank shutdown device.
 - f) Low water temperature alarm.
 - g) High engine temperature prealarm.
 - h) High engine temperature.
 - i) High engine temperature shutdown device.
 - j) Low lub oil pressure alarm
 - k) Low lub oil pressure shutdown
 - l) Overspeed alarm.
 - m) Overspeed shutdown device.
 - n) Coolant low-level alarm.
 - o) Coolant low-level shutdown device.
 - p) EPS load indicator.
 - q) Battery high-voltage alarm.
 - r) Low cranking voltage alarm.
 - s) Battery-charger malfunction alarm.
 - t) Battery low-voltage alarm.
 - u) Contacts for local and remote common alarm.
 - v) Lamp test.
 - w) Coolant high-temperature alarm.
 - x) Coolant low-temperature alarm.
 - y) Coolant high-temperature shutdown device.
 - z) Hours of operation.
 - aa) Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
 - bb) Remote manual stop shutdown device.
 - cc) Air shutdown damper alarm when used.
 - dd) Air shutdown damper shutdown device when used.
 - ee) Generator overcurrent protective device not closed alarm.

- D. Connection to Power Monitoring and Control System: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.
- E. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.
- F. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
 - 1. Overcrank alarm.
 - 2. Coolant low-temperature alarm.
 - 3. High engine temperature prealarm.
 - 4. High engine temperature alarm.
 - 5. Low lube oil pressure alarm.
 - 6. Overspeed alarm.
 - 7. Low coolant level alarm.
 - 8. Low cranking voltage alarm.
 - 9. Contacts for local and remote common alarm.
 - 10. Audible-alarm silencing switch.
 - 11. Air shutdown damper when used.
 - 12. Run-Off-Auto switch.
 - 13. Control switch not in automatic position alarm.
 - 14. Low cranking voltage alarm.
- G. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
- H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.07 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.
- B. Generator Overcurrent Protective Device:
 - 1. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying UL 489.

- a) Tripping Characteristic: Designed specifically for generator protection.
- b) Trip Rating: Matched to generator rating.
- c) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
- d) Mounting: Adjacent to or integrated with control and monitoring panel.
- C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of the alternator will occur. When signaled by the protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from the load circuits. Protector shall perform the following functions:
 - 1. Initiates a generator overload alarm when the generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
 - 2. Under single or three-phase fault conditions, regulates the generator to 300 percent of rated full-load current for up to 10 seconds.
 - 3. As the overcurrent heating effect on the generator approaches the thermal damage point of the unit, the protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
 - 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.08 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1 and specified performance requirements.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.
- G. Enclosure: Dripproof.

- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.09 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description:
 - 1. Vandal-resistant, sound-attenuating, weatherproof steel housing. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
 - a) Sound Attenuation Level: Level I
 - 2. Prefabricated or preengineered, galvanized-steel-clad, integral structuralsteel-framed, walk-in enclosure erected on concrete foundation.
- B. Construction:
 - 1. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph (160 km/h).
 - 2. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
 - 3. Hinged Doors: With padlocking provisions.
 - 4. Space Heater: Thermostatically controlled and sized to prevent condensation.
 - 5. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
 - 6. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
- C. Muffler Location: Within enclosure
- D. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

- 1. Louvers: Fixed-engine cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- 2. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.
- E. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
- F. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.010 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil and water resistant and factory cut to sizes that match requirements of the equipment supported.
 - 1. Rubber Isolator Pads: Elastomer (neoprene or silicone) arranged in single or multiple layers and molded with a nonslip pattern and steel baseplates of sufficient stiffness to provide uniform loading over the pad area.
 - 2. Load range: from 10 to 50 psig and a deflection not less than 0.08 inch per 1 inch of thickness. Do not exceed a loading of 50 psig.
- B. Comply with requirements in Div. 23 "Vibration Isolation for HVAC" " for vibration isolation and flexible connector materials for steel piping, exhaust shroud and ductwork..

2.011 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.012 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests:
 - a) Comply with IEEE 115.
 - 2. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype shall have been factory tested to demonstrate compatibility and reliability.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

- 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
- 2. Test generator, exciter, and voltage regulator as a unit.
- 3. Full load run.
- 4. Maximum power.
- 5. Voltage regulation.
- 6. Transient and steady-state governing.
- 7. Single-step load pickup.
- 8. Safety shutdown.
- C. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Comply with engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
 - 1. For installations where field-deployed after treatment equipment is utilized, install equipment in accordance with manufacturer's requirements to ensure the final installation meets the manufacturer's definition of a factory-certified arrangement.
- B. Equipment Mounting:
 - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
 - 3. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure to anchor bolts installed in concrete base.

C. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
 - 1. Install fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
 - 2. Connect fuel piping to engines with a gate valve and union.
 - a) Natural gas piping, valves, and specialties for gas piping inside the building are specified in Division 23 Section "Fuel Gas Piping."
 - 3. Connect exhaust-system piping to engines.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section " Low-Voltage Electrical Power Conductors and Cables ."
- D. 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 and UL 486B.

3.04 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC piping and Equipment" and Division 26 Section "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.05 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

- a) Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with Drawings and the Specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that the unit is clean.
- b) Electrical and Mechanical Tests:
 - 1) Perform insulation-resistance tests according to IEEE 43.
 - a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
 - b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
 - 2) Test protective relay devices.
 - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
 - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 5) Verify correct functioning of the governor and regulator.
- 2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a) Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c) Verify acceptance of charge for each element of the battery after discharge.
 - d) Verify that measurements are within manufacturer's specifications.
- 3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
- 4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
- 5. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
- 6. Exhaust Emissions Test: Comply with applicable government test criteria.
- 7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100

percent step-load increases and decreases, and verify that performance is as specified.

- 8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
- 9. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.06 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.07 **DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.
 - 1. Coordinate this training with that for transfer switches..

END OF SECTION

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

- A. This section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.
 - 2. Remote annunciation systems.
 - 3. Remote annunciation and control systems.

1.02 RELATED SECTIONS INCLUDING THE FOLLOWING:

- A. Related Sections include the following:
 - 1. Division 26 Section "Engine Driven Generators" for Generator coordination.

1.03 SUBMITTALS REQUIRED FOR REVIEW

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
 - 2. Schematic diagrams.
 - 3. Wiring diagrams.
- C. Factory test reports.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For each type of product 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. Features and operating sequences, both automatic and manual.
 - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.04 DEFINITIONS

- A. Closed Transition (Make–Before–Break): In a switching device, a configuration in which the new connection path is established before the previous contacts are opened. This prevents the switched path from ever seeing an open circuit.
- B. Open Transition (Break-Before-Make): A switch that is configured to break (open) the first set of contacts before engaging (closing) the new contacts. This prevents the momentary connection of the old and new circuit paths together.
- C. Withstand duration: The withstand rating value is the level of fault current that must be withstood for a specified length of time, i.e., 42000 amps at 3 cycles.
- D. Level 1 Equipment: Level 1 is the more stringent NFPA emergency life safety requirement and is imposed when failure of the emergency system, including the transfer equipment could result in loss of human life or serious injury.
- E. Level 2 Equipment: Level 2 is the less stringent NFPA emergency life safety requirement and is imposed when failure of the emergency system including the transfer equipment is less critical to human life safety.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- 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 automatic transfer switches, remote annunciators and remote annunciator and control panels through one source from a single manufacturer. The manufacturer furnishing the generator shall be the same supplier of the transfer switch. The transfer switch circuit breaker (if present) shall be coordinated with the generator circuit breaker to provide coordinated tripping.
- 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 NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.
- J. Installed equipment must be UL listed and bear the UL label.

1.06 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the Transfer Switch that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a) Damage from transient voltage surges.
- B. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
- C. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contactor Transfer Switches:
 - a) Caterpillar; Engine Div.
 - b) Eaton Electrical Inc.; Cutler-Hammer
 - c) Emerson; ASCO Power Technologies, LP.

- d) GE Zenith Controls.
- e) Kohler Power Systems; Generator Division.
- f) Onan/Cummins Power Generation; Industrial Business Group.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Voltage and Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated. Voltage ratings shall be consistent with applications from 115 volts AC to 600 volts and single or three phase as required by the application. Current ratings and the number of poles shall be as indicated on the plans.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
 - 2. Where the transfer switch internal fault-current protection can not exceed the indicated fault-current values, an enclosed fused switch with current limiting fuses shall be installed ahead of the transfer switch.
- C. Controls: Microprocessor control having repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C. All internal controls components shall be accessible from the equipment front.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of fullrated current between active power sources.
 - 1. Switch Action: Double throw; mechanically held in both directions.
 - 2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles. [The neutral switch shall be located on the common shaft with the phase poles.]
- H. Neutral Terminal: Solid and fully rated bus bar, unless otherwise indicated.
- I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- J. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- K. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. All factory wiring shall be accessible from the equipment front. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated. Power terminals shall be rated for 90 degree C and copper or aluminum cable.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- L. Enclosures: General-purpose NEMA 250, Type [1] [3R] [12], complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
- M. Bus and Wiring: All Bus and cable /control wire shall be copper.
- N. Service Entrance Rating: The Automatic transfer switch shall be UL rated for use as service entrance equipment.

2.03 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

- D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:
 - 1. Fully automatic make-before-break operation.
 - 2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
 - 3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - a) Initiation occurs without active control of generator.
 - b) Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 - 4. Failure of power source serving load initiates automatic break-before-make transfer.
- H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- J. Automatic Transfer-Switch Features:
 - Undervoltage Sensing for Each Phase of Normal Source: Sense low phaseto-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to

98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

- 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
- 3. Frequency: Monitor the frequency of the incoming normal power circuit. For the normal source, initiate transfer if the frequency varies more that 5% from the rated nominal value. For the emergency source, inhibit transfer if the normal source circuit frequency varies more that 5% from the rated nominal value.
- 4. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
- 5. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
- 6. Test Switch: Simulate normal-source failure.
- 7. Switch-Position Pilot Lights: Indicate source to which load is connected.
- 8. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b) Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
- 9. Unassigned Auxiliary Contacts: Two normally open, single-pole, doublethrow contacts for each switch position, rated 10 A at 240-V ac.
- 10. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
- 11. Engine Starting Contacts: Time Delay, adjustable from 0 to 6 seconds, is included. Engine starting contact shall remotely start the generator immediately upon initiation by the normal source monitor.
- 12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- 13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory

settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

- a) Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
- b) Push-button programming control with digital display of settings.
- c) Integral battery operation of time switch when normal control power is not available.

2.04 BYPASS/ISOLATION SWITCHES

- A. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Bypass/Isolation switch shall have main contacts and operating mechanism similar to the Automatic Transfer Switch except all operations shall be manual. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - 1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transferswitch operation, except for testing or maintenance.
 - 2. Bypass/Isolation Switch Configuration, Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - 3. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 - 4. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less. Operation of the bypass/isolation switch shall be allowed regardless of the position of the automatic transfer switch. Switch operation shall provide for positive and complete sequencing of all contact motion and shall prevent any form of intermediate stop or delayed motion.
 - 5. Engine Run Circuit Interface: There shall be sufficient controls included to assure that the engine run circuit remains closed when the switch is in the bypass-to-emergency position even though the associated transfer switch is in the normal position or completely removed from the enclosure.
 - 6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - 7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors. If the unit is constructed such that removal of components is not allowed, then the Automatic Transfer Switch section shall be isolated from the Bypass Isolation Switch section by means of insulated barriers.
 - 8. The bypass isolation switch shall be provided with indicating lights identifying location in bypass position, full isolation position, and source availability.

- B. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.
- C. The bypass isolation switch maybe located in the same enclosure as the automatic transfer switch or maybe located separately in a dedicated enclosure adjacent to the automatic transfer switch enclosure.
- D. The bypass/isolation switch shall maintain a mechanical separation of the normal and emergency power sources to guard against the inadvertent connection of unsynchronized sources together. Electrical interlocking alone will not be considered acceptable.

2.05 REMOTE ANNUNCIATOR SYSTEM

- A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
 - 1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - 2. Switch position.
 - 3. Switch in test mode.
 - 4. Failure of communication link.
- B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 - 1. Indicating Lights: Grouped for each transfer switch monitored.
 - 2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
 - 3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
 - 4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.06 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

- A. Functional Description: Include the following functions for indicated transfer switches:
 - 1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - 2. Indication of switch position.
 - 3. Indication of switch in test mode.
 - 4. Indication of failure of digital communication link.
 - 5. Key-switch or user-code access to control functions of panel.
 - 6. Control of switch-test initiation.
 - 7. Control of switch operation in either direction.
 - 8. Control of time-delay bypass for transfer to normal source.
- B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of

communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

- C. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - 1. Controls and indicating lights grouped together for each transfer switch.
 - 2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
 - 3. Digital Communication Capability: Matched to that of transfer switches supervised.
 - 4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

2.07 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 - Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- C. Identify components according to Division 26 Section "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.02 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FACTORY TESTS:

A. The Automatic Transfer Switch and Bypass Isolation Switch shall be factory tested to verify compliance with these specifications and ensure proper operation

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a) Check for electrical continuity of circuits and for short circuits.
 - b) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c) Verify that manual transfer warnings are properly placed.
 - d) Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b) Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c) Verify time-delay settings.
 - d) Verify pickup and dropout voltages by data readout or inspection of control settings.

- e) Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
- f) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
- g) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a) Verify grounding connections and locations and ratings of sensors.
- C. Testing Agency's Tests and Inspections:
 - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a) Check for electrical continuity of circuits and for short circuits.
 - b) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c) Verify that manual transfer warnings are properly placed.
 - d) Perform manual transfer operation.
 - 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b) Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c) Verify time-delay settings.
 - d) Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e) Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

- g) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a) Verify grounding connections and locations and ratings of sensors.
- D. Coordinate tests with tests of generator and run them concurrently.
- E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- F. Remove and replace malfunctioning units and retest as specified above.
- G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This section includes field-mounted Surge Protective Devices (SPDs) for low-voltage (120 to 600 V) power distribution and control equipment, including:
 - 1. Surge Protection Devices at Service Entrance Equipment
 - 2. Surge Protection Devices at Distribution Equipment
 - 3. Surge Protection Devices at Branch Panelboards

1.02 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. In or Inominal: Nominal Discharge Current. Peak value of surge current, selected by the manufacturer, through the SPD having current wave shape of 8/20 microseconds where the SPD remains functional after 15 surges. In is posted on the device UL label.
- C. MCOV: Maximum Continuous Operating Voltage. The maximum continuous operating voltage rating of a Metal Oxide Varistor (MOV) that can be applied without the MOV being damaged and/or destroyed by thermal runaway. MCOV is posted on the device UL label.
- D. SCCR: Short Circuit Current Rating. The maximum current rating the SPD can sustain without being damaged and/or destroyed. SCCR is posted on the device UL label.
- E. SPD: Surge Protective Device. A broad class of protective devices, installed parallel with the distribution panel or service disconnect, meant to protect downstream electrical distribution equipment from the effects of high voltage surges on the line.
- F. SPD Type definitions:
 - 1. TYPE 1: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device. Type 1 devices are required for Master Certification of Lightning Protection System installations under UL 96A.
 - 2. TYPE 2: Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch circuit panel.

G. VPR: Voltage Protection Rating. The average of measured limiting voltage before and after Nominal Discharge Testing (In), rounded up to one of UL's VPR categories (indicated in the latest ANSI/UL 1449 edition) such as 330 volt, 400 volt, 500 volt, etc. VPR is posted on each device UL label.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate SPD devices with Division 26 Section "Electrical Power Monitoring and Control."
- B. Coordinate layout and installation of SPDs and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access.
- C. Fault-Current Study, Coordination Study, and Overcurrent Protective Device Settings report must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. If studies have not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the contractor at no additional cost to the project. Refer to specification section "Overcurrent Protective Device Coordination Study".
- D. Do not energize or connect any electrical or low voltage equipment to their sources until SPDs are installed and connected.
- E. Do not perform insulation resistance tests of the distribution wiring equipment with the SPD installed. Disconnect before conducting insulation resistance tests and reconnect immediately after the testing is over.

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".
- B. Product Data: For each SPD type, accessory, component and enclosure indicated. Include dimensions and Manufacturer's technical data on features, performance, electrical characteristics, ratings, weights, furnished options, specialties, accessories, and finishes. Tabulate model number, SPD type, system voltage, phases, modes of protection, MCOV, VPR, and I_n.
- C. Shop Drawings: For SPDs.
 - 1. Detail enclosure types and details.
 - 2. Include general arrangement drawing showing dimensions and weights of each assembled device.

- 3. Include installation and mounting details for SPDs internal to equipment.
- 4. Detail bus connection configuration, current, and voltage ratings, including size and number of bus bars and current rating for each bus.
- 5. Detail short-circuit current rating of SPD assembly and overcurrent protective devices.
- 6. Include schematic and wiring diagrams for power, signal, and control wiring.
- 7. Include insertion loss bode plots.
- 8. Include nameplate legends.
- 9. Include list of materials.
- D. Product Certificates: For SPDs, from manufacturer.
- E. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Project Record Documents: Record actual installed equipment and circuiting arrangements.
- H. Operation and Maintenance Data: For SPDs 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 SPDs and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting SPDs.
 - 3. Time-current curves for each type of overcurrent protective device.
 - 4. Features and operating sequences, both automatic and manual.
 - 5. Video recording of operation training and demonstration.
- I. Follow-up service reports.

1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."
- C. Source Limitations: Obtain SPDs of each type and associated components and accessories through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
- E. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
- F. Comply with NEMA LS 1.
- G. Comply with ANSI/ UL 1449.
- H. Comply with NFPA 70.
- I. The SPDs shall be compliant with the restrictions of the Hazardous Substances (RoHS) Directive 2002/95/EC.

1.06 PROJECT CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- B. Environmental Limitations:
 - 1. Do not install SPDs until spaces are enclosed and weathertight. Equipment shall be protected from any remaining wet work in the space and work above equipment. Provide temporary HVAC system for maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a) Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - b) Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - c) Humidity: 0 to 85 percent, noncondensing.
 - d) Altitude: Less than 10,000 feet (6090 m) above sea level.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space, protected from weather and so condensation will not form on or in units. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic. Handle carefully in accordance with manufacturer's instructions to avoid damage to equipment components, enclosure, and finish.
- B. Handle and prepare SPD components according to manufacturer's written instructions.

1.08 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.09 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Manufacturers:
 - 1. ABB USA.
 - 2. Eaton.
 - 3. Leviton Mfg. Company Inc.
 - 4. Siemens.
 - 5. Schneider Electric.
 - 6. Surge Suppression Incorporated.
- B. Surge Protective Device Ratings: Device type ratings shall be:
 - 1. Type 1 Service entrances
 - 2. Type 2 Service entrance equipment or distribution equipment
 - 3. Type 3 Utilization equipment or point of use.
- C. Nominal System Voltage: Match the system voltage to which the SPD is connected, as indicated on the drawings.
- D. Maximum Continuous Operating Voltage: Not less than 125 percent of nominal system voltage for 240V or less power systems, and not less than 115 percent of nominal system voltage for 600V and 480V power systems.
- E. Comply with ANSI/UL 1449.
- F. SPDs for Lightning Protection: For Lightning Protection Systems specified or otherwise required to be "Master Labeled" per UL 96A utilize Type 1 (20kA rated I_n) SPDs at each Service entrance switchboard and generator distribution panelboard.

2.02 SURGE PROTECTION DEVICES AT SERVICE ENTRANCE EQUIPMENT

- A. Surge Protection Devices: Externally mounted, wired-in, solid-state, parallelconnected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating matching or exceeding the available short-circuit indicated on the plans, and with the following features and accessories:
 - 1. Fuses, rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Redundant suppression circuits; with individually fused metal-oxide varistors,
 - 4. Redundant replaceable modules.
 - 5. EMI filtering: Minimum 45dB at 100kHz for L-N Modes.
 - 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 10. Six-digit transient-event counter set to totalize transient surges.
- B. Nominal Discharge current (In): The SPD shall be tested to meet UL 1449 Nominal Discharge Current requirements. All modes of protection shall be tested including any required overcurrent protection.
 - 1. Type 1 SPD's shall be tested and labeled at 20kA per mode.
- C. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 250 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
- D. Protection Modes:
 - 1. Protection mode VPR for grounded wye circuits 3-phase, 4-wire circuits shall be as follows:

	480Y/277 V	208Y/120 V	600Y/347 V
Line to Neutral	1200	700	1500
Line to Ground	1200	700	1500
Neutral to Ground	1200	700	1500

2.03 SURGE PROTECTION DEVICES AT DISTRIBUTION EQUIPMENT

- A. Surge Protection Devices: Externally mounted, wired-in, solid-state, parallelconnected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating matching or exceeding the available short-circuit indicated on the plans, and with the following features and accessories:
 - 1. Fuses, rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Redundant suppression circuits; with individually fused metal-oxide varistors,
 - 4. Redundant replaceable modules.
 - 5. EMI filtering: Minimum 45dB at 100kHz for L-N Modes.
 - 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 10. Six-digit transient-event counter set to totalize transient surges.
- B. Nominal Discharge current (I_n): The SPD shall be tested to meet UL 1449 Nominal Discharge Current requirements. All modes of protection shall be tested including any required overcurrent protection.
 - 1. Type 1 SPD's shall be tested and labeled at 20kA per mode.
 - 2. Type 2 SPD's shall be tested and labeled at 10kA per mode.
- C. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 150 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
- D. Protection Modes:
 - 1. Protection mode VPR for grounded wye circuits, 3-phase, 4-wire circuits shall be as follows:

	480Y/277 V	208Y/120 V	600Y/347 V
Line to Neutral	1200	700	1500
Line to Ground	1200	700	1500
Neutral to Ground	1200	700	1500

2.04 SURGE PROTECTION DEVICES AT BRANCH PANELBOARDS

- A. Surge Protection Device: Externally or Integrally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating matching or exceeding the available short-circuit indicated on the plans, and with the following features and accessories:
 - 1. Fabrication using bolted compression lugs for internal wiring.
 - 2. Redundant suppression circuits; with individually fused metal-oxide varistors,
 - 3. Redundant replaceable modules.
 - 4. EMI filtering: Minimum 45dB at 100kHz for L-N Modes.
 - 5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 6. LED indicator lights for power and protection status.
 - 7. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 8. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
 - 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 10. Six-digit, transient-event counter set to totalize transient surges.
- B. Nominal Discharge current (I_n): The SPD shall be tested to meet UL 1449 Nominal Discharge Current requirements. All modes of protection shall be tested including any required overcurrent protection.
 - 1. Type 2 SPD's shall be tested and labeled at 10kA per mode.
- C. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 100 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
- D. Protection Modes:
 - 1. Protection mode VPR for grounded wye circuits, 3-phase, 4-wire circuits shall be as follows:

	480Y/277 V	208Y/120 V	600Y/347 V
Line to Neutral	1200	700	1500
Line to Ground	1200	700	1500
Neutral to Ground	1200	700	1500

2.05 ENCLOSURES

- A. All SPD Units shall be fully enclosed unless otherwise noted. Provide enclosures suitable for the locations indicated and as described below:
 - 1. Indoor Enclosures:
 - a) NEMA 250 Type 1 constructed of a polymer or steel material
 - 2. Outdoor Enclosures:
 - a) NEMA 250 Type 3R constructed of steel material and with a gasket to exclude dirt, windblown dust, and water (rain, sleet, and snow) from entering the enclosure when shut.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surge suppression devices before installation. Reject equipment that is damaged, or rusted, or have been subjected to water saturation.
- B. Examine areas, surfaces, substrates, and elements to receive SPDs with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that field measurements are as indicated.
 - 2. Verify that manufacturer's written instructions for environmental conditions have been established in spaces where equipment will be installed, before installation begins.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install SPDs and accessories in accordance with manufacturer's instructions.
- B. Coordinate layout and installation of equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access.
- C. Wall-Mounted Surge Protective Devices: Install SPDs on walls adjacent to equipment served, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For SPDs not at walls, mount to similar support structure for equipment served by device. Comply with Division 26 Section "Hangers and Supports for Electrical Systems."
- D. Install SPD devices at service entrance on load side, with ground lead bonded to service entrance ground.

- E. Install SPD devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide circuit breaker as a dedicated disconnecting means for SPD unless otherwise indicated.
- F. Mount equipment plumb and rigid without distortion of enclosure.
- G. Install fuses in fusible devices.
- H. Comply with NECA 1.

3.03 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Connect to building automation system.
- D. 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 for control wiring.

3.04 IDENTIFICATION

- A. Nameplates: Label external device enclosures with equipment served.
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- C. Warning Labels: Label device with a warning label in accordance with NFPA 70 and NFPA 70E.

3.05 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Vacuum dirt and debris from interior of equipment; do not use compressed air to assist in cleaning. Remove paint splatters and other spots. Repair exposed surfaces to match original finish.

3.06 ADJUSTING

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

3.07 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control tests and inspections:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, to assist in testing, and to assist in adjusting device settings.
- B. Acceptance Testing Preparation:
 - 1. After installing SPD but before equipment is energized, test for compliance with requirements.
 - 2. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
 - 3. Complete startup checks according to manufacturer's written instructions.
 - 4. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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. Report results of tests and inspections in writing. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. SPDs will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.08 **DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain equipment, overcurrent protective devices, instrumentation, and accessories.
- B. Video record demonstrations presentation for Owner's records.

END OF SECTION

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PART 1 - GENERAL

1.01 SUMMARY

- A. Included in the work of this section are labor, material, and appurtenances required to complete the work of this Section as specified herein, including, but not limited to:
 - 1. Interior light fixtures, lamps, LEDs, reflectors, lenses or faceplates, ballasts, transformers, drivers and power supplies (includes exterior light fixtures normally installed on exterior surfaces of buildings).
 - 2. Emergency lighting units.
 - 3. Exit signs.
 - 4. Light fixture supports.
 - 5. Emergency Lighting Mini-Inverter.
 - 6. Coordination.
 - 7. Quality assurances.
 - 8. Specific requirements.

1.02 RELATED SECTIONS INCLUDE THE FOLLOWING:

- A. Division 26 Section "General Electrical Requirements" for general requirements and related documents that apply to this Section.
- B. Division 26 Section "Common Work Results for Electrical" for raceways, conductors, cables, and cords.
- C. Division 26 Section "Exterior Lighting" for exterior light fixtures, except those normally mounted on exterior surfaces of buildings.
- D. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.03 SUBMITTALS

- A. General:
 - 1. Only those light fixtures and manufacturers per each fixture type designated and listed in the Light Fixture Schedule or on the Drawings, and approved in accordance with paragraph 1.4-SUBSTITUTIONS of this Section, or both, will be accepted. Where the Light Fixture Schedule indicates an allowance to be made for a specific light fixture, the price is a contractor price and monies shall be allotted for freight, installation, and lamping (if designated). Alternate manufacturers presented at bid shall be disqualified.

- 2. Submit all light fixtures, specified for use on this Project, in a single submittal package of portfolios, so that all light fixtures can be reviewed at one time.
- 3. Prepare portfolios from manufacturer's standard specification sheets, and include the fixture tag indicated on the Light Fixture Schedule to identify each light fixture. Do not combine more than one light fixture type on a single sheet.
- 4. Fixture or other materials shall not be shipped, stored, or installed into the work without approval of shop drawings.
- 5. Modifications to fixtures shall be in accordance with Architect's comments.
- B. Product Data: For each type of light fixture, collated and bound in sets, and arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Summary page with the following for each light fixture type
 - a) The number, type and wattage of the light fixture lamps or LEDs (including, but not limited to, assemblies, arrays, bars or modules).
 - b) Light fixture ballast, driver or auxiliary device manufacturer, number and type.
 - 2. Fixture cut sheets with name of manufacturer and options to be provided marked, including, but not limited to, voltage, lensing, and finish/color.
 - a) Descriptive information providing physical characteristics of light fixture, including, but not limited to, materials, dimensions, fixture efficacy and/or efficiency, and verification of indicated parameters.
 - b) For LED fixtures, include also L70 lifetime and wattage of luminaire including driver/power supply losses.
 - 1) Include MacAdam ellipse step information for:
 - a) All interior light fixtures
 - b) Exterior luminaires installed on exterior building surfaces specified with 80 CRI or greater.
 - 3. Light fixture mounting details, including non-standard outlet boxes.
 - 4. Construction of light fixture housing and door (if applicable).
 - 5. Ballast cut sheet with options marked, providing physical description of ballast including, but not limited to, voltage, lamp, ballast factor, power factor, amperage and wattage.
 - 6. Power supply, transformer, and/or driver cut sheet with options marked, providing physical description of auxiliary device including, but not limited to, voltage, power factor, amperage, wattage, and maximum remote distance charts between device and light fixture.
 - 7. Light fixture finish and color (if applicable).
 - 8. Lamp cut sheet with options marked, providing physical description of lamps, including, but not limited to, voltage, wattage, efficacy, CCT, CRI, lumens, and life expectancy.

- a) For LED lamps, include also number of MacAdam ellipse steps and L70 lifetime.
- 9. Photometric data, in IESNA format, including LM-79 for LED luminaires, based on laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in this Project.
 - a) For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
 - b) Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
- 10. Emergency ballast cut sheet: Descriptive cut sheets providing physical description of emergency ballasts for use in normal light fixtures, including, but not limited to, complete battery information, lumens, and method for testing per NFPA 101.
- C. Shop Drawings: Show details of non-standard or custom light fixtures. Indicate dimensions, finish color, including, but not limited to, custom color, weights, methods of field assembly, components, features, accessories, and modifications. Scaled documents shall be provided for custom fixtures.
- D. Submittal Schedule
 - 1. Within 30 days of Division 26 contractor award, shop drawings covering all light fixtures within this section shall be forwarded to architect to begin approval process. Any shop drawings submitted after the required time frame will require the contractor to submit only the 1st named manufacturer and associated specification data listed on the fixture schedule as the only approved manufacturer. No substitutions will be allowed after the specified time frame.
 - 2. Within 15 days of "approved" and "approved as noted" shop drawings, contractor shall forward to Architect a guaranteed ship date for each specified fixture.
 - 3. Within 15 days after contractor's receipt of "reject and resubmit" or "not approved" shop drawings, contractor shall provide Architect with resubmitted shop drawings for only those fixtures deemed unacceptable.
 - 4. Contractor is responsible to call to the attention of the Architect any submittals that have not been returned to him in a timely manner that may affect delivery of fixtures or as otherwise affecting Section 1.4.D of this specification.
- E. Control Wiring

- F. Coordination Drawings: Refer to architectural reflected ceiling plans or details for exact location of light fixtures; engineering documents shall not be referenced for exact fixture positions. Contractor shall check and verify dimensions and details on drawings before proceeding with the work. If any question arises about the true meaning of drawings, refer the matter to the Architect, whose decision is final. In no case proceed with work with any uncertainty. Architectural documents shall show and coordinate with assistance from installers of items involved:
 - 1. Light fixtures.
 - 2. Suspended ceiling components.
 - 3. Structural members to which suspension systems for light fixtures will be attached.
 - 4. Other items in finished ceiling including the following:
 - 5. Air outlets and inlets.
 - 6. Speakers.
 - 7. Sprinklers.
 - 8. Smoke and fire detectors.
 - 9. Occupancy sensors.
 - 10. Access panels.
- G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
- H. Qualification Data: For agencies providing photometric data for light fixtures.
- I. Field quality-control test reports.
- J. Operation and Maintenance Data: For lighting equipment and fixtures to include in operation and maintenance manuals.
- K. Warranties: Special warranties specified in this Section.

1.04 SUBSTITUTIONS

- A. Refer to Division 26 Section "General Electrical Requirements".
- B. Prior to the Bid Date, substitutions will not be considered unless the Architect/Engineer have received written request for approval at least ten calendar days prior to the date for receipt of Bids. Include in each such request the Light Fixture Schedule designation, name of the material or equipment for which it is to be substituted and complete Product Data for the proposed substitute, as defined in SUBMITTALS above, and all other information necessary for an evaluation. Provide interior point-by-point photometric calculations, under both normal and emergency lighting conditions, as applicable, if required by the Engineer. Submit a \$100.00 review fee to the Engineer with each such point-by-point calculation for use of electronic base files. The fee will be returned if the substitution is added to the specification.

- C. After the Bid Date, proposals to substitute light fixtures for those shown on the Drawings or specified herein, will only be considered as a deduct. Submit proposed substitutions separately, in Submittal form, with a list of proposed substitutions together with a deduct price for each substitution. Proposed substitutions will then be reviewed by the Architect/Engineer.
- D. During the construction period, no substitutions shall be considered if product delay is due to contractor's failure to order products in a timely manner after presentation of fixture schedules and specifications. Additional costs associated with air freight or special factory runs to meet schedule due to contractor's error shall be at the expense of contractor.
- E. The Architect/Engineer has the final authority as to whether the light fixture is an acceptable replacement to the specified item. The proposed substitution may also be rejected for aesthetic reasons if felt necessary or desirable. In the event the proposed substitutions herein described are rejected, provide the specified item(s).

1.05 **DEFINITIONS**

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature
- C. CRI: Color-rendering index.
- D. CU: Coefficient of utilization.
- E. EISA: Energy Independence and Security Act of 2007.
- F. L70: minimum 70% maintained initial-rated lumens at average rated life for LEDs
- G. LED: Light Emitting Diode
- H. LED Lamp: Replaceable LED light source with an integral driver within envelope of lamp. Lamp/Base types may include MR16/bi-pin, PAR/medium base, etc.
- I. LED Module: Light source that contains LEDs, and may include additional components such as lenses, reflectors, or refractors, however do not include drivers.
- J. LER: Light fixture (Luminaire) efficiency rating.
- K. Light Fixture: Complete light fixture, including ballast housing if provided.
- L. RCR: Room cavity ratio.

1.06 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories:

- 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- 2. Marked for intended use.
- B. Comply with NFPA 70.
- C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- D. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
- E. Regulatory Agencies: Provide fixtures conforming to nationally- or internationally-recognized accredited testing agencies, such as U.S., ETL, ARL, or others in acceptance with local code enforcement policy.
- F. Electrical Components and Devices: Provide only fixtures that comply with National Electric Code (NEC), and in particular to Section 410. All ceiling recessed fixtures, whether indicated in a catalog number or not, shall be equipped with an integral thermal protection device.
- G. FMG Compliance: Light fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

1.07 COORDINATION

- A. Unless otherwise noted, perform all electrical Work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other Divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.
- B. Coordinate layout and installation of light fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including, but not limited to, HVAC equipment, fire-suppression system, and partition assemblies. Contractor shall arrange his installation in proper relation to other work so that there shall be no interference, damage or delay to other trades' work
- C. Give ample notice of any special openings or rough-in work required for placing electrical/lighting work so as to avoid cutting or removal of completed work.
- D. Where work of this Section is to be flush or concealed, install it so it does not project beyond finished lines of walls, ceilings or floor surface.

E. Verify all ceiling systems and coordinate light fixture type and accessories prior to ordering light fixtures. Coordinate and cooperate with ceiling installer in regards to the location and installation of light fixtures.

1.08 WARRANTY

- A. General Guarantee: For a period of one year after Owner's initial acceptance and establishment of the beginning date of the guarantee period, and at no cost to the Owner, Contractor shall promptly furnish and install replacements for any fixtures or components deemed by the Owner as defective in workmanship under normal operating conditions, excluding lamp replacement as noted in Section 1.10.A.1. Contractor shall repair installed equipment on the job site to Owner's satisfaction. For any time during said guarantee period that fixtures are not fully functional due to defects in material or workmanship, Contractor shall provide or pay for suitable temporary light fixtures, and shall remove said temporary fixtures upon installation of replacement elements. Contractor shall furthermore guarantee replacement fixtures for a period of one year following replacement.
- B. Contractor shall not be held responsible for damage of fixtures or equipment components occurring after the beginning of the guarantee period due to acts of vandalism, acts of war, or acts of God.
- C. LED Warranties: Shall be free from defects in materials and workmanship for the period indicated from date of factory shipment.
 - 1. LED Luminaires, including LED modules, arrays and drivers: Five years.
 - 2. LED Lamps: Three years.
- D. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining coverage years.
 - 2. Warranty Period for Self-Powered Exit Sign Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining coverage years.

1.09 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. Additional light fixtures and accessories as scheduled on the Drawings.

B. Where light fixtures are specified with tamper proof hardware, provide the Owner with three tools for each different type of hardware.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

- A. In Light Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 - 1. Basis-of-Design Product: The design for each light fixture is based on the product named.

2.02 LIGHT FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Provide light fixtures as shown on the drawings and/or specified. This shall include all lamps, material and labor to securely hang light fixtures, clean them and make them completely ready for use. Provide all hangers, supports, and miscellaneous hardware required to install light fixtures. Provide additional tie wires connected to structure to conform to applicable seismic requirements where required.
- B. Light fixture models scheduled on the Drawings are to show the manufacturer, grade and style of light fixtures required. Regardless of the manufacturer's catalog number suffixes indicated, provide all options and features as described in the Light Fixture Schedule.
- C. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures. Manufacturer of recessed fixtures shall provide mounting brackets suitable for connection to ceiling system structure. Modifications to standard mounting brackets shall be coordinated with contractor and delivered with fixture so that no delays to product delivery shall be allowed.
- D. Metal Parts: Free of burrs and sharp corners and edges.
- E. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- G. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 85 percent.
 - 3. Diffusing Specular Surfaces: 80 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.

- H. Plastic Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a) Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
 - b) UV stabilized.
 - 2. Glass: Annealed crystal glass, unless otherwise indicated.
- I. Where located within structural concrete, light fixture housing and any other luminaire components in direct contact with concrete shall be effectively coated and/or covered to prevent chemical reactions with the concrete in accordance with the American Concrete Institute Code.
- J. Fixture Finishes:
 - 1. Apply fixture finishes after fabrication in a manner that assures a durable wear-resistant surfacing. Give exposed metal surfaces (brass, bronze, aluminum and others) and finished castings, except chromium-plated or stainless steel parts, an even coat of high-grade meth/acrylate lacquer or transparent epoxy.
 - 2. For corrosive or salt water environments, manufacturer shall provide fixtures with low copper/zinc cast aluminum (AB-47100 aluminum with less than 0.6% copper classified for corrosive areas) housings to prevent salts from "pitting" aluminum housing. Manufacturer shall provide, in addition to or in lieu of, AB-47100 aluminum, ion added or pre-anodized polyester powder cast finish for "marine grade" applications. Manufacturer shall otherwise provide all stainless steel housing in conjunction with stainless steel hardware.
- K. Reflectors:
 - 1. Provide aluminum reflectors or reflecting cones for downlight style fixtures comprised of #12 aluminum reflector sheet, 0.57 inch (15 gauge) or heavier and free of tool-making indentations, including spinning lines caused by assembly techniques. All reflectors shall be of first-quality, anodized finish :Alzak" with specular or semi-specular finish and color as selected. Provide specular reflectors with no apparent brightness above 45 degrees from Nadir and semi-specular, diffuse reflectors with no apparent brightness above 75 degrees from Nadir.
- L. Mounting hardware and trims:
 - 1. Coordinate as need to suit ceiling conditions.
 - 2. Light fixtures near or in contact with insulation shall comply with code.

- 3. Maintain a 3" minimum working clearance between non-IC rated light future housings and insulation on all adjacent ductwork, piping, walls and ceilings.
- M. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps, LEDs, ballasts and/or drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp, LEDs, ballast and/or driver characteristics:
 - a) "USE ONLY" and include specific lamp or LED type.
 - b) LED type, wattage, beam angle (if applicable) for LED luminaires. Indicate maximum allowed wattage.
 - c) CCT and CRI for all luminaires.
- N. Emergency lights and exit signs with integral battery back-up shall be connected to a separate unswitched conductor bypassing all other controls and contactors. Exit signs shall not be switched. Allow battery to charge for a minimum of 48 hours before light level testing. In order to prevent battery damage, do not turn off power for extended periods of time after the emergency light has been powered.

2.03 EMERGENCY LIGHTING UNITS

- A. Description: Self-contained units complying with UL 924.
 - 1. Battery: Sealed, maintenance-free, lead-acid type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - 7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.04 DRIVERS FOR LED LUMINAIRES

- A. Description: Designed for type and quantity of LED diodes of light fixture. Drivers shall tolerate sustained open circuit and short circuit output conditions without damage. Driver shall be designed for full light output unless dimmer or bi-level control is indicated:
 - 1. Sound Rating: A.
 - 2. Total Harmonic Distortion Rating: Less than 20 percent. Shall comply with ANSI C82.77.
 - 3. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 4. Power Factor: 0.90 or higher at full load.
 - 5. Driver shall operate with maximum sustained variations of +/-10% input voltage and frequency with no damage to driver.
 - 6. Driver output shall be regulated to maximum +/- 5% published load range or requirements of downstream LED fixture.
 - 7. LED Current Crest Factor: 1.5 or less.
 - 8. LED drivers shall not over-drive LEDs at a current or voltage above LED rated values in order to increase LED lumen output.
 - 9. Meets EN610000 for input harmonics.
 - 10. ROHS Compliant.
- B. Dimming Drivers:
 - 1. Dimming Range: Visually flicker-free, strobe-free, continuous dimming of source as follows, unless specifically noted otherwise in the Light Fixture Schedule whichever is more stringent:
 - a) Luminaires: 100 to 10 percent of rated lumens.
 - b) Lamps: 100 to 20 percent of rated lumens.
 - 2. 0-10V dimming drivers: Compliant with IEC 60929 standard for 4-wire dimming.
 - 3. Compatibility: Certified by manufacturer for use with specific dimming control system and LED indicated.
 - 4. Control: Coordinate to ensure that the dimming driver, power supply, controller, dimming module, and/or wallbox dimmer and connecting wiring are compatible.

2.05 EMERGENCY LIGHTING MINI-INVERTER

- A. Manufacturer
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a) Bodine (by Signify),
 - b) Iota Engineering (Acuity Brands),
 - c) Myers Emergency Power Systems,

- B. Description Self-contained uninterruptible or fast-transfer inverter designed for normal and emergency operation of connected lighting loads. Unit shall be capable of operating HID, incandescent, fluorescent, induction and LED fixtures with no break or interruption of illumination. UL 924 listed and meets NFPA 101, NFPA 70 and local codes.
 - 1. Battery: Sealed, maintenance-free lead-calcium or lead-acid type. 68 deg F to 86 deg F optimum operating temperature.
 - 2. Charger and Electronics: Fully automatic, thermal compensating variable rate battery charger. AC lockout feature, low battery voltage disconnect; DC overload, short circuit and brownout protection. 32 deg F to 104 deg F electronics operating temperature.
 - 3. Operation: Inverter shall allow connected emergency lighting fixtures to be normally on. Upon loss of normal utility power, the emergency lighting fixtures will be delivered emergency power for their full lumen output rating with no break (<2 ms) in illumination for a minimum of 90 minutes.
 - 4. 120V, single phase input and output voltages. Input voltage shall match output voltage, and +/- 3% voltage regulation, 60 Hz.
 - 5. Maximum remote mounting distance of 1000'-0".
 - 6. Housing: Designed for surface mounting installation to floor or wall. 16 gauge steel housing with scratch-resistant powder coat paint finish..
 - 7. Testing: Integral testing means by either manual test switch or self-testing, self-diagnostic with manual testing capabilities.
 - 8. Onboard LED indicating lights for inverter status indication.
 - 9. Manufacturer's warranty or minimum 2 year warranty on electronics and battery and seven-year prorata warranty on battery, whichever is greater.
 - 10. Overload and short circuit protection on input and output of inverter. Circuit breakers or fusing on output side.
- C. Where wattage of inverter is different from Basis-of-Design manufacturer's selected wattage, provide quantity of inverters as required to meet design intent. If additional inverters are required, confirm additional equipment will fit within available space constraints.
- D. Where physical size of inverter is different from Basis-of-Design manufacturer, confirm equipment will fit within available space constraints.

2.06 LAMPS GENERAL

- A. Unless specific manufacturers and lamp types are called for in the Light Fixture Schedule, all lamps provided for this project shall be by the same manufacturer. Lamps shall be manufactured by:
 - 1. Eiko
 - 2. General Electric
 - 3. Osram/Sylvania
 - 4. Philips
 - 5. Soraa

- B. All lamps shall be new and shall be delivered to the project in manufacturer's original sealed package.
- C. Substitutions of specific lamp manufacturer as addressed in Fixture Schedule shall not be allowed. Costs associated with re-lamping due to non-compliance with specification, for both labor and material costs, shall be the sole responsibility of the contractor. For those fixtures with lamp included in fixture, contractor shall coordinate with manufacturer to ensure only approved lamp(s) is (are) installed. Lamp manufacturers indicated on Fixture Schedule are for reference. Where required, contractor shall coordinate with Owner regarding national purchasing agreement of specific lamp manufacturers. Purchasing of lamps, whether through competitive bidding of listed manufacturers or proprietary supply, shall be at the discretion of the Owner.

2.07 LED LAMPS AND LUMINAIRES

- A. Comply with ANSI C78.377 for white light LED color range. Unless noted otherwise in the Light Fixture Schedule, LED color quality characteristics shall be 80 CRI minimum and 3500K CCT.
- B. LED binning specification tolerance to be within 3 MacAdam ellipses of rated values or as indicated in the Light Fixture Schedule, whichever is more stringent. All LEDs used for same fixture type throughout the project to originate from same production bin.
- C. Unless indicated otherwise in the Light Fixture Schedule, minimum 70% maintained initial-rated lumens at average rated life of as follows:
 - 1. LED lamps: 20,000 hours
 - 2. LED luminaires: 50,0000 hours
- D. ROHS compliant
- E. Manufacturer of LED chips will be evaluated based on the manufacturer's product literature and data. At a minimum, LED fixtures or lamps will incorporate Bridgelux, Cree, Nichia, Osram or Xicato LEDs; additional manufacturers may be considered however the Architect or Engineer has the authority to reject other manufacturers for technical or aesthetic reasons if felt necessary or desireable.

2.08 AUXILIARY DEVICES FOR LOW VOLTAGE AND LED FIXTURES

A. Provide remote power supplies, drivers and/or transformers for light fixtures as required for a complete and operational system. Where equipment is not indicated as plenum rated, provide an additional enclosure for the device(s) suitable for the installed environment.

2.09 LIGHT FIXTURE SUPPORT COMPONENTS

- A. Comply with Sections "260548 Seismic Controls for Electrical" and "260529 -Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.010 TRANSFORMERS FOR LOW VOLTAGE FIXTURES

A. Provide transformers to low voltage lamps which are suitable for the electrical characteristics of the supply circuits to which they are to be connected. For remote electronic or magnetic transformers, contractor shall remote transformers so as to reduce voltage drop. For 25 amp low-voltage linear systems, contractor shall not daisy-chain 25A loaded runs together. Contractor shall provide home-run from end of run to remote transformer.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify conditions of equipment and installation prior to beginning work.
- B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Light Fixtures: All work shall be executed to present a neat appearance. Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- C. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum

number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

- D. Support for Light Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from light fixture corners.
 - 2. Support Clips: Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
 - 4. Install at least one independent support rod or wire from structure to a tab on light fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- E. Suspended Light Fixture Support:
 - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end. Provide suitable connectors or collars to connect adjoining units to appear as a continuous unit.
 - 4. Decorative pendant mounted light fixtures
 - a) Provide cord and/or stem lengths to match elevations above finished floor as indicated on architectural elevations. If architectural elevations do not indicate suspension heights, coordinate with Architect to determine final suspension heights. Regardless, contractor shall not field cut pendants or order rigid stems without elevation approval from Architect. Pendant suspensions on electrical documents are for reference only.
 - 1) Cord-mounted: Manufacturers shall supply luminaires with flexible, field cutting cords. Contractor shall field cut cords as required.
 - 2) Field-cuttable, rigid-stem mounted: Manufacturers shall supply luminaires with field cutting rigid stems. Contractor shall field cut stems as required.
 - 3) Factory-cut rigid stem mounted: Contractor shall provide rigid stem dimensions to the manufacturer as required.
 - b) Junction boxes used to feed light fixtures shall be covered by manufacturer supplied canopy plates.

- F. Installation within non-standard ceilings, including, but not limited to, wood and metal ceilings.
 - 1. For recessed downlight light fixtures, specification is based on standard throats to accommodate ceiling thicknesses of ³/₄" or less. If non-standard ceiling (such as wood, thickened gypboard ceilings and metal plank type) require throats greater than ³/₄", modifications to manufacturer's standard ³/₄" throat shall be determined by Architect and Contractor prior to shop drawing submission.
 - 2. For light fixtures recessed into metal ceilings, rigidly support light fixture to ensure that trim fits flush with ceiling plane.
- G. Manufacturer shall supply contractor with a complete list of component elements to comply with design intent for either 20-amp (flexible low voltage track systems or line voltage track) or 50-amp bus bar track systems. Contractor shall install track systems based on design requirements outlined herein or Light Fixture Schedule.
- H. Connect wiring according to Section "260519 Low-Voltage Electrical Power Conductors and Cables."
- I. Through wiring of recessed light fixtures, in suspended ceilings, is not permitted. Connect each light fixture by a whip to a junction box. The whip shall be of sufficient length to allow the light fixture to be relocated within a 6-foot radius.
- J. Wall Mounted Light fixtures
 - 1. Unless otherwise noted, conceal all raceways and back boxes for wall mounted light fixtures. Coordinate all wall-mounted light fixtures with interior elevations. Where specific elevations or dimensions are not indicated, verify the correct location with Architect prior to installation. Contractor shall supply structure to support weight of fixture.
- K. Contractor shall construct light coves according to architectural details. Contractor shall ensure, unless otherwise directed, that top of fixture lamp is flush with top of cove lip. Contractor shall provide blocking as needed under fixture to ensure stated requirement.
- L. Auxiliary Devices for low voltage and LED Fixtures
 - 1. Install device within maximum remote distances and with wiring sized per manufacturer's recommendations.
 - 2. In public areas or other areas where remote device visibility is undesireable, install device where concealed from view, well ventilated and accessible. Provide access panels as required.
 - 3. Provide label on device indicating fixture type and location/room served along with panelboard circuit number.
 - 4. Properly support remote lighting devices, including transformers, power supplies, and drivers, per Code and manufacturer's recommendations.

3.03 DIMMING

- A. For dimmable light fixtures, provide both control and power wiring between light fixture and control device and between light fixtures. Quantity of low voltage and line voltage wiring and wire type shall be per manufacturer's recommendations. At a minimum, provide the following based on control type at either 120V or 277V, unless recommended otherwise by the manufacturer:
 - 1. 0-10V two low voltage conductors and two line voltage conductors plus ground
 - 2. DMX two line voltage conductors plus ground and DMX cabling
- B. Coordinate light fixture and control device dimming types for compatibility.

3.04 COORDINATION

- A. Light fixtures shown on the Electrical Drawings represent general arrangements only. Refer to Architectural Drawings for exact locations.
- B. Coordinate the installation and location of light fixtures with other work and all other trades before installation to avoid conflicts. Coordinate light fixture locations in mechanical rooms with final installed piping and ductwork layouts.
- C. Verify all ceiling systems and coordinate light fixture type and accessories prior to ordering light fixtures. Coordinate and cooperate with ceiling installer in regards to the location and installation of light fixtures.
- D. Coordinate final light fuxture locations in walk-in coolers and freezers with refrigeration coils and other trades.
- E. Wall-Mounted Light fixtures
 - 1. Coordinate all wall-mounted light fixtures with the architectural features of the building. Where specific elevations or dimensions are not indicated, verify the correct location with the Architect prior to beginning any work.

3.05 ADJUSTING

- A. Contractor shall adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Architect.
- B. At the time of substantial completion, aim all track lights, flood lights, spot lights, and other fixtures requiring aiming per the Architect's direction. Contractor shall make provisions for supplying all scaffolds, lifts, and other tools and equipment as required.
- C. Where required, focusing shall be done during hours of darkness. Upon notification by contractor that all fixtures are correct as per shop drawings and functioning, that specified lamps have been verified, lighting designer or Architect shall coordinate

with contractor as to a mutually agreed upon time to complete focusing. Failure of contractor to notify Architect during substantial completion will result in failure to comply with specifications.

3.06 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Clean light fixtures of dirt and debris upon completion of the installation. Protect installed light fixtures from damage during the remainder of the construction period.
- C. Upon completion of the installation of light fixtures, and after building circuits have been energized, energize lighting branch circuits to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.
- D. At the time of final acceptance of this project by the Owner, ensure that all lamps are in working order and all light fixtures are fully lamped.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.07 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires and dimming luminaires to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.
 - 2. Adjust dimmable luminaires in the presence of architect.

END OF SECTION

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following lighting equipment:
 - 1. Exterior LED light fixtures with LED modules and drivers.
 - 2. Light-fixture-mounted photoelectric relays.
 - 3. Poles and accessories.

1.02 SUBMITTALS

- A. General:
 - 1. Only those light fixtures and manufacturers per each fixture type designated and listed in the Light Fixture Schedule or on the Drawings, and approved in accordance with paragraph 1.4-SUBSTITUTIONS of this Section, or both, will be accepted. Where the Light Fixture Schedule indicates an allowance to be made for a specific light fixture, the price is a contractor price and monies shall be allotted for freight, installation, and lamping (if designated). Alternate manufacturers presented at bid shall be disqualified.
 - 2. Submit all light exterior fixtures, specified for use on this Project, in a single submittal package of portfolios, so that all exterior light fixtures can be reviewed at one time.
- B. Prepare portfolios from manufacturer's standard specification sheets, and include the number indicated on the Light Fixture Schedule to identify each light fixture. Do not combine more than one light fixture type on a single sheet.
 - 1. Fixture or other materials shall not be shipped, stored, or installed into the work without approval of shop drawings.
 - 2. Modifications to fixtures shall be in accordance with Architect's comments.
- C. Product Data: For each light fixture, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - 1. Summary page with the following for each light fixture type
 - a) The number, type and wattage of the light fixture lamps or LEDs (including, but not limited to, assemblies, arrays, bars or modules).
 - b) Light fixture ballast, driver or auxiliary device manufacturer, number and type.
 - 2. Fixture cut sheets with name of manufacturer and options to be provided marked, including, but not limited to, voltage, lensing, and finish/color.
 - a) Descriptive information providing physical characteristics of light fixture, including, but not limited to, materials, dimensions,

effective projected area, fixture efficacy and/or efficiency, and verification of indicated parameters.

- b) For LED fixtures, include also L70 lifetime and wattage of luminaire including driver/power supply losses.
- Include MacAdam ellipse step information for luminaires specified with 80 CRI or greater.
- 3. Light fixture mounting details, including, but not limited to, non-standard outlet boxes.
- 4. Construction of light fixture housing and door (if applicable).
- 5. Power supply, transformer, and/or driver cut sheet with options marked, providing physical description of auxiliary device including, but not limited to, voltage, power factor, amperage, wattage, and maximum remote distance charts between device and light fixture.
 - a) For dimming LED, also include dimming type technology and dimming range/limits.
- 6. Lamp cut sheet with options marked, providing physical description of lamps, including, but not limited to, voltage, wattage, efficacy, CCT, CRI, lumens, and life expectancy.
 - a) For LED lamps, include also number of MacAdam ellipse steps and L70 lifetime.
- 7. Details of attaching light fixtures and accessories.
- 8. Details of installation and construction.
- 9. Photometric data, in IESNA format, including LM-79 for LED luminaires, based on laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in this Project.
 - a) For indicated light fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining light fixtures shall be certified by manufacturer.
 - b) Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- 10. For pole-mounted LED area lighting fixtures, IES-TM-21 LED luminaire lifetime and lumen maintenance projections.
- 11. Emergency ballast cut sheet: Descriptive cut sheets providing physical description of emergency ballasts for use in normal light fixtures, including, but not limited to, complete battery information, lumens, and method for testing per NFPA 101.
- 12. Photoelectric relays.
- 13. Materials, dimensions, and finishes of poles.
- 14. Means of attaching light fixtures to supports, and indication that attachment is suitable for components involved.

- 15. Anchor bolts for poles.
- 16. Manufactured pole foundations.
- D. Delegated-Design Submittals for Pole-Mounted Area Lighting: Submit the following documents, signed and sealed by a qualified professional engineer:
 - 1. Structural analysis data and calculations used for pole selection and foundations.
 - a) Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles and equipment anchorage devices, complies with AASHTO LTS-4 or as required by the local authority having jurisdication, whichever is more stringent, for location of project.
 - 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 - 3. Design calculations for the following:
 - a) Design calculations indicating strength of screw foundations and soil conditions on which they are based.
 - b) Design calculations for determination of poured-in-place concrete foundation size and reinforcement
 - 4. Shop Drawings:Submittal Schedule
 - a) Within 30 days from Division 26 Contractor award, shop drawings covering all light fixtures within this section shall be forwarded to architect to begin approval process. Any shop drawings submitted after the required time frame will require the contractor to submit only the 1st named manufacturer and associated specification data listed on the fixture schedule as the only approved manufacturer. No substitutions will be allowed after the specified time frame.
 - b) Within 15 days of "approved" and "approved as noted" shop drawings, Contractor shall forward to Architect a guaranteed ship date for each specified fixture.
 - c) Within 15 days after Contractor's receipt of "reject and resubmit" or "not approved" shop drawings, Contractor shall provide Architect with resubmitted shop drawings for only those fixtures deemed unacceptable.
 - d) Contractor is responsible to call to the attention of the Architect any submittals that have not been returned to him in a timely manner that may affect delivery of fixtures or as otherwise affecting Section 1.4.D of this specification.
 - 5. Show details of non-standard or custom light fixtures. Indicate dimensions, finish color, including, but not limited to, custom color, weights, methods of field assembly, components, features, accessories, and modifications. Scaled documents shall be provided for custom fixtures.
 - 6. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

- 7. Wiring Diagrams: Power and control wiring.
- E. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 or as noted elsewhere in this specification and that loads imposed by light fixtures and attachments have been included in design. This certification shall be based on design calculations by a professional engineer.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For light fixtures and poles to include in operation and maintenance manuals.
- H. Warranty: Special warranties specified in this Section.

1.03 SUBSTITUTIONS

- A. Refer to Division 26 Section "General Electrical Requirements".
- B. Prior to the Bid Date, substitutions will not be considered unless the Architect/Engineer have received written request for approval at least ten calendar days prior to the date for receipt of Bids. Include in each such request the Light Fixture Schedule designation, name of the material or equipment for which it is to be substituted and a complete description of the proposed substitute including cut sheets, photometric data, and all other information necessary for an evaluation. Provide interior point-by-point calculations if required by the Engineer. Submit a \$100.00 review fee to the Engineer with each such point-by-point calculation for use of electronic base files. The fee will be returned if the substitution is added to the specification.
- C. After the Bid Date, proposals to substitute light fixtures for those shown on the Drawings or specified herein, will only be considered as a deduct. Submit proposed substitutions separately, in Submittal form, with a list of proposed substitutions together with a deduct price for each substitution. Proposed substitutions will then be reviewed by the Architect/Engineer.
- D. The Architect/Engineer have the final authority as to whether the light fixture is an acceptable replacement to the specified item. The proposed substitution may also be rejected for aesthetic reasons if felt necessary or desirable. In the event the proposed substitutions herein described are rejected, provide the specified item(s).

1.04 **DEFINITIONS**

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature
- C. CFL: Compact Fluroescent

- D. CRI: Color-rendering index.
- E. CU: Coefficient of utilization.
- F. CV: Coefficient of Variance. The ratio of standard deviation for all illuminance values to the mean illuminance value.
- G. Delegated-Design Submittals: Documents, including, but not limited to, drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by Owner and authorities having jurisdiction.
- H. EISA: Energy Independence and Security Act of 2007.
- I. Horizontial Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches above the ground, unless otherwise indicated.
- J. L70: minimum 70% maintained initial-rated lumens at average rated life for LEDs
- K. LED: Light Emitting Diode
- L. LED Lamp: Replaceable LED light source with an integral driver within envelope of lamp. Lamp/Base types may include MR16/bi-pin, PAR/medium base, etc.
- M. LED Module: Light source that contains LEDs, and may include additional components such as lenses, reflectors, or refractors, however do not include drivers.
- N. LER: Light fixture efficacy rating.
- O. Light fixture: Complete light fixture, including ballast housing if provided.
- P. LLD: Lamp Lumen Depreciation.
- Q. LLF: Light Loss Factor.
- R. Luminaire: Complete lighting fixture, including ballast housing if provided.
- S. Pole: Light fixture support structure, including tower used for large area illumination.
- T. Standard: Same definition as "Pole" above.
- U. Target Illumination: Average maintained illumination level, calculated by multiplying initial illuminace by LLF.
- V. UG: Uniformity Gradient; the rate of change of illuminance over a lighted area, expressed as a ration between the illuminances of adjacent measuring points on a uniform grid.

AWSOM

W. Vertical Illuminance: Measurement in foot-candels (lux), in two directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.

1.05 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of light fixture and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in latest AASHTO LTS-4.
- B. Live Load: Single load of 500 lbf, distributed as stated in latest AASHTO LTS-4.
- C. Ice Load: As stated in latest AASHTO LTS-4 or as required by the local authority having jurisdiction, whichever is more stringent.
- D. Wind Load: As stated in latest AASHTO LTS-4 or as required by the local authority having jurisdiction, whichever is more stringent.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.
- B. Light Fixture Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- C. Light Fixture Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
- 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 IEEE C2, "National Electrical Safety Code."
- F. Comply with NFPA 70.

1.07 COORDINATION

- A. Unless otherwise noted, perform all electrical Work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other Divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.
- B. Coordinate layout and installation of light fixtures, poles, foundations, and underground raceway system with other above- and below-grade site construction

and utilities. Notify Architect/Engineer of conflicts before proceeding with the Work.

1.08 WARRANTY

- A. General Guarantee: For a period of one year after Owner's initial acceptance and establishment of the beginning date of the guarantee period, and at no cost to the Owner, Contractor shall promptly furnish and install replacements for any fixtures or components deemed by the Owner as defective in workmanship under normal operating conditions, excluding lamp replacement as noted in Section 1.12.A.1. Contractor shall repair installed equipment on the job site to Owner's satisfaction. For any time during said guarantee period that fixtures are not fully functional due to defects in material or workmanship, Contractor shall provide or pay for suitable temporary light fixtures, and shall remove said temporary fixtures upon installation of replacement elements. Contractor shall furthermore guarantee replacement fixtures for a period of one year following replacement.
- B. Contractor shall not be held responsible for damage of fixtures or equipment components occurring after the beginning of the guarantee period due to acts of vandalism, acts of war, or acts of God.
- C. LED Warranties: Shall be free from defects in materials and workmanship for the period indicated from date of factory shipment.
 - 1. LED Luminaires, including LED modules, arrays and drivers: Five years.
 - 2. LED Lamps: Three years.
- D. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Light fixtures: Free from defects in materials and workmanship (excluding fuses and lamps) for a period of 5 years from date of Substantial Completion.
 - 2. Warranty Period for Poles: Repair or replace light poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than 5 years from date of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

- C. Retain factory-applied pole wrappings on metal poles until right before pole installation.
- D. Handle all poles with web fabric straps.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

- A. In Light Fixture Schedule (on the drawings) where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 - 1. Basis-of-Design Product: The design for each light fixture is based on the product named.

2.02 LIGHT FIXTURES, GENERAL REQUIREMENTS

- A. Light fixture models scheduled on the Drawings are to show the manufacturer, grade and style of light fixtures required. Regardless of the manufacturer's catalog number suffixes indicated, provide all options and features as described in the Light Fixture Schedule.
- B. Light fixtures shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- C. Comply with IES RP-8 for parameters of lateral light distribution patterns indicated for light fixtures.
- D. Comply with IES BUG ratings where indicated on the Light Fixture Schedule.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed light fixtures.
- H. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- I. Exposed Hardware Material: Stainless steel for latches, fasteners, and hinges.
- J. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

- K. Light Shields: Metal baffles or louvers, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- L. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- M. Gaskets for Lenses and Refractors: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in light fixture doors.
- N. Where located within structural concrete, light fixture housing and any other luminaire components in direct contact with concrete shall be effectively coated and/or covered to prevent chemical reactions with the concrete in accordance with the American Concrete Institute Code.
- O. Light Fixture Finish: Manufacturer's standard paint applied to factory-assembled and -tested light fixture before shipping. Where indicated, match finish process and color of pole or support materials.
- P. Factory-Applied Finish for Steel Light Fixtures: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a) Color: As indicated on the Light Fixture Schedule.
- Q. Factory-Applied Finish for Aluminum Light Fixtures: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating:
Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

- 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a) Color: As indicated on the Light Fixture Schedule.
- R. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps, LEDs, ballasts and/or drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp, LEDs, ballast and/or driver characteristics:
 - a) "USES ONLY" and include specific lamp or LED type.
 - b) LED type, wattage, beam angle (if applicable) for LED luminaires. Include maximum allowed wattage.
 - c) For LED luminaires, includes CCT and CRI.

2.03 LAMPS GENERAL

- A. Unless specific manufacturers and lamp types are called for in the Light Fixture Schedule, all lamps provided for this project shall be by the same manufacturer. Lamps shall be manufactured by:
 - 1. Eiko
 - 2. General Electric
 - 3. Osram/Sylvania
 - 4. Philips
 - 5. Soraa
 - 6. Venture
- B. All lamps shall be new and shall be delivered to the project in manufacturer's original sealed package.
- C. Substitutions of specific lamp manufacturer as addressed in Fixture Schedule shall not be allowed. Costs associated with re-lamping due to non-compliance with specification, for both labor and material costs, shall be the sole responsibility of the contractor. For those fixtures with lamp included in fixture, contractor shall coordinate with manufacturer to ensure only approved lamp(s) is (are) installed. Lamp manufacturers indicated on Fixture Schedule are for reference. Where required, contractor shall coordinate with Owner regarding national purchasing agreement of specific lamp manufacturers. Purchasing of lamps, whether through competitive bidding of listed manufacturers or proprietary supply, shall be at the discretion of the Owner.

2.04 DRIVERS FOR LED LUMINAIRES

- A. Description: Designed for type and quantity of LED diodes of light fixture. Drivers shall tolerate sustained open circuit and short circuit output conditions without damage. Driver shall be designed for full light output unless dimmer or bi-level control is indicated:
 - 1. Sound Rating: A.
 - 2. Total Harmonic Distortion Rating: Less than 20 percent. Shall comply with ANSI C82.77.
 - 3. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 4. Power Factor: 0.90 or higher at full load.
 - 5. Driver shall operate with maximum sustained variations of +/- 10% input voltage and frequency with no damage to driver.
 - 6. Driver output shall be regulated to $\pm -5\%$ published load range.
 - 7. LED Current Crest Factor: 1.5 or less.
 - 8. LED drivers shall not over-drive LEDs at a current or voltage above LED rated values in order to increase LED lumen output.
 - 9. Meets EN610000 for input harmonics.
 - 10. ROHS Compliant.
 - 11. Suitable for use in outdoor light fixtures.
 - 12. Dimming Drivers
 - a) Dimming Range: Visually flicker-free, strobe-free, continuous dimming of source as follows, unless specifically noted otherwise in the Light Fixture Schedule whichever is more stringent:
 - 2) Luminaires: 100 to 10 percent of rated lumens.
 - 3) LED Lamps: 100 to 20 percent of rated lumens.
 - b) 0-10V dimming drivers: Compliant with IEC 60929 standard for 4wire dimming.
 - c) Compatibility: Certified by the manufacturer for use with specific dimming control system and LED indicated.
 - d) Control: Coordinate to ensure that the dimming driver, power supply, controller, dimming module, and/or wallbox dimmer and connecting wiring are compatible.

2.05 LED LAMPS AND LUMINAIRES

- A. Comply with ANSI C78.377 for white light LED color range. Unless noted otherwise in the Light Fixture Schedule, LED color quality characteristics shall be 70 CRI minimum and 3000K CCT. Additionally, color-important light fixtures, as indicated with 80 CRI or better the Light Fixture Schedule shall be 80 CRI minimum and 3000K CCT. All LEDs used for same fixture type throughout the project to originate from same production bin.
- B. LED binning specification tolerance to be within 3 MacAdam ellipses of rated values for color as indicated in the Light Fixture Schedule.

- C. Unless indicated otherwise in the Light Fixture Schedule, minimum 70% of maintained initial-rated lumens at the average rated life as follows:
 - 1. LED outdoor pole mounted area lights: 100,000 hours
 - 2. LED lamps: 20,000 hours
 - 3. Other LED luminaires: 50,0000 hours
- D. ROHS compliant
- E. Manufacturer of LED chips will be evaluated based on the manufacturer's product literate and data. At a minimum, LED fixtures or lamps will incorporate Bridgelux, Nichia, Cree, Xicato or Osram LEDs; additional manufacturers may be considered however the Architect or Engineer has the authority to reject other manufacturers for technical or aesthetic reasons if felt necessary or desireable.

2.06 AUXILIARY DEVICES FOR LOW VOLTAGE AND LED FIXTURES

A. Provide remote power supplies, drivers and/or transformers for light fixtures as required for a complete and operational system.

2.07 LIGHT FIXTURE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.
 - 1. Relay with locking-type receptacle shall comply with NEMA C136.10.
 - 2. Adjustable window slide for adjusting on-off set points.

2.08 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
 - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article.
 - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of light fixtures and brackets by a factor of 1.25 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Light Fixture Attachment Provisions: Comply with light fixture manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.

- 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M or ASTM A 153/A 153M unless stainless-steel items are indicated.
- 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, 3000-psi (28-day minimum compressive strength, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, light fixture(s), and accessories.
- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.09 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: As indicated in the Light Fixture Schedule.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support light fixture or light fixtures and brackets indicated, and securely fastened to pole top.
- D. Vibration Dampeners: Factory furnish for poles over 20' high.
- E. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- F. Brackets for Light fixtures: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate light fixture.
 - 2. Finish: Same as light fixture.

- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Manufacturer's standard polyester powder coated finish with minimum 2.5mil thickness.
 - a) Color: As indicated in the Light Fixture Schedule.

2.010 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.02 EXAMINATION

- A. Verify conditions of equipment and installation prior to beginning work.
- B. Verify that equipment is ready for connecting, wiring, and energizing.

3.03 LIGHT FIXTURE INSTALLATION

- A. Install lamps in each light fixture.
- B. Fasten light fixture to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust light fixtures that require field adjustment or aiming.
- D. Baffles and Louvers for Spill Light Correction: Install on lighting fixtures with fasteners provided by the manufacturer. Install and adjust to correct out-of-limit spill-light and glare measurements.
- E. Install controls and remote ballast or driver housings in cabinets mounted on support structure at least 10 feet above finished grade.
- F. Auxiliary devices for low voltage and LED fixtures installation
 - 1. Install device within maximum remote distances and with wiring sized per manufacturer's recommendations.

- 2. In public areas or other areas where remote device visibility is undesireable, install device where concealed from view, well-ventilated and accessible. Provide access panels as required.
- 3. Provide label on device indicating fixture type and location/room served along with panelboard circuit number.
- 4. Properly support remote lighting devices, including, but not limited to, transformers, power supplies, and drivers, per Code and manufacturer's recommendations.
- 5. Provide enclosures suitable for installation environment as required.

3.04 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of light fixtures and their mounting provisions on the pole. Install poles and other structural units level, plumb, and square.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
 - 3. Trees: 10 feet.
 - 4. Shrub: 4 feet.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space. Grout materials, installation, and finishing requirements are specified in Division 05 Section "Metal Fabrications".
 - 3. Install base covers, unless otherwise indicated.
 - 4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Poles and Pole Foundations Set in Concrete Paved Driveway, Parking or Roadway Areas: Install poles with minimum of 2-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

- 1. Install protective pipe bollards on three sides of each embedded pole installed in paved areas. Refer to Division 05 "Metal Fabrications" for pipe bollards.
- F. Raise and set poles using web fabric slings (not chain or cable).

3.05 BOLLARD LIGHT FIXTURE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or flush at paved surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.06 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Raceways and Boxes for Electrical Systems", including use of coated conduits in concrete foundations.

3.07 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole, unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting light fixture to grounding system.

3.08 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Architect.
- C. Upon completion of the installation of light fixtures, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

- D. Clean light fixtures of dirt and debris upon completion of the installation. Protect installed light fixtures from damage during the remainder of the construction period.
- E. At the time of Substantial Completion, aim all adjustable fixtures, such as flood and spot lights, per the Architect's direction. Provide all necessary equipment to support this effort, such as scaffolds and lifts, as required.
- F. At the time of Final Acceptance of this Project by the Owner, all lamps shall be in working order and all light fixtures shall be fully lamped.
- G. Illumination Observations: Verify normal operation of lighting units after installing light fixtures and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.
- H. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.09 CORRECTION OF DEFICIENCIES

- A. Correction of Illumination Deficiencies: Make corrections to illumination quality or quantity measured in field quality-control tests that vary from specified illumination criteria by plus or minus 10 percent or more; add or replace lighting fixtures, or change mounting height, revise aiming, or install louvers, shields, or baffles. If lighting fixtures are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures, if indicated. Retest as specified above after repairs, adjustments, or replacements are made. Report results in writing.
- B. Correction of Excessive Illumination in Spill-Light-critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity measured in field quality-control tests that reduce levels to within specified maximum values. Replace lighting fixtures, or change mounting heights, revise aiming, or install louvers, shields, or baffles. Obtain Architect's approval to replace luminaires with units of higher or lower wattage. If mounting height is changed, revise aiming and recalculate and modify or replace support structures, if indicated. Retest as specified above after repairs, adjustments, or replacements are made. Report results in writing.
- C. Exterior athletic lighting will be considered defective if it does not pass tests and inspections.

3.010 DEMONSTRATION

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

END OF SECTION