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## **SECTION 26 0501 - ELECTRICAL GENERAL PROVISIONS**

### **PART 1 GENERAL**

#### **1.1 COMPLETENESS**

- A. It is the intent of these Specifications to provide complete systems. Completeness shall mean that all materials, equipment, and systems as installed and operating on this project have been installed properly with the best practices of the trade; are suitable for the intended purpose, location, and environment; properly fit within the physical space limitations for the project; are in conformance with applicable codes and reference standards; have been started-up, tested, adjusted, and commissioned for the intended use; have maintained applicable UL Listings; are in compliance with manufacturer's recommendations and warranty requirements; ready for the Owner's use, and in the opinion of the Architect, performing as designed.

#### **1.2 DESCRIPTION**

- A. The General and Supplementary Conditions are a part of the requirements for the work under this Division of the Specifications.

#### **1.3 WORK INCLUDED**

- A. Provide labor and materials required to install, test and place into operation the electrical systems as called for in the Contract Documents, and in accordance with applicable codes and regulations.
- B. Provide labor, materials, and accessories required to provide complete, operating electrical systems. Labor, materials or accessories not specifically called for in the Contract Documents, but required to provide complete, operating electrical systems shall be provided without additional cost.

#### **1.4 QUALITY ASSURANCE**

- A. Comply with the current applicable codes, ordinances, and regulations of the Authority or Authorities Having Jurisdiction, the rules, regulations and requirements of the utility companies serving the project, and the Owner's insurance underwriter.
- B. Drawings, specifications, codes and standards are minimum requirements. Where requirements differ, the most stringent apply.
- C. Should any change in drawings or specifications be required to comply with governing regulations, notify the Architect prior to submitting bid.
- D. All electrical equipment, materials, devices and installations shall meet or exceed minimum requirements of ADA, ANSI, ASTM, IEEE, IES, NEC, NEMA, NETA, NFPA, OSHA, SMACNA and UL.
- E. Execute work in strict accordance with the best practices of the trades in a thorough, substantial, workperson-like manner by competent workpeople. Provide a competent, experienced, full-time Superintendent who is authorized to make decisions on behalf of the Contractor.
- F. Equipment shall be certified for use in the District of Columbia and shall meet the DC energy code.

- G. The Architect or Architect's Representative may conduct unannounced field reviews of any work completed or in progress during the Contractor's working hours. A report will be issued to the Contractor if the field review of the electrical, mechanical, plumbing and fire protection systems construction has revealed elements of the work, which are inconsistent with the Contract Documents. All items in the report shall be addressed in writing by the Contractor within two (2) weeks and corrections in the field shall be made as directed.

## 1.5 ABBREVIATIONS AND DEFINITIONS

### A. Abbreviations:

1.	ADA	Americans with Disabilities Act
2.	ANSI	American National Standards Institute
3.	ASA	Acoustical Society of America
4.	ASTM	American Society for Testing and Materials
5.	BIL	Basic Impulse Level
6.	CBM	Certified Ballast Manufacturers
7.	ECC	Engineer's Control Center
8.	EIA	Electronic Industries Alliance
9.	ETL	Electrical Testing Laboratories, Inc.
10.	FCC	Fire Control Center
11.	FM	Factory Mutual
12.	IEEE	Institute of Electrical and Electronic Engineers
13.	IES	Illuminating Engineering Society
14.	IPCEA	International Power Cable Engineers Association
15.	LED	Light Emitting Diode
16.	NEC	National Electric Code
17.	NEMA	National Electrical Manufacturers Association
18.	NETA	National Electrical Testing Association
19.	NFPA	National Fire Protection Association
20.	OEM	Original Equipment Manufacturer
21.	OSHA	Occupational Safety and Health Administration
22.	SCC	Security Control Center
23.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
24.	TIA	Telecommunications Industry Association
25.	UL	Underwriters Laboratories Inc.

### B. Definitions:

1. Where it is stated in these specifications to submit to Engineer for review, refer to Architectural General and Supplementary Conditions for proper procedures.
2. FURNISH means to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories and all other items customarily required for the proper and complete application.
3. INSTALL means to join, unite, fasten, link, attach, set up or otherwise connect before testing and turning over to Owner, complete and ready for regular operation.
4. PROVIDE means to FURNISH and INSTALL.
5. AS DIRECTED means as directed by the Architect, or the Architect's Representative.
6. CONCEALED means embedded in masonry or other construction, installed behind wall furring or within drywall partitions, or installed above suspended ceilings.
7. SUBMIT means submit to Architect for review.



## 1.6 GUARANTEE

- A. Submit a single guarantee stating that the work is in accordance with the Contract Documents. Guarantee work against faulty and improper material and workmanship for a period of one year from the date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are provided or specified herein, the longer term shall apply. Correct any deficiencies, which occur during the guarantee period, within 24 hours of notification, without additional cost and to the satisfaction of the Owner. Obtain similar guarantees from subcontractors, manufacturers, suppliers and sub-trade specialists.

## 1.7 USE OF THE ARCHITECT'S AND ENGINEER'S DRAWINGS

- A. The Contractor shall obtain, at the Contractor's expense, from the Architect a set of AutoCad, Revit or compatible format architectural and engineering drawings on electronic media where desired by the Contractor and/or required by the Specifications for use in preparing the shop drawings, coordination drawings, and record drawings. The Contractor shall provide to the Architect and Engineer a written release of liability acceptable to the Architect and Engineer prior to receiving the electronic media.

## 1.8 MOCK-UP REQUIREMENTS

- A. Participate in and provide equipment, materials and labor as required to construct at the Project Site a complete electrical "mock-up", in or out of sequence, of the following:
- B. See Architectural Specification Section 014339 for details and construction requirements. The field "mock-up" will remain in place for use in the completed building systems. The "mock-up" will be reviewed and will serve as a model for the electrical system installation on other floors.

## 1.9 SUSTAINABLE BUILDING REQUIREMENTS

- A. The Owner requires the Contractor to implement practices and procedures to meet the project's environmental performance goals, which include achieving LEED Gold Certification. Specific project goals that may impact this area of work include: use of recycled-content materials; use of locally-manufactured materials; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan. The Contractor shall ensure that the requirements related to these goals, as defined in Section 018113, are implemented to the fullest extent. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
- B. LEED Submittals
  - 1. Product data for Credit IEQ 4.1: For adhesives and sealants applied within the building water proofing envelope, documentation including printed statement of VOC content in g/L.
  - 2. Product data for Credit IEQ 4.2: For paints and coatings applied within the building water proofing envelope, documentation including printed statement of VOC content in g/L.
  - 3. Product data for Credit IEQ 4.4: For composite wood installed in the building interior as equipment backer boards, documentation indicating no added urea formaldehyde resins.

C. LEED Product Data

1. Adhesives, sealants, paints and coatings applied within the building waterproofing envelope: Comply with low-emitting requirements in Division 01 Section "Indoor Air Quality Requirements."
2. Composite wood installed in the building interior as equipment backer boards: Contain no added urea formaldehyde resins.

D. Related requirements

1. Construction Waste Management – Section 017419.
2. Sustainable Design Requirements – Section 018113
3. Construction IAQ Requirements – Section 018119

PART 2 PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. Provide products and materials that are new, clean, free of defects, and free of damage and corrosion.
- B. Products and materials shall not contain asbestos, PCB, or any other material that is considered hazardous by the Environmental Protection Agency or any other Authority Having Jurisdiction.
- C. Replace materials of less than specified quality and relocate work incorrectly installed as directed by the Architect at no additional cost.
- D. Provide name/data plates on major components of equipment with manufacturer's name, model number, serial number, capacity data and electrical characteristics attached in a conspicuous place.
- E. Install materials and equipment with qualified trades people.
- F. Maintain uniformity of manufacturer for equipment used in similar applications and sizes.
- G. Fully lubricate equipment where required.
- H. Follow manufacturer's instructions for installing, connecting, and adjusting equipment. Provide a copy of such instructions at the equipment during installation.
- I. Where factory testing of equipment is required to ascertain performance, and attendance by the Owner's Representative is required to witness such tests, associated travel costs and subsistence shall be paid for by the Contractor.
- J. Equipment capacities, ratings, etc., are scheduled or specified for job site operating conditions. Equipment sensitive to altitude shall be de-rated with the method of derating identified on the submittals.
- K. Enclosures for electrical equipment installed in mechanical equipment rooms shall be NEMA type 1. Enclosures for electrical equipment installed outdoors shall be NEMA type 3R - gasketed.

- L. Energy consuming equipment shall be certified for use in the District of Columbia and shall meet the DC Energy Code and local energy ordinances.

## 2.2 SUBSTITUTIONS

- A. Contract Documents are based on equipment manufacturers as called out in the Specifications and indicated on the Drawings. Acceptance of substitute equipment manufacturers does not relieve Contractor of the responsibility to provide equipment and materials, which meet the performance as, stated or implied in the Contract Documents.
- B. Submit proposals for review and approval, to provide substitute materials or equipment, in writing, fifteen business days prior to submission of bid. Substituted materials or equipment received after that time will not be acceptable or reviewed. Reimburse Owner for costs associated with the review of the proposed substitution whether substitution is accepted or rejected.
- C. Indicate revisions required to adapt substitutions including revisions by other trades. Substitutions that increase the cost of the work and related trades are not permitted or shall be paid for by the contractor.
- D. The proposed substitution shall conform to the size, ratings, and operating characteristics of the equipment or systems as specified and shown on the Drawings.
- E. Proposals for substitutions shall include the following information:
  - 1. A description of the difference between the Contract Document requirements and that of the substitution, the comparative features of each, and the effect of the change on the end result performance. Include the impact of all changes on other contractors and acknowledge the inclusion of additional costs to the other trades.
  - 2. Schematic drawings and details.
  - 3. List of revisions to the Contract Documents that must be made if the substitution is accepted.
  - 4. Estimate of added or reduced costs the Contractor may incur in implementing the substitution, such as test, evaluation, operating and support costs.
  - 5. Statement of the time by which a Contract modification accepting the substitution must be issued, noting any effect on the Contract completion time or the delivery schedule.
  - 6. A statement indicating the reduction to the Contract price if the Owner accepts the substitution. Include required modifications to all related trades.

## PART 3 EXECUTION

### 3.1 FEES AND PERMITS

- A. Pay all required fees and obtain all required permits related to the electrical installation.
- B. Pay royalties or fees in connection with the use of patented devices and systems.
- C. Provide controlled inspection where required by Authorities Having Jurisdiction or by these specifications.

### 3.2 SUBMITTALS AND REVIEWS

- A. Comply with pertinent provisions of Division 1 Sections governing Submittals and the additional requirements of this Section.
- B. Submit shop drawings, manufacturer's product data sheets, samples, and test reports as specified.
- C. Per General Contractor's Contract, after notice to proceed by the Owner or Owner's Representative, or after execution of Owner/Contractor Agreement, submit a complete typed list of all electrical equipment manufacturers and material suppliers for the equipment proposed to be provided on this project as well as names of all subcontractors.
- D. Per General Contractor's Contract, after notice to proceed by the Owner or Owner's Representative or after execution of Owner/Contractor Agreement, prepare an index of all submittals for the project. Include a submittal identification number, a cross-reference to the specification sections or drawing number, and an item description. Prefix the submittal identification number by the specification sections to which they apply. Indicate, on each submittal, the submittal identification number in addition to the other data specified. All subcontractors shall utilize the assigned submittal identification number.
- E. After the Contract is awarded, obtain complete shop drawings, product data and samples from the manufacturers, suppliers, vendors, and all subcontractors, for all materials and equipment as specified. Submit data and details of such materials and equipment for review. Prior to submission, certify that the shop drawings, product data and samples are in compliance with the Contract Documents. Include as part of the Shop Drawing the specification section and a statement of Compliance or Non Compliance by each paragraph or requirement. Check all materials and equipment upon their arrival on the job site and verify their compliance with the Contract Documents. Modify any work, which proceeds prior to receiving accepted shop drawings as required to comply with the Contract Documents and the shop drawings.
- F. Review of submittals is for general compliance with the design concept and Contract Documents. Comments or absence of comments shall not relieve the Contractor from compliance with the Contract Documents. The Contractor remains solely responsible for details and accuracy, for confirming and correlating all quantities and dimensions, for selecting fabrication processes, for techniques of construction, for the means and methods, for performing the work in a safe manner, and for coordinating the work with that of other trades.
- G. No part of the work shall be ordered, procured, started in the shop or in the field until the shop drawings and samples for that portion of the work have been submitted, reviewed and returned with either "No Exceptions Noted" or "Exceptions Noted" marked on the submission.
- H. A minimum period of ten (10) working days, exclusive of transmittal time, will be required in the Architect/Engineer's office each time a shop drawing, product data and/or samples are submitted for review. This time period must be considered by the Contractor in the scheduling of the work.
- I. Submit electronic submittals of the shop drawing or product data as PDF electronic files in compliance with the Division 1 requirements. All electronic submittals shall include the associated cover sheet and submittal number. Submit all material samples with the appropriate cover sheet and sample number.

J. Deviations and Additional Information: On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Architect and Construction Manager on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

K. Submittals will be stamped as follows:

Stamp		Interpretation
<input type="checkbox"/>	No Exceptions Noted	Fabrication, manufacture, or construction may proceed providing submittal complies with the Contract Documents.
<input type="checkbox"/>	Exceptions Noted: Resubmit for Record	Fabrication, manufacture, or construction may proceed providing submittal complies with both the Contract Documents and the Engineer's notations. Resubmit revised submittal for record only.
<input type="checkbox"/>	Exceptions Noted: No Resubmission Required	Fabrication, manufacture, or construction may proceed providing submittal complies with both the Contract Documents and the Engineer's notations.
<input type="checkbox"/>	Revise and Resubmit	Submittal does not comply with the Contract Documents. Do not proceed with fabrication, manufacture, or construction. The work and/or shop drawings are not permitted at the job site.
<input type="checkbox"/>	For Review Only	Informational Submittal: Submittal does not require the Engineer's responsive action.

L. Submit materials and equipment by manufacturer, trade name, and model number. Include copies of applicable brochure or catalog material. Maintenance and operating manuals are not acceptable substitutes for shop drawings.

M. Identify each sheet of printed submittal pages (using arrows, highlighting, underlining or circling) to show applicable sizes, types, model numbers, ratings, capacities and options actually being proposed. Cross out non-applicable information. Note specified features such as materials or paint finishes. Submittal pages that include information that is not highlighted as applicable or crossed out as not applicable will be returned and noted as Revise and Resubmit.

N. Include dimensional data for roughing in and installation and technical data sufficient to verify that equipment meets the requirements of the Contract Documents. Include wiring, piping and service connection data.

O. Maintain a complete set of reviewed and stamped shop drawings and product data on site.

P. For each room or area of the building containing electrical equipment, submit the following:

1. Floor Plans: Plan and elevation layout drawings indicating the equipment in the exact location in which it is intended to be installed. These plans shall be of a scale not less than 1/4 inch to 1 foot. These plans shall be submitted during the MEPFP coordination phase. They shall be prepared in the following manner:

- a. Indicate the physical boundaries of the space including door swings and ceiling heights and ceiling types (as applicable).

- b. Illustrate all electrical equipment proposed to be contained therein. Include top and bottom elevations of all electrical equipment. The Drawings shall be prepared utilizing the dimensions contained in the individual equipment submittals. Indicate code and manufacturer's required clearances.
  - c. Illustrate all other equipment therein such as conduits, detectors, luminaries, ducts, registers, pull boxes, wireways, structural elements, etc.
  - d. Indicate the operating weight of each piece of equipment.
  - e. Indicate the heat release from each piece of electrical equipment in terms of BTU per hour. This information shall be that which is supplied by the respective manufacturers.
  - f. Illustrate concrete pads, curbs, etc.
  - g. Indicate dimensions to confirm compliance with code-required clearances.
  - h. Indicate maximum normal allowable operating temperature for each piece of equipment (as per each respective manufacturer's recommendation).
  - i. Equipment removal routes.
- Q. The work described in shop drawing submissions shall be carefully checked by all trades for clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and coordination with other trades on the job. Each submitted shop drawing shall include a certification that related job conditions have been checked by the Contractor and each Subcontractor and that conflicts do not exist.
- R. The Contractor is not relieved of the responsibility for dimensions or errors that may be contained on submissions, or for deviations from the requirements of the Contract Documents. The noting of some errors but overlooking others does not grant the Contractor permission to proceed in error. Regardless of any information contained in the shop drawings, product data and samples, the Contract Documents govern the work and are neither waived nor superceded in any way by the review of shop drawings, product data and samples.
- S. Inadequate or incomplete shop drawings, product data and/or samples will not be reviewed and will be returned to the Contractor for resubmittal and marked Revise and Resubmit.
- T. Indicate the following on the lower right hand corner of each shop drawing and on the front cover of each product data brochure cover: The submittal identification number; title of the sheet or brochure; name and location of the project; names of the Architect, Engineer, Contractor, Subcontractor, manufacturer, supplier, and vendor; the date of submittal; and the date of each correction, version and revision. Number all pages and drawings in product data brochures consecutively from beginning to end. Unless the above information is included, the submittal will be returned for resubmission. Resubmittals of product data or brochures shall include a cover letter summarizing the corrections made in response to the review comments.
- U. The distribution equipment, short circuit and coordination study, and room layout submittals shall be submitted concurrently. Failure to submit concurrently may result in the immediate return of the submittal marked "REVISE AND RESUBMIT".
- V. Obtain the short circuit and coordination study. Review the requirements of the study, incorporate corrections and recommendations. Review the switchgear / switchboard / panelboards and adjust the fault current rating of the equipment to coordinate with the short circuit and coordination study. After this coordination has occurred, include a letter stating such and submit the short circuit and coordination study, switchgear / switchboard / panelboards and letter concurrently for review and comment.

### 3.3 CONNECTIONS TO EQUIPMENT

- A. Mechanical, Plumbing, and Fire Protection Equipment: The Contractor shall make final electrical connections to all items of mechanical, plumbing and fire protection equipment and other equipment provided by under Divisions including all motors and unit heaters for a complete and operational system.
- B. Elevator Connections: The Contractor shall make final connections to the elevator control panel(s) and provide the required outlets for the elevator accessories as required by the elevator manufacturer. Padlocking hardware shall be provided for all fused disconnects in the elevator machine room(s). Enclosed fused disconnects shall be provided for all elevators within the elevator machine room "in sight" of elevator controllers. Contractor shall provide a 160 deg F heat detector connected to the fire alarm system as required by the local code authority having jurisdiction and hard wired to the 120 volt standby power system with 120V, 20A rated contact(s). Control wiring shall be provided such that upon activation of detector, a standby powered 120V, 20A circuit shall be completed which shall shunt trip "off" main line power to elevator controllers. All work for the elevator installation shall be in accordance with applicable requirements of the ANSI Standard Safety Code for Elevators, Dumbwaiters, Escalators, and Moving Walks, A17.1, published by the American Society of Mechanical Engineers.

### 3.4 COORDINATION OF WORK

- A. The Contract Documents establish scope, materials and quality but are not detailed installation instructions. Drawings are diagrammatic.
- B. Coordinate work with related trades and furnish, in writing, any information necessary to permit the work of related trades to be installed satisfactorily and with the least possible conflict or delay.
- C. The electrical drawings show the general arrangement of equipment and appurtenances. Follow these drawings as closely as the actual construction and the work of other trades will permit. Provide offsets, fittings, and accessories, which may be required but not shown on the Drawings. Investigate the site, and review drawings of other trades to determine conditions affecting the work, and provide such work and accessories as may be required to accommodate such conditions.
- D. The locations of lighting fixtures, outlets, panels and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions, or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.
- E. Exercise particular caution with reference to the location of panels, outlets, switches, etc., and have precise and definite locations accepted by the Architect before proceeding with the installation.
- F. The Drawings show only the general run of raceways and approximate locations of outlets. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Architect for review before such alterations are made. Modifications shall be made at no additional cost.

- G. Verify with the Architect the exact location and mounting height of outlets and equipment not dimensionally located on the Drawings prior to installation.
- H. Circuit tags in the form of numbers are used where shown to indicate the circuit designation numbers in electrical panels. Show the actual circuit numbers on the as-built Record Drawings and on the associated typed panelboard directory card. Where circuiting is not indicated, provide required circuiting in accordance with the loading indicated on the Drawings and/or as directed.
- I. The Drawings generally do not indicate the number of wires in conduit for the branch circuit wiring of fixtures and outlets, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and/or circuit numbers indicated, the control intent, referenced wiring diagrams (if any), the specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC.
- J. Carefully check space requirements with other trades to insure that equipment can be installed in the spaces allotted.
- K. Wherever work interconnects with work of other trades, coordinate with other trades to insure that they have the information necessary so that they may properly install the necessary connections and equipment. Identify items (remote ballast, pull boxes, etc.) requiring access in order that the ceiling trade will know where to install access doors and panels.
- L. Consult with other trades regarding equipment so that, wherever possible, motor controls and distribution equipment are of the same manufacturer.
- M. Furnish and set sleeves for passage of electrical risers through structural masonry and concrete walls and floors and elsewhere as required for the proper protection of each electrical riser passing through building surfaces.
- N. Provide firestopping around all pipes, conduits, ducts, sleeves, etc. which pass through rated walls, partitions and floors.
- O. Provide detailed information on openings and holes required in precast members for electrical work.
- P. Provide required supports and hangers for conduit and equipment, designed so as not to exceed allowable loadings of structures.
- Q. Examine and compare the Contract Documents with the drawings and specifications of other trades, and report any discrepancies between them to the Architect and obtain written instructions for changes necessary in the work. Install and coordinate the work in cooperation with other related trades. Before installation, make proper provisions to avoid interferences.
- R. Wherever the work is of sufficient complexity, prepare additional detail drawings to scale to coordinate the work with the work of other trades. Detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit these drawings to the Architect for review. At completion include a set of these drawings with each set of Record Drawings.
- S. Furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate work with the work of other trades. No work shall be installed before coordinating with other trades.



- T. Coordinate with the local electric utility company as to their requirements for service connections and provide all necessary metering provisions, grounding, materials, equipment, labor, testing, and appurtenances.
- U. Before commencing work, examine adjoining work on which this work is in any way affected and report conditions, which prevent performance of the work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.
- V. Adjust location of conduits, panels, equipment, etc., to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each conduit prior to fabrication.
  - 1. Right-of-Way: Lines which pitch have the right-of-way over those which do not pitch. For example: condensate, steam, and plumbing drains normally have right-of-way. Lines whose elevations cannot be changed have right-of-way over lines whose elevations can be changed.
  - 2. Provide offsets, transitions and changes in direction of conduit as required to maintain proper headroom and pitch on sloping lines.
- W. In cases of doubt as to the work intended, or in the event of need for explanation, request supplementary instructions from the Architect.

### 3.5 CONTRACTOR'S COORDINATION DRAWINGS

- A. The Contractor shall coordinate efforts of all trades and shall furnish (in writing, with copies to the Architect) any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.
- B. The Contractor and all trade contractors shall prepare a complete set of construction Coordination Drawings indicating the equipment actually purchased and the exact routing for all lines such as busway, conduit, piping, ductwork, etc., including conduit 1-1/4" or larger embedded in concrete floors and cast in place concrete. The Coordination Drawings shall be submitted complete to the Architect and the Engineer, within three months after notice to proceed is given, and in compliance with the construction schedule for the project. The sheet metal drawings, at a scale of not less than 1/4 inch to 1 foot, shall serve as the base drawings to which all other Contractors shall add their work. Each separate trade contractor shall draw their work on separate layers with different color assignments to facilitate coordination. Each Coordination Drawing shall be completed and signed off by the other Trade Contractors and the Contractor prior to the installation of the HVAC, plumbing, electrical and fire sprinkler work in the area covered by the specific drawing. The Contractor's work shall be installed according to the shop drawings and coordination drawings. If the Contractor allows one trade to install their work before coordination with the work of other trades, the Contractor shall make all necessary changes to correct the condition at no additional cost.
- C. The Contractors' Coordination Drawings shall indicate structural loads at support points for all piping 10 inch and larger, racked piping, racked conduit, busway, and suspended electrical equipment. Submit to Structural Engineer for review and approval. The elevation, location, support points, static, dynamic and expansion forces and loads imposed on the structure at support and anchor points shall be indicated. All beam penetrations and slab penetrations shall be indicated and sized and shall be coordinated. Work routed underground or embedded in concrete shall be indicated by dimension to column and building lines and shall be coordinated.

Coordination Drawings shall document all required structural penetrations for initial construction. Penetrations shall be dimensioned for walls, floors and roofs. These structural coordination requirements require review and approval by the Structural Engineer prior to completion and submittal of the Drawings.

- D. This requirement for Coordination Drawings shall not be construed as authorization for the Contractor or trade contractors to make any unauthorized changes to the Contract Documents. Contract document space allocations shall be maintained such as ceiling height, designated clearance for future construction and flexibility, chase walls, equipment room size, unless prior written authorization is received from the Architect to change them.
- E. Prior to final acceptance of the Work, the Contractor shall submit the Coordination Drawings as part of the Record Drawings submittal.

### 3.6 EXAMINATION OF SITE

- A. Prior to the submitting of bids, visit the project site and become familiar with all conditions affecting the proposed installation and make provisions as to the cost thereof.
- B. The Contract Documents do not make representations regarding the character or extent of the sub-soils, water levels, existing structural, mechanical and electrical installations, above or below ground, or other sub-surface conditions which may be encountered during the work. Evaluate existing conditions, which may affect methods or cost of performing the work, based on examination of the site or other information. Failure to examine the Drawings or other information does not relieve the Contractor of responsibility for the satisfactory completion of the work.

### 3.7 EXCAVATION AND BACKFILL

- A. Provide excavation for the work of this Division. Excavate all material encountered, to the depths indicated on the Drawings or as required. Provide grading as may be necessary to prevent surface water from flowing into trenches or other excavations. Remove any water, which accumulates. Provide sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel.
- B. Provide trenches of widths necessary for the proper execution of the work. Grade bottom of the trenches accurately to provide uniform bearing and support the work on undisturbed soil at every point along its entire length. Except where rock is encountered, do not excavate below the depths indicated. Where rock excavations are required, excavate rock to a minimum overdepth of four inches below the trench depths indicated on the Drawings or required. Backfill overdepths in the rock excavation and unauthorized overdepths with loose, granular, moist earth, thoroughly machine-tamped to a compaction level of at least 95 percent to standard proctor density or 75 percent relative density or as specified by the Architect. Whenever unstable soil that is incapable of properly supporting the work is encountered in the bottom of the trench, remove soil to a depth required and backfill the trench to the proper grade with coarse sand, fine gravel or other suitable material.
- C. Excavate trenches for utilities that will provide the following minimum depths of cover from existing grade or from indicated finished grade, whichever is lower, unless otherwise specifically shown:
  - 1. Electric service: three feet minimum.

- D. Trenches should not be placed within ten feet of foundation or soil surfaces, which must resist horizontal forces.
- E. Do not backfill trenches until all required tests have been performed and installation observed by the Architect. Comply with the requirements of other sections of the Specifications. Backfill shall consist of non-expansive soil with limited porosity. Deposit in six layers and thoroughly and carefully compact until the work has a cover of not less than one foot. Backfill and compact remainder of trench at one-foot intervals until complete. Uniformly grade the finished surface.

### 3.8 CUTTING AND PATCHING

- A. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of conduit or other equipment, lay out the work carefully in advance. Repair any damage to the building, piping, equipment or defaced finished plaster, woodwork, metalwork, etc., using skilled tradespeople of the trades required at no additional cost.
- B. Do not cut, channel, chase or drill unfinished masonry, tile, etc., unless permission from the Architect is obtained. If permission is granted, perform this work in a manner acceptable to the Architect.
- C. Where conduit or equipment are mounted on a painted finished surface, or a surface to be painted, paint to match the surface. Cold galvanize bare metal whenever support channels are cut.
- D. Provide slots, chases, openings and recesses through floors, walls, ceilings, and roofs as required. Where these openings are not provided, provide cutting and patching to accommodate penetrations at no additional cost.

### 3.9 MOUNTING HEIGHTS

- A. Mounting heights shall conform to ADA requirements.
- B. Verify exact locations and mounting heights with the Architect before installation.
- C. Electrical outlets shall be mounted no higher than 48 inches above finished floor to top of the outlet box and no lower than 15 inches above finished floor to bottom of the outlet box.
- D. Electrical switches shall be mounted no higher than 48 inches above finished floor to top of the outlet box and no lower than 36 inches above finished floor to bottom of the outlet box.
- E. Fire alarm manual pull stations shall be mounted no higher than 48 inches above finished floor to top of the outlet box and no lower than 36 inches above finished floor to bottom of the outlet box.
- F. Wall Mounted Audible, Visual and combination Audible/Visual Notification Appliances: Mount not less than 80 inches to the bottom or 96 inches to the top of the device. Where low ceiling heights do not permit mounting at a minimum of 80 inches, visible appliance shall be mounted within 6 inches of ceiling. Height of all notification appliances shall be uniform in public areas and office areas throughout.
- G. Wall-Mounted Exit Signs: Two inches above top of door to bottom of sign.

- H. Low-Level Exit Signs: Six inches to bottom of sign.
- I. Stairwell and utility corridor wall-mounted lighting fixtures shall be mounted 8 feet-6 inches above finished floor or one foot below ceiling or structure above, whichever is lower.

### 3.10 CLEANING UP

- A. Avoid accumulation of debris, boxes, loose materials, crates, etc., resulting from the installation of this work. Remove from the premises each day all debris, boxes, etc., and keep the premises clean and free of dust and debris.
- B. Clean all fixtures and equipment at the completion of the project. Wipe clean exposed lighting fixture reflectors and trim pieces with a non-abrasive cloth just prior to occupancy.
- C. All electrical equipment shall be thoroughly vacuumed and wiped clean prior to energizing and at the completion of the project. Equipment shall be opened for observation by the Architect as required.

### 3.11 WATERPROOFING

- A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, make penetration prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Architect and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.
- B. Restore waterproofing integrity of walls or surfaces after they have been penetrated without additional cost.

### 3.12 SUPPORTS

- A. Support work in accordance with the best industry practice. Provide supports, hangers, auxiliary structural members and supplemental hardware required for support of the work.
- B. Provide supporting frames or racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets and mechanical equipment rooms.
- C. Provide supporting frames or racks for equipment which is to be installed in a freestanding position.
- D. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them.
- E. Adequate support of equipment (including outlet, pull and junction boxes and fittings) shall not depend on electric conduits, raceways, or cables for support.
- F. Electrical equipment or raceway shall not rest on or depend for support on suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling).

Provide independent support of electrical equipment. Do not attach to supports provided for ductwork, piping or work of other trades.

- G. Provide required supports and hangers for conduit, equipment, etc., so that loading will not exceed allowable loadings of structure. Electrical equipment and supports shall not come in contact with work of other trades.

### 3.13 FASTENINGS

- A. Fasten equipment to building structure in accordance with the best industry practice.
- B. Where weight applied to building attachment points is 100 pounds or less, conform to the following as a minimum:
  - 1. Wood: Wood screws.
  - 2. Concrete and solid masonry: Bolts and expansion shields.
  - 3. Hollow construction: Toggle bolts.
  - 4. Solid metal: Machine screws in tapped holes or with welded studs.
  - 5. Steel decking or sub-floor: Fastenings as specified below for applied weights in excess of 100 pounds.
- C. Where weight applied to building attachment points exceeds 100 pounds, but is 300 pounds or less, conform to the following as a minimum:
  - 1. At concrete slabs provide 24-inch by 24-inch by 1/2-inch steel fishplates on top with through bolts. Fishplate assemblies shall be chased in and grouted flush with the top of slab screed line, where no fill is to be applied.
  - 2. At steel decking or sub-floor for all fastenings, provide through bolts or threaded rods. The tops of bolts or rods shall be set at least one inch below the top fill screed line and grouted in. Suitable washers shall be used under bolt heads or nuts. In cases where the decking or sub-floor manufacturer produces specialty hangers to work with their decking or sub-floor, such hangers shall be provided.
- D. Where weight applied to building attachment points exceeds 300 pounds, coordinate with and obtain the approval of Architect and conform to the following as a minimum:
  - 1. Provide suitable auxiliary channel or angle iron bridging between building structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.
- E. For items, which are shown, as being ceiling-mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging tying to the building structural elements.
- F. Wall-mounted equipment may be directly secured to wall by means of steel bolts. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels as manufactured by Kindorf or Unistrut are acceptable.

### 3.14 IDENTIFICATION

- A. Identify electrical equipment with permanently attached black phenolic nameplates with 1/2-inch high white engraved lettering. Identification shall include equipment name or load served as appropriate. Nameplates for equipment connected to the emergency power system shall be red with white lettering. Nameplates shall be attached with cadmium-plated screws. Peel-and-stick tape or glue-on type nameplates are not allowed.
- B. Cable tags shall be flameproof secured with flameproof non-metallic cord.
- C. Provide an engraved nameplate for each switch controlling loads, which are not local to the switch.
- D. Wherever raceways for future use are terminated outside of the building, stake the location with a 4-foot long, 4-inch by 4-inch clear pressure treated member.
- E. See individual Sections for additional identification requirements.

### 3.15 PROHIBITED LABELS AND IDENTIFICATIONS

- A. In all public areas, tenant areas, and similar locations within the project, the inclusion or installation of any equipment or assembly which bears on any exposed surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited, unless otherwise approved by the Architect.
- B. Required UL labels shall not be removed nor shall identification specifically required under the various technical sections of the Specifications be removed.

### 3.16 EQUIPMENT PADS AND ANCHOR BOLTS

- A. Provide concrete pads under all floor-mounted electrical equipment. Equipment pads shall conform to the shape of the piece of equipment it serves with a minimum 1-inch margin around the equipment and supports. Pads shall be a minimum of 4 inches high and made of a minimum 28 day, 2500 psi concrete reinforced with 6-inch by 6-inch 6/6 gauge welded wire mesh. Trowel tops and sides of pad to smooth finishes, equal to those of the floors, with all external corners bullnosed to a 3/4-inch radius. Shop drawings stamped "NO EXCEPTIONS NOTED" shall be used for dimensional guidance in sizing pads.
- B. Provide galvanized anchor bolts for all equipment placed on concrete equipment pads, inertia blocks, or on concrete slabs. Provide bolts of the size and number recommended by the manufacturer of the equipment and locate by means of suitable templates. Equipment installed on vibration isolators shall be secured to the isolator. Secure the isolator to the floor, pad, or support as recommended by the vibration isolation manufacturer.
- C. Where equipment is mounted on gypsum board partitions, the mounting screws shall pass through the gypsum board and securely attach to the partition studs. As an alternative, the mounting screws may pass through the gypsum board and be securely attached to 6 inches square, 18 gauge galvanized metal backplates, which are attached to the gypsum board with an approved non-flammable adhesive. Toggle bolts installed in gypsum board partitions are not allowed.

### 3.17 DELIVERY, DRAYAGE AND HAULING

- A. Provide drayage, hauling, hoisting, shoring and placement in the building of equipment specified and be responsible for the timely delivery and installation of equipment as required by the construction schedule. If any item of equipment is received prior to the time that it is required, the Contractor shall be responsible for its proper storage and protection until the time it is required. Pay for all costs of drayage or storage.
- B. If equipment is not delivered or installed at the project site in a timely manner as required by the project construction schedule, the Contractor shall be responsible for resulting disassembly, re-assembly, manufacturer's supervision, shoring, general construction modification, delays, overtime costs, etc., at no additional cost.

### 3.18 EQUIPMENT AND MATERIAL PROTECTION

- A. Protect the work, equipment, and material of other trades from damage by work or workmen of this trade, and correct damaged caused without additional cost.
- B. Take responsibility for work, materials, and equipment until finally inspected, tested and accepted. Protect work against theft, injury, or damage, and carefully store material and equipment received on site, which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material. Cover and protect equipment and materials from damage due to water, spray-on fireproofing, construction debris, etc. Store equipment to moisture damage in dry, heated spaces.
- C. Provided adequate means for fully protecting finished parts of materials and equipment against damage from whatever cause during the progress of the work until final acceptance. Protect materials and equipment in storage and during construction in such a manner that no finished surfaces will be damaged or marred, and moving parts are kept clean and dry. Do not install damaged items; take immediate steps to obtain replacement or repair.
- D. Lighting fixtures shall be installed with factory-mounted plastic protective bags around reflector and housing assembly. Remove protective bag just prior to occupancy.

### 3.19 TESTING OF ELECTRICAL SYSTEMS

- A. Comply with the project construction schedule for the date of final performance and acceptance testing, and complete work sufficiently in advance of the Contract completion date to permit the execution of the testing prior to occupancy and Contract close-out. Complete any adjustments and/or alterations, which the final acceptance tests indicate as necessary for the proper functioning of all equipment prior to the completion date. See individual Sections for extent of testing required.
- B. Provide a detailed schedule of completion indicating when each system is to be completed and outlining when field testing will be performed. Submit completion schedule for review within six months after the notice to proceed by Owner's Representative has been given. Update this schedule periodically as the project progresses.

### 3.20 OPERATING INSTRUCTIONS

- A. Provide the services of factory-trained specialists to provide an operating instructions seminar for equipment and systems. The seminar shall be conducted over a five-day (consecutive)

period. Instruction time is defined as straight time working hours and does not include nights, weekends, or travel time to and from the project.

- B. Submit seminar agenda, schedule and list of representatives to the Architect for approval 30 days prior to suggested date of seminar. Do not commence seminar until the Architect has issued a written acceptance of the starting time and attendees. Confirm attendance of seminar by written notification to participants.
- C. Instruct Owner's operating personnel in proper starting sequences, operation, shut-down, general maintenance and preventative maintenance procedures, including normal and emergency procedures.
- D. Submit final copies of Record Drawings and Operating and Maintenance Manuals to Owner at seminar.
- E. Submit a written record of minutes and attendees of the seminar to the Owner.

### 3.21 OPERATING AND MAINTENANCE MANUALS

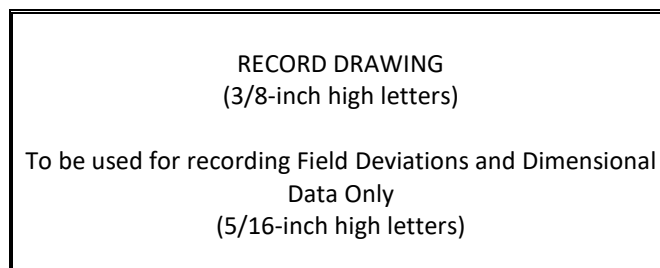
- A. Instruction Seminar: Perform systems instruction seminar and walk-through with the Owner's representatives after preparation and review of the Operation and Maintenance Manuals
- B. Provide Operating and Maintenance Manuals for equipment and materials furnished under this Division.
- C. Submit electronic copies of all operating and maintenance data books for review at least ten (10) weeks before the completion date. Assemble data in a completely indexed volume or volumes and identify the size, model, and features indicated for each item.
- D. After the Architect's and Engineer's review, and any required Contractor revisions, submit a complete electronic copy. along with two (2) final hard copies of operating and maintenance data books.
- E. Provide 8.5-inch by 11-inch, expanding spine catalog binders bound with heavy red fabric, hot stamp lettering on front and spine identifying project name and Owner's name. Assemble data in a completely indexed volume or volumes and identify the size, model, and features indicated for each item.
- F. Maintenance manuals shall include complete cleaning and servicing data compiled in a clear and easily understandable format. Show model numbers of each piece of equipment, complete lists of replacement parts, capacity ratings, and actual loads.
- G. Provide the following information where applicable:
  - 1. Identifying name and mark number
  - 2. Locations (where several similar items are used, provide a list)
  - 3. Complete nameplate data
  - 4. Certified Record Drawings and Final Reviewed submittals
  - 5. Parts list
  - 6. Performance curves and data
  - 7. Wiring diagrams



8. Manufacturer's recommended operating and maintenance instructions with all non-applicable information deleted
9. List of spare parts recommended for normal service requirements
10. Assembly and disassembly instructions with exploded-view drawings where necessary
11. Test reports
12. Trouble shooting diagnostic instructions, where applicable

### 3.22 RECORD DRAWINGS

- A. The Contractor shall maintain on a daily basis at the Project site a complete set of Record Drawings. The Record Drawings shall initially consist of a set of black line plots or AutoCAD or Revit files of the Contractor's Coordination Drawings. The prints shall be marked or the AutoCAD or Revit files electronically updated to show the precise location of all buried or concealed work and equipment, including embedded conduit, raceways and boxes, and all changes and deviations in the Electrical work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without definite written instructions from the Architect or Engineer. The updated Coordination Drawings shall be used to produce the final Record Drawings that shall be delivered to the Owner in AutoCAD electronic format media upon Project completion.
- B. Three sets of prints (two full size and one half size) and three CD-ROMs of as-built drawings. As-built drawings must include all modifications made to the Contract Documents.
- C. Record dimensions clearly and accurately to delineate the work as installed. Suitably identify locations of all equipment by at least two dimensions to permanent structures.
- D. The Contractor and Subcontractor shall mark all in-progress Record Drawings on the front lower right hand corner with a rubber stamp impression or an AutoCAD image similar to the following:



- E. Upon completion of the work, the Contractor and Subcontractor(s) shall certify all Record Drawings on the front lower right hand corner adjacent to the above marking with a rubber stamp impression or an AutoCAD image similar to the following:

RECORD DRAWING CERTIFIED CORRECT (3/8-inch high letters)	
(Printed Name of General Contractor) (5/16-inch high letters)	
Date:	
(Printed Name of Subcontractor) (5/16-inch high letters)	
Date:	

- F. Prior to final acceptance of the Work of this Division, the Contractor shall submit properly certified Record Drawings to the Architect and Engineer for review and shall make changes, corrections, or additions as the Architect and/or Engineer may require to the Record Drawings. After the Architect's and Engineer's review, and any required Contractor revisions, the Record Drawings shall be delivered to the Owner on electronic media in AutoCAD format. The Architect and Engineer do not assume any responsibility for the accuracy or completeness of the Record Drawings.

### 3.23 FINAL PUNCHLIST

- A. Prior to the Final Punchlist, certify that systems and equipment are complete, operational, and are in compliance with the Contract Documents.
- B. During the Final Punchlist, provide personnel with access keys, hand held radios, and necessary expertise to operate each system and piece of equipment to demonstrate operational compliance with the Contract Documents.
- C. Any deficiencies noted on the Final Punchlist shall be expeditiously corrected and certified in writing.

### 3.24 EARLY OCCUPANCY

- A. Complete those systems which are necessary to allow partial early occupancy of the building.
- B. Verify and comply with requirements for temporary occupancy with the local Building and Fire Departments.

END OF SECTION

## **SECTION 26 0502 - EQUIPMENT CONNECTIONS AND COORDINATION**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide equipment connections and coordination in accordance with the Contract Documents.

#### **1.2 SUBMITTALS**

- A. No requirements.

### **PART 2 PRODUCTS**

NOT APPLICABLE

### **PART 3 EXECUTION**

#### **3.1 GENERAL**

- A. Provide equipment connections and coordination in accordance with manufacturer's recommendations and product submittals.
- B. Provide loose disconnect switches not integral with equipment where applicable. Where equipment requires fuse protection, provide fusible type disconnect switches with fuses rated in accordance with equipment manufacturer's requirements. Disconnect switches for single-phase equipment shall be thermal overload type. Locate disconnect switches in coordination with the layout of equipment. Provide supports for a free-standing installation if required to allow access to disconnect switch and/or proximity to equipment served.
- C. Provide final connections to hard-wired equipment with a minimum of two feet of liquid-tight flexible metal conduit.
- D. Verify the requirements of cord and plug equipment and provide receptacles, branch circuiting and branch circuit overcurrent protection to match. Receptacle types shown on the Drawings are for bidding purposes only.
- E. In areas where equipment is subject to physical damage, where required by code, and supplied from conduit run under or within the floor slab, extend conduit to a junction box mounted on a two-foot stub up of rigid steel conduit. Provide suitable bracing on conduit stub up.

#### **3.2 EQUIPMENT CONNECTION TYPES**

- A. Provide equipment connection types as indicated on the equipment connection schedule.
- B. Equipment Connection Types:
  - 1. Type DP: Duplex pump system with controller provided under Division 23. Provide connection to controller and connections from controller to pumps in accordance with the controller manufacturer's installation instructions. Provide connections for local

controls and alarms in accordance with the controller manufacturer's installation instructions.

2. Type FR: Fractional horsepower single-phase motor. Provide thermal overload/disconnect switch, when not furnished by the equipment manufacturer, and motor connection.
3. Type FWS: Equipment furnished with starter. Install starter and provide connection to starter and connection from starter to equipment.
4. Type M: Motor with starter provided under Division 26. Provide disconnect switch and motor connection.
5. Type SPC: Single point connection. Provide single point connection to equipment provided with factory-mounted starter/controller listed for single point power connection. Where required by code or the equipment manufacturer, provide fusible disconnect switch with fuses sized in accordance with equipment nameplate requirements.
6. Type VFD: Variable frequency drive furnished under Division 23. Install VFD and provide connection to VFD and connection from VFD to equipment.

### 3.3 ELEVATORS

- A. Locate equipment and points of connection in elevator machine rooms and elevator pits in accordance with the requirements of the elevator vendor and the Authority Having Jurisdiction.
- B. Provide a fused switch or circuit breaker, dedicated three-phase branch circuit utilizing copper conductors, and power connection for each elevator. Fused switch or circuit breaker shall be located within elevator machine room. Fuse or circuit breaker rating shall be in accordance with elevator manufacturer's requirements.
- C. Provide a dedicated 120V, 20A emergency circuit with lockable disconnect switch and connection to each elevator cab for elevator cab lighting and ventilation.
- D. Provide a dedicated 120V, 20A circuit and connect to elevator system intercom in elevator machine room.
- E. Provide a dedicated circuit and connect to each elevator controller for control power. Circuit rating shall be in accordance with the elevator vendor's requirements.
- F. Provide weatherproof lighting fixtures, lighting switches and duplex receptacles within each elevator pit.
- G. Provide a dedicated telephone outlet for each elevator. Provide an empty 3/4-inch raceway from each telephone outlet to the nearest telephone backboard.
- H. Provide empty raceways from elevator shafts to the elevator control and status panel(s). Size, quantity and location of raceway termination points shall be in accordance with the elevator vendor's requirements.
- I. Provide a fire alarm speaker within each elevator cab. Connect to the Fire Management System – Voice Communication System.

- J. Provide a firefighter's telephone jack in each elevator cab. Connect to Fire Management System – Firefighter's Telephone System.
- K. Connect power supply circuits serving elevators and related controls and accessories to the emergency power distribution system.
- L. Provide conduit and wire between elevator controllers and automatic transfer switches and make connections required for automatic recall and operation of elevators from the emergency power distribution system in the event of power failure.

#### 3.4 MECHANICAL/PLUMBING EQUIPMENT

- A. Provide electrical connections to mechanical/plumbing equipment.
- B. Where motor controllers are furnished by others, install controller and provide connections at line and load side of controllers.
- C. Where reduced voltage, multiple speed, duplex, triplex, lead-lag, pony motor or other unusual controller types are utilized, coordinate specific requirements of motor(s) and controller and provide required wiring between motor(s) and controller.
- D. Provide branch circuits and connections to chiller oil heaters and pumps.
- E. Provide branch circuits and connections to sump and sewage ejector pump alarm bell systems. Connect to emergency power distribution system.
- F. Where electric duct heaters are provided with remote power panels, provide branch circuits between remote panel and duct heater elements in accordance with the equipment manufacturer's recommendations.
- G. For electric water coolers verify whether the equipment is hard wired, cord- and plug-connected and whether a remote chiller is provided. Provide circuiting and connections to match.

#### 3.5 OWNER FURNISHED EQUIPMENT

- A. Provide electrical connections to Owner-furnished equipment.
- B. Inspect Owner-furnished equipment for damage, defects, missing components, etc. Report deficiencies to the Owner immediately. Do not install or connect deficient equipment.
- C. Provide supports, fastenings, and auxiliary hardware necessary for a complete installation in accordance with the finished building conditions.

END OF SECTION

## **SECTION 26 0519 - 600 V WIRE AND CABLE**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide 600V wire and cable in accordance with the Contract Documents.
- B. Related work specified in other divisions of these specifications.
  - 1. Raceways and Boxes

#### **1.2 REFERENCE STANDARDS**

- A. Rubber Insulated Wire and Cable: ICEA S-19-81, NEMA WC 3, and UL 44.
- B. Thermoplastic Insulated Wire and Cable: ICEA S-61-402, NEMA WC 3, and UL 83.
- C. Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable: ICEA S-66-524, NEMA WC 7, and UL 44.
- D. Service Entrance Cable: UL 854.
- E. Annealed Copper Wire for Conductors: ASTM B3.
- F. Terminal Blocks: UL 1059.

#### **1.3 QUALITY ASSURANCE**

- A. Wire and cable shall be of the same manufacturer.

#### **1.4 SUBMITTALS**

- A. Field test reports.
- B. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.

#### **1.5 FIELD TESTING**

- A. Inspect splices and terminations and make mechanically and electrically tight during the 15-day period immediately prior to final acceptance of the work.
- B. Feeder insulation shall be tested after installation, and before final connection.
  - 1. Tests shall be performed with a 500 volt megger, and conductors shall test free from short circuits and grounds.
  - 2. Conductors shall be tested phase-to-phase and phase-to-ground.

3. Furnish the instruments, materials, and labor required.
- C. Demonstration: Subsequent to wire and cable installation and connection, energize circuits and demonstrate functioning in accordance with contract requirements. Correct deficiencies and retest to demonstrate compliance.

## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

#### A. Wire and Cable:

1. Copper: Southwire, Anaconda, Brand-Rex, Collyer, Cyprus, General Cable, Hatfield, Houston, Kaiser, Kerite, National, Okonite, Simplex, or Triangle.
2. Aluminum: Prohibited.

#### B. Connectors:

1. Copper Wire size number 14 through number 6:
  - a. Hand applied: Piggy (Thomas & Betts), Scotchlock (3M), or Wing Nut (Ideal).
2. Copper Wire size number 4 through number 750kcmil:
  - a. IlSCO NIMBUS PBT INS BLK / OFFSET: UL Listed and CSA Certified.
  - b. 600 volt at 90 Deg C.
  - c. For ampacity as rated.
  - d. UL Listed, factory installed mechanical lugs that are dual rated.
  - e. Connectors shall be dual rated: ALCU, AL7CU or AL9CU.
  - f. Tool applied: Compression type,
    - (1) IlSCO Surecrimp two hole long barrel, UL Listed 486A/B, CSA 600 V at 90 Deg. C
    - (2) IlSCO CTL Long barrel sleeve, UL Listed 486A/B, CSA 600 V at 90 Deg. C.
    - (3) IlSCO pin terminals ACM, ACO CPM UL Listed 486A/B, CSA 600 V at 90 Deg. C.

#### 3. Aluminum conductors:

- a. Prohibited.

#### C. Electrical Tape:

1. Insulating type, Johns-Manville or 3M.

### 2.2 WIRE AND CABLE

#### A. General:

1. 600V minimum insulating rating.

B. Conductor:

1. Electrical grade, annealed copper, tinned if rubber insulated, and fabricated in accordance with ASTM and ICEA standards. Minimum size number 12 for branch circuits; number 14 for control wiring.
2. Compact stranded conductors 1 AWG through 1000 MCM marked as XHHW-2 and shall be made of an AA-8000 series electrical-grade aluminum alloy conductor material fabricated in accordance with ASTM and ICEA standards.
3. Aluminum conductors are prohibited.

C. Stranding and Number of Conductors:

1. Number 12 and number 10 shall be solid.
2. Larger than number 10, stranded ASTM Class B.
3. Control wires stranded in accordance with ASTM Class B stranding designations.
4. Cables for low-voltage systems shall be multi-conductor type unless otherwise noted.

D. Insulation:

1. 600 volts, PVC insulation, nylon jacket, surface-printed identification, listed as type THHN or THWN THWN-2 per UL 83.

E. Color Coding:

1. Wiring shall be color coded as follows:

Conductor	120/208V System	277/480V System
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Grey
Ground	Green	Green
Isolated Ground	Green/Yellow Stripe	Green/Yellow Stripe

2. Wire number 8 and smaller shall be factory-color coded the entire length. Wire number 6 and larger shall be color coded by color taping entire length of exposed conductor at all accessible locations or factory-color coded where available.
3. Control wiring shall be color coded in accordance with manufacturer's recommendations.

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Maximum of three branch circuits in one conduit. Derating of conductors shall apply for more than (3) branch circuits as required by code.
- B. Provide minimum number 10 wiring for 120-volt branch circuits exceeding 150 feet in length from panelboard to furthest outlet. Provide minimum number 10 wiring for 277-volt branch circuits exceeding 250 feet in length from panelboard to furthest outlet.



- C. Do not install wire until raceway systems are complete.
- D. Provide split wedge cable supports for vertical risers.
- E. Wire size shall be uniform for the entire length of the circuit unless noted otherwise.
- F. Do not splice feeders or dedicated branch circuits unless otherwise indicated.
- G. Make connections, splices, taps, and joints with solderless devices, mechanically and electrically secure. Coat connections with oxide inhibitor and torque to manufacturer's specifications.
- H. Lubricate cables to facilitate pulling. Lubrication material shall be inert to cable insulation and raceways.
- I. Install compression connectors with hydraulic die, embossing die code into connector. Connect to bus with Bellville type washers for positive pressure over complete contact area. Insulate with heat-shrink tubing.
- J. Provide a separate neutral for dimmed branch circuits, ground fault interrupter branch circuits, and branch circuits serving isolated ground and isolated ground surge suppressor type receptacles.
- K. Conductors in underfloor electrical systems shall be number 10 AWG minimum.

END OF SECTION

## **SECTION 26 0526 - GROUNDING SYSTEM**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide grounding system in accordance with the Contract Documents and as specified herein.

#### **1.2 QUALITY ASSURANCE**

- A. Utility company approval of service installation.

#### **1.3 REFERENCE STANDARDS**

- A. UL 467
- B. ANSI C-1
- C. IEEE 142
- D. NEC
- E. National Electrical Safety Code
- F. Utility company requirements
- G. All equipment and material to be furnished and installed on this Project shall be UL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

#### **1.4 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.
- B. Field test report
- C. Conductors
- D. Connectors
- E. Grounding plates
- F. Compression fittings
- G. Ground rods
- H. Exothermic welding methods.

## 1.5 FIELD TESTING

- A. Resistance testing of ground rod system indicating maximum 5 ohms resistance to ground.

## 1.6 IDENTIFICATION

- A. Label each end of each grounding electrode conductor, identifying the connection point of the opposite end of the conductor. Label shall be a minimum of 3"x 5" brass plate with stamped lettering secured with braided cable or brass chain to the conductor.

## PART 2 PRODUCTS

### 2.1 GENERAL

- A. Grounding connections shall be brazed molded exothermic welded, bolted clamp terminal, or pressure connector type.
- B. All equipment and materials provided under this section of the Specifications shall be new, UL listed and bear the UL label.
- C. All switchboards, panelboards, motor control centers, transformers, busway, etc. shall be provided with a copper or aluminum equipment ground bar bolted, brazed or riveted to the associated enclosure or cabinet. Refer to each individual equipment Specification section for additional grounding requirements.
- D. All receptacles, switches, disconnects, individual motor controllers, etc. shall be provided with a grounding terminal connected to the device frame or enclosure with an insulated equipment bonding jumper. Refer to each individual equipment Specification section for additional grounding requirements. Self grounding devices equipped with a spring type grounding strap may be used but shall not rely on the spring type grounding strap as ground continuity.
- E. All conduit, cable tray, manufactured wiring systems, raceways, junction boxes, pull boxes, etc., shall be made electrically continuous by means of equipment grounding conductors, bonding jumpers, grounding bushings, etc., as specified herein and required by the NEC and the authorities having jurisdiction.

### 2.2 GROUNDING ELECTRODE SYSTEM

- A. Provide the following grounding electrodes, bonded together to form the grounding electrode system:
  - 1. Metal underground water pipe in direct contact with earth for 10 feet or more and electrically continuous to the points of connection of the grounding electrode conductor and the bonding conductors.
  - 2. The metal frame of the building, where effectively grounded.
  - 3. Concrete-encased electrode (Ufer ground) consisting of a minimum of 20 feet of bare copper conductor (size 3/0 minimum per Code) encased by a minimum of 2 inches of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth.
  - 4. Ground rod of copper clad steel, minimum 3/4-inch diameter, minimum 10 feet long, driven full length into the earth as located on the drawings and spaced not greater than

50' intervals at the ground test wells. If a maximum resistance to ground of 5 ohms cannot be obtained with a single ground rod, provide additional ground rods installed not closer than 6 feet apart until a maximum resistance to ground of 5 ohms is obtained.

5. Other grounding electrodes as shown on the Drawings.

## 2.3 GROUND BUS CABINETS

- A. Provide a main ground bus bar in the main switchboard room. Provide ground bus bars in other locations shown on the Drawings.
- B. Ground bus cabinets shall be NEMA 1 enclosure with drilled copper bus on stand off insulators.

## 2.4 TELECOMMUNICATIONS GROUNDING SYSTEM

- A. Refer to other specification sections for telecommunications grounding requirements.

# PART 3 EXECUTION

## 3.1 GENERAL

- A. Metallic raceways, cable trays, cable armor, cable sheath, enclosures, equipment frames, fittings, and other metallic noncurrent-carrying equipment parts and surfaces shall be effectively bonded to the grounding system. Nonconductive paint, enamel, or similar coating shall be removed at threads and contact surfaces to preserve grounding continuity or fittings shall be provided to make such removal unnecessary.
- B. The grounded conductor (neutral) of each separately derived system shall be connected to the ground riser bar in the floor electrical closet with an appropriately sized grounding electrode conductor. Separately derived systems include the following:
  1. Step-down transformers.
  2. Engine generator set.
- C. Neutral wiring shall be grounded at the system point of origin only and shall be isolated from downstream grounding systems.
- D. Provide an insulated equipment grounding conductor for all segments of branch circuits serving motors controlled by variable frequency drive controllers.
- E. Bond interior metal piping systems to the grounding electrode system. Where metallic piping and duct systems are rendered metallically non-continuous by nonconductive couplings, provide bonding jumpers to provide grounding continuity.
- F. Receptacles and lighting fixtures shall be grounded to the outlet box by means of a bonding jumper between the outlet box and the receptacle or lighting fixture grounding terminal.
- G. Feeders and branch circuits shall be provided with an insulated equipment grounding conductor run with the circuit conductors. This equipment grounding conductor shall be in addition to the ground path provided by the continuously grounded metallic raceway system that encloses the phase and neutral conductors.

- H. Provide bolted clamp terminal connectors where connected to removable equipment.
- I. Provide brazed molded exothermic welded connections to ground rods and connections to concrete embedded steel reinforcing bar.

END OF SECTION

## **SECTION 26 0533 - RACEWAYS AND BOXES**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide raceways and boxes in accordance with the Contract Documents.

#### **1.2 SUBMITTALS**

- A. Conduit, Tubing, Boxes, Wireways and Auxiliary Gutters:
  - 1. Manufacturer's product data sheets, volume dimensions, physical dimensions, Listing agencies, and weights.
- B. Manufacturer's product data sheets, volume dimensions, physical dimensions, Listing agencies, and weights.
  - 1. Manufacturer's product data sheets.
- C. Mineral insulated cable.

#### **1.3 IDENTIFICATION**

- A. Mark junction box covers, with permanent identification of panelboard and circuit numbers of wiring contained within.
- B. Paint fire alarm conduit and boxes red.
- C. Paint fire pump feeder and branch circuits and boxes red.

### **PART 2 PRODUCTS**

#### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Conduit and Boxes:
  - 1. UL Listed and labeled products of any manufacturer meeting the specified performance requirements are acceptable.
- B. Wireways and Auxiliary Gutters:
  - 1. Siemens, Square D, or equal.
  - 2. Wireways and auxiliary gutters shall be UL Listed and labeled.
- C. Mineral Insulated Cable
  - 1. UL 2196 listed and labeled product.
  - 2. Pyrotenax or equal.

## 2.2 CONDUIT AND FITTINGS

### A. Rigid Steel Conduit:

1. Rigid conduit, heavy wall, hot-dipped galvanized inside and out, threaded ends.
2. Threaded type fittings.
3. [Schedule 40](#)

### B. Electrical Metallic Tubing:

1. Continuous, seamless steel tubing galvanized or sherardized on exterior, coated on interior with smooth hard finish of lacquer, varnish or enamel.
2. Steel, set screw or compression type fittings. Provide concrete type fittings where required. Cast fittings prohibited.
3. Color coded conduit where exposed and accessible concealed locations and in Electrical and Mechanical rooms. As required per code and the local authority having jurisdiction.
4. Conforming to NEC Article 358

### C. Metal Clad Cable:

1. Light steel or aluminum armor, copper conductors, insulated copper equipment grounding conductor, and internal marker tape.
2. Conductor insulation type as specified in Section 260519.
3. Snap-in grounding type insulated throat type fitting.
4. Conforming to NEC Article 330.

### D. Flexible Metal Conduit:

1. Single strip, continuous, flexible interlocked double-wrapped steel, hot-dip galvanized inside and out forming smooth internal wiring channel.
2. Steel, compression type fittings.
3. Conforming to NEC Article 348.

### E. Liquidtight Flexible Conduit:

1. Same as flexible steel conduit except with tough, inert, watertight plastic outer jacket.
2. Fittings shall be cast malleable iron body and gland nut, cadmium-plated with one-piece brass grounding bushings threaded to interior of conduit. Spiral molded vinyl sealing ring between gland nut and bushing and nylon-insulated throat.
3. Conforming to NEC Article 350.

### F. Rigid Polyvinyl Chloride Conduit:

1. Schedule 40 polyvinyl chloride suitable for 90 degrees C.
2. Solvent cemented type fittings.
3. Conforming to NEC Article 352

- G. Liquidtight Flexible Nonmetallic Conduit
  - 1. Smooth seamless inner core and cover with reinforcement layer. (LFNC-A).
  - 2. Smooth inner surface with integral reinforcement in the conduit wall. (LFNC-B).
  - 3. The use of LFNC-C is prohibited.
  - 4. Conforming to Article 356
  - 5. Only permitted to be used for Load Center Feeders.

## 2.3 MINERAL INSULATED CABLE OR APPROVED EQUAL

- A. Factory assembly of one or more conductors insulated with highly compacted magnesium oxide insulation, enclosed in a seamless, liquid- and gas-tight continuous copper sheath.
- B. Conductors shall be solid, high electrical conductivity copper (suitable for equipment grounding purposes) with a cross sectional area corresponding to standard sizes.
- C. Insulation shall allow for proper spacing of conductors. Thickness on insulation shall be at least 55 mils for cable from 14 AWG through 250 MCM.
- D. Mineral-insulated cable shall be classified by Underwriters Laboratories as having a two-hour fire resistive rating.
- E. Fittings shall be identified for such use.
- F. Acceptable Manufacturer: Pryoténax. Cable sizes indicated are based on Pryoténax.

## 2.4 WIREWAYS AND AUXILIARY GUTTERS

- A. Sizes and shapes as indicated and/or as required.
- B. Provide necessary elbows, tees, connectors, adapters, etc.
- C. Continuous removable cover secured with screws and keyhole slots. Hinged cover where installed above suspended ceiling.
- D. Provide wire retainers at not greater than 12 inches on center.

## 2.5 OUTLET, JUNCTION, AND PULL BOXES

- A. Cast Type Boxes:
  - 1. Ferrous alloy box with inside threaded hubs for rigid steel conduit.
  - 2. Ferrous alloy box with compression or inside threaded hubs with adapter for electrical metallic tubing.
  - 3. Cast raised cover, size matched to contour of box.
  - 4. Tapered threads for hubs.
- B. Galvanized Pressed Steel Type Boxes:



1. General:
  - a. Pressed steel, galvanized or cadmium-plated, 4 inches minimum octagonal or square with galvanized cover or extension ring as required.
2. Concrete Box:
  - a. 4 inches minimum octagonal with removable backplate. Depth of box shall allow for minimum of 1 inch of concrete to be poured around the backplate.
3. Lighting Fixture Box:
  - a. 4 inches minimum octagon.
  - b. Where fixtures are mounted on or in an accessible type ceiling and a modular wiring system is not used, provide a junction box and extend flexible steel conduit to each fixture.
4. Provide 3/8-inch no-bolt fixture studs where required.

C. Sheet Steel Boxes:

1. No. 12 gauge sheet steel for boxes with maximum side less than 40 inches, and maximum area not exceeding 1,000 square inches; riveted or welded 3/4-inch flanges at exterior corners.
2. No. 10 gauge sheet steel for boxes with maximum side 40 to 60 inches, and maximum area 1,000 to 1,500 square inches; riveted or welded 3/4-inch flanges at exterior corners.
3. No. 10 gauge sheet steel riveted or welded to 1.5 inch by 1.5 inch by 1/4-inch welded angle iron framework for boxes with maximum side exceeding 60 inches and more than 1,500 square inches in area.
4. Covers:
  - a. Same gauge steel as box.
  - b. Subdivided single covers so no section of cover exceeds 50 pounds.
  - c. Machine bolts or machine screws threaded into tapped holes.
5. Paint:
  - a. Rust inhibiting primer, ANSI 61 grey enamel finish coat.

2.6 ELECTRICAL BOX PADS

- A. Non-Fire Rated: equal to Lowry's Outlet Box Pads as manufactured by Harry A. Lowry Associates, Sun Valley, California.
- B. Fire Rated: equal to Putty Pads manufactured by Specified Technologies, Inc.

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Provide raceways for all systems. 277/480V wiring shall be kept independent of 120/208V wiring. Emergency system wiring shall be kept independent of utility power wiring systems. Provide insulated grounding conductor in all raceways. Minimum conduit size shall be 1/2-inch. Wiring of each type and system shall be installed in separate raceways.
- B. Protect metallic raceway in earth or fill from corrosion with two coats of corrosion-resistant paint or tape wrap.
- C. Elbows for conduit installed below grade or embedded within floor slabs shall be rigid steel conduit with two coats of corrosion-resistant paint, tape wrap, or plastic-coated rigid steel conduit. [PVC conduit is acceptable following code requirements.](#)
- D. Tie embedded raceways securely in place prior to concrete placement. Raceways installed below or within floor slabs shall extend a minimum of 4 inches above the finished slab or housekeeping pad to the first connector. Install capped bushings on conduit stub ups.
- E. Locate raceways so that the integrity of structural members is not affected and they do not conflict with the services of other trades. Draw up couplings and fittings full and tight. Protect threads from corrosion after installation with zinc chromate or equivalent protection.
- F. Conceal raceways except at surface-mounted cabinets and freestanding equipment. Install minimum of 6 inches from flues, steam pipes, or other heated lines. Provide flashing and counter-flashing for waterproofing of raceways which penetrate the roof. Install power raceways a minimum of 24 inches from telecommunications raceways, cross at 90-degree angle. Route exposed raceways and raceways above suspended ceilings parallel or perpendicular to building lines with right-angle turns and symmetrical bends. Provide sleeves in concrete walls, floor slabs and partitions. Waterproof sleeved raceways where required.
- G. Provide raceway expansion joints for exposed and concealed raceways at expansion joints and between structures to compensate for differential movement. Provide bonding conductor.
- H. Provide one empty 3/4-inch raceway for each three spare unused poles or spaces of flush-mounted panelboards. Terminate conduit in an accessible location for future extension.
- I. Provide #12 AWG, pull string in empty raceways. Tag both ends noting destination.
- J. Clear raceway of all obstructions and dirt prior to pulling in wires or cables. Use ball mandrel (diameter approximately 85 percent of conduit insider diameter) followed by close-fitting wire brush and wad of felt or similar material. This assembly may be pulled with, but ahead of cable being installed. Clean empty raceways similarly. Clear or replace any raceway which rejects ball mandrel.
- K. Install exterior underground conduits 24 inches minimum below finished grade. Do not penetrate waterproof membranes unless proper seal is provided.

- L. Secure raceways clamps or supports to masonry materials with toggle bolts, expansion bolts, or steel inserts. Install raceway on steel construction with approved clamps which do not depend on friction or set-screw pressure alone.
- M. Provide independent support of raceways larger than 3/4 inch. Provide uni-strut support and threaded rod to structure above for multiple suspended raceways run together. Use of lathe channels or other miscellaneous steel to support raceways is not permitted. Use listed supports such as uni-strut or similar systems for support.
- N. Raceways Embedded in Floor Slabs:
- 1.
- O. Coordinated and installed per code requirements, structural drawings, details, and specifications for conduits with an outside diameter of 1-1/2" or less. Non-Metallic Raceway Installations:
1. Joints shall be made using the material recommended by the raceway manufacturer. Components shall be cleaned prior to assembly.
  2. Raceway cutoffs shall be square and shall not deform conduit. Ream rough surfaces.
  3. Provide male box adapters to terminate raceways.
  4. Where separable terminations are required, provide PVC threaded adapters with locknuts or bushings.
  5. Bends shall be made by methods that do not deform or damage the conduit.
  6. Provide expansion fittings where required.
  7. Raceway supports shall be installed to allow the non-metallic conduit to slide through the supports.
  8. Non-metallic raceway is allowed per the NEC.
- P. Raceways above Suspended Ceilings:
1. Single runs of MC Cable or 3/4-inch raceways may not be supported from ceiling support wires. Provide independent support using Caddy fasteners listed for the use. Baling wire is prohibited.
  2. Single runs of MC Cable or 3/4-inch raceways within partitions shall be supported and secured using Caddy fasteners listed for the use. Baling wire is prohibited.
  3. Provide independent support of raceways larger than 3/4 inch. Provide independent support of multiple raceways (more than one). Provide uni-strut support and threaded rod to structure above. Attachment to ceiling support wires is not permitted.
  4. Provide independent support of raceways installed above fire-rated ceilings. Attachment to ceiling support wires is not permitted.
  5. Install conduit 1 foot-0 inch minimum above top of ceiling.
- Q. Underground Duct Banks:
1. Provide underground conduit duct banks as indicated. Provide concrete encasement of power systems conduit duct banks except where duct banks run beneath building slab on grade. Provide concrete encasement of duct bank elbows for all systems. Provide steel reinforcing bars for concrete-encased duct banks. Provide spacers to permit concrete to completely surround and encase each conduit. Concrete strength shall be

- 3,000 pounds per square inch minimum. Provide red dye inhibiting agent in concrete mix.
2. Pitch conduit down and away where duct bank enters the building or equipment.
  3. Support raceways installed in duct banks every five feet to assure correct alignment prior to placing concrete.
  4. Terminate raceways with flared end bells. Clear raceway terminations of burrs and rough edges.
  5. Conductors serving electric fire pumps shall be either in conduit encased in a minimum of 2" of concrete as required to meet NEC rating requirements (concrete encasement is not required within fire pump room and electrical room where service originates) or in conduit run beneath the slab on grade, or mineral-insulated cable
  6. Conduit connected to rotating or vibrating equipment shall be flexible metal conduit or liquid-tight flexible conduit.

### 3.2 MINERAL INSULATED CABLE

- A. Provide supports identified for such use at intervals not exceeding three feet so designed and installed as not to damage cable.
- B. Where single conductor cables enter ferrous metal boxes or cabinets, the installation shall be made to prevent inductive heating.
- C. Provide seals immediately after stripping to prevent the entrance of moisture into the insulation. The conductors extending beyond the sheath shall be individually provided with an approved insulated material.

### 3.3 WIREWAYS AND AUXILIARY GUTTERS

- A. Install wireways above suspended ceilings such that cover will hinge upward from side.
- B. Provide 36 inches clear from wireway cover when in open position.

### 3.4 OUTLET, JUNCTION, AND PULL BOXES

- A. Provide outlet, junction, and pull boxes as indicated and as required for a complete installation and to facilitate proper pulling of wires and cables. Boxes shall be sized per National Electrical Code as minimum. Plug open knock outs.
- B. The exact location of outlets and equipment is governed by field conditions. Where necessary, relocate outlets so that fixtures and equipment are symmetrically located in accordance with the room layout and will not interfere with other work or equipment. Verify final location of outlets, fixtures, and equipment with Architect.
- C. Back-to-back outlets in the same wall, or "through-wall" type boxes are not permitted. Provide 12-inch minimum spacing for outlets shown on opposite side of a stud in common wall. Provide acoustical potting compound (Electrical Box Pads) on outlet boxes installed in private offices, conference rooms and in all sound-insulated drywall partitions. Install box pads on the outside of the box and fill all holes.

- D. Fit outlet boxes in finished ceilings or wall with appropriate covers, set flush with the finished surface. Where more than one switch or device is located at one point, use multiple gang boxes and covers. Provide tile box or a 4-inch square box with tile ring in masonry walls not plastered or furred. Where drywall material is utilized, provide plaster ring. Provide outlet boxes of type and size suitable for the specific application. Provide barriers where required for voltage or systems separation.
- E. Provide pull boxes so that an individual run of conduit does not contain more than the equivalent of four 90-degree bends (360 degrees total).
- F. Boxes recessed in walls or ceilings with a surface of concrete, tile, gypsum, plaster, or other non-combustible material shall be installed so that the front edge of the box shall not be set back from the finished surfaces more than 1/4 inch. Boxes recessed in walls and ceiling constructed of wood or other combustible surface material shall be flush with the finished surface.
- G. Where boxes are installed in plaster, drywall, or plasterboard surfaces with cut openings for box installation, the cut openings shall be repaired so there shall be no gaps or open spaces greater than 1/8 inch at the edge of the box or fitting.

### 3.5 APPLICATION OF RACEWAYS

#### A. Rigid Steel Conduit:

1. Where required by code and local AHJ.

#### B. Electrical Metallic Tubing:

1. General purpose feeders and branch circuits, except where another conduit type is specifically required.
2. Exposed indoor installations in branch electrical closets and telecommunications rooms below ten feet above finished floor.
3. Electrical and mechanical rooms.
4. Exposed ceilings and within exposed areas of the parking garage.

#### C. Metal Clad Cable:

1. Use in dry locations concealed above suspended ceilings or within hollow partitions for lighting and receptacle branch circuits.
2. MC Feeders 100A or greater.

#### D. Flexible Metal Conduit:

1. Dry locations only.
2. Connections to lighting fixtures in suspended ceilings.
3. Connections to equipment installed in suspended ceilings.
4. Transformer connections.
5. Connections to equipment where vibration isolation is needed.
6. Maximum length shall be six feet.
7. Busway plug-in units.

E. Liquid-Tight Flexible Steel Conduit:

1. Same as flexible steel conduit in damp or wet locations.
2. Motor connections.

F. Rigid Polyvinyl Conduit:

1. Underground duct banks.
2. Below slab on grade.
3. Embedded in floor slabs.
4. In areas allowed per code.

G. Wireways and Auxiliary Gutters:

1. Where indicated.
2. Above and below panelboards, lighting relay cabinets, fire alarm panels, and terminal cabinets to accommodate large concentrations of wires.

3.6 APPLICATION OF BOXES OUTLET, JUNCTION AND PULL BOXES

A. Cast Type Boxes:

1. Where connected to rigid steel, intermediate metal conduit, and liquid-tight flexible conduit, 1.25 inches and smaller.
2. Exposed conduit installations within ten feet above finished floor.
3. Where exposed to moisture and outdoors or damp or wet locations.

B. Galvanized Pressed Steel Type Boxes:

1. Where connected to electrical metallic tubing and flexible steel conduit, 1.25 inches and smaller.
2. Dry locations.
3. Where concealed in walls and above suspended ceilings.

C. Sheet Steel Boxes:

1. Where connected to conduit larger than 1.25 inches.

END OF SECTION

## **SECTION 26 0548 - VIBRATION ISOLATION**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide vibration isolation in accordance with the Contract Documents.
- B. Provide vibration isolation for engine generator set, dry type transformers, and at electrical connections to rotating or vibrating equipment.

#### **1.2 QUALITY ASSURANCE**

- A. Vibration isolators shall be of the same manufacturer.

#### **1.3 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.
- B. Manufacturer's product data sheets and installations for each vibration isolator.
- C. Plan and elevation diagrams showing equipment, points of attachment, vibration isolators, mounting methods, and hardware types and sizes.
- D. Field inspection report.

#### **1.4 FIELD INSPECTION**

- A. Upon completion of the installation, the manufacturer's local representative shall field inspect the installation and submit a report verifying the completeness and performance of the installation.

### **PART 2 PRODUCTS**

#### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Amber-Booth, Mason Industries, Vibration Eliminator Co., Vibration Mounting & Controls Inc., or Vibrex Vibration Control Systems.

#### **2.2 VIBRATION ISOLATION**

- A. General:
  - 1. Devices installed outdoors shall be weatherproof; steel components shall be hot-dipped galvanized, hardware shall be cadmium plated, and springs shall be neoprene coated.
  - 2. Spring diameters shall be no less that 0.8 of the compressed height of the spring at rated load.

3. Springs shall have an additional minimum travel to solid equal to 50 percent of the rated deflection.



B. Mounting Method Type A:

1. Floor-mounted spring isolators
2. Built-in resilient vertical limit stops
3. Tapped holes in top plate for bolting to equipment
4. Mounting holes in bottom plate for bolting to concrete housekeeping pad
5. Neoprene pad between concrete housekeeping pad and bottom of isolator
6. Mason Industries Type SLR

C. Mounting Method Type B:

1. Hanger rod neoprene isolators
2. Neoprene element with a projecting bushing to prevent steel-to-steel contact
3. Steel retainer box encasing the neoprene element
4. Rod shall be able to swing 15 degrees before contacting resilient bushing
5. Mason Industries Type HD

D. Mounting Method Type C:

1. Floor-mounted neoprene mounts
2. Metal surfaces neoprene covered to avoid corrosion
3. Mounting holes in base for bolting to concrete housekeeping pad
4. Mason Industries Type ND

### PART 3 EXECUTION

#### 3.1 GENERAL

- A. Installation shall be in accordance with manufacturer's installation instructions.
- B. Verify that mounting methods provide the required vibration isolation, and that there are no vibration short circuits.
- C. Conduit connected to rotating or vibrating equipment shall be flexible metal conduit or liquid-tight flexible conduit.

#### 3.2 MOUNTING SCHEDULE

Equipment	Mounting Method	Static Deflection
Engine Generator Set	A	2.0 inch
Dry Type Transformers – Suspended	B	0.3 inch
Dry Type Transformers – Floor Mounted	C	0.3 inch

END OF SECTION

## **SECTION 26 0573 - ELECTRICAL POWER SYSTEM STUDY**

### **PART 1 GENERAL**

#### **1.1 SUMMARY**

- A. Furnish and Electrical Power System Study for the electrical distribution system as defined herein.
- B. The study shall begin at the point of electrical service for the facility (utility transformer secondary bushing) and include all downstream distribution and branch panelboards, motor control centers and significant motor locations (50HP and larger). In addition, all equipment that is required to be rated for the available fault current shall be evaluated in the study including but not limited to, transformers, enclosed switches, individual motor controllers, contactors, variable speed drives, and enclosed circuit breakers. The project shall include all generators and any associated emergency power distribution equipment, including automatic transfer switches.
- C. Where any part of the electrical system is served by multiple power sources the system configuration that delivers the highest level of fault current shall be used for the evaluation.

#### **1.2 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.
- B. The final report shall be indexed and contain individual, tabbed sections. The tabbed section shall contain the information as outlined in Part 2 of this document including the following:
  - 1. Firm Name, Address, Phone Number and Professional Electrical Engineer's signature and seal of the registered professional Engineer that performed the study,
  - 2. Method used to perform the study and analysis,
  - 3. Short-circuit analysis with protective device evaluation,
  - 4. Protective device coordination study,
  - 5. Arc Flash Analysis including PPE ratings and incident energy and flash protection boundary calculation,
  - 6. Input Data,
  - 7. One-line diagram.
- C. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Design Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory. Protective device coordination in regards to selective coordination is required prior to the applicable equipment review process.

### 1.3 RELATED STANDARDS

- A. All studies shall be performed in accordance with the latest applicable industry standards including the following:
1. IEEE/ANSI Std 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
  2. NEMA AB 3 - AB 3 Molded Case Circuit Breakers and their Application
  3. NFPA 70 - National Electrical Code
  4. NFPA 70E - Standard for Electrical Safety in the Workplace
  5. IEEE 399 - General Study Procedures

### 1.4 QUALITY ASSURANCE

- A. Preparer Qualifications: Firm experienced in the analysis, evaluation, and coordination of electrical distribution systems.
- B. Short-Circuit Analysis, Arc Flash Analysis and Coordination Study shall be performed by a State of Maryland registered Professional Electrical Engineer. Study shall be signed and sealed by the Engineer. The Engineer shall have a minimum of eight years experience in the analysis, evaluation, and coordination of electrical distribution systems.

## PART 2 PRODUCTS

### 2.1 MANUFACTURER

- A. If it complies with the specifications, the engineering study specified herein shall be prepared by the following manufacturer providing the electrical switchboards for this project or manufacturer's authorized engineer:
1. Siemens
  2. Eaton/Cutler Hammer
  3. General Electric
  4. Square D

### 2.2 SHORT-CIRCUIT ANALYSIS WITH PROTECTIVE DEVICE EVALUATION

- A. Systematically calculate fault currents based on the available fault current at the facility service entrance. Study preparer shall obtain the maximum available fault current and power factor or X/R ratio of the fault current at the service entrance from the local utility.
- B. Motor contribution for motors 50HP and larger shall be incorporated in determining fault levels.
- C. Evaluate the distribution device and equipment ratings compared to the calculated fault current and make recommendations where equipment is overdutied. Analyze the short-circuit currents by preparing a tabulation comparing the fault levels to the device interrupting ratings. Indicate equipment in which series ratings are utilized.

- D. When the power factor or X/R ratio of the maximum symmetrical fault calculated at the device location is determined to be more inductive than that used to establish the device interrupting rating adjust the available short circuit current in accordance with ANSI/IEEE standard 242.
- E. Calculations shall be presented in tabular form and shall include:
  - 1. Location identification
  - 2. Voltage
  - 3. Manufacturer and type of equipment
  - 4. Equipment short-circuit current rating
  - 5. Calculated short-circuit current (and adjustments due to high X/R ratio where required)
  - 6. Calculated X/R ratio of the fault
  - 7. Indicate if series ratings are used
  - 8. Recommendations where equipment is calculated to be overdutied

## 2.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. Prepare coordination time-current characteristic curves to determine the required settings of the protective devices to achieve selectivity. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. These settings shall be obtained by the preparer, along with any other protective device setting requirements. The coordination curves shall be prepared on log-log paper and illustrate adequate clearing times between series devices. The curves provided shall reflect actual protective devices (manufacturer and model number) to be installed. Adequate time-current curves shall be generated to depict coordination.
- B. The coordination study shall include ground fault protection coordination and recommended device settings for the devices provided with ground fault protection.
- C. Protective device characteristics shall be plotted to reflect calculated short-circuit levels at the location.
- D. A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection. All curve sheets shall be multi-color or use hatching for improved clarity. Areas lacking complete coordination shall be highlighted and reasons provided for allowing condition to remain or provide recommendations to improve coordination.
- E. The following information shall be provided on all curve sheets.
  - 1. Device identification and associated settings/size.
  - 2. Voltage at which curves are plotted.
  - 3. Current multiplier.
  - 4. ANSI frequent fault damage curve.
  - 5. Cable insulation damage curves.
  - 6. Transformer inrush point.
  - 7. Single-line for the portion of the system.
  - 8. Motor starting profiles (where applicable).

F. The recommended device settings shall be provided in tabular form and shall include:

1. Location Identification
2. Voltage
3. Device Manufacturer
4. Device catalog number/series
5. Adjustable long time pickup and delay
6. Adjustable short time pickup and delay
7. Adjustable ground fault pickup and delay
8. Adjustable instantaneous pickup

#### 2.4 ARC FLASH ANALYSIS

A. An arc flash analysis shall be performed based on the short circuit values and device settings in conjunction with a short circuit and coordination study. The results from the short circuit and coordination study shall be used to determine arc energy levels at each power distribution location in the facility where work could be performed on energized parts.

B. Where any part of the electrical system is served by multiple power sources the system configuration that delivers the highest level of arc flash incident energy shall be used for the evaluation. Include significant motor contribution in the calculations.

C. For each location with a main device, the line and load side fault contributions shall be included in the calculations.


D. Arc Flash Calculation results shall be presented in tabular form and shall include:

1. Location identification
2. Voltage
3. Arcing fault magnitude
4. Protective device clearing time
5. Duration of arc
6. Arc flash boundary
7. Working distance
8. Incident energy
9. Hazard Risk Category

E. Arc Flash Warning Labels shall be provided as part of the report. Labels shall be provide in accordance with ANSI Z535.4. The labels shall be 3.5 inch x 5 inch thermal transfer type labels of high adhesion polyester for each work location analyzed. Labels shall be machine printed with no field markings. The labels shall include the following information:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category
5. Incident energy
6. Working distance

F. Sample Arc Flash Warning Label:

	
<b>Arc Flash and Shock Hazard Appropriate PPE Required</b>	
11' – 3" 9 #3	Flash Hazard Boundary Cal/cm2 Flash Hazard at 18 inches PPE Level Cotton underwear plus FR shirt & FR pants plus FR coverall
2.4 5' – 0" 2' – 2" 0' – 7"	kV Shock Hazard when cover is removed Limited Approach Restricted Approach – Class 1 voltage Gloves Prohibited Approach – Class 1 Voltage Gloves
Equipment Name: MCC 10-24-1 VALID FOR NORMAL SYSTEM CONFIGURATION ONLY.	

2.5 INPUT DATA

- A. The study shall be conducted based on the equipment and conductors being installed. Input data for the report shall be compiled from the contractor, manufacturers, and codes and standards as required providing the studies and conducting a proper evaluation.
- B. Conductor lengths, sizes, material, and raceway information shall be provided by the Electrical Subcontractor to the engineer performing the study so that the study is performed based on the final installation.
- C. Input data used for the studies shall be provided in the final report. The input data for the report shall include supporting data from the manufacturer used for the evaluation, lengths of all feeders provided by the contractor, transformer data, motor data, utility company and motor generator data and any other supporting data to the report.

2.6 SINGLE-LINE DIAGRAM

- A. The final report shall include a single-line diagram of the electrical distribution system within the scope of the project. The single-line shall include:
1. Transformer rating, voltage ratio, impedance, and winding connection.
  2. Feeder cables per phase, neutral and ground sizes, length of cable, conductor material, and conduit size and type.
  3. Switchgear, switchboards, panelboards, MCC's, individual motor controllers, variable speed drives, fuses, circuit breakers, ATS's and enclosed switches.
  4. Protective relays with appropriate device numbers and CT's and PT's with associated ratios.

5. Motor identification and horsepower used in the evaluation.

### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. The electrical equipment and protective devices shall not be installed prior to confirmation of adequate equipment fault ratings as specified herein.
- B. Schedule a review with the landlord and engineer to evaluate label are acceptable prior to installation.

#### 3.2 FIELD SETTINGS

- A. Adjustments shall be made to the protective devices as required for placing the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study and protective device evaluation / coordination study.
- B. Arc Flash Labels shall be affixed to the equipment after the study is approved by the Engineer.
  1. One label shall be affixed at a height and location that is clearly visible on the front of panelboards, switchboards, switchgear, motor control centers and other electrical equipment that is less than 8 feet in length unless otherwise noted.
  2. Switchboards, and switchgear that are longer than 6 feet shall have labels affixed at a height and location that is clearly visible on the front of the equipment at each end of the equipment.
  3. Transformers shall be labeled based on the high voltage side of the transformer.
  4. Labels shall be affixed at similar locations on each type of equipment. For example, multiple panelboards of similar size shall have labels located at the same location on the front of each panelboard cover.
  5. Where multiple labels are affixed to equipment, the labels shall be identical and identify the worse case information for that equipment.
  6. Where equipment is rear connected affix labels on both the front and rear of the equipment. Locate the labels on the rear at a similar height and location as on the front.
  7. Label each plug-in section of busway. Affixed at a height and location that is clearly visible. Labels shall be affixed on both sides of the busway.
- C. Device settings and adjustments and affixing of Arc Flash Hazard Labels shall be by one of the following companies: General Electric Engineering Services, Cutler Hammer Engineering Services, Siemens Industrial Services, Square D Technical Services or a manufacturer authorized service and testing organization.

END OF SECTION

## SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This section includes requirements for commissioning lighting systems, assemblies, and equipment.
1. Commissioning is a third-party quality assurance process. It does not take the place of or duplicate the Contractor's quality control services required per Division 01 Section "Quality Requirements" or testing, adjusting, and balancing and other quality control testing or inspections required in individual Sections and normally the responsibility of the Contractor.
- B. The following lighting systems, equipment and components are to be commissioned on this project:

Electrical	CxP Submittal Review	Construction Checklist	Functional Test Sampling
260936 Modular Lighting Controls	Yes	Yes	25%
260923 Stand-Alone Lighting Controls	Yes	Yes	25%
262923 Variable Frequency Drives	Yes	Yes	100%

- C. Related Sections:
1. 019113 Section "General Commissioning Requirements" for definitions of terms used in this Section, and for commissioning requirements applicable to all systems, including lighting.

#### 1.2 INFORMATIONAL SUBMITTALS

- A. Contractor Submittals and Shop Drawings: Concurrent with AE review, the Contractor will send submittals relating to systems to be commissioned to the CxP for review of compliance with the Contract Documents. Comments will be returned directly to the AE with a copy to the Owner for coordination of a final submittal review response from the AE to the Contractor. This includes all Division 26 submittals for systems referenced in 1.1 above.
- B. Commissioning Documentation: Submit the following information to the CxP:
1. Schedule: Schedule for completing construction checklists, pre-functional and start-up for lighting and electrical systems, assemblies, equipment and components to be commissioned.
  2. Test Equipment, Instrumentation, and Tools: Submit list of test equipment, instrumentation, and tools required to perform functional performance testing. Identify proprietary test equipment, instrumentation, and tools. Include calibration certificates for test equipment and instrumentation.
  3. Checklists: Completed construction checklists, pre-functional checklists and start-up forms for each piece of equipment or component.
  4. Certificate of Readiness: Using FPT Certificate of Readiness form provided in Division 01 "General Commissioning Requirements," certify that lighting systems, subsystems, equipment, components, and associated controls are ready for testing.
  5. Documentation of corrective actions for logged deficiencies.



### 1.3 CLOSEOUT SUBMITTALS

- A. Commissioning issues reports showing resolution of issues.
  - 1. Include correspondence or other documents related to resolution of issues.
  - 2. List unresolved issues. Provide written explanation for why each item on the list remains unresolved. Indicate reason, if any, are exempt from the requirements for Construction Phase Commissioning Completion.
- B. Training verification forms.

## PART 2 - PRODUCTS

### 2.1 TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

- A. General: Provide test equipment, instrumentation, and tools necessary to perform function performance testing. Use test equipment and instrumentation that has been calibrated, certified, and properly maintained.
  - 1. Test equipment and instrumentation required to perform the commissioning shall remain the property of Contractor unless otherwise indicated.
  - 2. Proprietary test equipment, instrumentation, and tools shall become the property of Owner at Substantial Completion.
    - a. Proprietary test equipment, instrumentation, and tools are those manufactured or prescribed by tested equipment manufacturer and required for work on its equipment as a condition of equipment warranty, or as otherwise required to service, repair, adjust, calibrate or perform work on its equipment.

## PART 3 - EXECUTION

### 3.1 COMMISSIONING PROVIDER (CxP) RESPONSIBILITIES

- A. Meetings: Attend and lead commissioning team meetings.
- B. Checklists: The CxP shall develop and provide Project-specific construction checklists.
- C. FPT Procedures: The CxP shall develop and provide functional performance test procedures for lighting systems, electrical systems, assemblies, equipment and components.
- D. FPT Testing: The CxP shall witness functional performance testing, and record test results.
- E. Commissioning Record: The CxP shall author a commissioning summary report and verify functional performance test data and certificates are included in the commissioning record.

### 3.2 CONTRACTOR RESPONSIBILITIES

- A. Meetings: Attend and participate in commissioning team meetings.

- B. FPT Testing: Perform functional performance testing for systems, assemblies, equipment, and components indicated to be commissioned.
- C. Documentation: Provide information requested by the CxP.
- D. Training: Participate in training for lighting and electrical systems, assemblies, equipment and components.
- E. Near-End-of-Warranty Walkthrough: Participate in the Near End-of-Warranty review meeting and walkthrough.

### 3.3 FUNCTIONAL PERFORMANCE TESTING (FPT) PREPARATION

- A. Start-up: Certify that lighting systems, subsystems and equipment have been installed, calibrated and started and are operating according to the Contract Documents. The following startups shall be witnessed by the CxP. Submit all the startup reports to the CxP for record.
  - 1. VFDs (262923)
  - 2. Modular Lighting (260936)
- B. Participation: Coordinate schedule to ensure that all required members of the commissioning team as indicated in functional performance testing (FPT) procedures are available to participate in FPT.

### 3.4 GENERAL FPT REQUIREMENTS

- A. General: Test all normal and emergency modes of operations including alarms.
  - 1. To greatest extent possible, use design conditions for test parameters, unless otherwise directed by Architect and CxP.
  - 2. Simulated conditions may be imposed to initially test systems; however, this does not relieve the Contractor of his duty to perform deferred testing. Alter set points and sensor values when simulating conditions is not practical.
- B. Re-Testing:
  - 1. If tests indicate that system, assembly, equipment, or component does not meet acceptance criteria indicated, document the deficiency and report it to the Architect. Upon resolution of deficiencies, re-test using same original parameters unless otherwise directed by Architect and CxP. Notify Architect and CxP a minimum of three days before re-test date of rescheduled tests.
  - 2. Deficiencies which prevent the verification of system performance may be uncovered during tests. In cases where the issue cannot be resolved within a reasonable amount of time, document the deficiency and report it to the Architect. Upon resolution of deficiencies, re-test using same original parameters unless otherwise directed by Architect and CxP. Notify Architect and CxP a minimum of three days before re-test date of rescheduled tests.

### 3.5 NEAR END-OF-WARRANTY REVIEW

- A. General: Participate in the Near End-of-Warranty review and walkthrough conducted by the CxP.
  - 1. The review will cover current building operation with input from the operation and facility staff. Outstanding issues related to the construction, particularly those related to warranty related

deficiencies will be addressed. Operational problems and concerns from the facility staff and occupants will be reviewed for compliance with design intent.

2. The CxP will provide a plan for corrective measures to the Architect and the Contractor for action.
  - a. Corrective Action: Where deficiencies and problems result from work not in compliance with the Contract Documents or are covered under warranty, provide the corrective actions indicated at no additional cost to Architect.

END OF SECTION

## **SECTION 260926 - PROGRAMMABLE LIGHTING CONTROL SYSTEM**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide programmable lighting control system in accordance with the Contract Documents. This specification only applies to lighting controls in BOH areas.
- B. The programmable lighting control system shall be a stand-alone system operating independently of other control systems. The system shall be the distributed processing type, allowing each lighting relay cabinet to function as an independent programmable lighting control system.
- C. The programmable lighting control system shall include an interface to the BMS for the control of lighting zones, relays and circuits as indicated on the electrical drawings and specifications.

#### **1.2 QUALITY ASSURANCE**

- A. Manufacturer and equipment supplier shall have a minimum of five years prior experience.
- B. Testing and burn-in per manufactures requirements.
- C. Factory-trained technicians and applications engineers shall be available to provide initial programming, field testing, system start up, training and operation assistance per PDI Systems proposal.
- D. Equipment shall be certified for use in the Jurisdiction and shall meet the latest energy code requirements.

#### **1.3 REFERENCE STANDARDS**

- A. Lighting Relay Cabinets: UL 916.
- B. Emissions Standard: FCC Part 15, Subpart J, Class A.

#### **1.4 SUBMITTALS**

- A. Manufacturer's product data sheets.
- B. Riser diagram showing lighting relay cabinets, control devices, PC interface equipment, and interconnecting conduit and wire.
- C. Wiring diagram for each type of control device.
- D. Detailed project-specific narrative system sequence of operation.
- E. Lighting relay cabinet schedules indicating relay number, system address, branch circuit panelboard and circuit number, control device, and specific description of load controlled.

## 1.5 FIELD TESTING

- A. Wiring shall be inspected and tested for continuity and short circuits.
- B. Field Test Reports:
  - 1. Certification that equipment has been properly installed and programmed and is in satisfactory operating condition.
  - 2. Detailed operational test report in matrix form indicating each relay and each control device. Report shall certify the following:
    - a. Successful operation of each relay.
    - b. Successful operation of each control device.
    - c. Successful operation of automatic control sequences.

## 1.6 IDENTIFICATION

- A. Provide an identification nameplate for each lighting relay cabinet.
- B. Provide a directory card in each lighting relay cabinet indicating relay number, system address, branch circuit panelboard and circuit number, and specific descriptions of loads controlled.

## 1.7 OPERATION

- A. The lighting relay cabinets shall switch relays ON and OFF in response to commands initiated from control devices, user-defined time of day schedules, and commands from the hand-held controller. Switch input control devices shall be capable of providing ON only, ON/OFF, and ON/OFF with time override (for OFF of a 2- to 999-minute delay should switch be left ON) control actions.
- B. Time of day schedules shall be developed within logic circuits of each lighting relay cabinet. Each lighting relay cabinet shall have capacity for nine separate daily schedules, including one holiday schedule. Weekly schedules and twenty holidays shall be developed from combinations of the daily schedules, up to one year in advance. Schedules shall contain provisions for daylight savings time and leap year adjustment.
- C. Off sweep function to line voltage shut-off switches shall open and close relays serving associated branch circuits for the time interval required by the line voltage shut-off switch.
- D. Exterior lighting shall automatically turn on in response to exterior photocell and automatically turn off in response to preprogrammed schedule.

## 1.8 WARRANTY

- A. Provide a two-year system warranty.

## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Lutron, LC&D, or Wattstopper

## 2.2 LIGHTING RELAY CABINETS

### A. General:

1. Relays and logic circuits shall utilize quick connectors on factory wiring to facilitate replacement.
2. Logic functions, schedules, and switch definitions shall be protected from loss of power for periods of up to ten years.
3. Each lighting relay cabinet shall have an RJ11 receptacle for connection of a portable hand-held controller for schedule and switch definition.

### B. Enclosure:

1. NEMA 1, surface wall-mounted steel enclosure, finish coated with ANSI 61 grey enamel over a rust inhibitor.
2. Enclosure faceplate shall be secured to the enclosure with captive screws. Provide a hinged, locking door for access to the low-voltage compartment.
3. Low-voltage compartment shall be physically separated from two line voltage wiring areas by steel barriers.

### C. Relays:

1. Provide relays in quantities indicated on the lighting relay cabinet schedules.
2. Each relay shall have a single set of contacts rated for 20 amps at 120 VAC or 277 VAC, tungsten and ballast rated. Coil shall be 24 volts, mechanically or electrically held.
3. Each relay shall have an LED indicator to display ON/OFF status of each relay.

### D. Switch Inputs:

1. Provide a programmable low-voltage switch input for each relay. Half of the switch inputs shall be two-wire type and half of the switch inputs shall be the universal type.
2. Two-wire switch inputs shall accommodate two-wire maintained contact (SPST) low-voltage switching devices or two-wire momentary contact (push ON/push OFF) low-voltage switching devices.
3. Universal switch inputs shall be the same as two-wire switch inputs and in addition shall accommodate three-wire momentary contact low-voltage switching devices.

E. Hand-Held Controller:

1. . Per equipment requirements and PDI Systems proposal.

2.3 CONTROL DEVICES

A. Low-Voltage Wall Switch:

1. Similar in appearance to lighting switches specified under Section 262726.
2. Two-wire maintained contact type.
3. Three-wire momentary contact type where multiple location is indicated.

B. Photocell:

1. Interior or exterior weatherproof type for automatic ON/OFF control of lighting fixtures in response to ambient lighting levels.
2. Adjustable time delay and foot-candle level setpoints.
3. Interior type shall include separate ON and OFF setpoints to prevent control from toggling inadvertently as the sensor passes through the control threshold.

C. Occupancy Sensors:

1. As specified under Section 262726. Occupancy sensors shall be of the same manufacturer.

D. Line Voltage Shut-Off Switch:

1. Provide line voltage shut-off switches to control lighting loads from 0.1 amperes to 5.0 amperes or from 1.0 amperes to 20.0 amperes based upon the actual load controlled. The switches shall be capable of operating in the manner of a conventional SPST or SPDT wall switch and also be capable of turning off automatically when their source voltage is interrupted for a period of five seconds or more.
2. When swept OFF by power interruption or turned OFF manually, the toggle of the switch shall drop to the conventional OFF position and illuminate to facilitate manual override if required. The switches shall be capable of maintaining the lighting load through a 1.5-second power interruption.

3. The switch shall be capable of controlling all types of loads including fluorescent, quartz, incandescent, metal halide, high-pressure sodium, mercury vapor, and low-pressure sodium. The switch shall conduct power to the lighting load via a standard metal-to-metal contact closure and shall not induce any harmonic distortion or notching on the power line. The switch shall have dimensions suitable for mounting in multi-ganged wall boxes and shall utilize standard dimension switch plate hardware.

### **PART 3 EXECUTION**

#### **3.1 GENERAL**

- A. Connect each lighting relay cabinet to the normal power supply.
- B. Provide an exterior photocell in suitable location on roof facing north sky.

#### **3.2 INITIAL PROGRAMMING**

- A. Provide one day of initial programming by the manufacturer or by local representation of the manufacturer of system including assignment of relays to low-voltage switching devices and assignment of relays to automatic schedules prior to system start-up and training. Time of day schedules shall be established by the Owner.
- B. Provide initial programming of reporting and monitoring software including project-specific maintenance, recording, and monitoring applications.
- C. Coordinate with the BMS controls contractor the programming of lighting control graphic screens and interactive application functions on the BMS.

#### **3.3 SYSTEM START-UP**

- A. Provide qualified technicians to confirm proper installation and operation of system components after initial programming and prior to training.

#### **3.4 TRAINING**

- A. Provide a minimum of two days of on-site training and instruction to the building's operating personnel by qualified application engineers. Include the instructor's cost of travel and subsistence.

#### **3.5 OPERATION ASSISTANCE**

- A. Factory telephone support shall be available at no cost to the Owner for the duration of the warranty period. Factory assistance shall consist of solving programming or application questions concerning the control equipment. The manufacturer shall be capable of troubleshooting the software aspects of the system from a factory location via remote connection.

### **END OF SECTION**



## **SECTION 26 09 43 - NETWORK LIGHTING CONTROLS**

### **PART 1 GENERAL**

#### **1.1 SECTION INCLUDES**

- A. Digital-network lighting control system and associated components:
  - 1. LED drivers.
  - 2. Power interfaces.
  - 3. Main units (Basis of Design: Lutron Grafik Eye QS).
  - 4. Lighting control modules (Basis of Design: Lutron Energi Savr Node).
  - 5. Lighting management hubs.
  - 6. Lighting management system computers.
  - 7. Lighting management system software.
  - 8. Control stations.
  - 9. Low-voltage control interfaces.
  - 10. Wired sensors.
  - 11. Wireless sensors.
  - 12. Accessories.
- B. All information in the following specification shall be coordinated with the indicated equipment and control strategy indicated on the construction documents.

#### **1.2 REFERENCE STANDARDS**

- A. 47 CFR 15 - Radio Frequency Devices; Code of Federal Regulations; current edition.
- B. ANSI C82.11 - American National Standard for Lamp Ballasts - High Frequency Fluorescent Lamp Ballasts - Supplements; 2011.
- C. ANSI/ESD S20.20 - Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices); 2014.
- D. ASTM D4674 - Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments; 2002a (Reapproved 2010).
- E. IEC 60929 - AC and/or DC-Supplied Electronic Control Gear for Tubular Fluorescent Lamps - Performance Requirements; 2015.
- F. IEC 61000-4-2 - Electromagnetic Compatibility (EMC) - Part 4-2: Testing and Measurement Techniques - Electrostatic Discharge Immunity Test; 2008.
- G. IEC 61000-4-5 - Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test; 2014.
- H. IEEE C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; 2002 (Cor 1, 2012).
- I. ISO 9001 - Quality Management Systems-Requirements; 2008.
- J. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2010.
- K. NECA 130 - Standard for Installing and Maintaining Wiring Devices; National Electrical Contractors Association; 2010.

- L. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts; National Electrical Manufacturers Association; 2011.
- M. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; 1999 (R 2010).
- N. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- O. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- P. UL 924 - Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.
- Q. UL 1472 - Solid-State Dimming Controls; Current Edition, Including All Revisions.
- R. UL 1598C - Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits; Current Edition, Including All Revisions.
- S. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; Current Edition, Including All Revisions.
- T. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

### 1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. Coordinate the placement of sensors and wall controls with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate the placement of wall controls with actual installed door swings.
  - 3. Coordinate the placement of daylight sensors with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
  - 4. Where motorized window treatments are to be controlled by the lighting control system provided under this section, coordinate the work with other trades to provide compatible products.
  - 5. Coordinate the work to provide luminaires and lamps compatible with the lighting controls to be installed.
  - 6. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- B. Pre-Wire Meeting: Conduct on-site meeting with lighting control system manufacturer prior to commencing work as part of manufacturer's standard startup services. Manufacturer to review with installer:
  - 1. Low voltage wiring requirements.
  - 2. Separation of power and low voltage/data wiring.
  - 3. Wire labeling.
  - 4. Lighting management hub locations and installation.
  - 5. Control locations.
  - 6. Computer jack locations.
  - 7. Load circuit wiring.
  - 8. Network wiring requirements.
  - 9. Connections to other equipment and other equipment.

10. Installer responsibilities.
  11. Power panel locations.
- C. Sequencing:
1. Do not install sensors and wall controls until final surface finishes and painting are complete.

#### 1.4 SUBMITTALS

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
  1. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams.
- C. Shop Drawings:
  1. Provide schematic system riser diagram indicating component interconnections. Include requirements for interface with other systems.
  2. Provide detailed sequence of operations describing system functions.
- D. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
- E. Warranty: Submit sample of manufacturer's Warranty or Enhanced Warranty as specified in Part 1 under "WARRANTY". Submit documentation of final execution completed in Owner's name and registered with manufacturer.

#### 1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications:
  1. Company with not less than ten years of experience manufacturing lighting control systems of similar complexity to specified system.
  2. Registered to ISO 9001, including in-house engineering for product design activities.
  3. Qualified to supply specified products and to honor claims against product presented in accordance with warranty.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

#### 1.7 FIELD CONDITIONS

- A. Maintain field conditions within manufacturers required service conditions during and after installation.

1. System Requirements - Unless Otherwise Indicated:
  - a. Ambient Temperature:
    - 1) Lighting Control System Components, Except Those Listed Below: Between 32 and 104 degrees F (0 and 40 degrees C).
    - 2) Lighting Management System Computer: Between 50 and 90 degrees F (10 and 35 degrees C).
    - 3) Fluorescent Electronic Dimming Ballasts: Between 50 and 140 degrees F (10 and 60 degrees C).
  - b. Relative Humidity: Less than 90 percent, non-condensing.

## 1.8 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Manufacturer's Standard Warranty, With Manufacturer Start-Up; Standard 2-Year Warranty:
  1. Manufacturer Lighting Control System Components, Except Lighting Management System Computer, Ballasts/Drivers and Ballast Modules:
    - a. First Two Years:
      - 1) 100 percent replacement parts coverage, 100 percent manufacturer labor coverage to troubleshoot and diagnose a lighting issue.
      - 2) First-available on-site or remote response time.
      - 3) Remote diagnostics for applicable systems.
    - b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.
  2. Lighting Management System Computer: One year 100 percent parts coverage, one year 100 percent manufacturer labor coverage.
  3. Ballasts/Drivers and Ballast Modules: Five years 100 percent parts coverage, no manufacturer labor coverage.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

- A. Basis of Design Manufacturer: Lutron. Alternate Manufacturers: Crestron.

### 2.2 DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS

- A. Sensor Layout and Tuning: No Lighting Control Manufacturer Sensor Layout and Tuning service to be provided.
  1. Contractor to utilize Lighting Control Manufacturer Installation Instructions to place/install sensors.
  2. At Pre-wire and Startup, Lighting Control Manufacturer to provide a rough sensor calibration only. Sensor fine-tuning to be the responsibility of Contractor.
- B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.

- C. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the control intent indicated.
- D. Shade Control Requirements:
  - 1. Capable of operating shades and recalling shade presets via keypad, contact closure input, infrared receiver, lighting management system software, or other lighting control system interface.
  - 2. Capable of operating any individual, group, or subgroup of shade electronic drive units within system without requiring separate group controllers.
  - 3. Capable of assigning and reassigning individual, groups, and subgroups of shades to any control within system without requiring additional wiring or hardware changes.
  - 4. Capable of controlling shade speed for tracking within plus or minus 0.125 inch (3.17 mm) throughout entire travel.
  - 5. Provide 10 year power failure memory for preset stops, open and close limits, shade grouping and sub grouping and system configuration.
  - 6. Capable of synchronizing multiple shade electronic drive units of the same size to start, stop and move in unison.
  - 7. Capable of stopping shades within accuracy of 0.125 inch (3.17 mm) at any point between open and close limits.
  - 8. Capable of storing up to 250 programmable stop points, including open, close, and any other position.
  - 9. Capable of controlling lights and shades from single wall control button.
  - 10. Capable of adjusting shade limits from user interface.
- E. Design lighting control equipment for 10 year operational life while operating continually at any temperature in an ambient temperature range of 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) and 90 percent non-condensing relative humidity.
- F. Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
- G. Dimming and Switching (Relay) Equipment:
  - 1. Designed so that electrolytic capacitors operate at least 36 degrees F (20 degrees C) below the capacitor's maximum temperature rating when the device is under fully loaded conditions at maximum rated temperature.
  - 2. Inrush Tolerance:
    - a. Utilize load-handling thyristors (SCRs and triacs), field effect transistors (FETs) and isolated gate bipolar transistors (IGBTs) with maximum current rating at least two times the rated operating current of the dimmer/relay.
    - b. Capable of withstanding repetitive inrush current of 50 times the operating current without impacting lifetime of the dimmer/relay.
  - 3. Surge Tolerance:
    - a. Panels: Designed and tested to withstand surges of 6,000 V, 3,000 amps according to IEEE C62.41.2 and IEC 61000-4-5 without impairment to performance.
    - b. Other Power Handling Devices: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
  - 4. Power Failure Recovery: When power is interrupted and subsequently restored, within 3 seconds lights to automatically return to same levels (dimmed setting, full on, or full off) as prior to power interruption.

5. Dimming Requirements:
  - a. Line Noise Tolerance: Provide real-time cycle-by-cycle compensation for incoming line voltage variations including changes in RMS voltage (plus or minus 2 percent change in RMS voltage per cycle), frequency shifts (plus or minus 2 Hz change in frequency per second), dynamic harmonics, and line noise.
    - 1) Systems not providing integral cycle-by-cycle compensation to include external power conditioning equipment as part of dimming system.
  - b. Incorporate electronic "soft-start" default at initial turn-on that smoothly ramps lights up to the appropriate levels within 0.5 seconds.
  - c. Utilize air gap off to disconnect the load from line supply.
  - d. Control all light sources in smooth and continuous manner. Dimmers with visible steps are not acceptable.
  - e. Load Types:
    - 1) Assign a load type to each dimmer that will provide a proper dimming curve for the specific light source to be controlled.
    - 2) Provide capability of being field-configured to have load types assigned per circuit.
  - f. Minimum and Maximum Light Levels: User adjustable on a circuit-by-circuit basis.
  - g. Line Voltage Dimmers:
    - 1) Dimmers for Magnetic Low Voltage (MLV) Transformers:
      - (a) Provide circuitry designed to control and provide a symmetrical AC waveform to input of magnetic low voltage transformers per UL 1472.
      - (b) Dimmers using unipolar load current devices (such as FETs or SCRs) to include DC current protection in the event of a single device failure.
    - 2) Dimmers for Electronic Low Voltage (ELV) Transformers: Operate transformers via reverse phase control. Alternately, forward phase control dimming may be used if dimming equipment manufacturer has recommended specific ELV transformers being provided.
    - 3) Dimmers for Neon and Cold Cathode Transformers:
      - (a) Magnetic Transformers: Listed for use with normal (low) power factor magnetic transformers.
      - (b) Electronic Transformers: Must be supported by the ballast equipment manufacturer for control of specific ballasts being provided.
  - h. Low Voltage Dimming Modules:
    - 1) Coordination between low voltage dimming module and line voltage relay: Capable of being electronically linked to a single zone.
    - 2) Single low voltage dimming module; capable of controlling the following light sources:
      - (a) 0-10V analog voltage signal.
        - (1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
        - (2) Sink current according to IEC 60929.
        - (3) Source current.
      - (b) 10-0V reverse analog voltage signal.
      - (c) DSI digital communication.
      - (d) DALI broadcast communication per IEC 60929:
        - (1) Logarithmic intensity values complying with IEC 60929.
        - (2) Linear intensity values for use with LED color intensity control.
      - (e) PWM per IEC 60929.
6. Switching Requirements:

- a. Rated Life of Relays: Typical of 1,000,000 cycles at fully rated 16 A for all lighting loads.
  - b. Switch load in a manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
  - c. Provide output fully rated for continuous duty for inductive, capacitive, and resistive loads.
- H. Device Finishes:
  - 1. Standard Colors: Comply with NEMA WD1 where applicable.
  - 2. Color Variation in Same Product Family: Maximum delta E of 1, CIE L\*a\*b color units.
  - 3. Visible Parts: Exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674. Provide proof of testing upon request.

## 2.3 POWER INTERFACES

- A. Provide power interfaces as indicated or as required to control the loads as indicated.
- B. General Requirements:
  - 1. Phase independent of control input.
  - 2. Rated for use in air-handling spaces as defined in UL 2043.
  - 3. Utilize air gap off to disconnect the load from line supply.
  - 4. Diagnostics and Service: Replacing power interface does not require re-programming of system or processor.
- C. Product(s):
  - 1. Phase-Adaptive Power Module; Lutron PHPM-PA: Provides interface for phase control input to provide full 16 A circuit output of forward/reverse phase control for compatible loads.

## 2.4 MAIN UNITS

- A. Basis of Design: Lutron GRAFIK Eye QS.
- B. Provide main units with configuration and quantity of zones as indicated or as required to control the loads as indicated.
- C. Connects to lighting management hub via RS485.
- D. Engrave units with button, zone, and scene descriptions as indicated on the drawings.
- E. Integrated Wireless Capability:
  - 1. Provide wireless communication inputs for:
    - a. Occupancy sensors.
    - b. Daylight sensors.
    - c. Wireless controller.
  - 2. RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
  - 3. RF Frequency: 434 MHz; operate in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
- F. Preset Lighting Control with Zone Override:
  - 1. Intensity for each zone indicated by means of one illuminated bar graph per zone.
  - 2. User-programmable zone and scene names.
  - 3. Utilize air gap off to disconnect the load from line supply.
  - 4. Astronomical time clock and programmer interface provides access to:
    - a. Scene selections.
    - b. Fade zone to a level.

- c. Fine-tuning of preset levels with scene raise/lower.
  - d. Lock out scenes and zones.
  - e. Fine-tuning of light levels with individual zone raise/lower.
  - f. Terminal block for wired infrared signal input.
  - g. Enable/disable wall station.
- 5. Light intensity with real time energy savings by digital display.
- 6. Fade time indicated by digital display for current scene while fading.
- 7. Integral wide angle infrared receiver.
- 8. For temporary local overrides, individual raise/lower buttons to allow zones to be adjusted without altering scene values stored in memory.
- 9. Direct Low-Voltage Control of Digital Ballasts and LED drivers (120V, 220/240V, 277V and/or 347V Lighting):
  - a. Electronically link a digital fluorescent lighting ballast to a zone for both dimming and turning on/off.
  - b. Electronically assign daylight sensors to digital ballasts and line voltage dimmers for proportional daylight harvesting.
  - c. Single integral controller with Class 1 or Class 2 isolated digital output signal conforming to IEC 60929; capable of direct control without interface.
- 10. Creates daylighting rows independent of control zones.
- 11. Capable of re-zoning without re-wiring using programming display on unit.
- 12. Outputs can be virtually mapped to other device's outputs.
- 13. Zone raise/lower buttons capable of controlling local lighting loads connected to the main unit or remote lighting zones in the system.
- G. Preset Shade Control with Zone Override:
  - 1. Preset expandable shade control: Provide up to three columns of shade control.
  - 2. For temporary local overrides, individual raise/lower buttons to allow zones to be adjusted without altering scene values stored in memory.
- H. Provides one direct-wired occupancy sensor connection without interface or power pack.

## 2.5 LIGHTING CONTROL MODULES (LUTRON ENERGI SAVR NODE)

- A. Basis of design: Lutron Energi Savr Node
- B. Provide lighting control modules as indicated or as required to control the loads as indicated.
- C. General Requirements:
  - 1. Listed to UL 508 as industrial control equipment.
  - 2. Delivered and installed as a listed factory-assembled panel.
  - 3. Passively cooled via free-convection, unaided by fans or other means.
  - 4. Mounting: Surface.
  - 5. Connection without interface to wired:
    - a. Occupancy sensors.
    - b. Daylight sensors.
    - c. IR receivers for personal control.
  - 6. Connects to lighting management hub via RS485.
  - 7. LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
  - 8. Contact Closure Input:



- a. Directly accept contact closure input from a dry contact closure or sold-state output without interface to:
  - 1) Activate scenes.
    - (a) Scene activation from momentary or maintained closure.
  - 2) Enable or disable after hours.
    - (a) Automatic sweep to user-specified level after user-specified time has elapsed.
    - (b) System will provide occupants a visual warning prior to sweeping lights to user-specified level.
    - (c) Occupant can reset timeout by interacting with the lighting system.
  - 3) Activate or deactivate demand response (load shed).
    - (a) Load shed event will reduce lighting load by user-specified amount.
- 9. Emergency Contact Closure Input:
  - a. Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
  - b. Allow configurable zone response during emergency state.
  - c. Disable control operation until emergency signal is cleared.
- 10. Supplies power for control link for keypads and control interfaces.
- 11. Distributes sensor data among multiple lighting control modules.
- 12. Capable of being controlled via wireless sensors and controls.
- D. Digital Fixture Lighting Control Modules:
  - 1. Product(s):
    - a. Lutron EcoSystem Energi Savr Node; Model QSN-1ECO-S: One EcoSystem Digital Link.
  - 2. Provides two-way feedback with digital fixtures for energy monitoring, light level status, lamp failure reporting, and ballast/driver failure reporting.
  - 3. Provide testing capability using manual override buttons.
  - 4. Each low-voltage digital communication link to support up to 64 ballasts or LED drivers capable of NFPA 70 Class 1 or Class 2 installation.

## 2.9 CONTROL STATIONS

- A. Provide control stations with configuration as indicated or as required to control the loads as indicated.
- B. Wired Control Stations:
  - 1. General Requirements:
    - a. Power: Class 2 (low voltage).
    - b. UL listed.
    - c. Provide faceplates with concealed mounting hardware.
    - d. Borders, logos, and graduations to use laser engraving or silk-screened graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.
    - e. Finish: As specified for wall controls in "Device Finishes" under DIGITAL NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS article above.
  - 2. Multi-Scene Wired Control:
    - a. General Requirements:
      - 1) Allows control of any devices part of the lighting control system.
      - 2) Allows for easy reprogramming without replacing unit.
      - 3) Replacement of units does not require reprogramming.
      - 4) Communications: Utilize RS485 wiring for low-voltage communications link.

- 5) Engrave keypads with button, zone, and scene descriptions as indicated on the drawings.
- 6) Software Configuration:
  - (a) Customizable control station device button functionality:
    - (1) Buttons can be programmed to perform single defined action.
    - (2) Buttons can be programmed to perform defined action on press and defined action on release.
    - (3) Buttons can be programmed using conditional logic off of a state variable such as time of day or partition status.
    - (4) Buttons can be programmed to perform automatic sequence of defined actions.
    - (5) Capable of deactivating select keypads to prevent accidental changes to light levels.
    - (6) Buttons can be programmed for raise/lower of defined loads.
    - (7) Buttons can be programmed to toggle defined set of loads on/off.
- 7) Status LEDs:
  - (a) Upon button press, LEDs to immediately illuminate.
  - (b) LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or LEDs to turn off if the button press was not processed.
  - (c) Support logic that defines when LED is illuminated:
    - (1) Scene logic (logic is true when all zones are at defined levels).
    - (2) Room logic (logic is true when at least one zone is on).
    - (3) Pathway logic (logic is true when at least one zone is on).
    - (4) Last scene (logic is true when spaces are in defined scenes).
- b. Wired Keypads; Lutron seeTouch QS Wallstations:
  - 1) Style: Architectural Insert Style.
  - 2) Mounting: Wallbox or low-voltage mounting bracket; provide wall plates with concealed mounting hardware.
  - 3) Button/Engraving Backlighting:
    - (a) Utilize backlighting for buttons and associated engraving to provide readability under all light conditions.
    - (b) Backlight intensity adjustable via programming software.
  - 4) Design keypads to allow field-customization of button color, configuration, and engraving using field-changeable replacement kits.
  - 5) Contact Closure Interface: Provide two contact closure inputs on back of unit which provide independent functions from front buttons; accepts both momentary and maintained contact closures.
  - 6) Terminal block inputs to be over-voltage and miswire-protected against reversals and shorts.
- C. Wireless (Radio Frequency) Controls:
  1. Product(s):
    - a. Type \_\_\_\_\_ - 2-Button with Raise/Lower Control; Lutron Pico Wireless Control Model PJ2-2BRL.
    - b. Wallbox Adapter; Lutron Model PICO-WBX-ADAPT.
  2. Communicates via radio frequency to compatible dimmers, switches, and plug-in modules.

3. Does not require external power packs, power or communication wiring.
4. Allows for easy reprogramming without replacing unit.
5. Button Programming:
  - a. Single action.
  - b. Toggle action.
  - c. Defined action on press and defined action on release.
6. Includes LED to indicate button press or programming mode status.
7. Mounting:
  - a. Capable of being mounted with a table stand or directly to a wall under a faceplate.
  - b. Faceplates: Provide concealed mounting hardware.
8. Power: Battery-operated with minimum ten-year battery life.
9. Finish: As specified for wall controls in "Device Finishes" under DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS article above.

## 2.10 LOW-VOLTAGE CONTROL INTERFACES

- A. Provide low-voltage control interfaces as indicated or as required to control the loads as indicated.
- B. Connects to lighting management hub via RS485.
- C. UL listed.
- D. Contact Closure Interface:
  1. Product: Lutron Model QSE-IO.
  2. The contact closure input device to accept both momentary and maintained contact closures.
  3. The contact closure output device can be configured for maintained or pulsed outputs.
  4. Contact closure can be programmed using conditional logic off of a state variable such as time of day or partition status.
- E. RS232 and Ethernet Interface:
  1. Product: Lutron Model QSE-CI-NWK-E.
  2. Provide ability to communicate via Ethernet or RS232 to audiovisual equipment, touchscreens, etc.
  3. Provide control of:
    - a. Light scene selections.
    - b. Fine-tuning of light scene levels with raise/lower.
    - c. Shade group presets.
    - d. Fine-tuning of shade preset levels with raise/lower.
    - e. Simulate system wall station button presses and releases.
  4. Provide status monitoring of:
    - a. Light scene status.
    - b. Shade group status.
    - c. Wall station button presses and releases.
    - d. Wall station LEDs.
  5. Provide ability to send custom output strings.
- F. Sensor Modules:
  1. Products:
    - a. Sensor module with both wired and wireless inputs; Lutron Model QSM2-4W-C.
  2. Wired Modules:

- a. Provide wired inputs for:
    - 1) Occupancy sensors.
    - 2) Daylight sensors.
    - 3) IR receivers for personal control.
    - 4) Digital ballast wall stations.
- 3. Wireless Modules:
  - a. Provide wireless communication inputs for:
    - 1) Occupancy sensors.
    - 2) Daylight sensors.
    - 3) Wireless controller.
  - b. RF Range: 30 feet (9 m) between sensor and compatible RF receiving devices.
  - c. RF Frequency: 434 MHz; operates in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
- 4. Communicate sensor information to wired low-voltage digital link for use by compatible devices.

## 2.11 WIRED SENSORS

- A. Infrared Partition Sensors:
  - 1. Product: Lutron Model GRX-IRPS-WH.
  - 2. Provide contact closure based on status of the partition wall (open/close) enabling automatic linking of controls.

## 2.12 WIRELESS SENSORS

- A. General Requirements:
  - 1. Operational life of 10 years without the need to replace batteries when installed per manufacturer's instructions.
  - 2. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.
  - 3. Does not require external power packs, power wiring, or communication wiring.
  - 4. Capable of being placed in test mode to verify correct operation from the face of the unit.
  - 5. RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
  - 6. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.
- B. Wireless Occupancy/Vacancy Sensors:
  - 1. General Requirements:
    - a. Provides a clearly visible method of indication to verify that motion is being detected during testing and that the unit is communicating to compatible RF receiving devices.
    - b. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
    - c. Sensing Mechanism: Passive infrared coupled with technology for sensing fine motions; Lutron XCT Technology. Signal processing technology detects fine-motion passive infrared (PIR) signals without the need to change the sensor's sensitivity threshold.
    - d. Provide optional, readily accessible, user-adjustable controls for timeout, automatic/manual-on, and sensitivity.

- e. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area. Provide adjustable timeout settings of 1, 5, 15, and 30 minutes.
  - f. Capable of turning dimmer's lighting load on to an optional locked preset level selectable by the user. Locked preset range to be selectable on the dimmer from 1 percent to 100 percent.
  - g. Color: As indicated in specification 26 27 16.
  - h. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
  - i. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.
  - j. Sensor lens to illuminate during test mode when motion is detected to allow installer to verify coverage prior to permanent mounting.
  - k. Ceiling-Mounted Sensors:
    - 1) Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
    - 2) Provide customizable mask to block off unwanted viewing areas.
2. Wireless Combination Occupancy/Vacancy Sensors:
- a. Ceiling-Mounted Sensors: Programmable to operate as an occupancy sensor (automatic-on and automatic-off), an occupancy sensor with low light feature (automatic-on when less than one footcandle of ambient light available and automatic-off), or a vacancy sensor (manual-on and automatic-off).
  - b. Product(s):
    - 1) Type \_\_\_\_\_ - Ceiling-Mounted Occupancy/Vacancy Sensor; Lutron Model LFR2-OCR2B-P-WH: Coverage from 324 square feet (30.2 sq m) to 676 square feet (62.4 sq m) depending on ceiling height from 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.
- C. Wireless Daylight Sensors:
- 1. Product: Lutron Model LFR2-DCRB.
  - 2. Open-loop basis for daylight sensor control scheme.
  - 3. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
  - 4. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
  - 5. Provide linear response from 0 to 10,000 footcandles.
  - 6. Color: as indicated in specification 26 27 16.
  - 7. Mounting:
    - a. Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
    - b. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
    - c. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.

## 2.13 ACCESSORIES

- A. Provide power supplies as indicated or as required to power system devices and accessories.

## 2.14 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Factory Testing; Lutron Standard Factory Testing:
  - 1. Perform full-function factory testing on all completed assemblies. Statistical sampling is not acceptable.
  - 2. Perform full-function factory testing on 100 percent of all ballasts and LED drivers.
  - 3. Perform factory audit burn-in of all dimming assemblies and panels at 104 degrees F (40 degrees C) at full load for two hours.

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, except for mounting heights specified in those standards.
- B. Install products in accordance with manufacturer's instructions.
- C. Provide dedicated network between lighting management system computer and lighting management hubs.
- D. Define each dimmer/relay load type, assign each load to a zone, and set control functions.
- E. Sensor Locations:
  - 1. Where Lighting Control Manufacturer Sensor Layout and Tuning service is specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS", locate sensors in accordance with layout provided by Lighting Control Manufacturer. Lighting Control Manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated. Where Lighting Control Manufacturer Sensor Layout and Tuning service is not specified, locate sensors in accordance with Drawings.
- F. Ensure that daylight sensor placement minimizes sensor view of electric light sources. Locate ceiling-mounted and luminaire-mounted daylight sensors to avoid direct view of luminaires.
- G. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
- H. LED Light Engine/Array Lead Length: Do not exceed 100 feet (31 m).

### 3.2 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Manufacturer's Startup Services; Lutron Standard Startup Services:
  - 1. Manufacturer's authorized Service Representative to conduct minimum of two site visits to ensure proper system installation and operation.
  - 2. Conduct Pre-Installation visit to review requirements with installer as specified in Part 1 under "Administrative Requirements".
  - 3. Conduct second site visit upon completion of lighting control system to perform system startup and verify proper operation:
    - a. Verify connection of power wiring and load circuits.

- b. Verify connection and location of controls.
  - c. Energize lighting management hubs and download system data program.
  - d. Address devices.
  - e. Verify proper connection of panel links (low voltage/data) and address panel.
  - f. Verify system operation control by control.
  - g. Verify proper operation of manufacturer's interfacing equipment.
  - h. Verify proper operation of manufacturer's supplied PC and installed programs.
  - i. Configure initial groupings of ballast for wall controls, daylight sensors and occupancy sensors.
  - j. Provide initial rough calibration of sensors; fine-tuning of sensors is responsibility of Contractor unless provided by Lighting Control Manufacturer as part of Sensor Layout and Tuning service where specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS".
  - k. Train Owner's representative on system capabilities, operation, and maintenance, as specified in Part 3 under "Closeout Activities".
  - l. Obtain sign-off on system functions.
4. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

### 3.4 CLOSEOUT ACTIVITIES

#### A. Training:

- 1. Include services of manufacturer's authorized Service Representative to perform on-site training of Owner's personnel on operation, adjustment, and maintenance of lighting control system as part of standard system start-up services.
  - a. Include training on software to be provided:
    - 1) Configuration software used to make system programming and configuration changes.
    - 2) Control and monitor.

### 3.5 PROTECTION

- A. Protect installed products from subsequent construction operations.

END OF SECTION 26 09 43

## **SECTION 262213 - DRY-TYPE TRANSFORMERS**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide dry-type transformers in accordance with the Contract Documents.
- B. Transformers shall be of the ratings and types shown on the Drawings.

#### **1.2 QUALITY ASSURANCE**

- A. Transformers shall be the same manufacturer as the switchboards.
- B. Transformers shall comply with energy efficiency standards and shall be NEMA TP-1-2002, Energy Star labeled.

#### **1.3 REFERENCE STANDARDS**

- A. ANSI C57.12.00, C57.96, and C57.110
- B. NEMA ST 20 and TR 27
- C. UL 506 and 1561

#### **1.4 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.
- B. Manufacturer's product data sheets, electrical ratings, heat release data, physical dimensions, noise ratings, and weights.
- C. Factory test reports.
- D. Certified vibration isolation details and product data showing the number and location of each support and the exact number, size, and type of each anchor.

#### **1.5 FACTORY TESTING**

- A. Ratio tests at the rated voltage connection and at all tap locations.
- B. Polarity and phase relation tests on the rated voltage connection.
- C. Applied and induced potential tests.
- D. No-load and excitation current at rated voltage on the rated voltage connection.



## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. The basis of design is Siemens. Square D, Cutler Hammer, and General Electric are acceptable manufacturers providing they meet all the specifications. Any revision, modification, change alteration required as a result of using a manufacturer other than the basis of design shall be accomplished at the Contractors option, expense, schedule impact or other factor. The use of a manufacturer other than the three specified is prohibited.

### 2.2 RATINGS

- A. Transformers shall be self-cooled, designed for continuous operation at rated KVA for 24 hours a day, 365 days a year.
- B. Voltage Ratings:
  - 1. Primary: 480V, 3 phase, 3 wire, delta connected.
  - 2. Secondary: 120/208V, 3 phase, 4 wire, wye connected.

### 2.3 CORE AND COIL ASSEMBLY

- A. Core shall be high grade, non-aging, grain oriented, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Coil windings shall be wound of electrical grade copper or aluminum with continuous-wound construction.
- B. The core and coil assembly shall be impregnated with non-hydroscopic thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration absorbing pads.
- C. Provide NEMA standard taps.
- D. The core and coil assembly shall be grounded to the enclosure by means of an adequately sized flexible copper grounding strap.
- E. Transformers identified on the Drawings with the designation TK shall be UL Listed as suitable for non-sinusoidal current loads with minimum K Factor of 13. The secondary neutral conductor and neutral pad shall be rated to carry 200 percent of normal phase current.

### 2.4 ENCLOSURES

- A. Heavy gauge steel, finished utilizing a continuous process of degreasing, cleaning, and phosphatizing, followed by an electrostatic deposition of thermosetting polyester powder coating and subsequent baking. Finish color shall be ANSI 61 grey enamel.
- B. Units rated 30 KVA and below shall be totally enclosed, non-ventilated, NEMA 3R where located in exterior areas, with lifting eyes and wall-mount hardware.
- C. Units rated 45 KVA and above shall be ventilated, NEMA 3R where located in exterior areas, drip-proof, with lifting holes.

## 2.5 INSULATION

- A. Insulation materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D635.
- B. Transformers shall be insulated with a 220 degrees C insulation system.

## 2.6 SOUND LEVELS

- A. Sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Transformer Capacity	Maximum Sound Level
Up to 50 KVA	45dB
51 to 1500 KVA	50dB

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Transformers shall be floor-mounted except where indicated on the Drawings to be suspended or wall-mounted.
- B. Suspended transformers shall be mounted on hanger rods with a spring isolator in each rod.
- C. Floor-mounted transformers shall be mounted on 4-inch high concrete housekeeping pads. Provide spring vibration isolators between transformer legs and housekeeping pad and anchor transformer to floor.
- D. Provide grounding electrode conductor from transformer secondary neutral to ground riser conductor in the electrical room.
- E. Conduit connected to transformers shall be flexible metal conduit, 24 inches minimum length, 60 inches maximum length.

END OF SECTION

## **SECTION 262413 - SWITCHBOARDS**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide switchboards in accordance with the Contract Documents.
- B. Switchboards include both main switchboards and distribution switchboards.

#### **1.2 QUALITY ASSURANCE**

- A. Utility company approval of service busway, incoming section, and metering provisions.

#### **1.3 REFERENCE STANDARDS**

- A. Switchboards:
  - 1. NEMA PB-2
  - 2. UL 891
  - 3. UL service entrance label
- B. Overcurrent Protection Devices:
  - 1. Circuit breakers: NEMA AB-1, Federal Specification W-C-375 B/GEN, UL 489
- C. Testing:
  - 1. NETA ATS
  - 2. ASTM 329
- D. Pepco Power requirements.

#### **1.4 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place.
- B. Manufacturer's product data sheets for overcurrent protection devices.
- C. Dimensioned layout and elevation drawings showing switchboards, housekeeping pads, and support locations and types.
- D. One-line diagram showing electrical ratings, overcurrent protection device ratings, cable lugs, utility company metering, metering displays and identification nameplate.
- E. Utility company approval for components subject to their specifications.
- F. Wiring diagrams.

- G. Installation instructions.
- H. Arc flash study.
- I. Short circuit and coordination study.
- J. Certified test reports.

#### 1.5 FIELD TESTING

- A. Field-inspection and field testing shall occur after installation is complete, feeders are terminated, and the room is secure. Testing shall be conducted not more than four weeks before equipment is energized.
- B. Testing Scope:
  - 1. Visual and physical inspection of equipment.
  - 2. Check control wiring and metering.
  - 3.
  - 4. Ground fault protection.
  - 5. Adjust circuit breaker settings based on recommendations in the short circuit and coordination study.
  - 6.
  - 7. System grounding.
- C. Certified Test Reports:
  - 1. Verify that the installation is in accordance with the manufacturer's instructions.
  - 2. Verify that the equipment has been fully tested and is operational.
  - 3. Perform testing and compile detailed test reports for each switchboard and overcurrent protection device. Re-test every component not passing field testing until the device passes.

#### 1.6 IDENTIFICATION

- A. Provide a permanent acrylic identification nameplate for each switchboard, each main, and each feeder overcurrent protection device.

#### 1.7 SHORT CIRCUIT AND COORDINATION STUDY

- A. Prepare a short circuit and coordination study based on the actual overcurrent protection devices proposed for use and the actual conductor sizes and lengths. The study shall be prepared by an electrical engineer licensed in the District of Columbia and shall be submitted as a supplemental permit submission to the Authority Having Jurisdiction.
- B. The study shall be submitted with the distribution equipment submittal and shall indicate where device substitutions are being made in order to achieve adequate interrupting capacity ratings for each piece of equipment.
- C. The study shall include recommended settings of adjustable overcurrent and ground fault settings.

- D. Provide overcurrent protective devices of suitable type and rating to meet or exceed the available short circuit currents indicated in the short circuit study. Circuit breakers serving the emergency power system as well as circuit breakers protecting elevators, including all upstream feeder circuit breakers, shall be of the appropriate frame size to ensure 100 percent selectivity in the instantaneous region of the trip curves at the calculated fault current. Coordination study shall demonstrate selective coordination is achieved and shall include the effects of ground fault protection devices indicated on the Drawings.
- E. Interrupting capacities shall be based on a fully rated protection system where all overcurrent protection devices are rated for the full prospective short circuit current (as indicated in the final short circuit submittal). Series-rated panelboards per manufacturers UL testing.
- F. Obtain from the utility company (and confirm in writing) the short circuit current available at the utility company's transformer secondary.

#### 1.8 ARC FLASH STUDY

- A. Prepare an arc flash study for electrical service and distribution equipment. The study shall be prepared by an electrical engineer licensed in DC. Include in the arc flash study the electrical engineer's name and license number.
- B. The study shall be submitted with the electrical service and distribution equipment submittal and shall indicate the required level of protective wear for each piece of electrical equipment.
- C. Schedule a review with the landlord and engineer to evaluate labels are acceptable prior to installation.

### PART 2 PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. The basis of design is Siemens. Square D and Cutler Hammer / Eaton are acceptable manufacturers providing they meet all the specifications and space allocations indicated on the drawings. Any revision, modification, change alteration required as a result of using a manufacturer other than the basis of design shall be accomplished at the Contractors option, expense, schedule impact or other factor. The use of a manufacturer other than the three specified is prohibited.

#### 2.2 RATINGS

- A. Switchboards shall be of the ratings and configurations shown on the Drawings.
- B. Switchboards and overcurrent protection devices shall have a minimum short circuit rating as specified herein or greater where indicated on the Drawings.
- C. Short-circuit ratings specified herein or where indicated on the Drawings shall serve as a guideline and reference point for panelboard ratings. Providing and installing equipment per the short-circuit ratings shown on the drawings or specified herein does not guarantee that the equipment will be properly rated. It shall be the responsibility of the Contractor to ensure that all installed equipment is rated per the recommendations of the required power systems study. The

contractor shall replace any installed equipment that does not meet the power study short-circuit rating requirements at no additional cost to the owner.

D. Main Switchboards:

1. Main switchboards are identified with the designation MS as shown on the Drawings.
2. Maximum allowable physical dimensions: 48 inches wide by 48 inches deep per section.
3. Main switchboards – circuit breaker type: 150,000 RMS symmetrical amperes minimum interrupting capacity or per the fault current and coordination study

E. Distribution Switchboards:

1. Distribution switchboards are identified with the designation DPL (120/208V or 208V) or DPH (265/460V or 460V) as shown on the Drawings.
2. Maximum allowable physical dimensions: 36 inches wide by 24 inches deep per section.
3. Distribution switchboards (DSL): 100,000 RMS symmetrical amperes minimum interrupting capacity.
4. Distribution switchboards – circuit breaker type (DSH): 100,000 RMS symmetrical amperes minimum interrupting capacity or per the fault current and coordination study

2.3 CONSTRUCTION

- A. Main switchboards shall be free standing, front accessible only, with individually mounted, compartmentalized, front-connected main overcurrent protection devices and group-mounted feeder overcurrent protection devices of the quantity, rating, and arrangement as shown on the Drawings. Vertical sections shall be aligned front and rear.
- B. Distribution switchboards shall be front accessible only, with group-mounted main and feeder overcurrent protection devices of the quantity, rating, and arrangement as shown on the Drawings.
- C. Switchboards shall be completely self-supporting structures of the required number of vertical sections bolted together to form a single metal-enclosed switchboard. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure. The frame structure members shall be die-formed, 12 gauge steel bolted together and reinforced at corners with rugged gussets internal and external to the switchboard members.
- D. Switchboards shall be provided with adequate lifting means, and be capable of being rolled or moved into position and bolted directly to the floor without the use of floor sills.
- E. Steel surfaces shall be chemically cleaned and treated, providing a bond between paint and metal surfaces to prevent the entrance of moisture and formation of rust under the paint finish. Finish shall be ANSI-61 gray enamel paint.
- F. Space for future devices shall include all necessary bus, overcurrent protection device supports and mounting, connections and fingers.
- G. Switchboard enclosures shall be NEMA Type 1. Switchboard sections shall be aligned on top, 90 inches high, unless lower height is required due to space limitations.

- H. Where required for conduit terminations, provide pull box on top of switchboard of same type of construction and finish as the switchboard.

- I. Where draw-out type overcurrent protection devices are provided, provide a portable type lifter or hoist, frame mounted on steel casters.
- J. Flash Protection:
  - 1. Equipment manufacturer shall provide arc flash warning labels directly on the equipment.
  - 2. Based on the results from the arc flash study, the required level of protective gear shall be clearly displayed on the warning labels.

## 2.4 BUS SYSTEM

- A. Bus bars shall be arranged throughout A-B-C left to right, top to bottom, and front to rear. Bus bars shall be permanently labeled by phase. Bus joints shall be bolted with high-tensile zinc-plated steel bolts with spring-loaded Bellville type washers.
- B. Bus bars shall be plated copper or aluminum based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure). In addition to full UL air clearances, bus shall be insulated with a minimum of 5-mil thickness of epoxy resin coating. Provide removable non-PVC boots for access to the cross bus joints for inspection and maintenance.
- C. Bus bars shall be non-tapered, of the ampere rating (continuous) shown on the Drawings. Neutral bus shall be full size copper or aluminum. Provide a 33 percent minimum copper or aluminum ground bus, extending along the full length of the switchboard.
- D. Horizontal bus shall be full size, tapered bus is not permitted. Provide bolt holes drilled and tapped for future extension at the end of bus bars including neutral and ground bus so that the addition of a future section would require only the installation of standard bolted splice plates. Provide the splice plates of the horizontal bus rating for phase, neutral and ground stored in the bottom of the last switchboard section.
- E. Busway terminating at switchboard shall be bus connected. Cable connections are unacceptable.

## 2.5 OVERCURRENT PROTECTION DEVICES

- A. General:
  - 1. Feeder overcurrent protection devices shall be bus-connected on the line side.
  - 2. Overcurrent protection devices shall have an external operating handle located on the front door.
  - 3. Stationary type construction for any breakers 1000A and over.
- B. Overcurrent protection device types:
  - 1. Main switchboards: Insulated case circuit breakers, molded case circuit breakers.
  - 2. Distribution Switchboards (DSL): Insulated case circuit breakers, Molded case circuit breakers.
  - 3. Distribution Switchboards (DSH): Insulated case circuit breakers, Molded case circuit breakers.



C. Insulated Case Circuit Breakers:

1. Stored energy charging mechanism and independent close and trip functions.
2. High interrupting capacity disconnect with electric trip for remote tripping or ground fault protection.
3. Breaker compartment interlocked to prevent access when breaker is closed.
4. Handle shall be capable of being padlocked in the OFF position.
5. Positive ON/OFF indicators, green for OFF, red for ON.
6. Provide integral residual-sensing ground fault protection for main and feeder devices. Set each ground fault sensor pick-up setting at 25 percent of the rating of overcurrent protection device with a 6-cycle time delay or as specifically indicated in the final short circuit and coordination study submittal.
7. UL Listed for continuous operation at 100 percent rated load.
8. Auxiliary switches for remote indication of breaker ON/OFF status.
9. Microelectronic digital processor based true RMS trip unit with interchangeable ratings plugs to change the continuous current rating. Provide a hand held, portable plug-in test kit for testing and verifying programmer settings. Provide the following functions:
  - a. Current setting adjustment (long delay pick-up)
  - b. Long-time delay adjustment
  - c. Short-time pick-up adjustment
  - d. Short-time delay adjustment
  - e. Instantaneous pick-up adjustment
  - f. I<sup>2</sup>t-In-Out-adjustment
  - g. Ground-fault pick-up adjustment
  - h. Ground-fault delay adjustment

D. Insulated Case Circuit Breakers, Drawout:

1. Circuit breakers shall comply with the requirements of UL489 and UL1066. Breakers shall be three-pole, 100% rated type or approved equal.
  - a. Circuit breaker element shall have connected, test and disconnected position indicators, spring charged/discharged indicators and circuit breaker open or closed and ready to close indicators all of which shall be visible to the operator with the compartment door closed. It shall be possible to rack the circuit breaker element from the connected to the disconnected position with the compartment door closed, otherwise known as "through the door drawout".
  - b. Provide interlocks to prevent racking the circuit breaker unless the breaker is open.
2. Ratings: Interrupting up to 100 kA at 460V without fuses. Short time current ratings for each circuit breaker shall be as indicated on the drawings or data tables. Circuit breakers shall be 600-volt class.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
  - a. Normal Closing Speed: independent of both control and operator
  - b. Electrical operator, field installable with manual charging
  - c. Operations counter

4. Each low voltage circuit breaker shall be equipped with self-powered, microprocessor-based trip-device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of high accuracy (<1%) Rogowski coil sensors on each phase, a release mechanism and the following features:
  - a. Field Installable and interchangeable front mounted trip units. Trip units can be upgraded for future expansion in functionality, such as communication.
  - b. Functions: Long time, short time and extended instantaneous protection function shall be provided (EIP) to allow the breaker to be applied at the withstand rating of the breaker with minus 0% tolerance so that there is no instantaneous override whatsoever. This feature shall furthermore allow the circuit breaker to be applied up to the full instantaneous rating of the breaker on systems where the available fault current exceeds the breakers withstand rating. Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I2t ramp and optionally I4t to improve co-ordination with fuses or inverse relays.
  - c. A software program shall be made available free of charge to support system co-ordination studies. The software will allow time current curves to be generated for the chosen settings.
  - d. Individual LED's shall indicate an overcurrent, short circuit or ground fault trip condition.
  - e. Time-current characteristics shall be field adjustable locally or optionally remotely via a bus system ModBus.
  - f. Current Adjustability shall be accomplished by use of dial settings ETU 776 and rating plugs on trip units. The rating plug shall be front mounted and upgradeable. Upgrades to the rating plugs shall not require changes to the CT.
  - g. Pickup Points: 10 Long Time Settings.
  - h. Field Installable Ground-fault protection with at least three time-delay bands and an adjustable current pickup and an I2t ramp. ETU 776. Arrange to provide protection for four-wire service.
  - i. Field installable zone selective interlocking: Connections will be made between main, tie and feeder circuit breakers to ensure that the circuit breaker closest to the fault trips for short time and ground fault conditions.
  - j. Field Installable Communications and metering functions shall be provided per schedule.
  - k. A LCD display shall be available to simplify settings & viewing data locally. ETU776.
  - l. The option to remotely switch protection settings shall be provided whenever a generator is part of the power distribution system.
  - m. Field installable configurable digital output relays shall be available to connect directly to the trip unit
  - n. Waveform capture and display shall be accomplished on the trip units LCD display. ETU776 only.
  - o. A visible pin shall indicate wear. In addition to the visible pin indicator, estimated contact wear shall be calculated in the trip unit and be communicated remotely.
5. Include a MOC (Mechanism Operated Cell switch) operated by the circuit breaker operating mechanism.
6. Terminal Block Connections, shall be front mounted and utilize Screw Type Terminals.

7. Padlocking Provisions shall be included to install at least three padlocks on each circuit breaker to prevent movement of the drawout mechanism.
8. Operating Handle shall be an integral part of the breaker. No external tools shall be required to rack the breaker
9. Control Switch: One for each electrically operated circuit breaker.
10. Key Interlocks: Mountings and hardware are included where future installation of key-interlock devices is indicated. A total of 14 different interlocking devices shall be available.
11. Undervoltage Trip – field installable: Adjustable time-delay.
12. Shunt-Trip – field installable.
13. Indicating Lights: To indicate circuit breaker is open or closed, for electrically operated circuit breakers.
14. Modular communication and relaying accessories are to be available for retrofitting by the clients chosen engineer. It shall not be necessary for the manufacturer's personnel to retrofit accessories.
15. Accessories shall be front mounted. Modular communications and relaying accessories are to be available for retrofitting by the clients chosen engineer. It shall not be necessary for the manufacturer's personnel to retrofit accessories.
16. Portable lifting yoke for drawout circuit breakers.
17. Field interchangeable accessories shall include CT's, trip units, racking mechanism and all internal & external accessories.
18. Provide shutters for all drawout circuit breakers.

E. Molded case circuit breakers, thermal-magnetic:

1. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Trip-free, trip-indicating, quick-make, quick-break, with inverse time characteristic. Single-handle and common tripping on multi-pole breakers. External handle shall be suitable for locking in the OFF position.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Provide main breakers in switchboards served from transformers.
5. Shunt-trip breakers shall be supplied with 120V AC coils.

F. Molded case circuit breakers, solid state:

1. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Trip-free, trip-indicating, quick-make, quick-break, with inverse time characteristic. Single-handle and common tripping on multi-pole breakers. External handle shall be suitable for locking in the OFF position.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Provide main breakers in switchboards served from transformers.
5. Shunt-trip breakers shall be supplied with 120V AC coils.
6. Continuous current rating shall be adjustable from 20 to 100% without the need for a rating plug. Solid state breakers shall be Siemens Sensitrip III design or Siemens VL or equivalent.
7. Solid state breaker trip functions shall include adjustments for continuous amperage, long time pickup and delay, instantaneous short time pickup and delay, ground fault pickup and delay where indicated on drawings, zone selective interlocking for short time and ground fault. Breaker ratings shall be as shown on the drawings.

## 2.6 GROUND FAULT PROTECTION

- A. Ground fault protection shall be provided where specified and on service disconnect switches rated 1000 amperes or more as required by the NEC.
- B. The main circuit breakers shall have a shunt trip mechanism for operation in conjunction with ground fault relays.
- C. The unit shall consist of coordinated current sensor, solid state relay and monitor panel all of the same manufacturer. The current sensors shall be arranged as a zero sequence type detector around all conductors and the neutral. Solid state relays shall be adjustable from 100 to 1200 amperes and from instantaneous to one second time delay by means of lockable, direct indicating knobs on the front of the relay. Monitor panel shall be mounted on the front panel with a light to indicate when a ground fault function has occurred. It shall also contain a reset push button, a push to test push button and a control power "on" pilot light.
- D. Ground fault setting shall be set at minimum setting for both current and time during construction. The switchboard manufacturer shall include, in the Shop Drawing data for the switchboard, the minimum setting of the devices and the recommended setting for normal building operation.
- E. The ground fault system provided for circuit protective devices serving emergency systems and/or fire pumps shall only signal the occurrence of a ground fault and shall not trip the emergency circuit protective device.

## 2.7 UTILITY METERING

- A. Provide utility metering cubicles in accordance with the requirements of the serving utility company.

## 2.8 METERING DISPLAY

- A. Provide an electronic digital true RMS-sensing metering display for each main switchboard main and each feeder serving a busway. Display shall be positioned not lower than 48 inches or higher than 72 inches above the finished floor.

## 2.9 SURGE PROTECTIVE DEVICES (SPD)

- A. Provide an integral SPD within each switchboard enclosure.
- B. Refer to specification section 264313 for the requirements related to SPD devices.

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Install switchboards when the area is dry, free and clear of dust and debris. Protect switchboards from dust and moisture. Do not utilize switchboard for temporary lighting and power services.
- B. Install switchboards on 4-inch high concrete housekeeping pads which shall follow the contour of switchboards with 1 inch of overlap on all sides.

- C. Provide channel iron sills below each switchboard where the switchboard frame is not suitable for use as a floor sill.
- D. Provide 2" empty conduit with pullstring from each utility meter location terminated horizontally at the exterior of the building eight to ten feet above grade. Provide a 6"x6"x6" NEMA 3R termination enclosure at the exterior termination with an accessible front cover. The interior termination shall be in a horizontal position on top of the meter panel section and be six to eight inches from the front. Temporarily cap all terminations.
- E. Provide junction box with 2" empty conduit with pullstring from each electrical room housing utility metering to the nearest telecommunications backboard for utility company use. Provide 1" empty conduit with pullstring from each utility meter section to junction box at 2" conduit termination. Temporarily cap all terminations.
- F. Provide 1" empty conduit and pullstring from each switchboard metering device to the location of the BMS head end system.

### 3.2 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.
- B. Perform the following tests and inspections:
  - 1. Perform the following infrared scan tests and inspections, and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
    - b. Instruments and Equipment:
      - (1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- C. Switchboard will be considered defective if it does not pass tests and inspections.
- D. 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.

END OF SECTION

## **SECTION 26 2416 - PANELBOARDS**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide panelboards in accordance with the Contract Documents.
- B. Panelboards include both branch panelboards and distribution panels.

#### **1.2 QUALITY ASSURANCE**

- A. Panelboards shall be of the same manufacturer as the switchboards.
- B. Interrupting capacities shall be based on a fully rated protection system where all overcurrent protection devices are rated for the full prospective short circuit current (as indicated in the final short circuit submittal). Series rated panelboards per manufactures UL testing

#### **1.3 REFERENCE STANDARDS**

- A. Panelboards:
  - 1. NEMA PB-1
  - 2. Federal Specification W-P-115A Type II, Class 1
  - 3. UL 50 and 67
- B. Circuit Breakers:
  - 1. NEMA AB-1
  - 2. Federal Specification W-C-375a and W-C-375b
  - 3. UL 489

#### **1.4 SUBMITTALS**

- A. General:
  - 1. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in it's place.
  - 2. Manufacturer's product data sheets, electrical ratings, and installation instructions.
  - 3. Support locations and types.
- B. Branch Panelboards:

1. Detailed description and layout of each panelboard, showing physical dimensions, circuit breaker ratings and layout, identification nameplate, and cable lugs.

C. Distribution Panels:

1. Dimensioned layout and elevation drawings showing physical dimensions and housekeeping pads.
2. Detailed description and layout of each distribution panel, showing overcurrent protection device ratings and layout, identification nameplate, and cable lugs.

1.5 IDENTIFICATION

- A. Provide a permanent acrylic identification nameplate for each panelboard, each main, and each feeder overcurrent protection device.
- B. Provide a typewritten directory card indicating load served by type and location for each branch circuit in each branch panelboard. Mount directory in frame on inside of branch panelboard door. Directory shall be provided after substantial completion of construction to minimize hand written additions and modifications.
- C. Current ratings of overcurrent protection devices shall be displayed on the device.

1.6 SHORT CIRCUIT AND COORDINATION STUDY

- A. Prepare a short circuit and coordination study based on the actual overcurrent protection devices proposed for use and the actual conductor sizes and lengths. The study shall be prepared by an electrical engineer licensed in DC and shall be submitted as a supplemental permit submission to the Authority Having Jurisdiction.
- B. The study shall be submitted with the distribution equipment submittal and shall indicate where device substitutions are being made in order to achieve adequate interrupting capacity ratings for each piece of equipment.
- C. The study shall include recommended settings of adjustable overcurrent and ground fault settings.
- D. Provide overcurrent protective devices of suitable type and rating to meet or exceed the available short circuit currents indicated in the short circuit study. Circuit breakers serving the emergency power system as well as circuit breakers protecting elevators, including all upstream feeder circuit breakers, shall be of the appropriate frame size to ensure 100 percent selectivity in the instantaneous region of the trip curves at the calculated fault current. Coordination study shall demonstrate selective coordination is achieved and shall include the effects of ground fault protection devices indicated on the Drawings.
- E. Interrupting capacities shall be based on a fully rated protection system where all overcurrent protection devices are rated for the full prospective short circuit current (as indicated in the final short circuit submittal). Series-rated panelboards are not permitted.

## 1.7 ARC FLASH STUDY

- A. Prepare an arc flash study for electrical service and distribution equipment. The study shall be prepared by an electrical engineer licensed in DC. Include in the arc flash study the electrical engineer's name and license number.
- B. The study shall be submitted with the electrical service and distribution equipment submittal and shall indicate the required level of protective wear for each piece of electrical equipment.

## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. The basis of design is Siemens. Square D and General Electric are considered equal provided they meet all the specifications and space allocations indicated on the drawings. Any revision, modification, change alteration required as a result of using a manufacturer other than the basis of design shall be accomplished at the Contractors option, expense, schedule impact or other factor. The use of a manufacturer other than the three specified is prohibited.

### 2.2 RATINGS

- A. Panelboards shall be of the ratings and configurations shown on the Drawings.
- B. Panelboards and overcurrent protection devices shall have a minimum short circuit rating as specified herein or greater where indicated on the Drawings.
- C. Short-circuit ratings specified herein or where indicated on the Drawings shall serve as a guideline and reference point for panelboard ratings. Providing and installing equipment per the short-circuit ratings shown on the drawings or specified herein does not guarantee that the equipment will be properly rated. It shall be the responsibility of the Contractor to ensure that all installed equipment is rated per the recommendations of the required power systems study. The contractor shall replace any installed equipment that does not meet the power study short-circuit rating requirements at no additional cost to the owner.
- D. Branch Panelboards:
  - 1. Branch panelboards are identified with the designation LP/MP (120/208V) or LPH (265/460V) as shown on the Drawings. Branch panelboards for mechanical equipment are identified with the designation MP as indicated on the Drawings.
  - 2. Maximum allowable physical dimensions: 22 inches wide by 6 inches deep.
  - 3. Branch panelboards, distribution panels AIC rating shall be as noted on the respective panel schedule.
- E. Distribution Panels:
  - 1. Distribution panels are identified with the designation DPL (120/208V or 208V) or DPH (265/460V or 460V) as shown on the Drawings.



2. Maximum allowable physical dimensions: 44 inches wide by 12 inches deep per section.

### 2.3 CONSTRUCTION

- A. Enclosures shall be corrosion resistant galvanized (zinc finished) sheet steel. Fronts shall be cold rolled steel, finish coated with ANSI 61 gray enamel over a rust inhibitor. Panel locks shall be keyed alike. Recessed flush-mounted panels shall have overlapping front.
- B. Doors for branch panelboards shall be one-piece bolt-on front with a lockable hinged door over the overcurrent protection devices.
- C. Provide door-in-door construction for all panelboards.
- D. Space for future devices shall include all necessary bus supports, and connections.

### 2.4 BUS SYSTEM

- A. Bus bars shall be sequence phased, rigidly supported by high-impact resistant, insulated supporting bus assemblies to prevent vibration and resulting damage when subjected to stress, vibration, or short circuits. Solderless terminations shall be suitable for either copper wire or cable.
- B. Bus bars shall be of the ampere rating shown on the Drawings. Bus bars shall be copper or aluminum and sized in accordance with UL standards to limit temperature rise on any current-carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
- C. Tenant floor panelboards shall be equipped with copper or aluminum bus bars.
- D. Neutral bus shall be full size copper or aluminum. Neutral bus shall be 200 percent rated when supplied from an oversized neutral conductor. Neutral bus shall be capable of terminating one conductor per pole position minimum.
- E. Provide a copper or aluminum equipment ground bus in each panelboard. In addition to the equipment ground bus, provide a copper or aluminum isolated ground bus when supplied from a feeder that includes an isolated grounding conductor. Each ground bus shall be capable of terminating one conductor per pole position minimum.

### 2.5 OVERCURRENT PROTECTION DEVICES

- A. Overcurrent Protection Device Types:
  1. Branch panelboards (LP, LPH, and MP): Molded case circuit breakers.
  2. Distribution panels (DPH and DPL): Molded case circuit breakers.
- B. Molded Case Circuit Breakers:

1. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Bolt-on type. Plug-in type is not permitted.
3. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time characteristic. Single-handle and common tripping on multi-pole breakers. External handle shall be suitable for locking in the OFF position.
4. Silver alloy contacts with auxiliary arc-quenching devices.
5. Breakers for lighting circuits shall be SWD rated.
6. Breakers for mechanical equipment shall be HACR rated.
7. Breakers serving outlets within dwelling unit bedrooms, family rooms, dining rooms, parlors, libraries, dens, sunrooms, recreation rooms, closets, hallways, and similar rooms shall be AFCI type.
8. Provide main breakers in panelboards served from transformers.
9. Shunt-trip breakers shall be supplied with 120V AC coils.

### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. Mount panelboards 6 feet above finished floor to top unless otherwise noted.
- B. Where panelboards are mounted recessed flush in wall, maintain fire integrity of wall. Provide one empty 3/4-inch EMT conduit stubbed up into nearest accessible ceiling location for every three spare or space positions.
- C. Neatly arrange wiring and tie together in each gutter with Thomas & Betts nylon Ty-Raps or equal at minimum 4-inch intervals.
- D. Provide plugs on open knockouts.
- E. Where multiwire branch circuits are allowed, provide identified handle ties in accordance with Code for each grouping of single pole circuit breakers supplying the multiwire branch circuit.

#### 3.2 TOUCH UP AND CLEANING

- A. Backboxes shall be clean, dry, and free of construction debris and fireproofing overspray prior to installation of panelboard interior.
- B. Vacuum backboxes clean of debris after installation and wiring of branch circuits.
- C. Repair and touch up paint damaged surfaces.

#### 3.3 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.

B. Tests and Inspections:

1. Perform the following infrared scan tests and inspections and prepare reports:
  - a. 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.
  - b. Instruments and Equipment:
    - (1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

C. Panelboards will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

## **SECTION 26 2726 - WIRING DEVICES**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide wiring devices in accordance with the Contract Documents.

#### **1.2 QUALITY ASSURANCE**

- A. Switches, receptacles and wallplates shall be of the same manufacturer.
- B. Occupancy sensors shall be certified for operation with specific ballasts utilized in controlled lighting fixtures.
- C. Occupancy sensors shall have a minimum three-year warranty.
- D. Equipment shall be certified for use in DC and shall meet the DC Energy Code and local energy ordinances.
- E. Coordinate service fittings with electrified furniture system supplier.
- F. Floor boxes shall comply with UL scrub water tests for carpet, wood and tile floors.

#### **1.3 REFERENCE STANDARDS**

- A. Switches: Federal Specification WS-896E.
- B. Receptacles: Federal Specification WC-596D, NEMA WD-1, and UL 498.
- C. Ground Fault Circuit Interrupter Receptacles: UL 943 Class A.
- D. Wall Dimmers: ANSI C62.41, UL 20.

#### **1.4 SUBMITTALS**

- A. Wiring Devices complete with physical dimensions, materials, connector details, voltage and current ratings, installation details, etc.
- B. Samples of each receptacle, switch, wall plate and coverplate intended for use on this Project. All device samples shall be reviewed by and approved by the Architect and Owner prior to ordering.
- C. Occupancy sensor layout drawings, including switchpacks, power packs, emergency transfer relays, and control devices, and including interwiring details, minimum 1/8-inch scale.
- D. Manufacturer's product data sheets.

1.5 FIELD TESTING

- A. Lighting Controls Acceptance Testing: Provide acceptance testing for all occupancy sensors as required for completion by the District of Columbia.

1.6 COLORS

- A. Device and coverplate colors shall be as selected by Architect. Catalog numbers, where included in this Specification, are not to be used to determine colors of devices and coverplates.
- B. Switches and receptacles connected to the emergency power system shall be red.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Catalog numbers shall not be used to determine colors of devices and coverplates. Catalog numbers are used to establish minimum acceptable standard.
- B. Switches and Receptacles: Cooper, Hubbell, Leviton, or Legrand Pass & Seymour.
- C. Wall Dimmers: Lutron, Leviton, or Legrand Pass and Seymour.
- D. Occupancy Sensors: Lutron or Wattstopper .
- E. Floor Boxes and Fittings:
  - 1. Poke through type: Walker/Wiremold as indicated on drawings.
  - 2. Recessed flush floor box type: Walker/Wiremold as indicated on drawings.

2.2 SWITCHES

- A. General:
  - 1. Switches shall be of the type indicated on the Drawings.
  - 2. Switches shall be commercial specification grade, 20A, 120/277V, 1HP rated at 120V, 2HP rated at 240V, back- and side-wired, silent handle operation.
  - 3. Pre-terminated plug style switches and sensors are permitted.
- B. Transfer Fan Switches:
  - 1. Toggle handle type, single pole: Leviton 1221-2, P&S PS20AC1, coverplate engraved FAN.
  - 2. Rocker handle type, single pole: Leviton Decora 5601-2, P&S TM870, coverplate engraved FAN, or equivalent by Cooper, Hubbell, or Pass & Seymour.
- C. Weatherproof Switches:

1. Weatherproof handle/coverplate.
- D. Electronic or Digital Timer Switches:
1. Wattstopper TS-400 or approved equal.
- 2.3 RECEPTACLES
- A. General:
1. Receptacles shall be of the type indicated on the Drawings.
  2. Receptacles shall be commercial specification grade, 125V, grounding type, back- and side-wired.
  3. Receptacles shall have a single piece, heavy duty brass ground contact and mounting strap.
  4. Receptacles shall have a nylon face and heat resistant base.
  5. Pre-terminated plug style receptacles are permitted.
- B. Standard Receptacles:
1. Duplex, 20A: Leviton 5362; Hubbell HBL5362; Cooper 5362; P&S 5362
  2. Designer style duplex, 20A: Leviton Decora 16352; Hubbell HBL2162; Cooper 6362; ; P&S 26352
- C. Isolated Ground Receptacles:
1. Duplex, 20A: Leviton 5362-IG; Hubbell IG5352; Cooper IG5362;P&S IG5362
  2. Designer style duplex, 20A: Leviton Decora 16352-IG Hubbell IG2162; Cooper IG8362RN;P&S IG26362
- D. Isolated Ground Surge Suppressor Receptacles:
1. Duplex, 20A: Leviton 5380-IG; Hubbell IG5362 SA; Cooper 5350S; P&S IG5362SP
- E. Ground Fault Circuit Interrupter Receptacles:
1. Duplex, 20A: Leviton 8898-HG; Hubbell GF20; Cooper VGF20; P&S 2095
- F. USB Charging Receptacles:
1. USB Charging Receptacles:
    - a. Special Use Receptacles: USB Combination Charger:
      - (1) USB Charging minimum 3 Amp,5VDC Dual Ports:
        - (a) Complies with battery charging specification USB BC1.2
        - (b) Compatible with USB 1.1/2.0/3.0 devices, including Apple products

- (c) Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-59615 Amp and 20 Amp 125Volt Tamper Resistant Duplex
  - (d) 2P 3W grounding straight blade
  - (e) Complies with Part 16 of the FCC rules
- 2. Hubbell 20 Amp 125 Volt Series Cat #USB20X2; P&S TR535USB (single); P&S TR5362USB (double)
- G. Special Purpose Receptacles: Nema configuration as indicated on the Drawings.
- H. Clock Receptacles:
  - 1. Simplex, 15A: Leviton 5261-CH; Hubbell 5235; P&S S3733SS
- I. Weatherproof Receptacles:
  - 1. Duplex, weatherproof while-in-use rated coverplate with hinged door.
  - 2. All 15- and 20-ampere, 125- and 250-volt non-locking receptacles located in damp or wet locations shall be a listed weather-resistant type. Listed devices shall bear a "WR" marking on the face that is visible when installed.

#### 2.4 WALL DIMMERS

- A. Wall dimmers shall be suitable for control of the load type (incandescent, low-voltage magnetic, low-voltage electronic, solid state, or fluorescent), load capacity, and branch circuit voltage of the lighting fixtures controlled.
- B. The Contractor is responsible for coordinating loads, load types, and ganging of wall dimmers.
- C. Dimmers shall be ganged with adjacent switches to allow for a multi-gang coverplate where multiple devices are installed in a common wall. Where ganged, Contractor shall ensure the de-rated dimmer (where heat fins are removed) is suitable for the load controlled.
- D. Large paddle switch with a captive linear-slide dimmer for a standard designer coverplate to match the adjacent lighting switches; Lutron Diva series or P&S Trademaster LS Series or approved equal.
- E. Dimmers shall incorporate solid state Triac dimming rated for a minimum of 150 percent of the control's capacity.
- F. Dimmers shall incorporate surge protection to withstand surges of 6000V, 200A meeting ANSI/IEEE std. C62.41-1980.
- G. Dimmers shall include voltage compensation to stabilize light output from variations in the AC line-voltage. Dimmers in which the light output is not held constant with varying AC line-voltage shall not be acceptable.

- H. Dimmers shall utilize a large toroidal choke to minimize radio frequency interference. Dimmers shall not be susceptible to damage due to 16kV static discharges.
- I. Dimmer slide position shall indicate perceived light level, using the square law power curve in the IESNA Lighting Handbook, 9th edition. Dimmers shall provide smooth and continuously variable control of light intensity.
- J. Three-way dimmers shall be capable of operating in either 3-way switch location.
- K. Plastic parts shall not fade or yellow with prolonged exposure to sunlight. Visible parts shall exhibit ultraviolet stability as defined in ASTM D4674-89.

## 2.5 OCCUPANCY SENSORS

- A. Occupancy sensors shall be suitable for control of the load type (incandescent, low voltage, or fluorescent), load capacity, and branch circuit voltage of the lighting fixtures controlled.
- B. Ceiling-mounted devices shall be dual-technology type with self-adjusting time delay and sensitivity. Wall switch devices shall be passive infrared.
- C. Bi-Level PIR Wall Switch:
  - 1. Manual and automatic ON/OFF control switches.
  - 2. Single level control switch or as indicated on the drawings.
  - 3. Bypass override ON switch in the event of product failure.
  - 4. 120/277V operation.
  - 5. Provide sensors appropriate for the room size coverage.
  - 6. Watt Stopper DW-100 or approved equal.
- D. Ceiling Mounted:
  - 1. One way type: Watt Stopper DT-200 or approved equal.
  - 2. 360 degree type: Watt Stopper DT-300 or approved equal.
  - 3. Corridor type: Watt Stopper WT-2250 or approved equal.
- E. Switchpacks:
  - 1. Provide power packs as required for circuiting and control as shown.
  - 2. 120/277V operation.
  - 3. Watt Stopper BZ-150 or approved equal.

## 2.6 FLOOR BOXES AND FITTINGS

- A. General:
  - 1. Provide floor boxes and fittings of the types, ratings, and configurations as shown on the Drawings.
  - 2. Floor boxes and fittings shall be suitable for the fire rating and thickness of the floor.



3. Combination power/telecom outlets shall have barrier to separate power and telecom wiring.

B. Recessed Flush Type Floor Box:

1. Cast iron box, multiple gang, 2-inch shallow depth, brass carpet flange and coverplates in amenity areas. Coordinate conduit requirements with Low Voltage drawings. Provide (1)  $\frac{3}{4}$ " conduit for power.
  - a. Screen room – Legrand Evolution 4-gang floorbox or approved equal.
  - b. Leasing Meeting Rooms – Legrand Evolution 4-gang floorbox or approved equal.
  - c. Gym areas – Legrand Omnibox 2-gang or approved equal.
2. PVC floor box, multiple gang, 2-inch shallow depth, carpet flange and coverplates in non-amenity areas

2.7 COVERPLATES

- A. Provide coverplates for wiring devices. Provide multiple gang coverplates where multiple devices are installed in a common location.
- B. Provide stainless steel, smooth-face coverplates in equipment rooms. Provide nylon thermoplastic, smooth-face coverplates in other areas. Thermoset coverplates are not acceptable.

PART 3 EXECUTION

3.1 GENERAL

A. General:

1. Verify the exact location of wiring devices with Architect.
2. Devices mounted above counters shall be two inches above the top of the backsplash to the bottom of the coverplate.
3. Provide a number 12 grounding conductor from the device grounding terminal to the panelboard ground bus. Bond wiring device to the outlet box.
4. Provide a number 12 grounding conductor from the device grounding terminal to the outlet box.
5. Switches that control devices that are connected to the emergency power system shall be the illuminated handle type.
6. Receptacles mounted in boxes shall be installed so that the mounting yoke or strap of the receptacle is held rigidly against the surface of the wall. Drywall or plaster surfaces shall be repaired so there are no gaps greater than 1/8 inch from the edge of the box or fitting.
7. Receptacle faces shall project a minimum of 0.015 inches from the faceplate. Faceplates shall be installed so as to completely cover the opening and seat against the mounting surface.

B. Switches:

1. Mount switches vertically with the ON position on top.
2. Mount switches on the strike side of doors.
3. Provide toggle handle type lighting switches in equipment rooms. Provide rocker handle type lighting switches in other areas.

C. Receptacles:

1. Mount receptacles vertically with the grounding pin on bottom.
2. Provide conventional style duplex receptacles in equipment rooms. Provide designer style type duplex receptacles to match rocker handle type lighting switches in other areas.

D. Occupancy Sensors:

1. It shall be the Contractor's responsibility to locate and aim sensor(s) in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations, as the range of coverage of occupancy sensors may vary from one manufacturer to another.
2. Rooms shall have 90 to 100 percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The locations and quantities of sensors shown on the Drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The Contractor shall provide additional sensors if required to properly and completely cover the respective room. Where two or more occupancy sensors are indicated within a room or space, they shall be arranged so that the coverage overlaps an adjacent sensor's coverage by not less than 25 percent.
3. It is the Contractor's responsibility to arrange a pre-installation meeting with the manufacturer's factory-authorized representative, at the Owner's facility, to verify placement of sensors and installation criteria.
4. Proper judgment must be exercised in executing the installation so as to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components.
5. Face plate color to be selected by Architect. Submit samples of standard colors to Architect for review.
6. Provide switchpacks as required for multiple sensor locations and multiple control circuits.
7. Provide override switch at wall for ceiling-mounted occupancy sensor locations.

E. Coverplates:

1. Install device plates in full contact with wall surface. Plates shall not project out from the wall.
2. Coverplates for multiple gang wall dimmers shall be continuous flush type tailored to match wall dimmer physical dimensions.

### 3.2 CONTROL DEVICE COMMISSIONING

- A. Upon completion of the installation, all control systems and devices shall be commissioned. Occupancy sensors shall be completely commissioned by the manufacturer's factory-authorized technician who will verify all adjustments and sensor placement to ensure a trouble-free occupancy-based lighting control system.
- B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days' written notice of the scheduled commissioning date.
- C. Upon completion of the controls system fine-tuning, the factory-authorized technician shall provide the training necessary to familiarize the Owner's personnel with the operation, use, adjustment, and problem-solving diagnosis of the occupancy sensing devices and systems.

END OF SECTION

## **SECTION 26 2813 - 600V FUSES**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide 600V fuses in accordance with the Contract Documents.

#### **1.2 QUALITY ASSURANCE**

- A. All fuses shall be of the same manufacturer.

#### **1.3 REFERENCE STANDARDS**

- A. UL 198 and 977.

#### **1.4 SUBMITTALS**

- A. No requirements.

### **PART 2 PRODUCTS**

#### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Bussmann or Littlefuse.

#### **2.2 FUSES**

- A. 601 amperes through 6000 amperes:

1. UL Class L.
2. 200,000 RMS-symmetrical amperes interrupting rating.
3. Bussmann KRP-C or Littlefuse KLP-C.

- B. 600 amperes and below:

1. UL Class RK1.
2. 200,000 RMS-symmetrical amperes interrupting rating.
3. Bussmann LPN-RK (250V) or LPS-RK (600V); or Littlefuse LLN-RK (250V) or LLS-RK (600V).

#### **2.3 SPARE FUSES**

- A. Provide 10 percent (minimum of 3) spare power and control fuses of each type and rating utilized.
- B. Provide spare fuse cabinets in rooms with equipment utilizing 15 or more fuses.

PART 3 EXECUTION

3.1 GENERAL

- A. Fuses shall not be installed until equipment is ready to be energized.

END OF SECTION

## **SECTION 26 28 16 - DISCONNECT SWITCHES AND MOTOR CONTROLLERS**

### **PART 1 – GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide disconnect switches and individual motor controllers in accordance with the Contract Documents.

#### **1.2 QUALITY ASSURANCE**

- A. Disconnects and individual motor controllers shall be of the same manufacturer as the switchboards.

#### **1.3 REFERENCE STANDARDS**

- A. Disconnect Switches:
  - 1. Federal Specification W-S-865C
  - 2. NEMA KS1
  - 3. UL 98 (File #4776) and 508
- B. Individual Motor Controllers:
  - 1. NEMA ICS 2-321
  - 2. UL 547, 845 and 1004

#### **1.4 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place.
- B. No other requirements.

#### **1.5 FIELD TESTING**

- A. Test each individual motor controller and verify proper operation.
- B. Test motors under load and verify proper rotation.

#### **1.6 IDENTIFICATION**

- A. Provide an identification nameplate for each disconnect switch and individual motor controller.
- B. Identify electrical equipment with permanently attached black phenolic nameplates with 1/2-inch high white engraved lettering. Identification shall include equipment name or load served as appropriate. Nameplates for equipment connected to the emergency power system shall be red with white lettering. Nameplates shall be attached with cadmium-plated screws; peel-and-stick tape or glue-on type nameplates are not allowed.

## PART 2 – PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Siemens, General Electric, Square D, or Cutler Hammer.

### 2.2 DISCONNECT SWITCHES

- A. Heavy duty, horsepower rated, quick-make, quick-break, dead-front type. Self-contained unit in a NEMA 1 gasketed enclosure (NEMA 3R where installed outdoors), externally operable from the front.
- B. Defeatable interlock to prevent opening the door when the switch is in the ON position. Handle shall be capable of being padlocked in the OFF position.
- C. Fusible switches shall be equipped with rejecting type clips suitable for UL Class R fuses up to 600A, suitable for UL Class L fuses above 600A. Interrupting rating shall be 200,000 RMS-symmetrical amperes.
- D. Voltage, ampacity, horsepower rating, and number of poles shall be appropriate for system and load served. Provide neutral pad for circuits with neutral conductors. Provide ground lug.
- E. Provide 6-pole switches for connection to motors requiring 6-motor leads.

### 2.3 THERMAL OVERLOAD/DISCONNECT SWITCH

- A. Single-phase manual motor starter with quick-make, quick-break toggle mechanism and field-adjustable overload heater element.
- B. Manual motor starters shall be sized for the motors served.

### 2.4 INDIVIDUAL MOTOR CONTROLLER

- A. Self-contained unit in a NEMA 1 gasketed enclosure (NEMA 3R where installed outdoors), externally operable from the front.
- B. Provide full voltage non-reversing (FVNR) type combination magnetic starters for motors of 1/2 HP to 60 HP.
- C. Provide reduced voltage, non-reversing, auto-transformer type combination magnetic starters for motors 75 HP and larger.
  - 1. Two-winding, open delta connected type.
  - 2. Adjustable timing relay for start-to-run transfer timing.
  - 3. Closed transition from reduced to full voltage.
  - 4. Field-adjustable auto-transformer taps: 50 percent, 65 percent and 80 percent. Factory-set at 80 percent.
- D. Fusible switch type disconnect with clips for UL Class R type fuses.
- E. Provide an individual control power transformer with two primary and one secondary control fuses for each motor controller. The other secondary lead shall be grounded. Secondary voltage shall be 120V AC.

- F. Provide each motor controller with three phase, ambient temperature compensating, thermal overload relays with heaters. Overload relays shall be adjustable from 90 percent to 110 percent of heater rating, factory-set at 100 percent. Provide an insulated pushbutton on the outside of door to reset overload relays.
- G. Provide each motor controller with a Hand-Off-Automatic (HOA) selector switch. Provide a Hand-Automatic (HA) selector for life safety equipment. Mount switch on outside of door.
- H. Provide each motor controller with two normally open and two normally closed auxiliary contacts, green OFF and red RUNNING long life (50,000 hours) pilot indicators on outside of door, auxiliary relays, and other devices required for operation of the equipment to be controlled.

### PART 3 – EXECUTION

#### 3.1 GENERAL

- A. Disconnect switches and individual motor controller shall be installed within ten feet of load served and installed within sight of the motor.
- B. Provide independent support; do not mount on the housing of the equipment served.
- C. Conduit connected between disconnect switch or individual motor controller and load served shall be liquid-tight flexible metal conduit, 24 inches minimum length, 36 inches maximum length.
- D. Each disconnect switch serving smoke control system air handling equipment shall be provided with an integral, internal auxiliary switch which shall be connected to the Fire Management System for status indication of the OPEN/CLOSED status of the disconnect switch.

END OF SECTION 26 28 16



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## SECTION 26 31 00 - PHOTOVOLTAIC SYSTEMS

### PART 1 – GENERAL

#### 1.01 DESCRIPTION

- A. Provide a complete and functional 200 KW photovoltaic (PV) system. The system shall include photovoltaic modules, inverter(s), disconnects, combiner box, wire, conduit, utility interconnection, metering, and all associated design, coordination, analysis, and submittals as indicated herein and as otherwise required
- B. The system shall consist of an array of photovoltaic modules with aluminum frames designed for grouping on racks, terminal and combiner box(es), quick-connect electrical connectors, DC wiring, DC disconnect, grid-connected inverter(s), AC disconnect, and optionally a data acquisition and monitoring system (DAS) and isolation transformer, as specified in final project specifications. The inverter shall be wired to the building's electrical system and interconnected with the utility grid.
- C. The actual orientation and tilt of the array shall be optimized based upon computer studies for the specific project location and its associated weather data and sun patterns. Provide design analysis and installation recommendations considering first cost, optimum annual energy output and energy savings.
- D. The location of the PV array will be a designated by the Project Architect. Provide shading analysis of this location based on a roof or site survey, or the most current construction documents.

#### 1.02 WORK INCLUDED

- A. Provide engineering, labor, materials, and accessories required to furnish, install, start up, and commission a complete operating solar photovoltaic system. Labor, materials, or accessories not specifically called for in the Contract Documents, but required to provide a complete operating system, shall be provided without additional cost to the Owner.
- B. Determine, coordinate, and incorporate the design and construction requirements of the Architect, Structural Engineer, Mechanical Engineer, Electrical Engineer, General Contractor, other Subcontractors, and local power service provider.

#### 1.03 RELATED DOCUMENTS

- A. Division 26 – Electrical Specifications

#### 1.04 REFERENCE STANDARDS

- A. Standards: The photovoltaic installation shall be designed and manufactured in compliance with the following standards and codes:
  - 1. NEC
  - 2. UL 1741
  - 3. UL 1703
  - 4. IEEE 929
  - 5. IEEE 1547

6. Local Codes

1.05 QUALITY ASSURANCE

- A. Comply with the current applicable codes, ordinances, and regulations of the Authority or Authorities Having Jurisdiction; the rules, regulations and requirements of the utility companies serving the project; and the Owner's insurance underwriter.
- B. Equipment supplier shall have local representation and shall have been actively engaged in installation and service of solar photovoltaic systems and inverters for a period of not less than ten years.
- C. All equipment and installations shall meet or exceed minimum requirements of ADA, ANSI, ASTM, IEEE, IES, NEC, NEMA, NETA, NFPA, OSHA, SMACNA, UL and the Maryland Fire Marshal.
- D. Equipment shall be certified for use in Maryland and shall meet or exceed the requirements of the Maryland energy code.
- E. Maintain uniformity of manufacturer for equipment used in similar applications and sizes.

1.06 SUBMITTALS

- A. Proposal Submittal:
  - 1. Pricing breakdown in accordance with the Invitation to Bid.
  - 2. Written technical description of the proposed systems broken down into the following categories:
    - a. PV modules
    - b. Mounting system
    - c. DC combiner boxes
    - d. Grounding system
    - e. DC/AC inverter
    - f. Isolation transformer(s)
    - g. Utility Interconnection
    - h. AC disconnecting means
    - i. Visible blade disconnecting means
  - 3. Voluntary alternates to the base proposal may be presented, at the Subcontractor's option. All such alternates shall include a description of the item, benefits obtained by the Owner, and associated add or deduct cost. Creativity and ingenuity are encouraged in this regard; however, the impact imposed on the building's architecture and structure systems should be considered.
- B. Design:
  - 1. Submit a PV system design which meets the 200 KW output. Provide complete system pricing, required area, kW capacity, and estimated annual energy output for this system.
- C. Perform a shading analysis of the proposed PV array location using building construction documents or a site survey to identify any rooftop equipment or structures that could shade the array in the proposed location. Provide a report showing shade study findings. If findings show

annual production loss greater than 5% of production specified, provide recommendations for an alternate location.

1. Prepare and submit complete engineering plans, specifications, and calculations for the solar photovoltaic system. Engineering work shall be in accordance with all laws and regulations applying thereto.
2. Respond in writing to review of engineering documents made by Architect.
3. Construction Drawings:
  - a. Provide detailed drawings of the solar photovoltaic system and accessories with dimensioned locations of components and external connections and attachments.
  - b. Detailed source circuit and DC home run wiring diagrams showing PV modules and DC balance of systems.
  - c. PV module mounting method plans and details, including ballast specification and/or mechanical attachments. Provide structural design drawings signed and sealed by a Maryland Professional Engineer, verifying design meets uplift and lateral force requirements.
  - d. Grounding plan of solar modules, racking, and balance of systems.
  - e. Floor plans and elevations showing AC equipment layout, dimensions and interconnecting conduit and wire.
  - f. Site plan showing location of PV array, AC system components, point of utility interconnection to main switchboard.
  - g. Single line diagram, including all AC PV system components, utility net meter, protective relaying, and utility visible blade AC disconnect with manufacturer and model number.
  - h. Submit one 100-percent Construction Documents set.
4. Construction Specifications:
  - a. CSI 2010 format
  - b. General Electrical Provisions
  - c. Electrical Materials and Methods
5. Design Calculations:
  - a. Electrical sizing calculations
  - b. Structural framing and drawings by base building engineer.
- D. Manufacturer's product data sheets for all equipment. All irrelevant information shall be marked out leaving only pertinent data.
- E. Operating and maintenance manuals for all system components.
- F. Utility company and/or state PV incentive (rebate or PBI) calculations and application forms for eligible items for Owner's application for incentive.

#### 1.07 IDENTIFICATION

- A. Provide an identification nameplate for each photovoltaic inverter and each feeder overcurrent protection device.

- B. Provide additional markings and identification of equipment as required by NEC 690 and 705.10 through 705.12.

#### 1.08 COORDINATION

- A. Coordinate layout and installation of PV array and balance of systems with other roof-mounted equipment and structures.
- B. Coordinate and communicate the final approved PV module mounting conditions, orientation, and tilt angle with the project structural engineer. Coordinate final support detailing and system live and dead load requirements with structural engineer.
- C. Coordinate installation of equipment supports, and roof/wall penetrations. Any building envelope penetration shall be designed to prevent moisture ingress into the envelope from the exterior and vapor diffusion into the envelope from the exterior. These items are specified in other Divisions of the specifications.
- D. Coordinate size and location of housekeeping bases and support points.

#### 1.09 ENVIRONMENTAL REQUIREMENTS

- A. Operating Temperature: minus 20 degrees C to plus 45 degrees C.
- B. All outdoor equipment shall be NEMA 3R enclosed.

#### 1.10 WARRANTY

- A. The system installation shall be warranted as specified in the purchase agreement, but shall be no less than one year from the time of acceptance. The solar photovoltaic system manufacturer shall replace or repair any defective parts within the first year of operation at no extra cost to the Owner.
- B. System acceptance shall be granted after 30 days of AC power output within 10% of predicted power at operating test conditions.
- C. The photovoltaic module power output shall be covered by the photovoltaic manufacturer's warranty for a minimum of 20 years, and the module workmanship shall be covered for a minimum of 10 years. These warranties shall be passed through the supplier to the customer.
- D. The inverter shall be covered by the manufacturer's warranty for a period of not less than five years, and shall be passed through the supplier to the customer.

### PART 2 – PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Photovoltaic Panels: Hanwha Q-Cells, Canadian Solar, Sharp, Schuco, Suniva, Sunpower, or approved equal.
- B. Inverter: Solar Edge, Advanced Energy, Fronius, Power One, SMA America, or approved equal.

## 2.02 RATINGS

- A. DC input voltage shall be 600V or 1,000V.
- B. AC output voltage shall be directly compatible with building or site distribution voltage without the use of an external voltage transformer.
- C. Inverter AC nameplate rating: 100 kW.
- D. Total Harmonic Distortion less than two percent at rated power.
- E. Inverter Peak Energy Efficiency greater than 95 percent.
- F. Power Factor greater than 0.99 percent

## 2.03 CONSTRUCTION

- A. The inverters shall be complete with the following features:
  - 1. Convection forced air cooling
  - 2. Islanding protection to meet IEEE 929 and UL 1741.
  - 3. Protective functions and annunciation:
    - a. AC over/under voltage
    - b. AC over/under frequency
    - c. Ground over current
    - d. Over temperature
    - e. AC and DC over current
    - f. DC over voltage
  - 4. User display
  - 5. AC and DC disconnects
  - 6. Remote display monitor
  - 7. PV ground fault protection system
  - 8. DC subcombiner
  - 9. Maximum Power Point Tracking
  - 10. Lightning arrester AC/DC protection
  - 11. Communications software capable of remotely reporting kWh production
- B. Roof-mounted systems shall employ crystalline silicon photovoltaic modules enclosed in a corrosion-resistant heavy-duty frame with tempered low-iron anti-reflective coated glass and clear encapsulated insulation.
- B.1 Façade mounted and BIPV systems shall use off-the-shelf or custom PV modules employing either crystalline or amorphous silicon technology. Products must meet Contract Document requirements for architectural interface and energy production.  
The Contractor shall refer to architectural drawings for elevation details.

## 2.04 SAFETY FEATURES

- A. The utility interactive inverter shall incorporate a maintained position on/off switch located on the enclosure. Under normal conditions, the on/off switch is in the ON position. Turning the

switch to the OFF position will initiate a controlled shut-down and open the A/C contactor within the unit. The A/C contactor shall not close unless the switch is in the ON position. The inverter shall be prevented from being restarted until the on/off switch is turned back to the ON position.

- B. The system shall be equipped with ground fault detection circuitry. Upon detection of a ground fault, the system shall execute an orderly shut-down, and annunciate a ground fault at the operator interface. The system shall remain faulted until the ground fault is remedied and cleared at the operator interface. This must be the only point of PV conductor ground.
- C. Anti-Island Protection: A digital phase-shift-loop (PSL) circuit shall be implemented in the inverter controller to prevent "Islanding" of the system. In the event of a utility outage, these adjustments destabilize the feedback between the inverter and the remaining load, resulting in an over/under frequency or voltage condition. The system shall perform an orderly shut-down. The fault condition will remain until the utility voltage and frequency have returned to normal for five minutes.

## 2.05 VENDORS

- A. Paradise Energy Solutions, Ipsun Solar, Solar Energy Services or certified approved equal.

## PART 3 – EXECUTION

### 3.01 FEES, PERMITS AND INSPECTIONS

- A. Pay all required fees and obtain required permits and associated inspections related to the complete photovoltaic installation.
- B. Pay royalties or fees in connection with the use of patented devices and systems.
- C. Provide controlled or witnessed inspection where required by Authorities Having Jurisdiction, Supply Authority or by these specifications.

### 3.02 INSTALLATION AND INTERCONNECTION

- A. Inspect all equipment for damage upon arrival. Report any damage equipment and obtain replacement(s) from manufacturer.
- B. Measure and record open circuit voltage ( $V_{oc}$ ) and short circuit current ( $I_{sc}$ ) of each module and compare the results to the manufacturer's specifications to ensure modules are within manufacturer's specified tolerances. If any modules are found to perform outside tolerance, deem module defective and do not install it. Record ambient air temperature and solar irradiance during field testing. Complete testing under constant solar irradiance and temperature conditions.
- C. Connect and mount the complete photovoltaic installation per manufacturer's instructions and Contract Drawings.
- D. Coordinate with the Electrical Contractor for building PV wiring and point of interconnection to the building distribution system and utility grid.

- E. Ship, store, and install products and materials in a manner that will protect them from physical damage, water damage, weather and entry of debris. If items are damaged in the opinion of the Architect, take immediate steps to obtain replacement or repair.
- F. Prepare and submit utility interconnection application and all supporting documents. Provide all required utility interconnection protection devices as required by the utility company.

### 3.03 TESTING

- A. Submit PV module factory flash test data to Owner for approval.
- B. Inverter shall be factory-tested for performance, and results shall be included in the O & M manual.
- C. System start-up procedure shall be performed as outlined by the inverter manufacturer's installation manual.
- D. System testing of installed photovoltaic array shall be performed on all PV system strings and recorded in the O & M manual. Measure and record  $V_{oc}$  and  $I_{sc}$  for each string under sunny weather conditions. Record ambient temperature and solar irradiance.
- E. Correct all installation defects identified by field testing.

### 3.04 TRAINING

- A. The Contractor shall furnish the services of competent instructors to give instruction in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. The training shall be oriented toward the system installed rather than being a general training course. Each instructor shall be thoroughly familiar with all aspects of the subject matter they are to teach. The Contractor shall provide all equipment and material required for classroom training.
- B. The training program shall be accomplished in two phases for the time interval specified for each phase.
- C. The first phase shall be given prior to the acceptance test period at a time mutually agreeable between the Contractor and the Owner, and shall be at least one (1) day (8 hours/day) in length. Operating personnel shall be trained in the functional system operation.
- D. The second phase shall be conducted after system acceptance testing for a period of one (1) day. The training shall occur up to one year after the first phase of training as determined by the Owner.

### 3.05 MEASUREMENT AND VERIFICATION

- A. GENERAL
  - 1. Provide metering of instantaneous and continuous kW and kWh output with continuous integration for outputting to the Building Management System (BMS).
  - 2. Communications protocol to the BMS shall be compatible with the building BMS system.



END OF SECTION

## **SECTION 26 32 13 - ENGINE GENERATOR SYSTEM**

### **PART 1 - GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide an engine generator system in accordance with the Contract Documents.
- B. It shall be the responsibility of the Contractor to complete the Local Air Quality Management District permits for Prince George's County. The Genset supplier shall provide the required engine manufacturer's data sheet and assist with other technical data requirements required to complete the permit submission application.
- C. Related work specified in other divisions of these specifications:
  - 1. Natural gas piping and regulator.
  - 2. Exhaust system piping.
  - 3. Insulation of exhaust piping.
  - 4. Installation of exhaust silencer.

#### **1.2 QUALITY ASSURANCE**

- A. The engine shall be natural gas fueled configured for four (4) cycle, water-cooled, while operating with nominal speed not exceeding 1800 RPM. The engine will utilize in-cylinder combustion technology, as required, to meet applicable EPA stationary regulations and/or the EPA NSPS rule for stationary reciprocating spark ignition engines. The GenSet will be NSPS EPA certified for the stationary emergency application.
- B. Equipment supplier shall have local representation and shall have been actively engaged in installation and service of generator sets and automatic transfer switches for a period of not less than 10 years.
- C. Equipment suppliers shall have full parts backup and 24 hour per day service availability for this equipment.
- D. The generator set supplier shall review the fuel system design and certify that the design and the installation meets the engine manufacturer's requirements and will allow for proper operation of the generator set at full rated load.
- E. The equipment shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
- F. The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.

### 1.3 REFERENCE STANDARDS

A. Alternator:

1. ASTM D396
2. NEMA MG-1-198, Part 32

B. Battery Charger:

1. UL 1236

C. Transfer Switches:

1. UL 508 and UL1008
2. NFPA 101
3. EN55011, Class B Radiated Emissions
4. EN55011, Class B Conducted Emissions
5. IEC 1000-4-5 (EN 61000-4-5); AC Surge Immunity or ANSI/IEE 62.41-1991
6. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
7. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
8. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
9. IEC 1000-4-6 Conducted Field Immunity
10. IEC 1000-4-11 Voltage Dip Immunity

D. Engine Generator:

1. Local Air Quality Management District
2. UL2200

E. General System Design Installation and Testing:

1. Designed to allow for installed compliance to NFPA 70, NFPA99 and NFPA 110, Level 1, Type 60
2. NFPA 37
3. CSA C22.2 No14
4. CSA 282
5. CSA 100
6. EN61000-6
7. EN55011
8. FCC Part 15 Subpart B
9. ISO8528
10. IEC61000
11. UL508
12. UL2200
13. UL142

F. Testing:

1. NETA

#### **1.4 LOCATION CRITERIA**

- A. Altitude: 500 feet above sea level.
- B. Maximum ambient temperature: 45 degrees C [110 degrees F]
- C. Minimum ambient temperature: minus 12 degrees C [10 degrees F]

#### **1.5 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place.
- B. Detailed drawing of the engine generator set and enclosure with dimensioned locations of components and external connections and attachments. Indicate position of radiator and direction of air movement.
- C. Engine manufacturer's specifications, performance data, certified power outlet curves, and certified fuel consumption curves.
- D. Provide a statement or show calculations that confirm that the brake horsepower of the engine with all attached accessories as described within is not less than that which is required by the full load rating of the generator, taking into consideration efficiency losses, plus a reserve factor of at least five percent (5%) under environmental conditions as set herein.
- E. Exhaust system back pressure calculations certifying that the engine exhaust system with proposed silencer (and/or particulate filter) for this installation is within the manufacturer's criteria.
- F. Starting battery sizing calculations showing compliance with specifications at ambient conditions.
- G. Drawing showing battery cells and connections.
- H. Certified vibration isolation details and product data showing the number and location of each support and the exact number, size, and type of each anchor. Submit for engine generator set, exhaust silencer, and battery rack.
- I. Manufacturer's product data sheets, specifications, and wiring diagrams for each engine generator system component.
- J. Detailed point-to-point wiring diagrams.
- K. Manufacturer's statement that the overall system design and specification has been reviewed and is satisfactory for system performance or list of exceptions.
- L. After the engine generator system is accepted, submit a completed permit application for the local Air Quality Management District for Prince George's County, ready for submission by the Owner.

- M. Manufacturer's product data sheets, performance data, detailed layout drawings, and control and wiring diagrams for the automatic transfer switches.
- N. Name and location of factory authorized service agency to approve and start up installation.
- O. Name and location of factory authorized service agency to perform warranty and service work.
- P. Name and location of certified testing agency to perform field testing.
- Q. Certified prototype, factory, and field test reports.

## **1.6 SYSTEM TESTING**

### **A. Factory Tests:**

1. Factory tests shall be conducted by the manufacturer.
2. Maximum power (kW)
3. Alternator temperature riser by embedded thermocouple and/or by resistance method per NEMA MG1-32.6.
4. Governor speed regulation under steady-state and transient conditions.
5. Voltage regulation and generator transient response.
6. Harmonic analysis, voltage waveform deviation, and telephone influence factor.
7. Three-phase short circuit tests.
8. Alternator cooling air flow.
9. Torsional analysis to verify that the generator set is free of harmful torsional stresses.
10. Endurance testing.
11. 4 hour 100% resistive and reactive load test at full rated load and power factor.
  - a. Monitor voltage stability
  - b. Monitor frequency stability
12. Oscillograph chart recordings of voltage and frequency of generator set transient performance for 100% step load addition and subtraction indicating compliance with specifications.
13. Equipment shall be Prototype Test Supported certified.

### **B. Final Production Tests:**

1. Single-step load pickup.
2. Safety shutdown device testing.
3. Rated Power @ .8 PF.
4. Maximum power
5. Upon request, a witness test, or certified test record sent prior to shipment

### **C. Field Tests:**

1. Field tests shall be conducted by factory certified technicians.
2. Field inspection and testing shall occur after installation is complete and the room is secure.

3. Test transfer switches, engine start circuits, time delay circuits, status points, and system control points.
4. Perform 4 hour 100% full resistive load test using a temporary load bank. Unsuccessful tests shall be fully documented, submitted, and re-tested until successful.
5. Conduct field tests in accordance with NFPA110.

## **1.7 OPERATING INSTRUCTIONS**

- A. The engine generator-set supplier shall provide a minimum of four hours of operating instructions on maintenance and operation of the emergency power system. Classes shall be open for up to three representatives of the Owner's maintenance staff. Instructions shall be administered by a full-time employee of the supplier.

## **1.8 WARRANTY**

- A. The generator set shall include a two year warranty to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from date of startup. Optional or extended warranties shall be available upon request.
- B. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and function tests performed on all systems. Spare parts as a minimum to include fuel filters, oil filters, air filters, igniters, gaskets, strip heaters, thermostats, hoses, battery connectors, belts and other components as recommended by the manufacturer.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE COMPONENT MANUFACTURERS**

- A. This entire engine generating system, shall be completely built, factory tested and shipped by an assembler/manufacturer who has been regularly engaged in the production of such equipment for the past ten years and who has parts and service facilities locally or provides service and parts on a national basis subject to approval by the Owner and Engineer. The performance of the electric plant shall be certified by an independent test laboratory acceptable to the Engineer as to the plant's full power rating, voltage and frequency regulation. The engine/alternator shop assembled unit shall be assembled, calibrated and tested by the listed manufacturer or an Engineer approved equal factory authorized assembler of the engine and alternator manufacturers listed hereinafter.
- B. The basis of design is a 300kW Kohler 300REZK model with weatherproof enclosure. The electrical output from a GenSet after considering the integral remote radiator fan load will be minimum 300 eKW 375 kVA. In addition, other acceptable manufacturers are Cummins, Caterpillar, and Generac. Any revisions, modification, change alteration required as a result of using a manufacturer other than the basis of design shall be accomplished at the Contractor's option, expense, schedule impact or any other

factor. If any acceptable manufacture, as listed above, is used, provide written substitution request a minimum of fifteen business days prior to bid. In the substitution request, provide an impact statement and information regarding schedule, cost, construction, coordination with other trades and any other factors useful in deciding for acceptance or rejection. If the basis of design or the acceptable manufactures are not selected, as listed above, is used, provide written substitution request a minimum of thirty business days prior to bid. In the substitution request, provide an impact statement and information regarding schedule, cost, construction, coordination with other trades and any other factors useful in deciding for acceptance or rejection. Submission of the substitution request does not guarantee acceptance. Reimburse engineer for costs associated with the review of the proposed substitution whether substitution is accepted or rejected. Refer to section 26 05 01 for further stipulations.

- C. In the event the basis of design unit is not selected, provide a calculation on the selected generator manufacturer's program with the input loads and starting sequences as identified on the drawings. Generator loading and calculations shall show that the selected unit has the starting and running capacity for the project loads to be considered as an acceptable unit.
- D. The minimum rating of the generator set shall be 300 kW.
- E. If it complies with these Specifications, specific engine generator equipment components manufactured by one of the following manufacturers will be acceptable:
  - 1. Diesel Engine: Kohler, Caterpillar, Cummins, Generac.
  - 2. Radiator: Kohler, IEA, Modine, Young, or equal.
  - 3. Exhaust Silencer: Cowl, Maxim, GT Exhaust or Nelson.
  - 4. Diesel Particulate Filter: Clean Air Systems, Cleaire or Harco.
  - 5. Vibration Isolators: CalDyn, Mason Industries or Vibration Eliminator.
  - 6. Batteries: C & D, Exide, Interstate, or Nife.
  - 7. Battery Charger: LaMarche, Sens, or equal.
  - 8. Generator: Kohler, Caterpillar, Kato, Marathon, or Onan.
  - 9. Governor: Kohler, Caterpillar, Woodward or equal.
  - 10. Circuit Breakers: Cutler Hammer, General Electric, Siemens or Square D.

## **2.2 ENGINE**

- A. The engine shall provide 300kW/375kVA when operating at 277/480 volts, 60 Hz, .8 power factor. The generator set shall be capable of a Standby 130°C rating while operating in an ambient condition of less than or equal to 77°F and a maximum elevation of 500 feet above sea level.F
- B. The engine shall be configured for natural gas fuel.

- C. The engine shall be turbo charged, compression ignition type, four stroke-cycle, water cooled, solid injection, either vertical in-line or vee configuration, and operate at 1800 rpm.
- D. The net brake horsepower of the engine at rated operation speed shall be not less than that which is required by the full load rating of the generator, taking into consideration efficiency losses, plus a reserve factor of at least (8) percent under environmental conditions as set herein. 1.45 times the rated standby electric kilowatt rating of the engine generator.
- E. Fuel consumption of the engine generator shall be substantiated by means of manufacturer's certified curves.
- F. The engine shall be equipped with an electronic governor to maintain engine speed within specified limits. Governor shall be adjustable from isochronous to five percent drop. Frequency shall be factory set at rated frequency.
- G. Engine safety devices, including high water temperature switch, overspeed sensing switch, low oil pressure switch, low water temperature switch, and other required devices to comply with NFPA110 shall be mounted on the engine and connected to the control and status panel instruments and alarms as specified herein.
- H. Engine wiring shall be industrial quality, heat resistant, insulated, copper conductors. Wiring shall be protected and shall be isolated from high temperature engine parts. Wiring for alternating current power circuits shall installed in conduit.

### **2.3 ELECTRIC STARTING SYSTEM**

- A. Provide an engine mounted electric starting motor with solenoid and over-running clutch drive. The starting motor shall be of the required voltage and ampere rating.
- B. Provide a system of lead acid batteries sized such that the engine generator set may complete three, complete cranking cycles as specified in NFPA110 at specified room temperature.
- C. Provide an enclosure wall mounted 120V AC battery charger which shall recharge battery to full capacity within twelve hours. Battery charger shall have both a high rate and float rate charging system. The battery charger shall be current limiting and shall not require cranking cutout contacts for charger protection when cranking. Accessories shall include: DC ammeter, fused input, DC voltmeter, high/low DC output voltage relay, and input voltage failure relay. Battery charger output shall be rated ten amperes minimum at required voltage. Charger current level shall automatically drop to a sufficiently low level to eliminate overcharging of the batteries.
- D. The entire electric starting system shall be rated for 24 VDC operation as recommended by the manufacturer.

### **2.4 ENGINE HEATING SYSTEM**

- A. Provide jacket water heaters sized to ensure that engine will start within the specified time period and ambient conditions. Provide thermostats, engine running heater disconnect, and required connection boxes. Provide crank case oil heaters, battery tray heaters, alternator strip heaters and battery chargers



to maintain engine starting temperatures.

- B. Provide branch circuit wiring in conduit from panelboard to jacket water heaters, crank case oil heaters, strip heaters and battery chargers, battery tray heaters. Circuit breakers shall have the appropriate ampere and pole configuration to suit the selected jacket water heaters.

## **2.5 ENGINE COOLING SYSTEM**

- A. The engine shall be grade mounted in a weatherproof / sound attenuated enclosure and liquid cooled by means of an enclosure mounted vertical core radiator. The radiator discharge air flow will be directed horizontally. The radiator shall be adequately sized to cool the engine on a continuous basis at the maximum ambient temperature and altitude specified. The radiator and fan shall be designed to properly cool the generator set with external static restraint of up to 0.5 inches H<sub>2</sub>O. Provide suitable expansion space by means of either a surge tank or radiator top tank. Engine coolant shall be a mixture of ethylene glycol based antifreeze and water as required to provide freeze protection at minimum ambient temperature. Provide duct adapter flange for flex connection to the exhaust outlet provided by others.
- B. The engine shall be equipped with a centrifugal type water circulating pump and thermostat valve to maintain the engine at recommended temperature level.

## **2.6 AIR INTAKE AND EXHAUST SYSTEM**

- A. Provide an air cleaner as recommended by the engine manufacturer. Air cleaners shall be dry type with replaceable elements.
- B. Engine exhaust outlets shall be coupled to the exhaust silencers by means of an adequately sized section of stainless corrugated flex. Flex connectors shall be flanged at both ends for mating to the engine and exhaust system.
- C. Exhaust silencers shall be critical grade. Exhaust silencers shall be sized to limit exhaust back pressure to acceptable values. Exhaust silencers shall be suitable for horizontal mounting, equipped with flanged bottom inlet and flanged end outlet. The exhaust silencers shall be double wall construction and shall have a high temperature anti-corrosion coating applied uniformly on the outside surface. Exhaust silencers shall be mounted within the enclosure and shall be insulated to limit surface temperature to not more than 38 degrees C (100 degrees F).
- A. Provide a shelving/enclosure system to securely store and house batteries.

## **2.7 FUEL SYSTEM**

- A. The engine shall run on natural gas.
- B. Provide fuel filters with replaceable elements. Fuel filters shall be located in an accessible housing
- C. Vent pipes shall be located such that any field extension of the pipe does not interfere with access to serviceable parts to the generator.
- D. Natural Gas fuel supply pressure, measured at the generator set fuel inlet downstream of any fuel system equipment accessories shall be within the operating range of 8 - 15 kPa (32 - 60 in. H<sup>2</sup>O) at full load rating of a generator.
- E. The natural gas fuel consumption by a generator at full load is determined by the generator manufacturer.

## **2.8 ALTERNATOR**

- A. Engine generator set shall be rated 277/480V, wye connected, three phase, four wire, 60 Hertz, 0.8 power factor, kilowatt capacity as indicated on the Drawings. The alternator shall be 2/3 pitch.
- B. The alternator shall be four pole, synchronous brushless type. The alternator shall be single bearing type coupled directly to the engine flywheel by means of a flexible disc coupling.
- C. The voltage regulator shall be digital, microprocessor based with fully programmable operating and protection characteristics. The regulator shall maintain generator output voltage within +/- 0.25% for any constant load between no load and full load. The regulator shall be capable of sensing true RMS in three phases of alternator output voltage, or operating in single phase sensing mode. The voltage regulator shall include a VAR/Pf control feature as standard. The regulator shall provide an adjustable dual slope regulation characteristic in order to optimize voltage and frequency response for site conditions. The voltage regulator shall include standard the capability to provide generator paralleling with reactive droop compensation and reactive differential compensation.
- D. The alternator insulation system shall be NEMA Class H and shall be a combination of epoxy coating and varnish. The alternator shall be sized and properly derated according to NEMA MG1-22 to yield a maximum temperature rise of 105 degrees C by resistance above an ambient temperature of 40 degrees C at rated altitude and load.
- E. Excitation shall be provided by a direct connected brushless permanent magnetic rotating exciter. The alternator shall be of the three phase design and connected to a full wave three phase rotating bridge. Diodes used shall be of the silicon type mounted on proper heat sinks with surge protector.
- F. Exciter field power shall be provided by a separate permanent magnet generator directly connected to the brushless exciter. The PMG shall provide sufficient power to the excitation system to produce 300% current from the main operator armature during a three phase fault with sufficient duration for protective devices to operate.
- G. The alternator shall be protected from all types of short circuit conditions, based on the thermal damage capability of the machine under faulted conditions. The alternator shall include protection or other means to prevent overvoltage conditions on single-phase faults. This protection shall be in addition to circuit breakers that are shown on the drawings and provided for feeder protection.

## 2.9 CONTROLS AND STATUS PANELS

### A. General:

1. Provide an audible alarm signal, silence switch, and lamp test button on each control and status panel. Provide power for alarm system from generator battery system.
2. Upon alarm activation, sound the audible alarm signal and indicate, by means of individual lights at annunciator panels, which particular malfunction is initiating the alarm.
3. Generator shall have the ability and equipment to be interface with the building management system, BMS.

### B. Control and Status Functions:

1. Provide a main control and status panel for each engine generator set. Panel shall be hinged door, mounted on the engine generator set with vibration isolators.
2. Main line circuit breakers. The breakers shall have a solid state trip unit with true RMS current sensing. Each circuit breaker shall be 100% continuous rated sized as shown on the Contract Documents. The circuit breaker shall be provided with a DPDT auxiliary contact to provide a supervisory indication should the breaker be in the off or tripped position. The breaker shall be UL/CSA Listed of IEC construction and connected to engine/generator safety shutdowns. Breaker shall be housed in an extension terminal box which is isolated from vibrations induced by the generator set. Mechanical type lugs, sized for the circuit breaker feeders shown on drawing, shall be supplied on the load side of breaker. When required by code or the authority having jurisdiction, the generator set shall be provided with residual ground fault sensing equipment with an auxiliary contact wired to alarm light on remote control and status panels. The equipment shall be configurable for either tripping or alarm only, and defaulted to provide alarm only on a ground fault condition.
3. The generator set shall be provided with 3-phase line-to-line and line-to-neutral displays for AC voltage and AC current. The control shall display all phases of data simultaneously, to allow viewing of load and voltage balance. The display shall include a frequency meter and kW meter. All metering shall be 2% accuracy or better.
4. Engine data displayed shall include engine coolant temperature, oil pressure, oil temperature, and starting/control battery DC voltage.
5. Control and status points as specified under remote control and status panels.

### D. Remote Control and Status Panels:

1. Provide two remote control and status panels for the engine generator set. Locate one in the Security Office. Provide control and status points as required by NFPA 110 for Level 1 systems and as specified herein. Provide separate switch status points for each transfer switch.
2. Provide control and status points as follows:

Condition	Engine Generator Control & Status Panel	Fire Control Center Remote Control & Status Panel	Engineer's Control Center Control & Status Panel	Engine Shut Down
High Coolant Temperature	Alarm	Alarm	Alarm	Yes
Approach to High Coolant Temperature	Alarm	Alarm	Alarm	No
Low Coolant Temperature	Alarm	Alarm	Alarm	No
Low Coolant Level	Alarm	Alarm	Alarm	No
Overspeed	Alarm	Alarm	Alarm	Yes
Approach to Low Oil Pressure	Alarm	Alarm	Alarm	No
Low Oil Pressure	Alarm	Alarm	Alarm	Yes
Over Crank	Alarm	Alarm	Alarm	Yes
High Battery Voltage	Alarm	No	No	No
Low Battery Voltage	Alarm	No	No	No
Low Cranking Voltage	Alarm	Alarm	Alarm	No
Battery Charger AC Failure	Alarm	No	No	No
Low Fuel Day Tank	Alarm	Alarm	Alarm	No
Low Fuel Main Tank	Alarm	Alarm	Alarm	No
Main Circuit Breaker Open or Tripped	Alarm	Alarm	Alarm	No
Main Circuit Breaker Ground Fault	Alarm	Alarm	Alarm	No
Load Bank Cooling Failure	Alarm	Alarm	Alarm	No
Generator Running Indication	NA	Yes	Yes	NA
Not In Auto	Yes	Yes	Yes	NA
Generator Start/Stop Switch	Yes	No	No	NA
Generator Online	Yes	Yes	Yes	No
Generator Derangement	Yes	Yes	Yes	No
Remote Emergency Stop (Located outside of room)	No	No	No	Yes
Lamp Test	Yes	NA	NA	NA
Audible Alarm Silencing Switch	NA	Yes	Yes	NA

## 2.10 ENGINE GENERATOR-SET PERFORMANCE

A. The engine generator set shall meet or exceed the following performance criteria:

1. Voltage regulation: plus or minus 1 percent from 0- to 100-percent load.
2. Steady-state voltage stability: plus or minus 0.5 percent rated voltage.
3. Balanced telephone interference factor (TIF): not to exceed 50.
4. Frequency regulation from no load to full load: plus or minus 0.00 percent.
5. Steady-state frequency stability: plus or minus 0.33 percent.
6. Generator set: capable of start-up and accepting rated load within 10 seconds.
7. Maximum frequency change on application change on application or removal of 100-percent rated load resistive and reactive load shall not exceed plus or minus 15.0 percent.
8. Maximum recovery time to return to frequency stability bandwidth shall not exceed 8.0 seconds.
9. Maximum voltage dip with step application of load up to 100-percent rated capacity at 0.8 power factor shall not exceed 35 percent.

10. Voltage recovery time with step application of load up to 100-percent rated capacity at 0.8 power factor shall not exceed plus or minus 1 percent voltage within 8.0 seconds.

#### **2.11 VIBRATION ISOLATION AND SEISMIC RESTRAINTS**

- A. Installation shall be in accordance with approved vibration isolation and seismic restraint submittal.
- B. Flexible fuel shall be stainless steel reinforced synthetic rubber hoses. Flexible coolant lines shall be fabric-reinforced rubber rated 150 degrees C minimum.
- C. Raceway connections to unit shall be in liquid-tight flexible metal conduit.

#### **2.12 WEATHERPROOF HOUSING**

- A. The engine generator set and related equipment shall be housed in a factory-fabricated outdoor weatherproof / sound attenuated enclosure. The design and placement shall be such that the generator will function properly without overheating in the ambient conditions specified.
- B. Enclosure roof shall be pitched for drainage and overlapping on all sides. Exhaust pipe opening shall be fitted water-tight sealing material. Provide a drip shield around the exhaust pipe opening.
- C. Doors shall be gasketed and mounted on hinges. Hinges shall have stainless steel pins and bushings. Provide a key lock for each door.
- D. Fixed storm-proof louvers shall be provided to allow the engine generator set to operate at the project location at rated conditions with all enclosure doors closed.
- E. Enclosure shall be of sufficient size to allow for code-required clearances and maintenance.
- F. Exhaust silencer shall be mounted within enclosure. Silencer shall be painted with heat- and weather-resistant paint. Provide a rain cap at the end port. Interior mounted silencer is required.
- G. All exterior surfaces shall be factory painted.
- H. Unit shall have sufficient guards to prevent entrance by small animals.
- I. Batteries to fit inside enclosure and along side the engine (batteries shall not be installed under the generator).
- J. Unit shall have coolant and oil drains outside the unit to facilitate maintenance. Provide a valve located near the fluid source.
- K. If necessary, the bottom of the enclosure will be sealed to prevent any intrusion by critters.
- L.

## 2.13 AUTOMATIC TRANSFER SWITCHES

- A. Automatic transfer switches shall be capable of switching all classes of load and shall be fully rated for continuous duty and installed in a non-ventilated enclosure.
- B. All transfer switches shown on Contract Documents to be located indoors shall be provided with a NEMA 1 enclosure.
- C. Basis of design for interior applications is Kohler. Other acceptable manufacturers are ASCO, Russelectric and Zenith.
- D. All transfer switches shall be warranted by the engine generator manufacturer.
- E. Transfer switches shall be 4-pole, with switched neutral unless otherwise shown on drawings.
- F. All four pole switches shall have all 4 poles connected to a common shaft and shall be open transition type transfer.
- G. The transfer switches shall not chatter or fail to transfer in any way on any switching operation within acceptable operating voltage range.
- H. The transfer switches shall be electrically operated and mechanically held. The electrical operator shall be a single solenoid mechanism, momentarily energized to minimize power consumption and heat generation. The transfer switch shall be capable of opening or closing to or from any source in not less than 3 electrical cycles from initiation of a signal to operate. Operation time of the transfer switch from source to source shall be configurable in a range of no intentional delay to 10 seconds, with a default of 0.5 seconds.
- I. The use of molded case circuit breakers, contactors, or other components not rated for continuous duty, repetitive switching, or transfer between two active power sources is not acceptable.
- J. The entire transfer switch and relay plate assembly shall be capable of withstanding a 2500 volt crest transient per IEEE Standard 472-1974. The transient voltage test shall be conducted across the normal source terminals, the emergency source terminals, and between adjacent normal and emergency source terminals. Minimum withstand and close-in ratings shall be as follows (ratings shall be higher where indicated on the Drawings):

Automatic Transfer Switch Ampere Rating	Circuit Breaker Rating	Current Limiting Fuse Rating
Up to 30	42,000	100,000
70, 100, 150	42,000	200,000
250, 260, 400	42,000	200,000
600, 800	65,000	200,000
1000, 1200	85,000	200,000
1600-4000	100,000	200,000

- K. Provide in line current limiting fuse protection within transfer switch where required to meet short circuit withstanding ratings.

#### **2.14 AUTOMATIC TRANSFER SWITCH FEATURES AND ACCESSORIES**

- A. Close differential solid state adjustable voltage sensing on all phases (line to neutral) of normal source:
  - 1. Set drop-out at 80% rated voltage.
  - 2. Set pick-up at 90% rated voltage.
- B. Three phase voltage sensing (line to line and line to neutral) of emergency source:
  - 1. Set pick-up at 90% rated voltage.
  - 2. Set drop-out at 80% rated voltage.
- C. Frequency sensing of emergency source:
  - 1. Pick-up field adjustable from 90 to 100%. Factory set at 95%.
- D. Time delay on engine start:
  - 1. Field adjustable from 0.5 to 3 seconds. Factory set at 1 second.
- E. Time delay on re-transfer to normal:
  - 1. Field adjustable from 0 to 30 minutes. Factory set at 10 minutes.
  - 2. Immediate bypass of time delay and transfer to normal source if emergency source fails.
- F. Time delay on transfer to emergency:
  - 1. Field adjustable from 0 to 60 seconds. Set at 0 seconds.
- G. Time delay between live sources adjustable from 0.4 to 2.0 seconds. Factory set at 1 second.
- H. Unload engine run cool down time delay:
  - 1. Field adjustable from 0 to 5 minutes. Factory set at 5 minutes.
- I. Engine start contacts:
  - 1. SPDT to operate upon failure of normal source.
- J. Test switch:
  - 1. Mounted on enclosure door.
  - 2. Simulates failure/return of normal source.
- K. Auxiliary contacts:

1. Provide 2 sets SPDT contacts to operate with switch in normal position.
  2. Provide 2 sets SPDT contacts to operate with switch in emergency position.
  3. Contacts shall be exclusive customer use and not utilized for any other ATS or generator system functions.
  4. Contacts shall be 120V AC, 10 amp rated minimum wired to a terminal strip and labeled.
  5. Provide additional contacts or other provisions as required to display information on remote annunciators described elsewhere in this specification.
- L. Indicating lights:
1. Mounted on enclosure door.
  2. Red indicates switch in emergency position.
  3. Green indicates switch in normal position.
  4. White to indicate normal source available.
- M. Pre-transfer contacts:
1. Provide a contact closure for elevator controls prior to transfer between live sources in either direction. Interval shall be adjustable from 0 to 30 seconds. Contacts shall be rated SPDT 120V AC, 10 amps.
- N. Exerciser clock: Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:
1. Day of week
  2. Time of day to start
  3. Duration of cycle
- O. Annunciator panel located at Security Office with the following indicators.
- |   |
|---|
| Transfer Switch Not in Automatic Mode (One per Transfer Switch)         |
| Transfer Switch Connected to Normal Source (One per Transfer Switch)    |
| Transfer Switch Connected to Emergency Source (One per Transfer Switch) |
| Transfer Switch Emergency Source Available (One per Transfer Switch)    |
| Transfer Switch Normal Source Available (One per Transfer Switch)       |
| Bypass switch in automatic mode (One per Transfer Switch)               |
| Isolation handle in closed position (One per Transfer Switch)           |
| Isolation Handle in closed position (One per Transfer Switch)           |
- P. Power Monitoring
1. Provide with power metering and monitoring module with auxiliary dry contacts for remote monitoring and communications. Basis of design is ASCO 135SB.



- Q. Service manual and wiring diagram shall be supplied inside of enclosure when shipped. Control wiring shall be labeled to correspond with wiring diagram.
- R. Surge Suppressive Devices
1. Provide all transfer switches with a surge suppressive device.
  2. Basis of design shall be Kohler series with a AIC rating matching that the transfer switch.
  3. The device shall be internal to the transfer switch and come pre-installed from the manufacturer.

## **PART 3 – EXECUTION**

### **1.1 GENERAL**

- A. Provide all necessary wiring and conduit to each remote alarm panel and to each transfer switch for start, transfer, cool down, and shut down signals.
- B. Position the generators to allow adequate ventilation over engine block and through the radiator and to prevent short cycling of radiator discharge air back to engine and radiator intake.
- C. Provide the following connections for generator equipment wired to the 100A, 208V single phase load center panel. Coordinate with final engine manufacturer for exact voltage, circuit breaker and connection requirements:
  - 1. Provide 120V branch circuit and circuit breaker and connection to battery charger. Connect to emergency power supply.
  - 2. Provide 120V branch circuit and circuit breaker and connection to battery heater. Connect to standby power supply.
  - 3. Provide 120V branch circuit and circuit breaker and connection to oil heater. Connect to standby power supply.
  - 4. Provide 120V or 208V 1-phase branch circuit and circuit breaker and connection to engine block heater. Connect to standby power supply.
  - 5. Provide 120V or 208V 1-phase branch circuit and circuit breaker and connection to the intake and exhaust fans required to provide the engine combustion air and any additional air flow inside the generator enclosure. Connect to standby power supply.
  - 6. Provide 120V or 208V 1-phase branch circuit and circuit breaker and connection to alternator strip heater. Connect to standby power supply.

### **1.2 SEQUENCE OF OPERATION**

- A. Engine start contacts shall signal generator to start when the voltage of the normal source drops below 80 percent on any phase, after a time delay of one second to allow for momentary dips. The voltage-sensing relays shall be field-adjustable while energized.
- B. The transfer switch shall transfer to emergency when 90 percent of rated voltage, and frequency of the emergency source have been reached. The maximum time interval from onset of power failure and transfer to emergency shall not exceed ten seconds.
- C. After restoration of normal power on all phases to 90 percent of rated voltage, an adjustable time delay period shall delay re-transfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall bypass the timing relay and transfer to the normal source.
- D. After re-transfer to normal, the engine generator shall be allowed to operate at no load for five minutes.
- E. A test on the transfer switch shall simulate normal power failure.

**1.3 HOUSEKEEPING PADS**

- A. Provide a 6-inch high concrete housekeeping pad beneath the generator.

**END OF SECTION 263213**

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## **SECTION 264313 - TRANSIENT VOLTAGE SURGE SUPPRESSION**

### **PART 1 GENERAL**

#### **1.1 DESCRIPTION**

- A. This Section describes the materials and installation requirements for Transient Voltage Surge Suppressors (TVSS), also referred to as Surge Protective Devices (SPD). These devices are used to protect sensitive electronics from the effects of lightning-induced transients, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching.

#### **1.2 QUALITY ASSURANCE**

- A. TVSS manufacturer shall be the same as the switchboards.

#### **1.3 REFERENCE STANDARDS**

- A. The specified system shall be designed, manufactured, tested, and installed in compliance with:
  - 1. UL 1449 Second Edition 2007 - Transient Voltage Surge Suppressors
  - 2. UL 1283 - Electromagnetic Interference Filters
  - 3. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits; C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low-Voltage AC Power Circuits; and C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
  - 4. NEC 2005, Article 285
  - 5. Federal Information Processing Standards Publication 94 (FIP PUB 94)
  - 6. National Electrical Manufacturer Association (NEMA)
  - 7. National Fire Protection Association (NFPA 20, 70, 75 and 780)
- B. The individual TVSS units shall be UL Listed under UL 1449 Second Edition (2007) Standard for Transient Voltage Surge Suppression (TVSS) and the surge ratings shall be permanently affixed to the TVSS. The unit shall also be complimentary listed to UL 1283 Standard for EMI/RFI Facility Filters.

#### **1.4 SUBMITTALS**

- A. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place.
- B. Product data and manufacturer's installation instructions shall be submitted concurrently with switchboard and panelboard submittals.
- C. The submittals shall include:
  - 1. Dimensional drawing of each TVSS type.
  - 2. Drawings illustrating mounting locations within switchboards and panelboards.

3. UL 1449 Second Edition Listing, Standard for Safety, Transient Voltage Surge Suppressors, documentation.
4. UL 1283 Listing, Electromagnetic Interference Filters, documentation.
5. ANSI/IEEE C62.41 and C62.45, Category C3 (20kV-1.2/50, 10kA-8/20µs waveform) clamping voltage test results.

#### 1.5 WARRANTY

- A. Provide a full ten-year warranty from date of acceptance by the Owner/Operator against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national electrical codes. Make available local field engineering service support. Where direct factory-employed service engineers are not locally available, travel time from the factory or nearest dispatch center shall be indicated.

#### 1.6 FACTORY TESTING

- A. The specified system shall be thoroughly factory tested before shipment.

### PART 2 PRODUCTS

#### 2.1 MANUFACTURER

- A. Siemens, Eaton/Cutter-Hammer, Square D/Schneider Electric.

#### 2.2 SERVICE ENTRANCE AND DISTRIBUTION EQUIPMENT

- A. Internal TVSS
  1. TVSS shall be listed in accordance with UL 1449 Second Edition 2007, and UL 1283 Electromagnetic Interference Filters.
  2. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449 Second Edition, Revision 2/9/2007 Section 37.3 and 37.4 at the standard's highest short circuit current rating (SCCR) of 200 kA, including intermediate level of fault current testing that was effective 2/9/2007.
  3. TVSS shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).
  4. TVSS shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems.
  5. The manufacturer of the TVSS shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped. Also, this distribution equipment shall be fully tested and certified to the following UL standards:

UL 67	=	Panelboards
UL 845	=	Motor Control Centers
UL 857	=	Busway
UL 891	=	Switchboards
UL 1558	=	Low Voltage Switchgear

6. Recommended TVSS ratings:

- a. Minimum surge current rating shall be 160 kA per phase (80 kA per mode) for service entrance and 80 kA per phase (40 kA per mode) for distribution applications.

- b. UL 1449 clamping voltage must not exceed the following:

VOLTAGE	L-N	L-G	N-G
240/120	800/400V	800/400V	400V
208Y/120	400V	400V	400V
480Y/277	800V	800V	800V

7. TVSS shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115 percent of nominal RMS voltage.
8. TVSS shall be constructed of one self-contained suppression module per phase.
9. Visible indication of proper TVSS connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each TVSS module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.
10. TVSS shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.
11. A connector shall be provided along with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete TVSS or module.
12. Terminals shall be provided for necessary power and ground connections.
13. The TVSS shall be equipped the following optional items:
  - a. A transient voltage surge counter shall be located on the diagnostic panel on the front cover of the enclosure. The counter shall be equipped with a manual reset and battery back-up to retain memory upon loss of AC power.
  - b. A remote monitoring device shall be provided to directly connect to the TVSS with a dry contact connector for simple installation. The device will have indicator lights and an audible alarm to monitor for normal and fault conditions.

### 2.3 SURGE SUPPRESSION COMPONENTS

- A. Each array shall be capable of withstanding over 1,250 pulses of the 10kA IEEE 62.41 Category C surge current without failure when tested per C62.11, C62.45, suggested wait times. The array shall consist of multiple gap-less metal oxide varistors, with each MOV individually fused.
- B. The arrays shall be designed and constructed in a manner that ensures MOV surge current sharing. No gas tubes, silicon avalanche diodes or selenium plates/rectifiers shall be used. The status of each array shall be continuously monitored and a green LED shall be illuminated if the array is in full working order. All protection modes, including N-G, shall be monitored and internally fused, for compliance to NEC articles 110.9, 110.10 and 280.22.



## 2.4 CONNECTIONS

- A. The unit shall be designed to be installed directly to the switchboard bus or to a meter breaker panel branch circuit breaker. All parallel connections to the TVSS shall be kept as short as possible. The connection to the TVSS shall be made using #10 AWG minimum.

## 2.5 ACCESSORIES

- A. Unit Status Indicators: The unit shall have an integral status circuit that monitors the operational status of all modes of protection, including Line to Neutral, Line to Ground and Neutral to Ground. No manual testing is required to confirm the integrity of the suppression and filter systems. If the unit does fail, the green LED will go out and the red LED will be lit.
- B. Summary Alarm Relay Contacts: In addition to the LED indicators, the unit shall be equipped with a summary alarm relay with one set of Normally Open and Normally Closed (Form C) dry contacts rated for 125 VAC, 1 amp (minimum). The contacts will change state and indicate a failure of the unit, a phase loss condition or a full power loss condition.

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Manufacturer shall install TVSS in the power distribution equipment for use at the utility service entrance to the facility and in each distribution panel to be protected, as indicated on the Drawings.
- B. The TVSS shall be installed on the load side of a service disconnect overcurrent device per NEC.
- C. Where the internal TVSS is connected to the power system with cables, keep the conductors as short as possible with no sharp bends.
- D. The TVSS's ground shall be connected to the power system ground.

### 3.2 INSTALLATION

- A. Where located in a switchboard, the manufacturer shall bus connect the TVSS in parallel to the power source. Where located in a meter/breaker panel, connect to a circuit breaker, keeping conductor length as short as practically possible.
- B. The unit shall be bussed to the switchboard and be supplied by a 30-amp circuit breaker or 60-amp circuit breaker as required by the TVSS manufacturer.
- C. Coordinate with the switchgear vendor and flush-mount user-interface panel integral into the switchgear front panel.
- D. The Contractor shall follow the TVSS manufacturer's recommended installation practices and comply with all applicable codes.

END OF SECTION

## SECTION 26 5000 - LUMINAIRES AND ACCESSORIES

### PART 1 – GENERAL

#### 1.1 DESCRIPTION

- A. Provide luminaires and accessories in accordance with the Contract Documents. Furnish and install luminaires as shown on the Drawings and herein specified.

#### 1.2 DEFINITIONS

- A. The term “Architect” refers to the Architect, Interior Designer, Lighting Designer or Owner’s Representative individually or collectively.

#### 1.3 GENERAL REQUIREMENTS

- A. Provide all luminaires as shown complete with lamps and accessories, appropriately wired, controlled, and securely attached to supports.
- B. Where a narrative and a catalog number or pictorial description are provided, the written description shall take precedence and prevail.
- C. General Contractor shall provide electrical subcontractor with entire lighting specification (including fixture illustrations and sketches); electrical subcontractor shall provide each specified manufacturer with complete information about the luminaires they will supply.
- D. Type of luminaires shall be as indicated alphanumerically and as specified.
- E. Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:
  - 1. Fixture performance is equal or improved.
  - 2. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
  - 3. Cost to the Owner is reduced or equal.
  - 4. Modifications have been reviewed and approved by the Architect in writing.
- F. The contractor shall coordinate dimmable lighting control interface of all light fixtures with approved lighting control system, insuring compatibility across full dimming range of light fixture.

#### 1.4 REFERENCE STANDARDS

- A. The standards and regulating committees referred to in these Specifications, and with which compliance is required, are:
  - 1. ANSI American National Standards Institute
  - 2. ASTM American Society of Testing and Materials
  - 3. CBM Certified Ballast Manufacturers
  - 4. NEC National Electric Code

- 5. NEMA National Electrical Manufacturers Association
- 6. NFPA National Fire Protection Association

7. UL Underwriters Laboratories, ETL, CSA, Per AHJ Requirements.

- B. All luminaires and assembled components shall be new, of good quality, and approved by and bear the label of UL or other approved testing agencies (i.e., CSA, ETL) unless otherwise specified in writing. Documentation of such testing shall be provided upon request.
- C. All luminaires shall meet required local, state and/or national building, electrical and energy codes and regulations.
- D. Luminaires installed in outdoor protected areas (such as building soffits) and indoors in areas subject to water or extreme humidity shall be UL Listed for damp locations. Luminaires in outdoor unprotected areas shall be UL Listed for wet locations.

#### 1.5 SUBMITTALS

- A. For standard catalog items with no modifications, submit catalog cut sheets, which clearly show all elements to be supplied, and all corresponding product data (including lamping, ballast quantity, ballast manufacturer and model number, voltage, input watts, materials, finishes, accessories and/or options and any miscellaneous items detailed in the written description of the specification). If a cut sheet shows more than one (1) fixture type, all non-applicable information shall be crossed out.
- B. Submittals for solid state lighting luminaires shall include LM-79 report from a laboratory accredited by the National Voluntary Lab Accreditation Program (NVLAP) or one of its Mutual Recognition Arrangement (MRA) signatories. Laboratory tests must be produced using specific module(s)/array(s) and power supply combination that will be used in production. LM-79 report shall include the following minimum information:
  - 1. Sample and testing description: testing laboratory and date of test, verification LM-79 was used, identification of photometric methods used, and version of product tested including catalog number, ballast or driver information, and accessories.
  - 2. Electrical characteristics: input voltage in volts, input current in amps, input power in watts.
  - 3. Total light output in lumens, luminaire efficacy in lumens per watt including power supply, thermal, optical, and fixture losses.
  - 4. Luminous intensity distribution in tabular and polar graph formats.
  - 5. Color characteristics: chromaticity coordinates (u',v'), correlated color temperature (CCT) in Kelvins, color rendering index (CRI), spectral power distribution graph.
  - 6. Exterior fixtures shall include BUG rating and isoilluminance plot.
- C. For Standard Cataloged Fixtures:
  - 1. When more than one louver panel occurs in a fixture, submit the dimensioned layout of individual louver panels and supporting "tee" members as a part of shop drawings.
- D. For luminaires such as custom, modified, linear mounted in continuous rows, and solid state lighting systems with remote ballasts and/or controllers submit a reproducible drawing prepared

by the manufacturer showing all details of construction, lengths of required runs, lamp layout, power locations, ballast locations, pendant locations where applicable, finishes and list of materials. Drawings must be to scale. Contractor shall provide manufacturer with field dimensions of all architectural coves where continuous runs are to be mounted. If scallop shields, wallwash reflectors or baffles are required, drawings shall indicate relative position to wall or adjacent vertical surface.

- E. For all submittals under Clauses A. through C. above, manufacturer shall provide submittals within two (2) weeks of receipt of order. All submittals shall have project name and fixture type clearly shown.
- F. Fixture cuts and shop drawings shall be submitted in quantities and format as described in the General Conditions Section of these Specifications.
- G. The Architect shall make the final determination as to whether or not the submittal contains sufficient information, and reserves the right to request a shop drawing if the fixture cut is insufficient.
- H. Mock-Ups:
  - 1. It shall be the responsibility of the Contractor to provide a mock-up of the lighting fixture or lighting system as indicated in Paragraph 2.02, LIGHTING FIXTURE SCHEDULE. The mock-up shall be erected within a time period and in a location that is acceptable to the Architect.
  - 2. The mock-up installation shall closely conform to the conditions of the actual installation as to: height, distance from adjacent surfaces, number and type of lamps, material, color, etc. The Contractor shall submit a written description of each proposed mock-up with drawings in order to obtain the Architect's approval prior to commencement of each mock-up.
  - 3. The purpose of the mock-up will be to study the general appearance and performance of the intended lighting systems. At that time, certain minimal test variations may be requested as to lamp location, lamp type, reflector shape, color, etc.
  - 4. Mock-up fixtures may not be used on the project.
- I. Samples:
  - 1. It shall be the responsibility of the Contractor to provide sample fixtures as indicated in Paragraph 2.02, LIGHTING FIXTURE SCHEDULE. When samples are called for, the manufacturer shall provide one working samples, unless otherwise noted, complete with specified lamp, ballast (rated for operation on local voltage and frequency) and 96-inch (2000-millimeter) pigtail with grounded plug.
  - 2. The sample(s) shall be shipped to a location determined by the Architect. Shipping and return shipping costs shall be provided as part of the contract.
  - 3. The purpose of the sample is to review manufacturing techniques, detailing, lamping and scale. Sample fixtures must be approved prior to fabrication of fixtures for the project.
  - 4. Sample fixtures may not be used on the project.

## 1.6 WARRANTIES

- A. All fixtures and workmanship shall be guaranteed free of defects and fully operational for a minimum of one (1) year after installation. Any fixtures or workmanship found to be defective during the warranty period shall either be fixed or replaced to the Owner's approval by the Contractor at no cost to the Owner.
- B. Ballasts for fluorescent and high intensity discharge fixtures shall be covered by a minimum two (2) year warranty after installation unless otherwise specified against defects in workmanship or material. Warranty shall include in-warranty service program providing for payment of authorized labor charges incurred in replacement of inoperative in-warranty ballasts.
- C. Solid state lighting luminaires, drivers, controllers, and other system components shall be covered by a minimum five (5) year warranty after installation unless otherwise specified against defects in workmanship or material. Warranty per manufacturer of approved luminaires including standard PDI warranty of workmanship of 1 year from substantial completion.

## 1.7 LEED SUBMITTALS

- A. SS Credit 8: Light Pollution Reduction
  - 1. For exterior luminaires, documentation indicating backlight, uplight, and glare ratings (BUG) rating.

## PART 2 – PRODUCTS

### 2.1 GENERAL MATERIAL REQUIREMENTS

- A. All material requirements shall comply with manufacturer's standards.
- B. Luminaires shall be completely factory-assembled and -wired, and equipped with necessary lampholders, ballasts, wiring, shielding, reflectors, channels, lenses, and other parts necessary to complete the luminaire installation.
- C. Luminaires shall be designed for bottom re-lamping, unless otherwise noted.
- D. Cast or extruded parts of luminaires shall be close grained, rigid, true to pattern, of ample weight and thickness, and properly fitted, filed, ground, and buffed to provide finished surfaces and joints free of imperfections or discolorations.

### 2.2 LIGHTING FIXTURE SCHEDULE

- A. Refer to sheet E0002 for Back of House lighting fixture schedule.

### 2.3 REFLECTORS

- A. Per manufacturers standards.

### 2.4 LENSES

- A. Per manufacturers standards.

2.5 LOUVERS

- A. Per manufacturers standards.

1.

2.6 SOLID STATE LIGHTING FIXTURES

- A. Housing, where applicable:

1. Per manufacturers standards.

- B. Finish:

1. Per manufacturers standards.

- C. Light Emitting Diode (LED) requirements:

1. Per manufacturers standards.

- D. Luminaire Efficacy:

1. Per manufacturers standards. .

- E. Thermal Management:

1. Per manufacturers standards. .

- F. Power Supplies/Drivers:

1. Per manufacturers standards. .

- G. Solid State Lighting Controls:

1. Control interface to dimmable power supplies shall consist of one of the following:

- a. Phase Dimming. Controls to be rated for forward phase (also referred to as leading edge or Triac) or reverse phase (also referred to as trailing edge or electronic low voltage) operation.
- b. Low voltage (0-10V) control. Controls to be compatible with either current sink or current source operation.
- c. Digital control via DMX, DALI, LonWorks, or Zigbee protocols.

The contractor shall coordinate solid state lighting control interface with approved dimming system, insuring compatibility across full dimming range of power supply.

2. Per manufacturers standards. .

- H. System Installation:

1. Per manufacturers standards and installation instructions. .

## 2.7 LUMINAIRE WIRING

- A. Voltage Rating:
  - 1. For voltages up to 120 volts, fixture wiring shall be rated for 300 volts minimum.
  - 2. For voltages above 120 volts, fixture wiring shall be rated for 600 volts minimum.
- B. Any fixture fed from more than one panel (i.e., for normal and night or emergency operation) shall have separate neutrals to each panel.
- C. Furnish code-approved wiring in ceiling cavities forming air plenums.

## 2.8 ACCESSORIES

- A. Recessed incandescent luminaires shall be furnished with thermal protection in accordance with Article 410-65 of the NEC.
- B. Where utilized as raceways, luminaires shall be suitable for use. Provide feed through splice boxes where necessary.
- C. Provide installation and supporting hardware including stems, plates, plaster frames, hangers, and similar items, for support of luminaires for the ceiling construction in which they shall be installed. Provide plaster frames made of non-ferrous metal, or of steel that has been suitably rust-proofed after fabrication. Provide seismic mounting as required.
- D. Air handling luminaires shall have hinged air control vanes within the side slots (bent metal vanes are not acceptable) factory-set at fully open. Provide heat removal slots at luminaire ends.
- E. Interior fluorescent and HID luminaires utilizing ballast sound rating of lower than A shall be provided per manufacturers standards.
- F. Provide tempered glass lenses for metal halide luminaires.
- G. Provide fastening devices of a positive locking type, which do not require special tools to apply or remove. Do not use tie wires in place of fastening devices.
- H. Attach reflectors to housing by means of safety chains to prevent reflectors from falling. No part of the chain shall be visible after installation.
- I. Provide a ceiling canopy for each stem. Canopy finish shall match stem finish.
- J. Luminaires installed in air plenums shall be enclosed and gasketed.
- K. Install all color, dichroic and imaging lenses and gels as required in Paragraph 2.02, LIGHTING FIXTURE SCHEDULE.

## 2.9 EXTERIOR LUMINAIRES

- A. Exterior luminaires shall be designed and manufactured specifically for outdoor service. Components including nuts, bolts, rivets, springs, and similar parts, shall be corrosion resistant.

- B. Exterior luminaires shall be suitably and effectively gasketed to prevent entrance of moisture into luminaire. Luminaires that are directly exposed to the elements shall be labeled for wet locations. Luminaires that are exposed to dampness shall be labeled for damp locations.
- C. Aluminum parts of exterior luminaires that are not specified as requiring a painted finish shall be anodized.
- D. Finishes:
  - 1. Surfaces shall be prepared, primed and material applied in accordance with manufacturer's requirements and standards.
  - 2. Colors shall be as specified under Paragraph 2.02 LIGHTING FIXTURE SCHEDULE.

### PART 3 – EXECUTION

#### 3.1 SHIPPING AND STORAGE

- A. All fixtures received at the site shall be stored in a clean and dry space until fixtures are installed.
- B. Manufacturer shall clearly mark each box with fixture designation prior to shipping.
- C. Reflector cones, baffles, louvers, aperture plates, and decorative elements of fixtures shall be packed by the manufacturer separate from the housing (body, stem, etc.) of the fixture.

#### 3.2 LOCATION

- A. Luminaire locations as indicated on the Drawings are general and approximate. Verify exact location and spacing of luminaires with Reflected Ceiling Plans and other reference data before ordering of fixtures. Confirm with Architect prior to installation.
- B. Coordinate space conditions with other trades before ordering of fixtures. Prove adequacy of clearance with other equipment such as ducts, pipes, conduit, or structural elements. Bring conflicts to Architect's attention before proceeding with work.
- C. Notify Architect about field conditions at variance with Contract Documents before commencing installation.
- D. Verify ceiling construction and furnish appropriate luminaire mounting supports, hardware, trim, and accessories for each luminaire.
- E. Coordinate length of continuous-run fluorescent fixtures with adjacent walls, partitions, coffers and other architectural elements as required.

#### 3.3 INSTALLATION

- A. Luminaires shall be installed per manufacturer standards, and installation instructions free of light leaks, warps, dents, or other irregularities. Light leaks are not acceptable.
- B. Install reflector cones, aperture plates, lenses, diffusers, louvers, and decorative elements of luminaires after completion of wet work, plastering, painting, and general clean-up in the area of the luminaires.



- C. Visible hanging devices shall be finished to match the luminaire finish, unless otherwise noted. Suspended fixtures shall hang level and aligned when installed in rows.
- D. Provide adequate and sturdy support for each lighting fixture. Contractor shall be responsible for verifying weight and mounting method of all fixtures, and shall furnish and install suitable supports. Fixture mounting assemblies shall comply with all local seismic codes and regulations.
- E. Surface Mounted Fixtures:
  - 1. Support surface-mounted fixtures from structural members other than ceiling tees.
- F. Pendant Mounted Fixtures:
  - 1. Pendant-mounted fixtures shall be supported from structural framework of ceiling or from inserts cast into slab.
  - 2. Per manufacturers standards. .
- G. Bracket Mounted Fixtures:
  - 1. Per manufacturers standards. .
- H. Recessed Fixtures:
  - 1. Contractor shall be responsible for adjusting aperture rings on all ceiling recessed fixtures to accommodate various ceiling material thicknesses. Contractor shall be responsible for coordinating the cut-out size in ceiling to ensure aperture covers cut-out entirely. .
- I. Top Re-Lamping Fixtures:
  - 1. Fixtures re-lamped from above shall have the necessary top re-lamping screws loosened and moderately tightened, prior to installation, to assure ease of operation when re-lamping.
- J. Plaster Ceilings:
  - 1. Furnish plaster frames for setting under other applicable sections. Direct the setting and be responsible for correct location; make sure the bottom of frame is flush with finished ceiling, forming screed edge for finished plaster.
  - 2. Fixtures shall be supported by plaster frames utilizing yokes or leveling lugs.
    - a. Fixtures and support elements shall not be mounted to or in contact with ducts or pipes.
    - b. Yoke shall have channel cross-section of sufficient gauge, and shall support a fixture by means of not fewer than two (2) bolts each.
- K. For fixtures with variable position lampholder assemblies, Contractor shall confirm prior to installation proper lampholder (socket) position in field, and shall adjust, if necessary, after coordination with manufacturer.

- L. Equipment requiring access for service and maintenance shall be installed so that components requiring access are readily accessible.
- M. Coordinate with all trades to install luminaires in mechanical equipment rooms after ductwork and piping installation. Locate and mount luminaires as indicated on the Drawings unless mechanical equipment prohibits or makes it impractical to do so. In such cases, chain- or wall-mount luminaires so that serviceable equipment is illuminated.
- N. Provide fire-rated enclosures around recessed luminaires that are installed in fire-rated ceilings.
- O. Install fixtures with vent holes free of air-blocking obstacles.
- P. Ascertain and ensure that all lamps installed are exactly as specified for each fixture type.
- Q. Replace all burned-out or inoperative lamps, and inoperative ballasts in all high intensity discharge and fluorescent fixtures, before the building is accepted by the Owner so that all lighting fixtures will be in premium operating condition.
- R. At the completion of construction, clean the lenses, baffles, louvers, reflector cones, and bottoms of the trims of all lighting fixtures, so as to render them free of any material, substance or film foreign to the fixture. Use soft, non-abrasive cloth and a cleaning solution recommended by the fixture manufacturer. If the Architect at the completion of the project deems the luminaires dirty, the Contractor shall clean them at no additional cost to the Owner. Luminaire components whose finishes are damaged shall be replaced at no cost.

END OF SECTION

## **SECTION 26 4100 LIGHTNING PROTECTION SYSTEM**

### **PART 1 – GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide air terminals and interconnecting conductors.
- B. Provide grounding and bonding for lightning protection.
- C. Obtain UL inspection and certification, and obtain UL Master Label.

#### **1.2 REFERENCE STANDARDS**

- A. ANSI/NFPA 780 Lightning protection installation standards.
- B. ANSI/UL 96 Lightning protection components.
- C. UL 96A Installation requirements for lightning protection systems.
- D. OSHA regulations (Standard 29 CFR).

#### **1.3 QUALITY ASSURANCE**

- A. Provide lightning protection system consisting of air terminals, bonding, interconnecting conductors, and grounding as required under the provisions of NFPA 780 except where specified in excess thereof, herein or in the contract drawings.
- B. Provide a UL 96A Master Labeled system consisting of air terminals, bonding, interconnecting conductors, and grounding as required under the provisions of UL 96A except where specified in excess thereof, herein or in the contract drawings. The system shall be designed to qualify for the maximum insurance rate reduction allowed for lightning protection for this type of construction.
- C. All equipment and materials to be furnished and installed on this Project shall be UL or ETL Listed, in accordance with the requirements of the Authority Having Jurisdiction, and suitable for its intended use on this project.

#### **1.4 SUBMITTALS**

- A. Shop drawings showing layout of air terminals, bonding connections to metal objects, bonding connections to structure, and ground electrodes. Shop drawings shall include sizes for air terminals, conductors, ground electrodes, and connection/termination details.
- B. Provide a compliance / non-compliance specification attached to the front of the submittal. Identify each paragraph stating the submittal complies with the specification or does not comply. For every statement of non-compliance, include clear language as to the reason for the non-compliance and the submitted provisions that are intended to operate in its place.

- C. Product data sheets showing application, dimensions, and material of each component utilized in the lightning protection system.
- D. Proof of manufacturer's listing in accordance with UL 96.
- E. Manufacturer's installation instructions under other provisions.
- F. OSHA approval of air terminals to be utilized in the installation.

#### 1.5 PROJECT RECORD DOCUMENTS

- A. Submit project record documents under other provisions.
- B. Accurately record all air terminal, bonding, grounding, and conductor locations.

#### 1.6 QUALIFICATIONS

- A. Manufacturer
  - 1. Company listed in the current UL Electrical Construction Directory specializing in the manufacture of lightning protection equipment.
- B. Installer
  - 1. Company listed in the current UL Electrical Construction Directory specializing in the installation of lightning protection systems.

#### 1.7 FIELD QUALITY CONTROL

- A. Field inspections will be held and documented.
  - 1. For inspection of down conductors prior to being covered by interior, exterior, or other installations.
  - 2. For inspection of lightning protection system grounds and connections prior to burial.
  - 3. The complete ground system shall have no more than 5 ohms of resistance as measured per the IEEE fall of potential method.
- B. Obtain the services of Underwriters Laboratories Inc. to provide the inspection and certification of the lightning protection system under the provisions of UL 96A.
- C. Obtain the UL Master Label.
- D. Certification that surge protection is installed on the electrical service with a minimum of 160-ka per phase surge capacity.
- E. Certification that surge suppression is installed on the antenna, telephone, radio, and television lead wires.
- F. At time of application for UL Master Label a copy of the application shall be sent to the Owner's Representative.

1.8 PRE-INSTALLATION CONFERENCE

- A. Convene a pre-installation conference with all applicable trades and disciplines two weeks prior to commencing work under this Section.

1.9 SEQUENCING AND SCHEDULING

- A. Coordinate work under other applicable provisions.
- B. Coordinate work under this Section with roof, interior, exterior, electrical, and mechanical installations.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. National Lightning Protection Corporation, Thompson Lightning Protection, VFC, or approved equal.
- B. Approved Equals
  - 1. Written requests for substitution shall be made a maximum of fifteen (15) days prior to bid date for consideration.

2.2 MATERIALS

- A. All equipment utilized in the lightning protection system shall be new.
- B. Components
  - 1. New in accordance with UL 96.
- C. Air Terminals
  - 1. Copper sized as required by structure class under provisions of UL 96A and NFPA 780 standards for lightning protection system installation except where specified in excess of herein.
- D. Ground Terminations
  - 1. Copper-clad ground rods: 3/4 inch by 10 feet
  - 2. Ground plates: 24 inches square by 26 gauge copper
  - 3. Electrolytic ground rods: 10-feet straight or AL@ shaped with cap to allow recharging.
  - 4. Ground loop conductor: 250MCM, 19 strand copper encased in San-Earth7 conductive concrete.
- E. Conductors
  - 1. Copper cable sized as required by structure class under the provisions of UL 96A and NFPA 780 standards for lightning protection system installation.

F. Connectors, Splices, and Bases

1. Above grade: Cast bronze or cast aluminum (new).
2. Concealed: Exothermic connections.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are ready to receive work.
- B. Verify dimensions and measurements shown on shop drawings with field conditions.
- C. Verify that all systems that may influence the lightning protection system design are included or referenced on the shop drawings.
- D. Verify adequate guards against impalement are in place or will be implemented as required by job progress.

3.2 PROTECTION OF SURROUNDING ELEMENTS

- A. Protect elements under other sections from damage or disfiguration during work under this section.
- B. Coordinate all below-grade lightning protection system installation with the general contractor.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. The lightning protection system shall be installed in a neat and orderly manner.
- C. Install in accordance with the NFPA 780 lightning protection installation standard.
- D. Install in accordance with UL 96A installation requirements for lightning protection systems.
- E. Cable conductors shall be concealed at all locations throughout the building. Cable conductors in parapets shall be coordinated with the window wall installation. Conductors shall be copper cable weighing not less than 375 pounds/1000 feet or aluminum cables of equivalent impedance where required due to roof and parapet construction material compatibility.
- F. Connection of supports, clamps, devices and other appurtenances to rust-protected metal structures exposed to the weather shall be made using rust-protected devices and shall be installed in a manner to preserve the rust protection of the structure. Coordinate material selection with Architect prior to installation.
- G. Down conductors shall interconnect with the ground ring of the grounding electrode system. Refer to Section 26 05 26 titled "Grounding" for additional information.

- H. Metals of conductance at any point within 6 feet of the lightning conductor system shall be securely bonded and made a part thereof, and materials for these interconnections shall be equivalent in quality to main conductor and fittings.
- I. Cable conductors shall interconnect all air terminals offering a two-way path to the ground electrodes.
- J. All required sealing, flashing, pavers, slip sheets, or pads required for the lightning protection system shall be furnished and installed by the roofing contractor to maintain roof warranty.
- K. All trenching, backfilling, and compaction required for the lightning protection ground system shall be provided by the general contractor.
- L. Surge suppression for the electrical system shall be installed by the electrical contractor.
- M. Surge protection for the telephone, radio, or radio lead wires shall be furnished and installed by the system vendor.

END OF SECTION