

SECTION 260500 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 APPLICABLE DOCUMENTS

- A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and shall include all Electrical Sections specified herein.

1.2 DESCRIPTION OF WORK

- A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

- 1. Specifications, in general, describe quality and character of materials and equipment.
- 2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:

- 1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation.
- 2. Conform to scaled and figured dimensions, notify Engineer of any conflicts prior to installation, cutting, drilling, etc.
- 3. Before proceeding with work check and verify all dimensions.
- 4. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
- 5. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
- 6. Where existing pipes, conduits and/or ducts prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits and/or ducts. Verify exact location and elevation of existing piping prior to any construction.
- 7. If any part of Specifications or Drawings appears unclear or contradictory, apply to Architect or Engineer for his interpretation and decision as early as possible during bidding period. If answer is not given prior to close of bid time then contractor shall assume the following:
 - a. The scope of work in question is to be included in his bid price. No change orders will be allowed to add to the scope of work.

- b. The greater cost/quality level alternative shall be included in his bid. No change orders will be allowed for assuming the lesser quality or cost.
- c. A separate line item may be included to clarify the bid but the scope of work and/or cost/quality level in question must be included in the overall bid price.

1.4 DEFINITIONS

- A. "Above Grade": Not buried in the ground and not embedded in concrete slab on ground.
- B. "Actuating" or "Control" devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.
- C. "Below Grade": Buried in the ground or embedded in concrete slab on ground.
- D. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.
- E. "Connect": Complete hook-up of item with required service.
- F. "Exposed": Not installed underground or "concealed".
- G. "Furnish": To supply equipment and products as specified.
- H. "Indicated," "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.
- I. "Install": To erect, mount and connect complete with related accessories.
- J. "Motor Controllers": Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.
- K. "Provide": To supply, install and connect as specified for a complete, safe and operationally ready system.
- L. "Reviewed", "Satisfactory," or "Directed": As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner.
- M. "Rough-In": Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.
- N. "Shall": An exhortation or command to complete the specified task.
- O. "Similar": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products; and as approved by engineer.
- P. "Supply": To purchase, procure, acquire and deliver complete with related accessories.
- Q. "Will": A desire to complete the specified task. Allows some flexibility in application as opposed to "shall".

- R. "Wiring": Raceway, fittings, wire, boxes and related items.
- S. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.5 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

- A. General: Follow the procedures specified in Division 01 Section "SUBMITTALS" except as expanded for this Division herein. Submittals processed by the Architect/Engineer are not cause for extra claims nor do they represent a change in the Contract Documents.
- B. Purpose: Contractor demonstrates to the Architect/Engineer understanding of the Contract Documents and design concept by indicating which material intended to be furnished and installed, and by detailing fabrication and installation methods intended to be used. Intention of using exactly the materials indicated does not relieve Contractor of obligation of submitting shop drawings and product literature.
- C. Identification: Include project name, both Contractor and electrical Installer names, address, telephone numbers and contact persons. Clearly mark all submittals to indicate use of the material.
- D. Shop Drawings: Submit on all major pieces of electrical equipment including (but not necessarily limited to) light fixtures, distribution equipment, starters, circuit breakers, panel boards, and transformers as identified in the Project Checklist below. Up to 11" x 17" size sheets must be submitted with product literature below. Over 11" x 17" size submit in accordance with Architect's requirements.
- E. Electronic files shall be submitted in three distinct electronic document processes.
 - 1. Electronic Submittals
 - 2. Equipment Inventory/Document Reference Index
 - 3. Electronic Folders for file management and drawings
 - 4. The GC/Prime shall maintain the master set of record documents to be turned over to the owner at completion of the project.
 - 5. Product Literature: Submit six copies CD (or DVD) maximum of manufacturer's descriptive literature and catalog cuts of standard electrical products used including, but not limited to conductors, connectors, raceway, special raceways, fittings, switches, outlets, etc.
 - 6. Submit all information described above, except for hardcopies of Shop Drawings, in electronic format (pdf-files in Adobe Reader 8), on standard Compact Diskettes (CDs). Electronic files shall be organized in electronic folders on the CD, by the Specification Section number and the Section name identified in the Project Checklist:
 - 7. Do not mix electronic Product Data Sheets (.pdf-files) with other electronic files, such as Shop Drawings or files in another format, such as AutoCAD .dwg-files.
 - 8. Each item of equipment shall be a separate, single electronic .pdf-file or xls-file, containing only pages of manufacturer's data pertinent to the item. Do not include literature intended for general sales purposes or for general product information, which does not pertain the exact item or product to be provided. Individual data files (.pdf-file and xls-file) for individual items will be arranged in the electronic Section folders named as indicated in the "CLOSEOUT DOCUMENT FILE NAME" column on the PROJECT

CLOSEOUT DOCUMENT REFERENCE INDEX. The PROJECT CLOSEOUT REFERENCE INDEX will be furnished by the Owner and include the filenames to be used.

9. Electronic files for electrical equipment and luminaries shall include the name of item as indicated on the Electrical Drawings issued "For Construction" (Architect's IFC Set), will be the origin of the equipment name (equipment identifier).
- F. Product Literature: Submit six copies maximum of manufacturer's descriptive literature and catalog cuts of standard electrical products used including, but not limited to conductors, connectors, raceway, special raceways, fittings, switches, outlets, etc.
- G. Binders: Three-ring Binders containing loose-leaf pages of Manufacturer's Product Data sheets are not required.
- H. Marking: Where more than one product is represented, clearly identify those products which the Contractor intends to furnish on this project. Strike out products which will not be used, or underline or arrow products on a given product sheet which will be used. Do not use highlighter pens. Place unspecified items in 260500 and number sequentially.
- I. Submittal Review: Submittals not conforming to the aforementioned requirements will not be accepted by the Engineer and will be returned without review. Such action shall not be cause for extra claims against the Owner, Architect or Engineer. Consult with the Engineer and obtain pre-approval of any deviations from the specified electronic format described above, prior to submission. After necessary approvals are received by the Contractor and revisions made thereto, the electronic product data files shall be updated to depict equipment items and products that are installed on the Project. These revised files shall be included as a section of the Electronic Operation and Maintenance Manuals.
- J. Submittal Dates: Submit product data sheet CD's within 30 calendar days of notice to proceed. Submit all product literature stragglers and shop drawings within 60 calendar days of notice to proceed, on separate CD's. Submit coordination drawings on a separate CD not less than 20 calendar days prior to the beginning of any work affected by the Division 26 work depicted. After such deadlines, the professional time to consider any submittal shall be paid for by the contractor. Such payment does not guarantee approval. Costs incurred to the project due to problems arising from late submittals shall be paid for by the contractor.

1.6 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements of Division 01 Section Closeout and Procedures and Project Record Documents. Provide to receive two hardcopies, full-size set of Record Drawings and (2) CDs of identical electronic AutoCAD drawing files including Equipment Installation Manual Programming Manual, System Block Diagrams, Point-to-Point Wiring Diagrams, Terminal Identification, User Manuals, Parts Lists pertinent to each piece and type of equipment installed on the Project, at the end of the project. In addition to the requirements specified in Division 01, Electronic AutoCAD files for Record Drawings shall indicate, by sheet note, installed conditions for:
 1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; busways; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
- B. Prepare electronic files of all approved submittal datasheets for all equipment, items and products installed in the Project. Update electronic Product Data Sheets to include equipment specifically utilized on the Project. Follow file format described in Electronic Product Literature, above. Include electronic Data Sheets from the original submittal CDs, if no modifications were made to the equipment or item modifications to equipment and hardware to be included here. Arrange all electronic Product Data Sheets on Record Document CDs by component type, as listed on the PROJECT CLOSEOUT DOCUMENT REFERENCE INDEX. Document Reference Index shall be grouped into the Closeout Document Folder under the division identified in the Project Checklist. Construction and as-installed drawings shall be placed in their respective folders in the division they belong.
1. After review and approval of RECORD DOCUMENTS by the Engineer and Architect, Contractor shall make revisions as noted to the Record Documents and provide all Record Drawings in pdf-format, and include in the electronic Operations and Maintenance Manual Sub-folder named: RECORD DRAWINGS. Each drawing sheet shall be a separate pdf-file with sheet name.
- C. Provide (1) blue line set, and (1) zip disk containing all ACAD drawing files.
- 1.7 CODES, STANDARDS, AND REQUIREMENTS OF REGULATORY AGENCIES
- A. Execute and inspect all work in accordance with Underwriters Laboratories (UL), and all local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the more stringent requirement shall be followed. Follow application sections and requirements and testing procedures of NFPA, IEEE, NEMA, CBM, ANSI, NECA, ICEA, and NETA.
 - B. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.
 - C. All material used on this project shall be U.L. listed and labeled and be acceptable to the Authority Having Jurisdiction as suitable for the use intended.
 - D. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
 1. All equipment to be installed to meet code requirements. Contractor to verify prior to installation and notify Architect, Owner and Engineer of any conflicts.
 2. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 3. Exterior wall and foundation penetrations
 4. Fire-rated wall and floor penetrations
 5. Equipment connections and support details.
 6. Sizes and location of required concrete pads and bases

7. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

1.8 GENERAL REQUIREMENTS

- A. Examine all existing conditions at building site.
- B. Review contract documents and technical specifications for extent of new work to be provided.
- C. Provide and pay for all permits, licenses, fees and inspections.
- D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access.
- E. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to equipment specifications in Divisions 02 through 26 for rough-in requirements.
- F. Coordinate electrical equipment and materials installation with other building components.
- G. Verify all dimensions by field measurements.
- H. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
- I. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
- J. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials. Conform to the requirements of Division 01, 02, 03 and 04. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted in Division 01.
- K. Where mounting heights are not detailed or dimensioned, install electrical services and overhead equipment to provide the maximum headroom possible.
- L. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Unless noted otherwise, do not route conduits on floor or in a manner that prevents access to equipment.
- M. Coordinate the installation of electrical materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, pneumatic tubes and other installations.

- N. Provide all access doors as may be required to maintain electrical equipment and connections located above ceilings. Access doors shall be fire rated to match ceiling in which they are installed. Provide in accordance with section 230500.
- O. Notify owner when work area is substantially complete, yet not concealed, so he can verify adequate service accessibility. Equipment requiring service shall be readily accessible.

1.9 INSTRUCTIONS, MAINTENANCE AND O&M MANUALS

- A. Prepare electronic Operation and maintenance manuals in .PDF file format accordance with Division 01 Section Operation and Maintenance Data. In addition to the requirements specified in Division 01, include the following information for equipment items identified in the Project Checklists below:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions, lubrication charts and schedules
 - 5. Complete list of parts and wiring diagrams.
 - 6. Names, addresses and telephone numbers of the Contractor, sub-contractors and local companies responsible for maintenance of each system or piece of equipment.
 - 7. The job name and address and Contractor's name and address shall be placed on the cover in a permanent manner. Dymo-tape is not acceptable. The Electronic O & M shall be sub-divided into specification section divisions by tabs, and shall include copies of approved shop drawings.
 - 8. Copies of all test reports shall be included in the manuals.
- B. Maintenance manuals are to be prepared in accordance with industry standards.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.11 TEMPORARY FACILITIES

- A. Provide temporary light, heating, power etc. services as necessary during the construction period and as required to maintain operation of existing systems.
- B. Light, Heat, Power, Etc.
 - 1. Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 01.
- C. Building distribution equipment and devices shall not be used without written permission of the Owner. If used for temporary power, the equipment shall be properly maintained and any damage resulting from use shall be repaired by the Contractor. The guarantee period for new equipment shall not begin until the equipment is turned over to the Owner.

1.12 DEMOLITION/REMODEL WORK

- A. Refer to Division 01 section on Summary of Work for requirements on working in Owner-occupied areas of the existing building and Division 02 section on selective demolition. The following expand the requirements specified in Division 01 and 02.
- B. Existing equipment that is removed and not scheduled to be reused shall remain the property of the Owner unless specifically indicated otherwise and shall be stored in a location designated by the Owner. Miscellaneous materials that are removed shall become the property of the Contractor.
- C. Existing equipment that is removed and is to be reused shall be cleaned, serviced and operable before being energized.
- D. Revise panelboard schedules to reflect removal or relocation of equipment. Circuit integrity of equipment shall be left intact.
- E. Where remodeling interferes with existing circuits and equipment which is not to be removed, such circuits and equipment shall be reworked and relocated as required to complete the project.
- F. The project involves renovation and remodel of the existing building. On the drawings, certain renovation symbols are used. These symbols are amplified as follows:
 - R = Existing items to be removed. Contractor shall remove the existing item and turn over to the Owner. The existing wiring shall be removed. Where the raceway serving the equipment is accessible (via removal of suspended ceiling, crawl space, etc.) The raceway shall also be removed. Where the removal of a raceway leaves visible evidence on an existing surface which is not being repaired or replaced as part of the Work, this Contractor shall repair the surface. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed. Where the concealed raceway is uncovered by demolition performed as part of the Work, the raceway shall be removed (or extended to new location if appropriate).
 - E = Existing item to remain in place. Contractor shall perform the following function based upon the item to remain:
 - Luminaries - Clean and re-lamp
 - Switches - Remove and replace with new in existing box.

- Receptacles - Remove and replace with new in existing box.
- RL = Existing item to be relocated. Contractor shall remove the existing item, and store in a safe place. The existing item shall be relocated to the new position as called for on the drawings. At contractors option, the existing wiring may be extended, or new wiring may be run from the source. Based upon the item to be relocated, the Contractor shall perform the following function:
- Luminaries - Clean and re-lamp
 Switches - Replace.
 Receptacles - Replace.

- G. The Contractor shall remove all distribution equipment, conductors, etc. which are indicated to be removed or which must be removed to accommodate demolition. Equipment to be removed may require reworking conduit and wiring in order to maintain service to other equipment.
- H. Where remodeling interferes with circuits serving areas outside of the project or phase limits or which are remodeled in later phases of the project, circuits shall be reworked or temporary circuits provided as required.
- I. Existing equipment and circuiting shown are based upon field surveys and/or Owner furnished drawings. The Contractor shall verify conditions as they exist with necessary adjustments being made to the drawing information.
- J. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated within the Contract Documents.
- K. Electrical Outages:
1. Contractor shall submit a Method of Procedure (MOP) for each outage to the Owner detailing the reasons for the outage, areas affected, sequence of procedures to accomplish work, estimated maximum duration, the date and time of day outage will occur. The Contractor shall meet with the Owner to set a schedule and date for the outage based upon the MOP. Due to the critical implications of power outage, the Owner may direct the Contractor as to the time of day or night and date an outage may take place. A 7 day notice is required.

1.13 SAFETY AND INDEMNITY

- A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.
- B. No act, service, drawing, review, or construction review by the Owner, Architect, the Engineers or their consultants is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.
- C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, Engineers and their consultants, and each of their officers and employees and agents, from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons and for all damages arising out of injury to or destruction of property arising directly or indirectly out of or

in connection with the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents, but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers and employees and agents.

1.14 ACCEPTANCE

- A. Upon completion of the mechanical systems covered by these specifications, a certificate of approval and acceptance will be issued for each system. This certificate will in no way relieve this Contractor from the terms of his guarantee. Refer to Division 01.

1.15 WARRANTIES

- A. Refer to the General Conditions and Division 01 for procedures and submittal requirements for warranties. All equipment shall be provided with a minimum one year warranty to include parts and labor. Refer to individual equipment specifications for extended or longer term warranty requirements.
- B. Provide complete warranty information for each item, to include product or equipment, and date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.16 GUARANTEE

- A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year after the Date of Final Acceptance, ordinary wear and tear excepted.
- B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in his work.

1.17 PROJECT CHECKLIST

- A. In addition to the requirements specified in Division 1 complete the requirements listed below.
- B. The contractor shall be responsible for the following Project checklist either by performing and/or coordinating such items throughout the term of the project and provide all closeout requirements prior to applying for certification of substantial completion.
 - 1. Refer to "Instructions, Maintenance, O&M Manuals" for Electronic O&M folder requirements. Include service manuals, programming manuals, sequence of operations, settings, as-installed software register definitions, block diagrams and point to point wiring diagrams. Equipment required to have owner-assigned Barcodes are identified in specification section 017901 and are to be coordinated and included with the owners "Closeout Document Reference Index."

2. O&M's to be submitted at 50% phase of project for review. Include bill of material(s) under each section tab, in addition to other identified required maintenance information. Include all test reports required in identified specification sections.
3. Refer to individual specification sections for additional requirements.
4. Spare Parts:
 - a. Submit master list of spare parts and extra materials as part of submittals. Refer to individual specification sections for requirements.
 - b. Turn over spare parts to General Contractor for delivery to Owner, via signed transmittals.
 - c. Include spare parts list and transmittals under separate tabs in O&M's.
5. Refer to Project Close Out Value Schedule for values that will be withheld from the contractor's final payment until Project Check List requirements are complete.
6. Submit schedule of values to the Architect and Engineer as part of the submittal process and as part of the closeout. Include all C.O. etc in the closeout schedule of values.

C. Division 26

SPEC SECTION	ITEM	REQUIREMENTS										
		SUBMITTALS			SUPPLEMENTAL INFORMATION IDENTIFIED IN SPEC SECTION		FACTORY REP SUPERVISION AT SITE	** TRAINING REQ'D AT SITE	SPARE PARTS/** EXTRA MATERIAL	At completion of project obtain owners sign off that the owner has received the following: Include owner sign off in O & M's		
		SHOP DRAWING	PRODUCT DATA	INCLUDE IN O&M	TESTING REQUIREMENTS	REPORT REQUIREMENTS				TRAINING FOR PRODUCTS SPARE PARTS/EXTRA MATERIALS	DOCUMENT	
	SCHEDULE OF VALUES			X		X						
260126	ENGINEERING ANALYSIS AND ELECTRICAL SYSTEMS TESTING		X	X	X	X						
260500	BASIC ELECTRICAL REQUIREMENTS											
260500	CONTRACTOR/EQUIPMENT WARRANTIES			X		X						X
260500	O&M MANUALS (ELECTRONIC FILE)								X	X	X	
260500	COORDINATION DRAWINGS	X										

SPEC SECTION	ITEM	REQUIREMENTS										
		SUBMITTALS			SUPPLEMENTAL INFORMATION IDENTIFIED IN SPEC SECTION		FACTORY REP SUPERVISION AT SITE	** TRAINING REQ'D AT SITE	SPARE PARTS/** EXTRA MATERIAL	At completion of project obtain owners sign off that the owner has received the following: Include owner sign off in O & M's		
		SHOP DRAWING	PRODUCT DATA	INCLUDE IN O&M	TESTING REQUIREMENTS	REPORT REQUIREMENTS				TRAINING FOR PRODUCTS SPARE PARTS/EXTRA MATERIALS	DOCUMENT	
260500	RECORD DRAWINGS (PAPER AND ELECTRONIC FILE)	X		X							X	
260519	WIRES AND CABLES		X	X	X	X						
260526	GROUNDING	X	X	X		X						
260529	SUPPORTING DEVICES	X	X	X	X	X						
260533	RACEWAYS BOXES AND CABINETS		X									
260548	VIBRATION ISOLATION FOR ELECTRICAL WORK	X	X	X	X	X						
260553	ELECTRICAL IDENTIFICATION	X	X									
260573	OVERCURRENT PROTECTIVE DEVICES	X	X	X								
262413	SWITCHBOARDS	X	X	X	X	X	X	X		X	X	
262416	PANELBOARDS	X	X	X	X	X			X		X	
262726	WIRING DEVICES		X	X	X	X						
262813	FUSES	X	X	X					X		X	
262913	CIRCUIT AND MOTOR DISCONNECTS	X	X	X	X							
263600	TRANSFER SWITCHES	X	X	X	X	X	X	X		X		
264313	TRANSIENT VOLTAGE SURGE SUPPRESSORS	X	X	X	X	X		X		X		

D. Electrical Project Close-out Value Schedule

1. The following values will be withheld from the contractor's final payment until such time as satisfactorily delivered to the Owner. (Amounts identified are for each item listed in the owners "Closeout Document Reference Index" by "Equipment Identifiers.")
2. Record Drawings (Bond paper prints and Electronic files) \$500.00 per sheet
 - a. Electronic O+M Manuals
 - 1) Electrical
 - a) Switchboards \$400.00
 - b) Packaged Engine Generators \$2500.00
 - c) Transfer Switches \$400.00

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL

- A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.
- B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work unless so indicated on Drawings or approved by Architect.

3.2 MANUFACTURER'S DIRECTIONS

- A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications

3.3 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 02 through 26 for rough-in requirements.

3.4 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of electrical systems with existing utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form and do not necessarily indicate every required conduit, box, fitting, etc. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect and Owner. The Owner reserves the right to make any changes in outlet, lighting or equipment locations prior to rough-in without additional cost. Change shall be interpreted as including any change of up to ten feet from the locations indicated on the drawings.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Install equipment and materials to maintain code required clearances and access.
11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in section 250500 Section "ACCESS DOORS and Access Panels".
12. Install systems, materials, and equipment giving right of way priority to systems required to be installed at a specified slope. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, space for mechanical and electrical systems within the cavity shall be allocated in the following order:
 - a. Plumbing waste, vent piping and roof drain mains and leaders.
 - b. Supply, return and exhaust ductwork.
 - c. Fire sprinkler mains and leaders
 - d. Electrical conduit
 - e. Domestic hot and cold water
 - f. Pneumatic control piping
 - g. Fire sprinkler branch piping and sprinkler run outs.
 - h. Junction boxes shall not be located above grid ceiling tiles containing sprinkler heads.

3.5 CUTTING AND PATCHING

- A. General: Perform cutting and patching in accordance with Division 01 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 01, the following requirements apply:
1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Uncover Work to provide for installation of ill-timed Work.
 - b. Remove and replace defective Work.
 - c. Remove and replace Work not conforming to requirements of the Contract Documents.
 - d. Remove samples of installed Work as specified for testing.
 - e. Install equipment and materials in existing structures.
 - f. Upon written instructions from the Architect and Owner, uncover and restore Work to provide for Architect and Owner observation of concealed Work.
 2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
 6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
 - a. Refer to Division 01 Section General Requirements for definition of experienced "Installer."
 7. Arrange for repairs required to restore other work, because of damage caused as a result of electrical installations.
 8. No additional compensations will be authorized for cutting and patching Work that is necessitated by ill-timed, defective, or non-conforming installations.

3.6 TESTING/INSPECTION SUMMARY

- A. Following is a list of items requiring inspections and/or testing as part of this contract. It is an attempt to summarize the requirements from individual Division 26 sections in a single location for owner and contractor convenience. Failure to list an item here that is included within individual Division 26 sections does not give the contractor cause to delete that scope of work. See specific Division 26 sections for more detailed scope requirements.

- B. See section 260126 Engineering Analysis and Electrical Systems testing for additional requirements

END OF SECTION 260500

SECTION 260519 - WIRES AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections: The following Sections contain requirements that relate to this section:
 - 1. Division 02 Section "Earthwork" for trenching and backfilling.
 - 2. Division 26 Section "Basic Electrical Requirements."
 - 3. Division 26 Section "Electrical Identification" for conductor and cable color coding and identification.
 - 4. Division 26 Section "Electrical Boxes and Fittings" for connectors for Terminating Cables in boxes and other electrical enclosures

1.2 SUMMARY

- A. This Section includes wires, cables, and connectors for power, lighting, control and related systems rated 600 volts and less.

1.3 SUBMITTALS

- A. None required.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the following code:
- B. NFPA 70 "National Electrical Code."
 - 1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.
- C. UL Compliance: Provide components which are listed and labeled by UL under the following standards.
 - 1. UL Std. 4 Armored Cable.
 - 2. UL Std. 83 Thermoplastic-Insulated Wires and Cables.
 - 3. UL Std. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 4. UL Std. 854 Service Entrance Cable.

- D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
1. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 2. WC-7 Cross Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 3. WC-8 Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- E. IEEE Compliance: Provide components which comply with the following standard.
1. Std. 82 Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wire and Cable:
 - a. Alflex
 - b. AFC
 - c. American Insulated Wire Corp.
 - d. Rome
 - e. Southwire Company
 2. Connectors for Wires and Cable Conductors:
 - a. AMP
 - b. 3M Company
 - c. O-Z/Gedney Co.
 - d. Square D Company

2.2 CONDUCTORS AND CABLES

- A. General: Provide wire and cable suitable for the temperature, conditions and location where installed.
- B. Conductors: Provide stranded conductors for all power and lighting circuits. Solid conductors are not acceptable.
- C. Conductor Material: Copper for all conductors and cables except where shown on the aluminum feeder schedule and only in the feeder sizes noted. Aluminum wiring shall be Stabiloy AA-8830, XHHW-2 type only.

- D. Insulation: Provide THHN/THWN insulation, 90 degrees C as a minimum, for all conductors size 500 KCMIL and larger, and no. 8 AWG and smaller. For all other sizes provide THW, THHN/THWN or XHHW insulation as appropriate for the locations where installed. Use low leakage copper wire (XHHW-2) for all wiring connected to isolation panels, heat trace cable interconnect wiring, GFCI breakers and other locations and where noted herein.
- E. Color Coding for phase identification in accordance with 260553.3.A., Identification.
- F. Jackets: Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90 deg. bends, for pulls in conduits underground or under slabs on grade, and where indicated.

2.3 CONNECTORS AND LUGS

- A. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.
- B. Insulated Spring Connectors: Ideal Wire Nut, 3M Scotchlok and Hyflex.
- C. Insulated Self Stripping Connectors: 3M 560 and 562.
- D. Insulated Crimp Sleeve Connectors: Scotchlok S-31, Panduit VN.
- E. Screw Terminal Lugs: Compression tool applied, insulated, flanged or locking fork; Panduit PN-FF and PN-LF, Burndy, TP and YAE-Z.
- F. Crimp Splice Connectors: Circumferential compression tool applied, with 600V heat shrink insulation; Square D Types VACS with VSS, Kearney, Panduit, Burndy, T&B.
- G. Crimp Lug: Circumferential compression tool applied for bolted connection, Panduit Panterm, Square D Type VCEL, Kearney, T&B. Use long barrel, multiple crimp, two hole lugs wherever possible. Set-screw type lugs are to be used only where crimp type lugs are not possible.
- H. Crimp Tap Connector: Compression tool applied for parallel connections; Square D Type VACC and VACT, T&B, Panduit.
- I. Mechanical Lugs: Set screw, clamp type for 2 AWG and larger; Square D, Burndy, IlSCO. Use two screw per conductor type lugs wherever possible and where crimp type lugs are not possible.
- J. Joint Compound: Burndy Penetrox, Square D Versa-Seal.
- K. Exothermically Welded: Erico Cadweld or approved substitute.
- L. Vertical Conduit Conductor Clamp Fittings: Burndy or approved substitute.

PART 3 - EXECUTION

3.1 WIRING METHOD

- A. Use the following wiring methods as indicated:
1. Conductors: install all conductors in raceway.
- B. Install the following minimum sizes of copper conductors for interior wiring of 20-ampere branch circuits for applications and circuit lengths unless otherwise indicated. For circuit lengths exceeding the scheduled values install as shown. Refer cases of uncertain applicability to the Engineer for resolution prior to conduit rough-in and install as directed as part of the Contract work. Circuits lengths are total current path, device terminal to device terminal. Integral device and fixture wires are excluded.

Application	Circuit Length (ft.)	Min. Size (AWG)
277V lighting total of through wiring & home run	0-150	12
	151-250	10
	250-400	8
277V lighting total of switch tap & switched leg to fixture	0-100	12
	101-200	10
	201-300	10
120V lighting total of through wiring & home run	0-75	12
	76-125	10
	126-200	10
120V lighting total of switch tap & switched leg to fixtures	100	12
	101-150	10
120V General Purpose receptacle total of through wiring & home run	0-50	12
	51-125	10
	126-200	10
120 V General Purpose receptacle total of circuit tap to device	0-50	12
	51-100	10
	101-150	10

- C. The above table is superceded if larger conductor sizes are shown on the drawings or specified elsewhere such as on site plan drawings.
- D. Install copper equipment ground conductor with all branch circuits; see Section 260526 "Grounding." Increase branch circuit equipment ground conductor sizes in accordance with NEC for voltage drop.
- E. All home runs, through wiring, exposed areas, buried or in-slab conditions, concealed circuits which become inaccessible in the finished work, feeders, special purpose outlets, special purpose receptacles and workstation receptacle power circuits must be installed in raceway, unless otherwise noted.

- F. Install cross linked polyethylene insulated hot and neutral conductors with dielectric constant of 3 on load side of ground fault circuit interrupters when one-way circuit length exceeds 50'; 600V type XLP typical.
- G. Portable Cord Type S: For flexible pendant leads to outlets and equipment where permitted by Code and as indicated.
- H. Installation of the following conductor and cable types for permanent wiring is prohibited:
 - 1. Aluminum Conductors: Prohibited.
 - 2. Nonmetallic Sheathed Cable Types NM and NMC: Prohibited.
 - 3. Service Entrance Cable, Types SE and USE: Prohibited.

3.2 INSTALLATION OF POWER WIRES AND CABLES

- A. General: Install electrical cables, wires, and connectors in compliance with NEC.
- B. Coordinate cable installation with other Work.
- C. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- D. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.
- E. Conceal all cable in finished spaces.
- F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible.
- G. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than no. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal. Identify neutral with correct phase conductor at each j-box and panel.
- H. Provide conductor clamp type supports in NEMA enclosures at code required intervals on vertical conduit runs. Terminations shall not bear the weight of the conductors.
- I. MC cable is a) permissible to be used in lieu of EMT conduit and conductors for all power circuits, except as noted herein. b) MC cable shall only be used for the drops concealed inside walls inside of a room down to the final branch device or below a raised floor. Do not run MC cable exposed to normal view. c) Conduit shall be used for all homeruns and "through-wiring" connections between rooms.
- J. All branch circuits shall be provided with separate neutral and shall not share a common neutral. Branch circuit breakers with tie bars are not acceptable.

3.3 CONNECTORS AND INSULATION

- A. Install splices only where such circuits must branch; splice conductors only at outlet boxes, junction boxes and splice boxes. Keep conductor splices to minimum.
- B. Install splice and tap connectors, which possess equivalent or better mechanical strength and insulation rating than conductors being spliced.
- C. Use splice and tap connectors which are compatible with conductor material.
- D. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.
- E. Join power limited circuit conductors with insulated crimp sleeve connectors and terminate in screw terminal lugs, except where otherwise required.
- F. Join 8 AWG or larger with crimp compression connectors wherever possible and insulate the joint equal to the insulation of the conductors. Mechanical connectors are allowed only in devices such as circuit breakers, where crimp connections are not available.
- G. Crimp Required: Install only crimp connectors and crimp lugs for wet locations such as junction boxes below grade. Install only crimp connectors and crimp lugs for separate grounding conductors larger than 10 AWG; comply with Section 260526 "Grounding."
- H. Lug Adaptors: Use crimp butt splices and short piece of 10 AWG conductor to adapt oversize 277-volt and 120-volt 20-ampere branch circuit conductors to lugs of devices (branch circuit breakers, contactors, etc.) labeled for 10 AWG maximum size conductors.
- I. Crimp Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor. Insulate splices equal to conductor insulation system.
- J. Use insulated self-stripping connectors only where specifically indicated; otherwise prohibited.
- K. Electrical contractor to provide all lugs inside switchboards, distribution boards, switchgear, panelboards, on bus bars, etc, except where the lugs are an integral part of a circuit breaker. Provide specified crimp type lugs wherever possible. This is to prevent mis-coordination issues between equipment vendors, changes in feeder sizes and type of lugs required.

3.4 IDENTIFICATION

- A. Refer to specification section 260553.

3.5 FIELD QUALITY CONTROL

- A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.
- B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.
- C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

END OF SECTION 260519

SECTION 260526 – GROUNDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."

1.2 SUMMARY

- A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.
- B. Related Sections: The following sections contain requirements that relate to this Section:
 - 1. Division 26 Section "Wires and Cables."

1.3 SUBMITTALS

- A. None required.

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
 - 1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- B. Field-Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.
- C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).

- D. UL Standard: Comply with UL 467, "Grounding and Bonding Equipment."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Anixter Bros., Inc.
 - 2. A.B. Chance Co.
 - 3. Engineered Products Co.
 - 4. Erico Products, Inc.
 - 5. GB Electrical, Inc.
 - 6. Ideal Industries, Inc.
 - 7. Kearney-National.
 - 8. O-Z/Gedney Co.
 - 9. Raco, Inc.
 - 10. Thomas & Betts Corp.

2.2 GROUNDING AND BONDING PRODUCTS

- A. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.
- B. Conductor Materials: Copper.

2.3 WIRE AND CABLE CONDUCTORS

- A. General: Comply with Division 26 Section "Wires and Cables." Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.
- B. Equipment Grounding Conductor: Green insulated.
- C. Grounding Electrode Conductor: Stranded cable. Do not use conductors with greater than 7-strands in direct burial applications. Smaller strands do not last as long.
- D. Bare Copper Conductors: Conform to the following:
 - 1. Solid Conductors: ASTM B-3.
 - 2. Assembly of Stranded Conductors: ASTM B-8.
 - 3. Tinned Conductors: ASTM B-33.

2.4 MISCELLANEOUS CONDUCTORS

- A. Ground Bus: Bare annealed copper bars of rectangular cross section.

- B. Braided Bonding Jumpers: Copper tape, braided No. 30 gage bare copper wire, terminated with copper ferrules.
- C. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.5 CONNECTOR PRODUCTS

- A. General: Listed and labeled as grounding connectors for the materials used.
- B. Pressure Connectors: High-conductivity-plated units.
- C. Bolted Clamps: Heavy-duty units listed for the application.
- D. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.
- E. Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lighting Protection Components," or UL 467.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Equipment Grounding Conductor Application: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.
 - 1. Install separate insulated equipment grounding conductors with circuit conductors for the following in addition to those locations where required by Code:
 - a. Feeders and branch circuits.
 - b. Lighting circuits.
 - c. Receptacle Circuits.
 - d. Single-phase motor or appliance circuits.
 - e. Three-phase motor or appliance branch circuits.
 - 2. Busway Circuits: Install separate insulated equipment ground conductor from the ground bus in the switchgear, switchboard, or distribution panel to the equipment ground bar terminal on the busway.
 - 3. Data Center Panel Circuits: Install separate insulated equipment ground wire in branch circuits from data center power panels.
 - 4. Nonmetallic Raceways: Install an insulated equipment ground conductor in nonmetallic raceways unless they are designated for telephone or data cables.
 - 5. Air Duct Equipment Circuits: Install an insulated equipment grounding conductor to duct-mounted electrical devices operating at 120-V and above including air cleaners and heaters. Bond the conductor to each such unit and to the air duct.

6. Water Heater, Heat Tracing, and Anti-Frost Heater Circuits: Install separate insulated equipment ground conductor to each electric water heater, heat tracing, and surface anti-frost heating cable. Bond this conductor to heater units, piping, and connected equipment and components.
- B. Signal and Communications: For telephone, alarm, and communication systems, provide a #4 AWG minimum green insulated copper conductor in raceway from the grounding electrode system to each terminal cabinet or central equipment location.
- C. Separately derived systems required by NEC to be grounded shall be grounded in accordance with NEC paragraph 250-26.
- D. Provide code sized grounding conductor bonded to "incoming water pipes" and all other metallic pipes in addition to the domestic water.

3.2 INSTALLATION

- A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.
- B. Electrical room Ground Bus: Size, location, and arrangement as indicated. Space 1 inch from wall and support from wall 6 inches above finished floor, except as otherwise indicated.
- C. Ground Rods: Locate a minimum of one-rod length from each other and at least the same distance from any other grounding electrode. Interconnect ground rods with bare conductors buried at least 24 inches below grade. Connect bare-cable ground conductors to ground rods by means of exothermic welds except as otherwise indicated. Make these connections without damaging the copper coating or exposing the steel. Use 3/4-inch by 10-ft. ground rods except as otherwise indicated. Drive rods until tops are 6 inches below finished floor or final grade except as otherwise indicated.
- D. Metallic Water Service Pipe: Provide insulated copper ground conductors, sized as indicated, in conduit from the building main service equipment, or the ground bus, to main metallic water service entrances to the building. Connect ground conductors to the main metallic water service pipes by means of ground clamps. Where a dielectric main water fitting is installed, connect the ground conductor to the street side of the fitting. Do not install a grounding jumper around dielectric fittings. Bond the ground conductor conduit to the conductor at each end.
- E. Braided-Type Bonding Jumpers: Install to connect ground clamps on water meter piping to bypass water meters electrically. Use elsewhere for flexible bonding and grounding connections.
- F. Route grounding conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.
- G. Bond interior metal piping systems and metal air ducts to equipment ground conductors of pumps, fans, electric heaters, and air cleaners serving individual systems.

3.3 CONNECTIONS

- A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
 - 2. Make connections with clean bare metal at points of contact.
 - 3. Aluminum to steel connections shall be with stainless steel separators and mechanical clamps.
 - 4. Aluminum to galvanized steel connections shall be with tin-plated copper jumpers and mechanical clamps.
 - 5. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.
- B. Exothermic Welded Connections: Use for connections to structural steel and for underground connections except those at test wells. Install at connections to ground rods and plate electrodes. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.
- D. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.
- E. Compression-Type Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.
- F. Moisture Protection: Where insulated ground conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

3.4 FIELD QUALITY CONTROL

- A. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.
- B. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified, at service disconnect enclosure ground terminal, and at ground test wells. Measure ground resistance without the soil being moistened by any

means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method in accordance with Section 9.03 of IEEE 81, "Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System."

- C. Ground/resistance maximum values shall be as follows:
 - 1. Equipment rated 500 kVA and less: 3 Ohms
 - 2. Equipment rated 500 kVA to 1000 kVA: 3 Ohms
 - 3. Equipment rated over 1000 kVA: 3 Ohms
- D. Deficiencies: Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated the provisions of the Contract, covering changes will apply.
- E. Report: Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

3.5 CLEANING AND ADJUSTING

- A. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other Work to their original condition. Include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, or mulching. Perform such Work in accordance with Division 02 Section "Landscape Work." Maintain disturbed surfaces. Restore vegetation in accordance with Section "Landscape Work." Restore disturbed paving as indicated.

END OF SECTION 260526

SECTION 260529 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Sections apply to this section:
 - 1. Division 26 "Basic Electrical Requirements."
 - 2. Division 03 Section "Concrete" for inserts, anchors, and sleeves to be installed in concrete for use with supporting devices.
 - 3. Division 05 Section "Metal" for requirements for miscellaneous metal items involved in supports and fastenings.
 - 4. Division 07 Section "Thermal and Moisture Protection" for requirements for Fire stopping at sleeves through walls and floors that are fire barriers.
 - 5. Refer to other Division 26 sections for additional specific support requirements that may be applicable to specific items.

1.2 SUMMARY

- A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product data for each type of product specified.
 - 1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.
- C. Shop drawings indicating details of fabricated products and materials.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

- B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

1.5 SEISMIC ANCHORAGE/RESTRAINT REQUIREMENTS

- A. Intent: It is the intent of the seismic portion of this specification to keep all electrical building system components in place during a seismic event. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
- B. This specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
- C. Seismic Zone Rating: All equipment and wiring shall be anchored to withstand forces generated by earthquake motions and certified to meet all applicable seismic requirements of the jobsite area.
- D. Contractor shall engage and pay for the services of a structural engineer, registered in the state of the project, with a minimum of 5 years experience in the industry, to perform structural design and submit installation details and calculations for the support of the following items: The Contractor shall provide assistance and proposed installation sketches to structural engineer as required.
 - 1. All electrical busway, overhead cable trays and ladder trays.
 - 2. All fire protection equipment and life safety equipment shall be seismically restrained using the required seismic force levels for life safety equipment.
 - 3. Wall mounted and ceiling hung equipment greater than or equal to 400 lbs.
 - 4. Conduit trapeze racks supporting more than two conduits where any conduit is greater than 1.25" in diameter.
 - 5. Anchor bolt calculations, signed and stamped by a licensed Structural Engineer in the state of the project, shall be submitted showing adequacy of the bolt sizing and type. Provide anchor bolts or drill in anchors that are seismically approved and properly selected, based on design calculations through the center of gravity. Anchor bolts must be embedded and spaced in accordance with ICBO standards.
 - 6. Seismic restraint exclusions:
 - a. All conduit less than 2.5" diameter suspended by individual hanger rods.
 - b. All conduits suspended by individual hangers 12" or less as measured from the top of the conduit to the bottom of the support where the hanger is attached. However, if the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run.
 - c. The 12" exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.

- E. When the exact location of conduit racks and equipment have been established, the Contractor's Structural Engineer shall check the adequacy of the building structure to ensure that the installation is adequate.
- F. Seismic calculations are not required for items not included in the above list, but the Contractor shall support all equipment and wiring in accordance with recognized seismic restraint design guidelines such as the "Superstrut: Seismic Restraint System" for conduits, and the "Kin-line: Seismic Restraint System" for conduits and "Mason Industries Seismic Restrain Guidelines." All suspended equipment must be braced against sway and axial motion. Cable braces or solid braces shall be used. Suspension rods shall include "strongback" bracing to prevent buckling when subjected to compression stress.
- G. Definitions:
 - 1. Life Safety Systems:
 - a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.
 - b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flow paths to fire protection and/or emergency lighting systems.
 - c. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.
 - 2. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.
 - 3. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.
 - 4. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.
- H. Submittal Data Requirements: The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:
 - 1. Descriptive Data:
 - a. Catalog cuts or data sheets on vibration isolating pads, anchor bolts and other specific restraints or supports detailing compliance with the specification.
 - b. Detailed schedules of flexible and rigidly mounted equipment, showing seismic restraints by referencing numbered descriptive drawings.
 - 2. Shop Drawings:
 - a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
 - b. Provide all details of suspension and support for ceiling hung equipment.

- c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for conduit and equipment must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
 - d. Provide specific details of seismic restraints and anchors; include the number, size, and type of anchor bolts, support rods/unistrut, cable restraints, etc., for each piece of equipment.
 - e. Provide specific structure details and design for housekeeping pad reinforcement and non-monolithic pad attachment. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.
3. Complete engineering calculations and drawings for all vibration and seismic requirements for all equipment, piping and ductwork.
 4. Seismic Certification and Analysis:
 - a. Seismic restraint calculations shall be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
 - b. All restraining devices shall have a pre-approval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Pre-approvals based on independent testing are preferred to pre-approvals based on calculations. Where pre-approved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45° to the weakest mode.
 - c. Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in following section acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.
- I. Related Work:
 1. Supplementary Support Steel: Contractor shall supply supplementary support steel for all equipment and wiring, etc., as required or specified.
 2. Attachments: Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the structural engineer's calculations.

J. Products:

1. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cables must be prestretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.
2. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be type SSB as manufactured by Mason Industries, Inc.
3. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.
4. Anchor bolts shall be manufactured by Hilti Redtop diameter and penetration depth as required for each application.

K. Execution:

1. General: All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
2. Installation of seismic restraints must not cause any change of position of equipment resulting in stresses or misalignment.
3. No rigid connections between equipment and the building structure shall be made that transmits noise or vibration. Provide specified flexible wiring connections and neoprene isolation pads for transformers and rotating or vibrating machinery. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
4. Coordinate work with other trades to avoid rigid contact with the building.
5. Any conflicts with other trades which will result in rigid contact with equipment or wiring due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractors expense.
6. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractors expense.
7. Correct, at no additional cost, all installations, which are deemed defective in workmanship and materials at the contractor's expense.

8. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:
 - a. Flanges of structural beams.
 - b. Upper truss cords in bar joist construction.
 - c. Cast in place inserts or wedge type drill-in concrete anchors.
9. Cable restraints shall be installed slightly slack only where required to not short-circuit the intent of isolating equipment that may transmit noise or vibration. Cable assemblies shall be installed taut on non-isolated systems. Seismic solid braces may be used in place of cables on rigidly attached systems only.
10. Support rods must be braced as required by design guidelines to prevent buckling under compressive loading condition.
11. Provide drill-in type male concrete anchors for ceiling and wall installation and female wedge type for floor mounted equipment.
12. Transverse restraints shall occur at 30' intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.
13. Longitudinal restraints shall occur at 60' intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a duct for an electric section connected perpendicular to it if the restraints are installed within 4' of the intersection of the electric run and if the restraints are sized for the larger electric run.
14. All rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Anchor bolts shall be designed in accordance with specified seismic forces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Slotted Metal Angle and U-Channel Systems:
 - a. Allied Tube & Conduit
 - b. B-Line Systems, Inc.
 - c. GS Metals Corp.
 - d. Unistrut Diversified Products
 2. Conduit Sealing Bushings:
 - a. Cooper Industries, Inc.
 - b. GS Metals Corp.
 - c. Killark Electric Mfg. Co.
 - d. O-Z/Gedney
 - e. Raco, Inc.
 - f. Spring City Electrical Mfg. Co.

- g. Thomas & Betts Corp.

2.2 COATINGS

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- B. Fasteners: Types, materials, and construction features as follows:
 - 1. Expansion Anchors: Carbon steel wedge or sleeve type.
 - 2. Toggle Bolts: All steel springhead type.
 - 3. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.
 - 4. Steel nail-in fasteners are not acceptable.
- C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.
- E. U-Channel Systems: 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.4 FABRICATED SUPPORTING DEVICES

- A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.
- B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

- C. Pipe Sleeves: Provide pipe sleeves of one of the following:
 - 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
 - a. 3-inch and smaller: 20-gage.
 - b. 4-inch to 6-inch: 16-gage.
 - c. Over 6-inch: 14-gage.
 - 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 - 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with the building structural system and with other electrical installation.
- C. Raceway Supports: Comply with the NEC and the following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
 - 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 - 6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
 - 7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
 - 8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
- D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

- E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.
- G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire-rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Fire Resistant Joint Sealers" requirement of Division 07 Section "Joint Sealers."
- H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
 - 1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
 - 2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
 - 3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1)	EMT (1)	RNC (1)
1/2,3/4	1 or 2	Flat ceiling or wall. Where it is difficult to provide supports except at intervals fixed by the building construction.	5	5	3
1/2,3/4	1 or 2	Flat ceiling or wall. Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7	---
1/2,3/4	3 or more	Any location	7	7	---
1/2-1	3 or more	Any location	6	6	---
1 & larger	1 or 2	Flat ceiling or wall. Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	---
1 & larger	1 or 2	Flat ceiling or wall. Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	---

VERTICAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1,3)	EMT (1)	RNS (1)
1/2,3/4		Exposed	7	7	
1,1-1/4		Exposed	8	8	
1-1/2 and larger		Exposed	10	10	
Up to 2		Shaftway	14	10	
2-1/2		Shaftway	16	10	
3 & larger		Shaftway	20	10	
Any		Concealed	10	10	

NOTES:

(1) Maximum spacing of supports (feet).

(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations:

EMT Electrical metallic tubing.

IMC Intermediate metallic conduit.

RMC Rigid metallic conduit.

RNC Rigid nonmetallic conduit.

END OF SECTION 260529

SECTION 260533 - RACEWAYS, BOXES, AND CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. Division 07 Section "Fire-stopping."
 - 2. Division 26 Section "Basic Electrical Requirements."
 - 3. Division 26 Section "Supporting Devices" for raceway and box supports.
 - 4. Division 26 Section "Grounding."
 - 5. Division 26 Section "Electrical Identification."
 - 6. Division 26 Section "Wiring Devices" for devices installed in boxes and floor box service fittings.

1.2 SUMMARY

- A. This Section includes metallic and nonmetallic conduit and tubing, telephone duct, special raceways, fittings, wall and floor outlet boxes, enclosures, under-floor duct systems and cabinets.
- B. Raceways include the following:
 - 1. Rigid metal conduit (GRC)
 - 2. Intermediate metal conduit
 - 3. Polyvinyl chloride (PVC) externally coated rigid steel conduit
 - 4. PVC externally coated intermediate metal conduit
 - 5. Electrical metallic tubing (EMT)
 - 6. Flexible metal conduit
 - 7. Liquidtight flexible conduit
 - 8. Rigid nonmetallic conduit
 - 9. Wireway
 - 10. Surface raceways
- C. Boxes, enclosures, and cabinets include the following:
 - 1. Device boxes
 - 2. Outlet boxes
 - 3. Pull and junction boxes
 - 4. Cabinets and hinged cover enclosures

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.
 - 1. Product data for surface raceway, wireway and fittings, floor boxes, hinged cover enclosures, and cabinets.
 - 2. Shop drawings for nonstandard boxes, enclosures, and cabinets. Include layout drawings showing components and wiring.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" , as amended by the State of Oregon Electrical Specialty Code, for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed and Labeled": As defined in the "National Electrical Code," Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- C. Comply with NECA "Standard of Installation."
- D. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide Products by of one of the following:
 - 1. Metal Conduit and Tubing:
 - a. Monogram Co., AFC
 - b. Allied Tube and Conduit, Grinnell Co.
 - c. Anixter Brothers, Inc.
 - d. Carol Cable Co., Inc.
 - 2. Nonmetallic Tubing and Conduit:
 - a. Carlon
 - b. Certainteed Corp, Pipe & Plastics Group
 - c. Cole-Flex Corp.
 - d. Condux International, Electrical Products
 - e. Electri-Flex Co.

- f. PW Pipe
- 3. Conduit Bodies and Fittings:
 - a. Carlon
 - b. Hubbell, Inc., Killark Electric Manufacturing Co.
 - c. General Signal, O-Z/Gedney Unit
 - d. Crouse Hinds
 - e. RACO
 - f. Regal
- 4. Wireway:
 - a. Hoffman Engineering Co.
 - b. Circle AW
 - c. Square D Co.
 - d. B-Line
- 5. Surface Metal Raceway:
 - a. See respective section below.
- 6. Surface Nonmetallic Raceway:
 - a. Anixter Brothers, Inc.
 - b. Butler Manufacturing Co., Walker Division
 - c. Hubbell, Inc., Wiring Device Division
 - d. Panduit Corp.
 - e. The Wiremold Co., Electrical Sales Division
- 7. Boxes, Enclosures, and Cabinets:
 - a. Cooper Industries, Midwest Electric
 - b. Hoffman Engineering Co., Federal-Hoffman, Inc.
 - c. Raco, Inc., Hubbell Inc.
 - d. Square D Co.
 - e. Thomas & Betts Corp.
 - f. Walker Duct
 - g. B-Line

2.2 METAL CONDUIT AND TUBING

- A. Galvanized Rigid Conduit (GRC): Rigid steel conduit, threaded-type hot-dip galvanized steel with overall zinc coating; all threads galvanized after cutting and protected by color coded end caps; comply with ANSI C80.1.
- B. Rigid Aluminum Conduit (RAC): Not allowed, unless specifically noted.

- C. Intermediate Metal Conduit (IMC): Hot dip galvanized steel with overall zinc coating; all threads galvanized after cutting and protected by color coded end caps; comply with ANSI C80.6.
- D. GRC with a minimum 40 mils thick plastic coating continuously bonded to exterior with an adhesive primer; bond between metal and plastic equal to or greater than the tensile strength of the plastic coating. Comply with NEMA RN 1. Robroy plasti-bond.
- E. Plastic-Coated Intermediate Metal Conduit (PVC Coated IMC): IMC with plastic coating as described above.
- F. Electrical Metallic Tubing (EMT): Hot-dip galvanized steel with overall zinc coating, and special interior lubricant coating, 4" maximum size; comply with ANSI C80.3.
- G. Flexible Metal Conduit (FMC): Zinc-coated steel or aluminum, ½" minimum size.
- H. Liquidtight Flexible Metal Conduit (LFMC): Single strip, flexible, continuous, interlocked, and double-wrapped steel, galvanized inside and out; coated with liquid-tight jacket of PVC; smooth-wall internal wiring channel; ½" minimum size.
- I. Metal Conduit Fittings, General: Comply with NEMA FB 1, compatible with conduit/tubing materials. Material to be steel, or cast up to 1 ½", except elbow and offset connectors with cadmium plated malleable iron bodies are acceptable.
- J. GRC & IMC Fittings: Plated malleable iron, threaded screw-on types unless otherwise indicated.
 - 1. Three Piece Couplings: Concrete tight, with bonding jumper; O-Z/Gedney 4-Series with Types BJ and ABJ.
 - 2. Hub Connectors: Insulated throat; T&B 370 Series.
- K. PVC Coated GRC & IMC Fittings: Conform to the requirements for GRC and IMC fittings; liquidtight with plastic coating same as the conduit; plastic sleeve extending one pipe diameter or 2" (whichever is less) beyond the end of the coupling; Robroy Plasti-bond 2.
- L. EMT Fittings:
 - 1. Compression Couplings & Connectors: Gland compression type; connectors with insulating bushing (or pre-insulated); RACO 2900 Series.
 - 2. Set Screw Couplings & Connectors: With insulating bushing (or pre-insulated); RACO 2000 and 2100 Series.
 - 3. Internal Insulators: Thomas & Betts.
 - 4. Indenter & Tap-On Fittings: Prohibited.
 - 5. Cast metal fittings: up to 1".
- M. FMC Fittings: Screw clamp type, plated malleable iron; insulated throat; RACO 3300 and 3200 Series.
- N. LFMC Fittings: Liquidtight compression type, plated malleable iron or steel; insulated throat; O-Z/Gedney Type 4Q.

2.3 NONMETALLIC CONDUIT AND TUBING

- A. Electrical Nonmetallic Tubing (ENT): NEMA TC 13. Not allowed unless otherwise noted in drawings
- B. Rigid Nonmetallic Conduit (RNC) or (PVC): NEMA TC 2, Schedule 40 or 80 PVC.
- C. PVC Fittings: Transition adapters, connectors and couplings to be Schedule 40 or 80 heavy wall PVC to match conduit type and material; fittings and solvent cement by the same manufacturer as raceway. Comply with NEMA TC 3.

2.4 CONDUIT ACCESSORIES

- A. General: Except as otherwise indicated, provide conduit, tubing and duct accessories of types, sizes, and materials indicated, including, but not limited to, hangers, clamps, rollers, straps, fasteners, brackets, transition adaptor couplings, protective caps and plugs, expansion and deflection fittings, complying with manufacturer's published product information and designed and constructed by manufacturer for use in applications indicated.
- B. Nipples: Insulated throat; O-Z/Gedney 7-T Series; or, all thread conduit with locknuts and insulated bushings.
- C. Expansion/Deflection Couplings: Sliding or offset types suitable for raceway type, location and use, with approved bonding jumper; O-Z/Gedney Types TX, AX, EX, DX, and DXX; Carlon Electrical Sciences E945, E955, and E946.
- D. Metal Conduit Bodies: Zinc plated malleable iron; threaded conduit entrances; with removable covers, neoprene gasket and corrosion resistant screws; O-Z/Gedney Types LB, X, LL, LR, T, and TB bodies with Type BS cover or BC cover and SGNC gasket.
- E. Plastic Conduit Bodies: Similar to metal except PVC with stainless steel screws; Carlon Electrical Sciences 980 Series with special screws.
- F. Sleeves:
 - 1. Cable Sleeves: Raceway and fittings as specified with bushed and insulated terminations except where hydrostatic seals are required provide same as raceway sleeves.
 - 2. Raceway Sleeves: Heavy wall steel or cast iron pipe, coated malleable iron bodies, core-bit drilled, or precast concrete; more than 5' below finish grade, provide a water stop plate, or other means which assures positive water sealing on the sleeve O.D.; Thunderline Type L.S.
 - 3. Fire Rated pre-manufactured pathway for low voltage cables. Size as shown on drawings or if not shown use 3" product. EZ-Path by Specified Technologies, Inc., or approved.
- G. Hydrostatic Seals: Pressure rated by the manufacturer in feet of water or equivalent psig for the maximum potential hydrostatic head; that is, the difference in elevation between the highest and lowest points in the raceway channel to be sealed, or the difference in elevation between finished grade and sub-grade penetration for raceway, whichever is greater.

- H. Raceway O.D. Seals: Up to 40' of head (20 psig); Thunderline Link Seal, O-Z/Gedney Type CSM Series.
- I. Raceway Channel Seals: Up to 40' of head; raceway fitting with compound chamber and O-Z/Gedney Polyseal 310 sealing compound.
- J. Locknuts: Hardened steel up to 1" trade size; O-Z/Gedney 1-Series.
- K. Grounding Bushings: Plated malleable iron, insulated, threaded type; lay-in ground lug; O-Z/Gedney Type BLG.
- L. Lubricant/Sealer: Anti-seize conductive thread lubricant, effective and stable -20°F to +200°F; maintains rain-tightness and inhibits corrosion; suitable for use between parts of dissimilar metals; Crouse-Hinds STL.

2.5 OUTLET AND DEVICE BOXES

- A. Sheet Metal Boxes: Comply with NEMA OS 1.
- B. Cast Metal Boxes: Comply with NEMA FB 1, type FD, cast ferrous alloy or aluminum with gasketed cover.
- C. Nonmetallic Boxes: Comply with NEMA OS 2.
- D. Interior Concealed: One piece, pressed steel, knockout type with zinc or cadmium coating; no smaller than 4" octagonal, 1-1/2" deep except where otherwise indicated; extension rings, plaster rings and covers as required for flush finish; Appleton, Bell, Eagle, RACO, Steel City.
- E. Recessed Box, One or Two Devices: Minimum 4" square box, 2-1/8" or more deep, with single or two-gang raised covers with barriers as required; RACO 232 and 951 Series.
- F. Recessed Box, Three or More Devices: One piece gang box with raised device cover; one gang minimum per device, with barriers as required.
- G. Interior Dry Location Surface Boxes: As above with raised device covers.
- H. Surface Box Extensions: For power connections up to 3/4" trade size conduit; Raco 5300 and 5400 series, Bell 940 Series or approved substitute.
- I. Exterior and Public and "Finished" Area Surface Boxes: Smooth cast metal, copper-free aluminum, threaded hub style with gasketed covers, grey color; RedDot Type FD and FS.

2.6 CABINETS AND ENCLOSURES

- A. General: Of general arrangement and sizes as indicated, with backboards for spare and future apparatus, terminals and wiring, and the following features unless otherwise indicated:
 - 1. Backboards: Full size 5/8" minimum plywood backing finished with black or gray insulating varnish.

2. Terminal Strips: As shown and/or as required by application; permanently legible markings, designations in accordance with NEMA, RETMA or manufacturer's standards.
 3. Finish: All metal structural and enclosure parts (tub and cover) completely painted using an electrodeposition process so that interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them; manufacturer's standard color (gray) baked-on enamel unless otherwise indicated.
 4. Barriers: Include metal barriers to separate wiring of different systems and voltage
- B. Indoor Enclosures: NEMA 250, steel enclosure with continuous cover and flush latch.
- C. Indoor Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front. Include metal barriers to separate wiring of different systems and voltage, key latch to match panelboards, and include accessory feet where required for freestanding equipment.
- D. Outdoor: As indicated, suitable for location and use, lockable, and rain and dust tight; Hoffman.

2.7 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Boxes: Comply with NEMA OS 1.
- B. Cast Metal Boxes: Comply with NEMA FB 1, cast aluminum with gasketed cover.
- C. Interior and Exterior Above Grade: Galvanized sheet steel with welded seams or cast metal, with screw-on cover; types, shapes and sizes to suit respective location and application; corrosion resistant hardware; gray baked enamel finish.

2.8 WIREWAYS

- A. General: Provide steel "lay-in" wireway similar to Square D Square-Duct.
- B. Listings: Every component including lengths, connectors and fittings UL 870 listed.
- C. Knockouts: Without knockouts unless otherwise indicated.
- D. Style: Suitable for "lay-in" conductors unless otherwise indicated; connector covers permanently attached so that removal is not necessary to utilize the lay-in feature.
- E. Finish: Rust inhibiting phosphatizing coating and gray baked enamel.
- F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
- G. Connectors: Slip-in type with self-retained mounting screws.
- H. Hangers: Two-piece with hook-together feature to permit pre-assembly of wireway and hanger bottom plate before hanging on pre-installed upper bracket.

- I. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireway as required for complete system. Select features where not otherwise indicated, as required to complete wiring system and to comply with NEC.
- J. Material: Sheet metal sized and shaped as indicated.
- K. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireway as required for complete system.
- L. Select features where not otherwise indicated, as required to complete wiring system and to comply with NEC.

2.9 SURFACE METAL RACEWAY

- A. General: Two-piece steel raceway construction of lengths indicated; factory applied gray, semi-gloss finish suitable for field painting. Provide nominal sections of 1-17/32" x 2-3/4" (G-3000), 1-3/4" x 4-3/4" (G-4000) and 3-9/16" x 4-3/4" (G-6000) as indicated. Product numbers are Wiremold.
- B. Outlets: Provide device brackets (G-3007C) or device covers (G-4007C and G-6007C) with specified wiring devices and plates unless otherwise indicated.
- C. Fittings and Accessories: Wire clips 30" O.C., couplings, supporting clips, cover clips, ground clamps, blank end fittings, elbows, tees, corner couplings and adapters as required and to comply with the manufacturer's recommendations.
- D. Manufacturer:
 - 1. Wiremold or approved substitute.

2.10 SURFACE MULTI-OUTLET ASSEMBLY

- A. Raceway: Two piece metal construction nominal 1-1/4" wide x 3/4" deep x length as indicated, with factory applied primer suitable for field painting; unless otherwise indicated, cover to be factory cut for receptacles on 6" centers; Wiremold 2000 Series.
- B. Receptacle Harness: Unless otherwise indicated, a three-wire, single circuit, grounding, factory wired harness of three-wire, 15A, 120V receptacles spaced to fit the raceway cover holes; Wiremold 20GB Series.
- C. Fittings & Accessories: Couplings, supporting clips, cover clips, ground clamps, blank end fittings elbows, tees, corner couplings and adapters as required and to comply with the manufacturer's recommendations.
- D. Manufacturer:
 - 1. Wiremold or approved substitute.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS

- A. Outdoors or Underground: Use the following wiring methods:

1. Exposed: GRC or IMC or (PVC- only where specifically allowed).
2. Concealed: GRC or IMC.
3. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): LFMC.
4. Boxes and Enclosures: NEMA Type 3R or Type 4
5. Refer to section below for riser and elbow allowable material types.

- B. Indoors: Use the following wiring methods:

1. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Flexible metal conduit, except in wet or damp locations use liquidtight flexible metal conduit.
2. Damp or Wet Locations: GRC or (PVC- only where specifically allowed).
3. Exposed: EMT, GRC, IMC or (PVC- only where specifically allowed).
4. Concealed: EMT, GRC, IMC or (PVC- only where specifically allowed).
5. Boxes and Enclosures: NEMA Type 1, except in damp or wet locations use NEMA Type 4, stainless steel or NEMA Type 3R, unless otherwise indicated.

3.3 INSTALLATION, GENERAL

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
- B. Install enclosures and cabinets plumb. Support at each corner.
- C. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.
- D. Install knockout seals in all unused knockout holes.
- E. Set floor boxes level and adjust to floor surface.

3.4 RACEWAYS

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
- B. Conceal conduit, unless otherwise indicated, within finished walls, ceilings, and floors.
- C. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.
- D. Install raceways level and square and at proper elevations. Provide adequate and Code required headroom.
- E. Complete raceway installation before starting conductor installation.
- F. Support raceway as specified in Division 26 Section "Supporting Devices." Do not support conduits or cables from the suspended ceiling structure. Provide independent supports.
- G. Use temporary closures to prevent foreign matter from entering raceway.
- H. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
- I. All underground elbows shall be PVC-coated rigid steel type or fiberglass. All risers to grade or finish floor shall be PVC-coated rigid steel or fiberglass except when they terminate under a free-standing, floor mounted switchboard or switchgear where they may be PVC only.
- J. Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
- K. Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, except as otherwise indicated. Only factory fittings will be allowed for underground nonmetallic raceways.
- L. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions, except as otherwise indicated.
- M. Raceways in Slabs On Grade (SOG): Conduit shall not be routed in slabs on grade except at point of penetration. Provide sand base for conduits below slabs. Minimal depth of conduits under slab on grade is 6" below the bottom of SOG. PVC conduit and fittings must be climatized before burial.
- N. Raceways Embedded in Above-grade Slabs: Only allowed where approved in writing by Engineer. In general, route all conduits in the ceiling space of the floor below and stub-up through floor through core-drilled hole concealed in walls. Fire-proof penetration through floor. Where allowed by Engineer; install embedded conduits in middle third of the slab thickness where practical, and leave at least 1 inch (25 mm) concrete cover.
 - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 - 2. Space raceways laterally to prevent voids in the concrete.

3. Run conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement. When at right angles to reinforcement, place conduit close to slab support.
 4. Transition nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above floor.
- O. Install raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
1. Run parallel or banked raceways together, on common supports where practical.
 2. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.
- P. Indoor Exposed Raceways: Install IMC or GRC conduit in the following situations:
1. Where raceway is potentially exposed to forklift, dolly, pallet jack, cart, traffic, heavy maintenance or other potential damage. Refer cases of uncertain applicability in writing to the Engineer. Engineer's written consent must be obtained to use other than IMC or GRC.
 2. Where adjacent to all roll-up door or similar openings, aisles, corridors, loading dock areas, mechanical rooms, warehouse areas and other similar areas. Conduit may transition to EMT 8'-0" and higher above the floor or grade.
 3. Where specifically noted to be in GRC.
- Q. Join raceways with fittings designed and approved for the purpose and make joints tight.
1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 2. Use insulating bushings to protect conductors.
- R. Tighten set screws of threadless fittings with suitable tool.
- S. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box. Use grounding type bushings for feeder conduits at switchboards, panelboards, pull boxes, transformers, transfer switches, motor control centers, VFD's, etc.
- T. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- U. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb (90 kg) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.
- V. Telecommunications and Signal System Raceways: In addition to the above requirements, install in maximum lengths of 150 feet and with a maximum of two 90-deg bends or equivalent. Install pull or junction boxes in accessible ceiling spaces and/or provide access doors in sheetrock ceilings where necessary to comply with these requirements. Access doors are not shown on drawings. Coordinate with architect prior to purchase and installation. Unless specifically shown otherwise in details, install 3/4" minimum size conduit for telephone/data (telecom) and signal

system outlets. Use long radius (per NEC as for lead sheathed cables) elbows. Serve no more than one individual telecom or signal outlet box with a common circular raceway, unless specifically shown on drawings. Refer to drawings for other installation details.

- W. Install raceway sealing fittings according to the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
1. Where conduits enter or leave hazardous locations.
 2. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
 3. Where otherwise required by the NEC.
- X. Fireproofing of Penetrations: Fireproof void around raceways that pass through walls or floors. Installer of cables in sleeves through floors and walls shall provide fireproofing around cables. Penetrations through floors shall also be waterproof.
- Y. Raceway Ends: Provide caps and engraved nameplates stating destination on both ends of empty raceways. Duct tape or other temporary type of closure is not acceptable. On underground raceways that rise above grade and contain conductors or cables fill void around same with approved expanding, waterproof type foam. On raceways entering the top of an outdoor enclosure or device provide raceway seal "EYS" fitting to prevent condensation and possible rainwater from entering enclosure. Install raceways terminating in outdoor devices or enclosures from behind or below wherever possible. In order to protect cables and provide a rounded edge, provide bell type end fittings on open raceway stubups and sleeves; this applies to conduits under free-standing switchboards/switchgear, telecommunication conduits, sleeves through floors, and similar stubups. Stubup sleeves and raceway ends that terminate at above-grade floor levels minimum 1" above floor level to aid in preventing water leaks spreading to lower floors. For stub raceway through fire rated wall, provide 12" to 24" extension from penetration in accessible area.
- Z. Stub-Up Connections: Extend raceways through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs, and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal raceway may be used 6 inches (150 mm) above the floor. Where equipment connections are not made under this Contract, install screwdriver-operated threaded flush plugs flush with floor.
- AA. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
- BB. Do not install aluminum conduit embedded in or in contact with concrete.
- CC. PVC Externally Coated Rigid Steel Conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit. GRC risers may be tape wrapped in one half width of tape overlaps. Use tape manufactured for the application.

- DD. Surface Metal Raceway: Install a separate green ground conductor in raceway from the junction box supplying the raceway to receptacle or fixture ground terminals.
1. Select each surface metal raceway outlet box to which a lighting fixture is attached to be of sufficient diameter to provide a seat for the fixture canopy.
 2. Where a surface metal raceway is used to supply a fluorescent lighting fixture having central stem suspension with a backplate and a canopy (with or without extension ring), the backplate and canopy will serve as the outlet box and no separate outlet box need be provided.
 3. Provide surface metal raceway outlet box, in addition to the backplate and canopy, at the feed-in location of each fluorescent lighting fixture having end stem suspension.
 4. Where a surface metal raceway extension is made from an existing outlet box on which a lighting fixture is installed (provide a backplate slightly smaller than the fixture canopy), no additional surface mounted outlet box need be installed.
- EE. Install hinged cover enclosures and cabinets plumb. Support at each corner.
- FF. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.
- GG. Ceiling Access: Do not install or support conduits or cables within 12 inches above removable ceiling tiles.

3.5 PULL AND JUNCTION BOXES

- A. Drawings do not necessarily show every pull and junction box required. Install additional boxes to save labor, to avoid difficulties, and to conform to code limits on the number of bends between boxes. Provide without added cost to the Owner and show on Record Drawings. Size according to code. Boxes in finished areas are generally prohibited. Where no other alternative can be shown and only after approval of Architect, locate as directed. Pull box and junction box locations shall be coordinated with grid ceiling layout in that tiles can be easily removed for box access.

3.6 OUTLET BOXES

- A. Before locating outlet boxes, check all Architectural and Owner equipment drawings for type of construction and to make sure that there are no conflicts with other equipment.
- B. Support boxes in conformance with Section 260529 "Supporting Devices."
- C. Use bar hangers and framing members to support and accurately locate outlet boxes in stud or furred partitions and ceilings.
- D. Use surface boxes for all exposed conduit runs; use cast metal where waterproof boxes are required.

- E. Install cast boxes, or other approved boxes, where surface mounting is required for flush device plates such that plates do not overlap the box edges.
- F. Install metal barriers in multi-gang boxes to separate 277 volt phase legs, normal and emergency power, power limited devices, etc.
- G. Install 4" square x 2-1/8" deep boxes with single-gang device for all combination telephone/data (telecom) outlets unless otherwise indicated.

3.7 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by the manufacturer.

3.8 CLEANING

- A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

3.9 TESTING

- A. All underground conduits shall be checked by pulling an 80 % ball type mandrill through them. To be witnessed by the Owner's representative.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
 - 2. Handholes and pull boxes.

1.3 DEFINITION

- A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Warning tape.
- B. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Cover design.
 - 3. Grounding details.
 - 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
- C. Qualification Data: For qualified professional engineer and testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Comply with IEEE C2.
- B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Engineer, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Engineer's, Construction Manager's and Owner's written permission.

1.8 COORDINATION

- A. Coordinate layout and installation of ducts and pull boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. AFC Cable Systems.
 - 2. ARNCO Corporation.
 - 3. Beck Manufacturing.
 - 4. Cantex, Inc.

5. CertainTeed Corp.
6. Condux International, Inc.
7. DCX-CHOL Enterprises, Inc.; ELECSYS Division.
8. Electri-Flex Company.
9. IPEX Inc.
10. Lamson & Sessions; Carlon Electrical Products.
11. Manhattan Wire Products; a Belden company.

B. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and retained to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

2.3 HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: Gray in sidewalks and Green in landscaped areas.
2. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering,
 - a. "ELECTRIC." "TELEPHONE." As indicated for each service..
 - b. Tier level number, indicating that the unit complies with the structural load test for that tier according to SCTE 77.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, retained to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two. Handholes and pull boxes shall comply with the requirements of SCTE 7 Tier 22 loading.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.

- c. CDR Systems Corporation.
 - d. Hubbell Power Systems; Lenoir City Division.
 - e. NewBasis.
- C. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Complying with SCTE 77 Tier 15 loading. Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
- D. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete, complying with SCTE 77 Tier 8 loading.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.
- E. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene, complying with SCTE 77 Tier 5 loading. Cover shall be polymer concrete.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carson Industries LLC.
 - b. Nordic Fiberglass, Inc.
 - c. Pencil Plastics.

PART 3 - EXECUTION

3.1 CORROSION PROTECTION

- A. Aluminum shall not be installed in contact with earth or concrete.

3.2 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

3.3 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.4 DUCT INSTALLATION

- A. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
- B. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 3 ft. outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."
- C. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.
- D. Direct-Buried Duct Banks:
 - 1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 ft. of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
 - 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
 - 4. Install backfill as specified in Division 31 Section "Earth Moving."
 - 5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 30 inches below finished grade unless otherwise indicated or required by code.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor unless otherwise indicated.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 36 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.5 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use pull box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level 6-inch- thick bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: Set so cover surface will be flush with finished grade.
- D. Install handholes and pull boxes with bottom below the frost line, below grade.
- E. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 1. Concrete: 3000 psi, 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
 2. Dimensions: 10 inches wide by 12 inches deep.

3.6 GROUNDING

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

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.8 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

SECTION 260553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 09 Section "Painting and Coatings" for related identification requirements.
 - 2. Division 26 Section "Basic Electrical Requirements."
- C. Refer to other Division 26 sections for additional specific electrical identification associated with specific items.

1.2 SUMMARY

- A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
 - 1. Equipment labels and signs
 - 2. Device labels
 - 3. Identification labeling for raceways, cables, and conductors
 - 4. Operational instruction signs
 - 5. Warning and caution signs
 - 6. Buried electrical line warnings

1.3 SUBMITTALS

- A. None required.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Almetek
2. American Labelmark Co.
3. Brother's Labels
4. Calpico, Inc.
5. Cole-Flex Corp.
6. Emed Co., Inc.
7. George-Ingraham Corp.
8. Ideal Industries, Inc.
9. Kraftbilt
10. LEM Products, Inc.
11. Markal Corp.
12. National Band and Tag Co.
13. Panduit Corp.
14. Radar Engineers Div., EPIC Corp.
15. Seton Name Plate Co.
16. Standard Signs, Inc.
17. W.H.Brady, Co.

2.2 CONDUCTOR AND CABLE IDENTIFICATION

- A. Conductor Designation Tape Markers: Vinyl or vinyl-cloth, self- adhesive, wraparound, conductor markers with preprinted numbers and letters. Handwritten graphics are prohibited.
- B. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self- locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50 deg F to 350 deg F. Provide ties in specified colors when used for color coding. For outdoor applications provide black UV resistant ties only; white ties are prohibited.

2.3 NAMEPLATES, LABELS, SIGNS, AND INSTRUCTION PLATES

- A. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field-printed legends to suit the application. Orange background, except as otherwise indicated, with Eyelet for fastener.
- B. Aluminum-Faced Card Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inches thick, and laminated with moisture-resistant acrylic adhesive. Pre-print legend to suit the application, and punch for tie fastener.
- C. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 inches by 2 inches by 19 gauge.

- D. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. All exterior plates shall be punched for mechanical fasteners (pop rivets). Refer to details on drawings. Use Rowmark "Matt" for indoor use and Rowmark "Ultra-Matt" for exterior use. Nameplate lettering font shall be Helvetica, with bold or extra-bold strokes where indicated.
- E. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.
- F. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide 1/4-inch grommets in corners for mounting.
- G. Legend Plates: Die-stamped metal legend plate with mounting hole and positioning key for panel mounted operator devices, i.e. motor control pilot devices, hand-off-auto switches, reset buttons, etc. Stamped characters to be paint-filled.
- H. Fasteners for Plastic-Laminated and Metal Signs:
 - 1. Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.
 - 2. Aluminum pop rivets.

2.4 PANELBOARD, DISTRIBUTION AND MCC IDENTIFICATION

- A. Circuit Numbering: Provide factory-supplied permanent self-adhesive labels to identify each pole of all panelboards.
- B. Nameplates: Provide nameplates per above section: "Nameplates, Labels, Signs, and Instruction Plates."
- C. Schedule Holder: Provide crystal clear, heavy duty, 5 1/8" x 8 1/2" vinyl, long side open. Storesmart #STB897 peel and stick 8GA. Vinyl or approved equal.

2.5 DEVICE COVERPLATE LABELS AND PAINT

- A. Coverplate material shall be as specified in Section 262726: Coverplates.
- B. Embossed metallic or plastic tape (Dymo) is not acceptable for any application.
- C. Methods of Inscription: (Unless otherwise noted)
 - 1. Self-adhesive Tape: For Imprinted or thermal transfer characters onto permanent waterproof tape lettering system. (Brother's or Kroy). Apply Matte finish spray coating (Krylon #1311) as required to make lettering waterproof.
- D. Paint covers per part 3 below.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Use numbers, lettering, and colors as approved in submittals and as required by code.
- B. Sequence of Work: Where identification is to be applied to surfaces that requires finish, install identification after completion of finish work.
- C. Installation:
1. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.
 2. Clean surface of dust, loose material, and oily films before applying identification.
 3. Install identification parallel to equipment lines.
 4. Apply using permanent methods and materials (such as tape and nameplate materials) that is suitable for the environment installed and will not degenerate over time due to UV, sunlight, humidity, temperature swings, etc.
 5. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment. Do not cover up other instructions or labels.

3.2 CONDUCTOR AND CABLE IDENTIFICATION

- A. Conductor Color Coding: Provide color coding for the following:
1. Secondary service, feeder, and branch circuit conductors throughout the project electrical system:

<u>208 and 120 Volts</u>	<u>Phase</u>	<u>480 and 277 Volts</u>
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	White with strip (preferred) or Grey (if allowed by local inspector)
Green	Ground	Green
Orange	Switch leg	Pink
Yellow	Traveler	Purple
 2. Control wiring inside custom electrical equipment and control panels throughout the project electrical system, refer to mechanical specifications.
 3. Use conductors with color factory-applied the entire length of the conductors except as follows:
 - a. The following field-applied color-coding methods may be used in lieu of factory-

- colored conductor for sizes larger than No. 10 AWG.
 - b. Apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
 - c. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each conductor or cable at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.
 - B. Future Connections: Tag or label conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.
 - C. Multiple Conductors/Circuits: Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure (except for color-coded, three-circuit, four-wire home runs) and wherever there is possible confusion in identifying each conductor, label each conductor or cable. Provide label indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by means of color-coded conductor insulation. For control and communications/signal wiring, use color coding or conductor/cable marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on conductor/cable marking tapes. Conductor numbers shall match the manufacturer's shop drawings.
 - D. Numbering system for all equipment and devices to be coordinate with existing system and the hospital's physical plant manager.
 - E. Cable and Feeder Identification Tags: Securely fasten identifying tags around cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms with stamped letters and numbers with legend to correspond with designations on Drawings. If metal tags are provided, attach them with approximately 55-lb test monofilament line or one-piece self-locking nylon cable ties.
- 3.3 NAMEPLATES, LABELS, SIGNS, AND INSTRUCTION PLATES
 - A. Apply warning, caution, and instruction signs and stencils as follows:
 - 1. Install warning, caution, or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
 - 2. Emergency Operating Signs: Install engraved, laminated signs with white text on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
 - B. Install equipment/system circuit/device identification as follows:

1. Apply equipment identification labels of engraved plastic-laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/ signal/alarm systems, unless the factory supplied labeling on the unit is acceptable to the Engineer.
2. Refer to drawings for details of signs, if details are not included provide the following minimum information:
 - a. Equipment or device designation. (Minimum 3/8" high)
 - b. Amperage, KVA or horsepower rating, where applicable.
 - c. Voltage or signal system name.
3. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment.
 - a. Panelboards, electrical cabinets, disconnects, and enclosures.
 - b. Access doors and panels for concealed electrical items
 - c. All junction boxes and enclosures larger than 4" square
 - d. Each circuit breaker or fused switch in distribution boards, switchboards and switchgear.
 - e. Electrical switchgear and switchboards
 - f. Bus duct (10' intervals)
 - g. Electrical substations
 - h. Motor control centers.
 - i. Motor starters
 - j. Pushbutton stations
 - k. Power transfer equipment
 - l. Contactors
 - m. Dimmers
 - n. Control devices
 - o. Transformers
 - p. Battery racks
 - q. Power generating units
 - r. Telephone switching equipment
 - s. Clock/program master equipment.
 - t. Call system master station.
 - u. Fire alarm master station or control panel.
 - v. Security monitoring master station or control panel
 - w. Spare conduits at both ends.

4. Engraved legend using the following color combinations: (Provide alternate color combinations as shown or noted)

Text Color	Background Color	System Description
White	Red	Danger and warning signs and devices such as emergency power off (EPO) switches.
Black	Yellow	Instructional and Operational signs.
White	Black	Device Nameplates for controls, pushbuttons, meters, indicating lights, etc.

Text Color	Background Color	System Description
White	Blue	Standby Power systems
White	Red	Emergency power systems
Black	White	Normal power systems
Red	White	Fire alarm device and enclosure nameplates

- C. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, circuit breakers in distribution, switchboard and switchgear, lights, motor control centers, and similar items for power distribution, except panelboards and alarm/signal components, where labeling is specified elsewhere.
- D. Provide legends on panel mounted operators devices such as pilot lights, reset buttons, hand-off-auto switches, pushbuttons and other control components.

3.4 PANELBOARD, DISTRIBUTION AND MCC IDENTIFICATION

- A. Circuit Numbering: Starting at the top, odd numbered circuits in sequence down the left hand side and even numbered circuits down the right hand side.
- B. Panelboard Nameplates: Mount nameplates with permanent non-carrier based double-stick tape in interior locations and pop rivets in exterior locations. In finished public areas, such as in lobby or corridor walls, mount the nameplate to the top of the inside of the inner door then also provide an additional 0.75" high, single-line, white nameplate with black 1/4" high panelboard name. All nameplates that are to be mounted on the outside shall be centered, 1/2" up from the top on the inner door on the outside of the outer door.
- C. Panelboard Schedule Holder: Mount schedule holder, secured to inside face of inner panel door. Contractor shall install construction panel schedules in holders during construction and replace with "as of record" panel schedules in holder at end of project. Final schedules shall include room numbers and explicit description and identification of items controlled by each individual breaker.

3.5 DEVICE COVERPLATE LABELS

- A. Provide self-adhesive type labels for all receptacles, switches, outlets, plugmold, etc. per the following:
 1. Lettering Type: Helvetica, 12 point or 1/8" high.
 2. Text: Label coverplates with identity of source and circuit number serving the device per the following convention: "Panel Name"- "Circuit Numbers" (except UPS circuits, which have word UPS as part of the label). Example: "MTE0032-1", "UPS MTE0033-3".
 3. Color of Characters shall be as follows:

Text Color	Background Color	System Description
Black	White	All blue, black, brown power device coverplates

Black	Clear	All white, ivory, gray, red, stainless steel power device coverplates
-------	-------	--

4. Installation of self-adhesive tape:
 - a. Imprinted tape shall be coated with a permanent, non-gloss protective finish. Spray coating shall be applied prior to installation or simultaneously as with Brother's unit.
 - b. Tape shall be applied to coverplate there is no need to wrap label and label should be at bottom of plate. Top of plate for special equipment designations.
 - c. Inscription shall be centered and square with coverplate.
- B. Provide engraved coverplates for switches, dimmers, etc. as follows: (in addition to panel-circuit number labels)
 1. All multi-ganged (three or more) switches or dimmers.
 2. All special purpose switches or controls, i.e. - fan, projector screen, etc. where it is not obvious what it controls.
 3. Engraving shall indicate fixtures or devices controlled (i.e. "Down Lights", "Cove Lights", etc.)
- C. Identify Junction, Pull, and Connection Boxes:
 1. Identify Junction, Pull, and Connection Boxes above accessible ceilings, exposed in mechanical and electrical rooms and other non-finished areas such as tunnels, loading docks, etc. by neatly spray painting the box and cover plate. Conform to site's standard colors for each system type. The boxes and covers shall be painted prior to installation. It is unacceptable to paint the boxes after installation where the overspray paints the conduits and other surrounding items. It is the electrician's responsibility to ensure that the boxes are not painted over by the architectural painting contractor. Refer to detail drawings for color code of conduits and J-boxes.

END OF SECTION 260553

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 sections apply to this Section:
 - 1. Engineering Analysis & Electrical Systems Testing Section 260126.
 - 2. Basic Electrical Requirements: Section 260500.

1.2 SUMMARY

- A. This Section includes overcurrent protective devices (OCPDs) rated 600 V and below and switching devices commonly used with them.
- B. Panelboards, Switchboards, and Motor Control Centers: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 26 sections.

1.3 DEFINITIONS

- A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.
- B. Ampere-Squared-Seconds: An expression of available thermal energy resulting from current flow. With regard to current-limiting fuses and circuit breakers, the ampere-squared-seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
 - 1. Product data for fuses, fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.
 - 2. Coordination study performed per section 260126. Where OCPD manufacturers other than those designated in schedules of overcurrent protective devices are proposed for use, submit a full coordination study showing graphically that the substitute OCPDs coordinate

selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics, device performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices. Study shall be commissioned and paid for by the Contractor.

3. Coordination study performed per section 260126. Show graphically how overcurrent protective devices coordinate selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics, device performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices. Study shall be commissioned and paid for by the Contractor.

1.5 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- C. Single-Source Responsibility: Obtain similar OCPDs from a single manufacturer.

1.6 EXTRA MATERIALS

- A. Maintenance Stock, Fuses: For types and ratings required, furnish spare fuses, amounting to one unit for every 5 installed units, but not less than one set of 3 of each kind.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Cartridge Fuses:
 - a. Bussmann Div., Cooper Industries, Inc.
 - b. Shawmut/Ferraz
 - c. Littelfuse Inc.
 2. Fusible Switches:
 - a. Square D Co.
 - b. General Electric

- c. Cutler Hammer/Eaton
 - d. Siemens
3. Molded Case Circuit Breakers:
- a. Square D Co.
 - b. General Electric
 - c. Cutler Hammer/Eaton
 - d. Siemens
4. Molded Case Current Limiting Circuit Breakers:
- a. Square D Co.
 - b. General Electric
 - c. Cutler Hammer/Eaton
 - d. Siemens
5. Molded Case Circuit Breakers With Solid-State Trip Devices:
- a. Square D Co.
 - b. General Electric
 - c. Cutler Hammer/Eaton
 - d. Siemens
6. Insulated Case Circuit Breakers:
- a. Square D Co.
 - b. General Electric
 - c. Cutler Hammer/Eaton
 - d. Siemens

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDS), GENERAL

- A. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards, and motor control centers; and also as individually enclosed and mounted single units.
- B. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)
- C. Short-circuit Interrupting Capacity: Provide equipment with short-circuit interrupting capacity ratings as required to obtain a fully rated distribution system except where series ratings is specifically noted to be allowed. Use coordination study to adjust noted distribution panel, switchboard, panel, motor control and circuit breaker short-circuit ratings as required.

2.3 CARTRIDGE FUSES

- A. General: NEMA Standard FU1, "Low-Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have

voltage ratings consistent with the circuits on which used. Provide blown-fuse indicating type fuses.

- B. Class J Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."
- C. Class L Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."
- D. Class RK1 and RK5 Dual Element Time-Delay Fuses: UL 198E, "Class R Fuses."
- E. Class RK1 Fast-Acting Fuses: UL 198E, "Class R Fuses."

2.4 FUSIBLE SWITCHES

- A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.
- B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.
- C. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to faults up to 100,000 RMS symmetrical amperes.
- D. Operation: By means of external handle.
- E. Interlock: Prevents access to switch interior except when in "off" position.
- F. Fuse Clips: Rejection type.
- G. Padlocking Provisions: For 2 padlocks, whether open or closed.
- H. Enclosure for Switchboard or Panelboard Mounting: Suitable for panel mounting where indicated.
- I. Enclosure for Switchboard Mounting: Provide individual mounting where indicated.
- J. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

2.5 MOLDED-CASE CIRCUIT BREAKERS

- A. General: UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."
- B. Construction: Bolt-in type, except breakers 225-ampere frame size and larger may be plug-in type if held in place by positive locking device requiring mechanical release for removal. Plug in breakers are acceptable for smaller breakers in I-Line panels.
- C. Characteristics: Indicated frame size, trip rating and number of poles.

- D. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.
- E. Adjustable Instantaneous Trip Devices: Factory adjusted to low-trip-setting current values.
- F. Enclosure for Switchboard or Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.
- G. Enclosure for Switchboard or Motor Control Center Mounting: Provide individual mounting where indicated.
- H. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.
- I. Combination Circuit Breakers and Ground Fault Circuit Interrupters: UL 943 "Ground Fault Circuit Interrupters," arranged for sensing and tripping for ground fault current in addition to overcurrent and short-circuit current. Provide features as follows:
 - 1. Match features and module size of panelboard breakers and provide clear identification of ground fault trip function.
 - 2. Trip Setting for Ground Fault: 4 to 6 milliamperes, listed and labeled as a class A, type 1 device.
 - 3. Trip Setting for Ground Fault: 30 milliamperes.
 - 4. Trip setting for ground fault as indicated.
- J. Current-Limiting Circuit Breakers: Arranged to limit let-through ampere-squared-seconds during fault conditions to a value less than the ampere-squared-seconds of one-half-cycle wave of the prospective symmetrical fault current. The circuit breaker shall use no fusible devices in its operation. The current-limiting characteristic shall be in addition to normal time-delay and instantaneous-trip characteristics and other features as indicated.
- K. Circuit Breakers With Solid-State Trip Devices: Provide indicated circuit breakers with solid-state trip devices having the following features:
 - 1. Ambient Compensation: Trip device insensitive to temperature changes between minus 20 deg C and plus 55 deg C.
 - 2. Adjustability: Breaker ratings and trip settings shall be changeable by operation of controls on front panel of breaker, by change of plug-in element without removing breaker from mounting, or by a combination of the two methods.
 - 3. Ground-Fault Tripping: Adjustable for pick-up and time-delay values. Provide for indicated units.

2.6 INSULATED-CASE CIRCUIT BREAKERS

- A. General: UL 489, "Molded-Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded-Case Circuit Breakers."
- B. Ratings: Continuous-current, interrupting, and short-time-current ratings, and voltage and frequency ratings as indicated.

- C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
1. Moving Contacts Closing Speed: Independent of both control and operator.
 2. Stored Energy Mechanism: Manually charged.
 3. Stored Energy Mechanism: Electrically charged, with provision for optional manual charging.
- D. Circuit Breaker Trip Devices: Solid state over current trip device system that includes one integrally mounted current transformer or sensor per phase, a release mechanism, and the following features:
1. Functions: Long time delay, short time delay, and instantaneous trip functions, which are independent of each other in both action and adjustment.
 2. Temperature compensation to assure accuracy and calibration stability from minus 20 deg C to plus 55 deg C.
 3. Field adjustable, time current characteristic.
 4. Current Adjustability: Effected by operating controls on front panel or by changing plug-in elements or current transformers or sensors.
 5. Three bands for long-time- and short-time-delay functions marked "minimum," "intermediate," and "maximum."
 6. Five pickup points, minimum, for long-time- and short-time-trip functions.
 7. Six pickup points, minimum, for instantaneous-trip functions.
 8. Ground fault protection with at least three short-time-delay settings and three trip-time-delay bands. Adjustable current pickup.
 9. Trip Indication: Labeled lights or mechanical indicators on trip device shall indicate type of fault causing breaker trip. If lights are used, integral power source shall maintain indication for 60 hours, minimum.
- E. Auxiliary Contacts for Remote Indication: Where remote indication of breaker position is indicated, provide a spare auxiliary switch in addition to other auxiliary switches required for normal breaker operation. The spare auxiliary switch shall consist of two Type "a" and two Type "b" stages (contacts), wired to a terminal block in the breaker housing.

2.7 OCPD ACCESSORIES

- A. Key Interlocks: Arrange interlocking so keys are held captive at devices indicated. Where future key interlocking provisions are indicated, provide necessary mountings and hardware as required for the future installation.
- B. Adjustable Time Delay Under voltage Trip Devices: For indicated OCPDs.

- C. Shunt-Trip Devices for Circuit Breakers: Where indicated, arrange to trip breaker from an external source of power through a control switch or relay contacts.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer's written installation instructions.
- B. OCPDs in distribution equipment shall be factory installed.

3.2 IDENTIFICATION

- A. Identify components in accordance with Division 26 Section "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between OCPDs and control/indication devices as specified in Division 26 Section "Wires and Cables" for hard wired connections.

3.4 CONNECTIONS

- A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.5 GROUNDING

- A. Provide equipment grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding. Refer to specification section 260533 for additional grounding requirements.

3.6 FIELD QUALITY CONTROL

- A. Reports: Prepare written reports certified by testing organization on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made.
- B. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

- C. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.
- D. Pretesting: Upon completing installation of the system, the Electrical Contractor shall perform the following preparations for independent tests:
 - 1. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.
 - 2. Make continuity tests of circuits.
 - 3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
 - 4. Provide manufacturer's instructions for installation and testing of OCPDs to test personnel.
- E. Contractor is responsible for conducting a detailed coordination study on the emergency system OCPDs per the Code. Submit coordination study to the engineer for review.

3.7 FIELD TESTING

- A. Refer to Specification Section 260126.

3.8 CLEANING

- A. Upon completion of installation, inspect OCPDs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION 260573

SECTION 26 24 13 - SWITCHBOARDS**PART 1 - GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section Includes:
 1. Service and distribution switchboards rated 600 V and less.
 2. Transient voltage suppression devices.
 3. Disconnecting and overcurrent protective devices.
 4. Instrumentation.
 5. Control power.
 6. Accessory components and features.
 7. Identification.
 8. Mimic bus.

1.03 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.04 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 6. Detail utility company's metering provisions with indication of approval by utility company.
 7. Include evidence of NRTL listing for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 10. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Qualification Data: For qualified Installer.
- D. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
- 1.05 **QUALITY ASSURANCE**
- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Comply with NEMA PB 2.
- G. Comply with NFPA 70.

H. Comply with UL 891.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards.

C. Handle and prepare switchboards for installation according to NECA 400 NEMA PB 2.1.

1.07 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

b. Altitude: Not exceeding 6600 feet (2000 m).

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet (2000 m).

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager Owner no fewer than seven days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Architect's written permission.

4. Comply with NFPA 70E.

1.08 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: ~~Five~~ One year from date of Substantial Completion.

1.10 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. Front-Connected, Front-Accessible Switchboards:
 1. Main Devices: Fixed, individually mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- D. Nominal System Voltage: 480Y/277 V unless otherwise noted. See single line diagrams.
- E. Main-Bus Continuous: See single line diagrams.
- F. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- G. Indoor Enclosures: Steel, NEMA 250, Type 1.
- H. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- I. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.
- J. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- K. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- L. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 2. Set back from front to clear circuit-breaker removal mechanism.
 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- M. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with tinned copper feeder circuit-breaker line connections.
 2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 3. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- N. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- O. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- P. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.
- 2.02 **DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**
- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.

- c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
- d. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- e. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Fuses are specified in Division 26 Section "Fuses."

2.03 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

- 1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
- 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
- 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
- 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

- 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
- 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.04 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.05 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.06 IDENTIFICATION

- A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NECA 400 NEMA PB 2.1.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install switchboards and accessories according to NECA 400 NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.
 - C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
 - D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 - E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
 - F. Install filler plates in unused spaces of panel-mounted sections.
 - G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 1. Set field-adjustable switches and circuit-breaker trip ranges.
 - H. Install spare-fuse cabinet.
 - I. Comply with NECA 1.
- 3.03 **CONNECTIONS**
- A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
 - B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.
- 3.04 **IDENTIFICATION**
- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- 3.05 **FIELD QUALITY CONTROL**
- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
 - C. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - D. Acceptance Testing Preparation:
 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.
- E. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. 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. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. 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.
 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Switchboard will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- 3.06 **ADJUSTING**
- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
 - B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."
- 3.07 **PROTECTION**
- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.
- 3.08 **DEMONSTRATION**
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION

SECTION 263213 - PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 26 Section "Transfer Switches" for transfer switches, including sensors and relays, to initiate automatic starting and stopping signals for engine generator set.

1.2 SUMMARY

- A. This Section includes a packaged diesel engine generator system including engine generator set, cooling system, fuel system, combustion air intake and engine exhaust systems, starting system, control/annunciation system, and the following additional features:
 - 1. Weatherproof housing
- B. The following items are to be furnished by the generator supplier. Furnish materials to the project site and turn over to Division 23 for installation and final connection. Electrical connections are under Division 26
 - 1. None

1.3 DEFINITIONS

- A. Emergency or Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.
- B. Operational Bandwidth: The total variation from the lowest to the highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- C. Power Output Rating: Gross electrical power output of generator set minus total power requirements of electric motor-driven accessories normally constituting part of the engine assembly.
- D. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hz or cycles per second.

1.4 SYSTEM DESCRIPTION

- A. System Includes: Standby-rated, automatically started diesel engine coupled to an A.C. generator unit. Engine and generator are factory-mounted and -aligned on a structural steel skid. Subsystems and auxiliary components and equipment are as indicated.
- B. Functional Description: When the mode selector switch on the control and monitoring panel is in the "automatic" position, remote control contacts in one or more separate automatic transfer switches initiate the starting and stopping of the generator set. When the mode selector switch is placed in the "on" position, the generator set starts manually. The "off" position of the same switch initiates shutdown of the generator set. When the unit is running, specified system or equipment failures or derangements automatically shut the unit down and initiate alarms. Operation of a remote emergency stop switch also shuts down the unit. Automatic transfer switches are specified in another Section of these Specifications.

1.5 SUBMITTALS

- A. Bid Responses: Bid responses shall clearly state whether the proposed product COMPLIES or if an EXCEPTION is taken to ANY requirement of this specification.
 - 1. Compliance: A non-response of EXCEPTION to any paragraph signifies complete compliance with all of the requirements of those paragraphs in the specification.
 - 2. Exceptions: A response of EXCEPTION to any paragraph shall:
 - a. State the specification section number/letter reference claimed by the manufacturer/supplier for the product being proposed.
 - b. Reference appropriate documentation to support this claim.
 - c. Include the referenced documentation supporting this claim as an attachment to the bid package
 - d. Suggest an alternate product or specification where EXCEPTION is stated.
 - 3. Support Documentation: The bid package shall be accompanied by one copy of each document listed in this Submittal section 1.5. The following documentation that supports the manufacturer/supplier's claim shall be included with the bid package:
 - a. Operation test data
 - b. Performance test data
 - c. Generator set weight
 - d. Generator set dimensions
 - e. Weatherproof Enclosure and accessories
 - f. Detail drawings
 - g. Product literature
 - 4. The manufacturer/supplier shall discuss exception and compliance problems with Owner prior to bidding if any requirements conflict with the bidder's standard manufacturing process. Bid responses shall be submitted on a paragraph-by-paragraph basis.
- B. General: Submit, within 30 days after written Notice of Award, the following according to Conditions of Contract and Division 1 Specification Sections.

- C. Product data for the following items specified in this Section. Include data on features, components, ratings, and performance. Cross-out all extraneous data or options or items not provided.
1. Engine/Generator Set and radiator system
 2. Generator with frame, insulation class, construction, reactances and time constants
 3. Battery Charger
 4. Batteries and rack with battery sizing calculations
 5. Critical grade exhaust silencer and connections
 6. Seismic zone rated vibration isolators
 7. Control Panel devices and instruments
 8. All specified accessories
 9. Make and model of main output circuit breaker
 10. Weatherproof Enclosure and accessories
- D. Additional Information:
1. Certified test data stating that the complete unit was factory tested at the rated full load at the rated power factor with ambient, altitude and fuel grade recorded. (Reactive load banks)
 2. Warranty documents.
 3. Furnish structural calculations for equipment anchorage performed by a structural engineer licensed in the State of the project.
 4. Manufacturer-published kilowatt output curve and published fuel consumption curve.
 5. Air flow requirements for combustion, ventilating, and radiator cooling air.
 6. Manufacturer-published transient response data of the complete engine generator set upon 50%, 75%, and 100% block loads at .9 pf. Data shall include maximum voltage dips, maximum frequency dips and recovery time periods.
 7. Locations and descriptions of the supplier's parts and service facilities within a 50 mile radius of the job site, including parts inventory and number of qualified generator set service personnel.
 8. Generator motor starting curves showing the voltage dips versus starting KVA.
- E. Maintenance data for system and components for inclusion in Operating and Maintenance Manual specified in Division 1. Include the following:
1. Lists: Tools, test equipment, spare parts, and replacement items recommended to be stored at the site for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 2. Detailed Operating Instructions: Cover operation under both normal and abnormal conditions.
 3. Instructions for routine maintenance
 4. Pictorial and schematic electrical drawings of wiring systems, including operating and safety devices, control panels, instrumentation and annunciators.
 5. Telephone numbers for the authorized parts and service distributors.
- F. Shop Drawings: Detail fabrication, piping, wiring, and installation of the field-installed portions of the system. Include general arrangement drawings showing locations of auxiliary components in relation to the engine generator set and duct, piping, and wiring connections between the generator set and the auxiliary equipment. Show connections, mounting, and support provisions

and access and working space requirements. Shop drawings shall be specific to this job, it is not acceptable to submit standard drawings that do not show all specified features or features that are not specified.

1. Include dimensioned outline plan and elevation drawings of engine generator set and other system components.
 2. Manufacturer-produced dimension drawings of the complete engine generator set showing labeled entrance points of each of the interconnections required.
 3. Actual electrical diagrams, including schematic diagrams and interconnection wiring diagrams for all equipment to be supplied. Indicate all termination points and quantity and size of all required field-installed wiring.
 4. Shop drawing of the job specific Skid mounted Fuel that will be supplied for the job, showing all specified options and pipe connection locations.
- G. Wiring Diagrams for System: Show power and control connections and distinguish between factory-installed and field-installed wiring.
- H. Qualification Data for Manufacturer: Include capabilities and experience data required to demonstrate qualifications specified in Quality Assurance Article. Include list of completed projects with project names and addresses and names of Engineers and Owners, plus other information specified. Include separate data for each of the following items:
1. Engine Generator System
- I. Independent Field-Testing Organization Certificates: Signed by Contractor, certifying that the organization complies with the requirements specified in Quality Assurance below.
- J. Certified Summary of Prototype Unit Test Report: Submit certified copies of actual prototype unit test report if subsequently requested.
- K. Certified Test Reports of Components and Accessories: Submit for devices that are equivalent, but not identical, to those tested on prototype unit.
- L. Certification of Torsional Vibration Compatibility: Conform to NFPA 110.
- M. Factory Test Reports: For units to be shipped for this Project showing evidence of compliance with specified requirements.
- N. Field Test Report: Record of tests specified in Part 3.
- 1.6 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Firms experienced in manufacturing equipment of the types and capacities indicated that have a record of successful in-service performance.
1. Emergency Service: System manufacturer maintains a service center capable of providing training, parts, and emergency maintenance and repairs at the Project site with 8 hours maximum response time.
- B. Comply with NFPA 70, "National Electrical Code." Latest adopted version.

- C. Comply with NFPA 110, "Standard for Emergency and Standby Power Systems," for requirements for a Level 1 emergency power supply system.
- D. Comply with UL 2200.
- E. NRTL Listing: System components of types and ratings for which NRTL listing or labeling service is established and components are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- F. Engine Exhaust Emissions: Comply with applicable Federal, State, and local government requirements. Comply with all federal EPA Tier standards.
- G. Single-Source Responsibility: Obtain engine generator system components from a single manufacturer with responsibility for entire system. Unit shall be a representative product built from components that have proven compatibility and reliability and are coordinated to operate as a unit as evidenced by records of prototype testing.
- H. Design Criteria: All materials, equipment and parts comprising the units specified herein, shall be new and unused, of current manufacture and of highest grade.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

1.8 EXTRA MATERIALS

- A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Owner.
 - 1. Fuses: 1 for every 10 of each type and rating, but not less than 1 of each.
 - 2. Pilot Lights: 2 for every 6 of each type used, but not less than 2 of each.
 - 3. Routine Maintenance: Provide to the owner the special tools and testing devices required for routine maintenance.

1.9 WARRANTY:

- A. The complete standby electric power system, including engine-generator set equipped with running time meter, shall be warranted for a minimum period of one (1) year from the date of initial start-up. Multiple warranties for individual components (engine, generator, controls, etc.) will not be acceptable. Satisfactory warranty documents must be provided.

- B. The warranty shall cover the costs for the parts and labor required to repair the unit and, when necessary, labor expenses associated with the removal and reinstallation of the Product if such work is done by an authorized distributor or designated service representative.
- C. The warranty shall cover all travel expenses for technicians to and from the equipment site when necessary to make on-site repairs. Repair and replacement parts shall then be covered under the original warranty for ninety (90) days or until the end of the two-year warranty period, whichever is greater.
- D. This warranty is in addition to the contractor's warranties.

1.10 START-UP SERVICE:

- A. On completion of the installation, start-up shall be performed by the generator set manufacturer trained dealer service representative.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Engine Generator Sets:
 - a. Caterpillar, Inc.
 - b. Kohler Co.
 - c. MTU (Detroit Diesel Corp)
 - d. Cummins Power Corp, Electrical Products Div.
 - 2. Skid Tank Systems:
 - a. Pryco
 - b. Simplex (preferred)
 - c. Tramont
 - d. Enclosure manufacturer
 - 3. Storage Batteries:
 - a. C&D Charter Power Systems
 - b. Chloride Systems
 - c. Exide Corp.
 - d. Hoppecke Battery Systems, Inc.
 - e. NIFE, Inc., NIFE, AB.
 - f. SAFT America, Inc., Advanced Battery Systems Div.
 - g. Sonnenschein Batteries, Inc.
 - h. Yuasa Battery (American), Inc.

4. Battery Chargers:
 - a. Exide Corp.
 - b. Kohler Co.
 - c. LaMarche Mfg. Co.
 - d. Master Control Systems, Inc.
 - e. Onan Corp.
 - f. Sens Energenius (preferred)

2.2 SYSTEM SERVICE CONDITIONS

- A. Environmental Conditions: Engine generator system withstands the following environmental conditions without mechanical or electrical damage and shall be capable of producing the rated KVA output:
 1. Ambient Temperature: Plus 10 deg F. to plus 108 deg F.
 2. Relative Humidity: 0 to 95 percent.
 3. Altitude: Sea level to 1000 feet.
- B. Design/Build Performance Specification: Engine generator system and components shall be designed and rated to supply a load that includes the prescribed load below without causing overheating or control problems. The actual size alternator shall be larger, as determined by vendor and as required, to take into account derating due to the project's altitude, maximum and minimum ambient temperature and the type and amount of non-linear and high-inrush loads that are connected. Submit documentation showing generator is capable of supplying the amount of non-linear load specified. The kW rating shown on the construction documents and as prescribed below are for useable output power to the Owner's loads.
 1. Owner's intent is to load generator to no greater than 90% of its maximum nameplate rated kW value at a power factor of .93 on a regular sustained basis, meaning for the duration of monthly testing and during utility power outages which could last for several days.
 2. The load will consist of the following loads: Electronic ballast fluorescent lighting; VFDs for motor HVAC motors and pumps and full-voltage non-reversing motor starters for pumps and fans.
- C. Unusual Service Conditions: Engine generator system operates in the following conditions:
 1. None
- D. Equipment supplied under this contract shall be approved for use within the city limits of the project location, and shall comply with all codes and ordinances of applicable Federal, State, County and local authorities. Any inspection, test, corrections or other required activities to insure the complete compliance of offered equipment shall be the responsibility of and at the expense of the vendor.
- E. Noise Emission: Provide all required sound attenuating equipment and accessories to comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation. Due to the noise

levels generated by the proximity to the I-5 and its location on campus there is no code requirement for the project site.

2.3 ENGINE GENERATOR SYSTEM

- A. General: System is a coordinated assembly of compatible components.
- B. Ratings: Voltage, frequency, and power output ratings of the system are as indicated on the single-line diagram.
- C. Output Connections: 3-phase, 4 wire.
- D. Safety Standard: Comply with ASME B15.1, "Safety Standard for Mechanical Power Transmission Apparatus."
- E. Nameplates: Each major system component is equipped with a conspicuous nameplate of the component manufacturer. Nameplate identifies manufacturer of origin and address, and the model and serial number of the item.
- F. Resistance to Seismic Forces that are applicable to the project site and mounting conditions. Use IBC guidelines: Internal and external supports for components, supports, and fastenings for batteries, wiring, and piping are designed to withstand static or anticipated seismic forces, or both, in any direction. For each item, use a minimum force value equal to the weight of the item.
- G. Limiting dimensions indicated for system components are not exceeded.

2.4 SYSTEM PERFORMANCE

- A. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
- B. Steady-State Voltage Modulation: Less than 1 Hz.
- C. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage recovers to remain within the steady-state operating band within 3 seconds.
- D. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
- E. Steady-State Frequency Stability: When the system is operating at any constant load within the rated load, there are no random speed variations outside the steady-state operational band and no regular or cyclical hunting or surging of speed.
- F. Transient Frequency Performance: Less than 5 percent variation for a 50 percent step-load increase or decrease. Frequency recovers to remain within the steady-state operating band within 5 seconds.

- G. Output Waveform: At no load, the harmonic content measured line-to-line or line-to-neutral does not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor determined according to NEMA MG1, "Motors and Generators," does not exceed 50.
- H. Sustained Short-Circuit Current: For a 3-phase bolted short circuit at the system output terminals, the system will supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to any generator system component.
- I. Temperature Rise of Generator: Within acceptable limits for insulation systems used according to NEMA MG1 when operating continuously at standby rating conditions with ambient temperature at the top of the range specified under "Environmental Service Conditions."
- J. Nonlinear Load Performance: System performance is not degraded from that specified in this Article by continuous operation, with the load current having a minimum total harmonic content of 15 percent RMS, and minimum single harmonic content of 10 percent RMS.
- K. Starting Time: Maximum total time period for a cold start, with ambient temperature at the low end of the specified range, is 10 seconds. Time period includes output voltage and frequency settlement within specified steady-state bands.

2.5 ENGINE GENERATOR SET

- A. Power Output Rating: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
- B. Skid: Adequate strength and rigidity to maintain alignment of the mounted components without dependence on a concrete foundation. Skid is free from sharp edges and corners. Lifting attachments are arranged to facilitate lifting with slings without damaging any components.
- C. Rigging Diagram: Inscribed on a metal plate permanently attached to the skid. Diagram indicates location and lifting capacity of each lifting attachment and location of the center of gravity.

2.6 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment. This does not apply to the generator itself, only items that need isolation such as control panels, battery chargers, etc.
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

C. Earthquake mounting design data shall be submitted by supplier.

2.7 ENGINE

A. Comply with NFPA 37, "Stationary Combustion Engines and Gas Turbines."

B. Fuel: Diesel fuel oil grade DF-2.

C. Maximum Speeds: Engine - 1800 rpm. Piston speed for 4-cycle engines – 2,250 feet per minute.

D. Lubrication System: Pressurized by a positive displacement pump driven from the engine crankshaft. The following items are mounted on the engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 microns and smaller while passing full flow.
2. Oil Cooler: Maintains lubricating oil at the manufacturer's recommended optimum temperature throughout continuous operation of the generator set at 100 percent of system power output rating with ambient temperature at the top of the range specified under "Environmental Service Conditions."
3. Thermostatic Control Valve: Controls flow in the system to maintain optimum oil temperature. Unit is capable of full flow and is designed to be fail-safe.
4. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without the use of pumps or siphons or special tools or appliances.

E. Engine Fuel System: Comply with NFPA 30, "Flammable and Combustible Liquids." System includes:

1. Integral Injection Pumps: Driven by the engine camshaft. Pumps are adjustable for timing and cylinder pressure balancing.
2. Main Fuel Pump: Mounted on the engine. Pump ensures adequate primary fuel flow under starting and load conditions. Adequate capacity to lift fuel as required for the fuel tank design as shown on the construction documents plus 20% spare capacity.
3. Relief/Bypass Valve: Automatically regulates pressure in the fuel line and returns excess fuel to the source.
4. Fuel pressure gauge and hand operated auxiliary priming pump.
5. Flexible fuel lines shall be installed between the engine and the fuel supply to isolate vibration.
6. Parallel Fuel Oil Filters: Provide a duplex fuel filter/water separator to protect the fuel system from water damage. They shall not require draining more than once per week. Ahead of the injection pumps. Provide engraved operating instructions using 1/4" high black letters on yellow background.

7. Since the fuel oil will be returned to the skid tank; provide fuel oil cooler to maintain fuel oil temperature within acceptable limits to allow engine to provide full rated horsepower.
- F. Jacket Coolant Heater: 120 V, 1-phase electric immersion type, factory-installed in the jacket coolant system. Unit is rated and thermostatically controlled to maintain an engine temperature of 120 deg F. at the low end of the ambient temperature range specified under "Environmental Conditions" above. Heater shall be automatically deactivated while the genset is running via the adjustable thermostat and a lube oil pressure switch. Set low coolant temperature warning light to activate at 90 deg F. To be connected via field wiring to a normal power circuit.
- G. Speed Governor: Adjustable electronic isochronous type, electronically controlling fuel injector duration and timing.
- H. Crankcase Breather Filter: Provide appropriately number and size of closed crankcase breather filters.

2.8 ENGINE COOLING SYSTEM

- A. Description: Closed-loop, liquid-cooled, with radiator factory-mounted on engine generator set skid and integral engine-driven coolant pumping. Factory-piped and -rated for specified coolant.
- B. Coolant: Minimum amount of ethylene glycol, mixed with water, to allow unit to operate at both temperature extremes in environmental conditions listed above.
- C. Cooling System Treatment: The engine cooling system shall be chemically treated for the inhabitation of internal corrosion.
- D. Expansion Tank: Constructed of welded steel plate and equipped with gage glass and petcock. Capacity as required or indicated.
- E. Temperature Control: Self-contained thermostatic control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by the engine manufacturer. Features include:
 1. Thermostatic Elements: Interchangeable and nonadjustable.
 2. Actuator Design: Normally-open valves to return to open position when actuator fails.
- F. Coolant Hose: Flexible assembly with nonporous rubber inside surface and aging, ultraviolet, and abrasion-resistant fabric outer covering.
 1. Rating: 50 psi (345 kPa) maximum working pressure with 180 deg F (82 deg C) coolant, and noncollapsible under vacuum.
 2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- G. Safety Guards: The engine shall be equipped with a metal guard to prevent accidental contact with the fan blade, belts, and pulleys. It shall be easily removed for access to these components. The guard shall also protect the radiator core from damage.

- H. Coolant Water Filter: The engine shall be equipped with a spin-on water filter that treats coolant and prevents corrosion and scale deposits in the system. This filter shall be compatible with all propylene glycols.
- I. Coolant Temperature Sensing:
 - 1. The engine cooling system shall include a temperature transducer to sense engine coolant temperature. Interface of the engine sensor and wiring may be required with the engine control panel and switchgear if stated in specification attachment.
 - 2. High Water Temperature Cutoff: The engine shall be equipped with a high water temperature cutoff designed to stop the engine when the maximum safe operating temperature is exceeded. Interface of the engine sensor and wiring may be required with the engine control panel and switchgear if stated in a specification attachment.

2.9 FUEL SYSTEM - SKID TANK

- A. System complies with NFPA 30, "Flammable and Combustible Liquids Code," and NFPA 37, "Standard for Stationary Combustion Engines and Gas Turbines." Complies with UL 142, "Steel Aboveground Tanks for Flammable and Combustible Liquids."
- B. General: Provide U.L. labeled, skid mounted 24-hour run time at 90% of maximum rated capacity, double walled, local Fire Marshal approved, generator fuel tank. The size indicated is for useable fuel; the tank shall be sized to include, in addition to the amount shown, extra tank capacity for space below fuel pickup tube for sediment and 10% air space above fuel. Fuel tank shall be factory pre-piped to generator. Minimum size shall be 200 gallons.
- C. Fuel Tank shall be constructed of heavy gauge steel, rust-proofed and finish painted outside and shall be built for earthquake resistance and shall be of the dual containment or rupture basin type design to fit under the generator specified. Minimize tank height as much as possible, therefore extend tank to maximum width of weatherproof enclosure and extend under turning vane if included.
- D. Fuel Tank Accessories:
 - 1. Fuel level monitor gauge complete with probes and control panel to indicate fuel level. Mount gauge so as to be visible from fuel tank filling inlet.
 - 2. Overfill catch basin with drain back into main tank.
 - 3. Provide all required normal and emergency vent lines. Normal vent shall extend above roof as required by code and include bug screens.
 - 4. Two Low level fuel probes and form C relay contacts wired to local and remote annunciator panels to indicate when fuel tank contains less than:
 - a. 3/4 of its capacity to warn user to order more fuel. (Low fuel level)
 - b. 8 hours of fuel remaining when operating at full load. (Critical Low fuel level)
 - 5. Leak detector complete with control unit and alarm relay for local and remote indication of the presence of fuel in the outer vessel of the double walled tank.
 - 6. Fuel tank size, construction and overfill prevention scheme shall be submitted to the local Fire Marshal for written approval. Genset will not be accepted without this written approval.

- E. Skid tank shall be fully filled with No. 2 diesel fuel. Fuel to be provided by the Owner.

2.10 ENGINE EXHAUST SYSTEM

- A. Muffler: Sized as recommended by the engine manufacturer. Measured sound level, according to the "DEMA Test Code for the Measurement of Sound from Heavy-Duty Reciprocating Engines" at a distance of 10 feet from the exhaust discharge, shall conform to the criteria as noted in the noise emission section above.
- B. Connections from Engine to Exhaust System: Flexible section of corrugated stainless steel pipe. Piping shall be supported and braced to prevent weight or thermal growth being transferred to the engine. Thermal expansion fittings shall be provided to accommodate thermal growth.
- C. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liners.
- D. Suitable guards shall be supplied to protect personnel from accidental contact with exhaust manifolds, turbochargers, exhaust pipe, etc.
- E. Insulation for Mufflers and Exhaust Piping: Provide industrial quality, removable, wire attached insulation on all exhaust piping and mufflers, where installed inside a building or inside an enclosure.
- F. Supports for Muffler and Exhaust Piping: Provide industrial quality, vibration isolating-type specified in Division 23 Section "Vibration Control."
- G. Thimbles for Exhaust Piping: Conform to NFPA 211, "Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances." Provide as required to accommodate exhaust piping exiting to the exterior.
- H. The exhaust piping shall discharge in the vertical direction. Provide rain cap.

2.11 COMBUSTION AIR-INTAKE SYSTEM

- A. Intake Air Filers: Standard -duty filter-type providing filtration as recommended by the engine manufacturer.
- B. Air-Intake Silencer:
 - 1. Sound level emanating from the air intake measured as specified in the "DEMA Test Code for the Measurement of Sound from Heavy-Duty Reciprocating Engines" at a distance of 25 feet is 54 dB or less in the 1200-4800 Hz frequency band and 56 dB or less in the 4800-10,000 Hz band.
 - 2. Mounting: Factory-installed on engine generator set at a location readily accessible for servicing.
- C. Intake Duct Connection: Size and connect intake duct to engine as recommended by manufacturer.

1. Flexible Connector: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL Standard 181, Class 1; and factory-fabricated with a strip of fabric 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 24-gage, galvanized sheet steel or 0.032-gage aluminum sheets. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard, 1st Edition, Figure 2-19.
- D. Supports for Air-Intake Piping and Filter-Silencer: Industrial quality vibration isolation-type as specified in Division 23 Section "Vibration Control."
- E. Air-Intake Duct: Round ducts with 16-gage galvanized steel, with spiral lockseam construction. Comply with SMACNA "HVAC Duct Construction Standards."

2.12 STARTING SYSTEM

- A. Description: 24 V electric with negative ground and including the following items:
 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with the ambient temperature at the maximum specified in paragraph "Environmental Conditions."
 2. Cranking Motor: Heavy-duty units that automatically engages and releases from the engine flywheel without binding. Quantity as required by manufacturer.
 3. Cranking Cycle: The starter shall crank the engine for three: 15 second on - 15 second off periods (45 seconds of cranking) before activating the over-crank lock-out device.
 4. Batteries: Shall be Lead-Acid Batteries and comply with SAE J537, "Storage Batteries," and have adequate capacity within the ambient temperature range specified in paragraph "Environmental Conditions" to provide the specified cranking cycle series at least twice without recharging. Battery shall be sized to take into consideration the DC lights that are specified with a run time of 60 minutes and still be able to start the generator per the spec above.
 5. Battery Cable: Size as recommended by the generator set manufacturer for the cable length required and to take into account voltage drop across the best-battery diode unit. Provide all interconnecting bars and extra-flexible locomotive cables with the batteries and high compression, circumferentially crimp type lugs. Locate batteries as close as possible to the starter.
 6. Battery Compartment: Factory-fabricated of metal or industrial quality plastic with acid-resistant finish and thermal insulation. Thermostatically controlled heater is arranged to maintain battery above 50 deg F regardless of external ambient temperature within low range specified under "Environmental Conditions." Include accessories required to support and fasten batteries in place. Compartment shall be structurally rated to be installed in the indicated seismic zone area. Mount on the genset frame.
 7. Battery-Charging Alternator: Factory-mounted on engine with solid-state voltage-regulation and 35 ampere minimum continuous rating.
 8. Battery Charger: Filtered Current limiting, solid-state, automatic equalizing and float charging-type designed for operation from a 120 V 60 Hz supply source. Unit complies with UL 1012, "Electrical Industrial Control Equipment," and includes the following features:

- a. Operation: Equalizing charging rate is initiated automatically after the battery has lost charge until an adjustable equalizing voltage is achieved at the battery terminals. The unit then automatically switches to a lower float-charging mode, and continues operating in that mode until the battery is discharged again. Unit shall not discharge battery when AC power fails. Unit shall operate and be capable of fully charging the starting batteries while the genset is running and shall be capable of returning to the fully discharged battery 100 percent of its ampere-hour rating within 24 hours.
- b. Sizing: Unit shall be sized to accommodate all control panel loads, such as meters and indicating lights, in addition to battery charging requirements.
- c. Automatic Temperature Compensation: Adjusts the float and equalizes voltages for variations in the ambient temperature from minus -10 deg F to plus 150 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
- d. Automatic Voltage Regulation: Maintains output voltage constant regardless of input voltage variations up to plus or minus 10 percent.
- e. Ammeter and Voltmeter: Flush mounted in door. Meters indicate charging rates.
- f. Output current shall be current limited to 120% of maximum and shall not require a cranking disconnect relay.
- g. Overcurrent Protection: Input and output shall be protected by circuit breakers if available or fuses if breakers are not available.
- h. Hermetically sealed semiconductors and integrated circuits.
- i. Green power on LED indicator light.
- j. All LED indicating lights shall be mounted on the front cover of the unit.
- k. Enclosure and Mounting: NEMA Class 1 wall-mounted cabinet.
- l. Safety Functions:
 - 1) Low DC battery voltage alarm relay and LED indicating light. Alarm shall be locked out during engine cranking.
 - 2) High DC battery voltage alarm relay and LED indicating light.
 - 3) AC input power failure alarm relay contacts and LED indicating light.
 - 4) DC Current Failure alarm relay contacts and LED indicating light
 - 5) Wire alarm relays #1 and #2 together in parallel so that any one or both will annunciate at system control and remote monitoring panels as "High or Low Battery Voltage".
 - 6) Wire alarm relays #3 and #4 above together in parallel so that any one or both will annunciate at system control and remote monitoring panels as "Battery Charger Malfunction".
- m. Unit shall be Sens model: Energenius series with alarm option, voltage and ampere output capacity as required or approved equal.
- n. Provide engraved sign with 1/4" high white letters on red background: "DISCONNECT BATTERY CHARGER WHEN REMOVING OR CONNECTING BATTERY LEADS TO PREVENT DAMAGE TO SOLID STATE EQUIPMENT"
- o. Charger(s) to be connected via field wiring to a 120V, standby power circuit.

2.13 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, complying with UL 489.
 - 1. Trip Settings: Selected to coordinate with generator thermal damage curve.

2. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
3. Mounting: Adjacent to or integrated with control and monitoring panel.
4. Provide one, form C, auxiliary contact rated 120 VAC, 10 amps on main output circuit breaker to annunciate as "Not-in- Auto" at the control panel and at the remote annunciator panel when the breaker is in the open or tripped position.

2.14 CONTROL AND MONITORING

- A. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages are grouped on a common control and monitoring panel mounted on the generator set. Mounting method isolates the control panel from generator set vibration. Panel features include:
 1. A.C. Voltmeter
 2. A.C. Ammeter
 3. A.C. Frequency Meter
 4. D.C. Voltmeter (Alternator Battery Charging)
 5. Engine Coolant Temperature Gage
 6. Engine-Lubricating Oil Pressure Gage
 7. Running Time Meter
 8. Ammeter/Voltmeter Phase Selector Switch or Switches
 9. Generator Voltage-Adjusting Rheostat
 10. Generator Frequency-Adjusting Rheostat
 11. Two Form C, 10-amp rated dry contacts for "engine running" status.
 - a. One for remote annunciation
 - b. One spare
 12. Auto-Start-Stop Switch
 13. Pre-High Coolant Temperature Indicating light or display
 14. High Coolant Temperature Shutdown Indicating light or display and shutdown device
 15. Low Coolant Level Indicating light or display
 16. Pre-Low Oil Pressure Indicating light or display
 17. Low Oil Pressure Shutdown Indicating light or display and shutdown device
 18. Fuel Tank Leak Alarm and indicating light or display
 19. High Fuel Tank Level-Shutdown of Fuel Supply Alarm and indicating light or display
 20. Low Fuel Level Alarm and indicating light or display. (see fuel section for description)
 21. Critical Low Fuel Level Alarm and indicating light or display. (see fuel section for description)
 22. Local or remote Emergency stop pushbutton activated indicating light or display
 23. Not-In-Auto or Generator Output Breaker Open or Tripped alarm and indicating light or display
 24. Low Jacket Water Temperature (<90°F) alarm and indicating light or display
 25. Over-speed alarm and indicating light or display and shutdown device
 26. Overcrank alarm and indicating light or display
- B. Indicating and Protective Devices, and Controls: Include those required by NFPA 110 for a Level 1 system plus the following:
 1. A.C. Voltmeter
 2. A.C. Ammeter
 3. A.C. Frequency Meter
 4. D.C. Voltmeter (Alternator Battery Charging)
 5. Engine Coolant Temperature Gage
 6. Engine-Lubricating Oil Pressure Gage
 7. Running Time Meter
 8. Ammeter/Voltmeter Phase Selector Switch or Switches
 9. Generator Voltage-Adjusting Rheostat
 10. Generator Frequency-Adjusting Rheostat
 11. Two Form C, 10-amp rated dry contacts for "engine running" status.
 - a. One for remote annunciation
 - b. One spare
 12. Auto-Start-Stop Switch
 13. Pre-High Coolant Temperature Indicating light or display
 14. High Coolant Temperature Shutdown Indicating light or display and shutdown device
 15. Low Coolant Level Indicating light or display
 16. Pre-Low Oil Pressure Indicating light or display
 17. Low Oil Pressure Shutdown Indicating light or display and shutdown device
 18. Fuel Tank Leak Alarm and indicating light or display
 19. High Fuel Tank Level-Shutdown of Fuel Supply Alarm and indicating light or display
 20. Low Fuel Level Alarm and indicating light or display. (see fuel section for description)
 21. Critical Low Fuel Level Alarm and indicating light or display. (see fuel section for description)
 22. Local or remote Emergency stop pushbutton activated indicating light or display
 23. Not-In-Auto or Generator Output Breaker Open or Tripped alarm and indicating light or display
 24. Low Jacket Water Temperature (<90°F) alarm and indicating light or display
 25. Over-speed alarm and indicating light or display and shutdown device
 26. Overcrank alarm and indicating light or display

27. Ground Fault alarm and indicating light or display. Does not trip output circuit breaker.
- C. Provide manufacturer's latest control panel design with digital readout.
 - D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items on engine, generator, or elsewhere as indicated. Where not indicated, locate to suit manufacturer's standard. All meters shall be true RMS sensing type to be compatible with non-linear loads.
 - E. Connection to Building Management System (BMS) Data Link: A separate terminal block factory-wired to Form-C dry contacts for each alarm and trouble status indication is reserved for connection to remote data terminals. Unless otherwise noted, factory wire in series all trouble condition dry contacts for single "Common Trouble" annunciation and factory wire in series all alarm condition dry contacts for single "Common Alarm" annunciation. Customer may elect to individually annunciate any single condition by adding more wires and isolating any set of dry contacts.
 - F. Remote Emergency Stop Pushbutton: Flush wall-mounted, except as otherwise indicated, emergency "stop" red mushroom-head pushbutton with plastic safety guard. Pushbutton with all required interface provisions for remote mounting shall be provided by generator vendor and be identical in operation to the emergency stop button on the generator control panel. Provide 6" square engraved nameplate with 1/2" high white letters on red background, "GENSET EMERG. STOP." Mounting, conduit and wire for the remote pushbutton will be provided by the installing contractor. Operation of any emergency off pushbutton shall be annunciated at all annunciation panels specified. Locate pushbutton adjacent to the automatic transfer switch unless otherwise noted.

2.15 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1, "Motors and Generators," and specified performance requirements.
- B. Drive: Generator shaft is directly connected to the engine shaft. Exciter is rotated integrally with generator rotor.
- C. Electrical Insulation/Temperature Rise: Class H or Class F rated for 130 C. maximum continuous temperature rise.
- D. Coil Construction: random -wound with amortisseur windings in the pole faces of the rotating field.
- E. Pitch: two-thirds pitch stator winding and fully-linked amortisseur winding.
- F. Subtransient Reactance: 18 percent minimum.
- G. Construction prevents mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating.
- H. Excitation shall be permanent magnet, brushless type, and be arranged to sustain generator output to 300% rated current for 10 seconds under short circuit conditions.

- I. Enclosure: Drip-proof.
- J. Instrument Transformers: Mounted within generator enclosure.
- K. Voltage Regulator: Digital, microprocessor based with programmable operating characteristics, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel provides plus or minus 5 percent adjustment of output voltage operating band.
 - 2. The regulator shall include a reactive droop network to allow paralleling with other generators. The network shall provide 8% minimum droop at full load and 0.8 pf.
 - 3. Coordinate with paralleling switchgear manufacturer as to the mounting location of the voltage regulator. Provide all required interface wiring and devices to allow complete coordination.
- L. Grounding: Provide factory installed, code sized grounding conductor from the generator ground pads to the engine/generator frame and to a grounding lug in the load termination junction box sized to accept the number of ground conductors in the feeder conduits as shown on the drawings. Provide factory installed grounding lug, adjacent to the load termination junction box, and a code sized grounding conductor from the generator neutral. The lug shall be used for field connection to the grounding electrode conductor as shown on drawings.
- M. Main Terminal Box:
 - 1. Generator load termination junction box shall be mounted with bottom of terminations at a minimum of 36" AFF, to allow easy installation of underground power conduits and conductors. The main terminal box shall be mounted on the left or the right side, as shown on the drawings.
 - 2. It shall include three rigidly mounted bus-bar type tinned copper terminals and one isolated neutral bus-bar, all suitable for the termination of the generator output feeder size and quantity as noted on the drawings.
 - 3. The bus bars shall be drilled for terminating high compression circumferentially crimped type stress cone/lugs having two holes on each lug, with NEMA drilling. Provide adequate room to easily train all of the cables. Provide extension box where use of it will not compromise code required clearances. Belleville washers shall be used
 - 4. Provide adequate bus bar sizing and space within the terminal box to accommodate the quantity of parallel feeder conduits specified in the feeder schedule.
 - 5. Provide provisions for adding a future second circuit breaker using a 100-225A frame molded case breaker.
- N. Connection Box:
 - 1. A suitable connection box (separate from the main terminal box) shall be furnished for space heater leads. This terminal box should be located adjacent to the terminal box, in a convenient area.
 - 2. The following protection elements shall be wired to this connection box:
 - a. Generator winding space heaters
 - b. Battery box space heaters

- O. Stator Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above the dew point. Locate thermostat in an easily accessible location. To be connected via field wiring to a normal power circuit.

2.16 LOAD BANK

- A. Not desired by PSU.

2.17 OUTDOOR GENERATOR SET ENCLOSURE

- A. Description: Weatherproof steel housing. Multiple hinged panels are lockable and provide adequate access to components requiring maintenance. Panels and doors shall be operable by one person without tools. The entire unit, comprising generator, fuel tanks, housing, accessories, etc. shall be shipped as one assembly with all items listed below completely factory installed and wired, ready for operation, except for the following exceptions:
 - 1. The generator vendor is responsible for all costs and labor to reassemble, at the jobsite all items that are required to be disassembled for transporting the unit due to highway regulations for shipping oversize loads or other reasons.
 - 2. All required connections to external field wiring such as power to heaters, lights, remote annunciators, etc., shall be wired to factory mounted terminal strips.
- B. General: The weatherproof housing shall be capable of completely enclosing and shielding from rain and wind the following equipment:
 - 1. Engine/Generator Set with all specified circuit breakers
 - 2. Batteries and battery rack(s)
 - 3. Battery charger
 - 4. Generator Control Panel
 - 5. Battery heaters
 - 6. DC and AC lights and GFCI duplex outlet
 - 7. Skid tank
 - 8. Turning Vane
- C. The housing shall be designed and certified by a Registered Structural Engineer that the housing and its anchoring scheme will withstand a 100 mile per hour wind.
- D. The weatherproof housings shall be equipped with a minimum number of doors per side and rear that allow complete access to all equipment and the ability to perform all maintenance procedures. Doors shall have 3 point, padlockable latches and heavy-duty hinges. Provide a latch for each door to insure adequate closing pressure to seal against harmful weather. All hardware shall be hot dipped galvanized. Door hinges shall have a minimum of ½" dia. stainless steel pins.
- E. The weatherproof housing over the generator set shall have supports built in of sufficient size and quantity to completely support the silencer(s) without deformation. The roof shall have a crown of 1/4" per foot in the width cross section starting at the center and sloping to both sides. Silencers shall be mounted on top of the enclosure. Only the fuel tank vent and exhaust pipe shall penetrate the roof

- F. The penetrations through the roof for the exhaust pipes shall have a collar that extends 1 inch above the roof and full seamed welded into the roof to prevent rain from entering the housing.
- G. The anchoring feet for the housing shall be constructed of plate steel and shall be bored to accept the minimum number of anchoring bolts to meet specified seismic zone requirements.
- H. Louvers: At air inlet and discharge. Louvers to prevent entry of rain and snow. The housing shall have fixed louvers on the air intake and gravity opening louvers on the radiator air discharge end.
- I. All louvers shall be high quality, low maintenance type. Louvers shall be sized for low enough feet per minute air velocities to not allow rain to be sucked into the enclosure.
- J. The housing shall be prepared for painting by thoroughly cleaning the entire surface both inside and out with degreasers and removing all of the mill scale prior to priming and painting. After assembly and priming the housing shall be completely seam sealed with a paintable silicone sealant prior to the final finish coats of paint.
- K. Provide as required 120 VAC battery heaters to maintain battery temperature between 50°F and 60°F based on environmental conditions specified above. All heaters shall be automatically deactivated while the engine is running and not be dependent on the thermostat for deactivation. To be connected via field wiring to a normal power circuit.
- L. Provide two 50 watt, 24-volt DC industrial grade enclosed and gasketed dome lights, connect to batteries. Locate one over the engine and one over the control panel. Provide two 0-6 hour, no-hold manual timer switch. Mount the switch by the control panel.
- M. Connections to Field Wiring: Provide hinged enclosures with labeled, finger-safe type, DIN rail mounted terminal blocks for all required field wiring. All required wiring to these terminals shall be factory installed. Provide barriers between emergency power and normal power terminal blocks. Provide barriers between low-voltage terminals and terminals that supply voltages greater than 50-volts.
- N. Air Flow Through Housing: Adequate to maintain temperature rise of system components within required limits when unit operates at 100-percent of rated load continuously with ambient temperature at the top of the range specified under "Environmental Service Conditions."
- O. All equipment shall be bolted to floor and/or wall in such a manner as to meet the requirements of the specified seismic zone
- P. Entire generator/ housing assembly shall conform to the criteria as noted in the noise emission section above.
- Q. Turning Vane: The housing shall include a turning vane at the radiator discharge end to allow the generator set to be surrounded by full height solid walls. Paint or finish inside turning vane must be able to withstand weather and heat from genset. Provide access door to turning vane area, large enough for a man to crawl inside.

2.18 SOURCE QUALITY CONTROL

- A. **Factory Tests:** Include prototype testing and Project-specific equipment tests (equipment manufactured specifically for this Project). All operational and alarm functions shall be factory tested prior to shipping to the field. Complete engine/generator set shall be completely factory tested under rated full load and rated power factor for performance and proper functioning of control and interfacing circuits.
- B. **Prototype Testing:** Performed on a separate engine generator set using the same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. **Tests:** Conform to those required for Level 1 energy converters in paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2 of NFPA 110.
 - 2. **Components and Accessories:** Items furnished with installed unit that are not identical to those on tested prototype have been acceptably tested to demonstrate compatibility and reliability.
- C. **Project-Specific Equipment Tests:** Test engine generator set and other system components and accessories prior to shipment. Test items individually and assembled and connected as a complete system at the factory in a manner equivalent to that required at the Project site. Record and report test data. Conform to SAE 8528, "Engine Power Test Code-Spark Ignition and Diesel," and the following:
 - 1. **Test Equipment:** Use instruments calibrated within the previous 12 months and with accuracy directly traceable to the National Institute of Standards and Technology (NIST).
 - 2. **Hydrostatic Test:** Perform on radiator, heat exchanger, and engine water jacket.
 - 3. **Engine Tests:**
 - a. Fuel consumption
 - b. Exhaust temperature
 - c. Exhaust Emissions Test: Conform to applicable government test criteria.
 - 4. **Generator Tests:**
 - a. Conform to IEEE 115, "Test Procedures for Synchronous Machines."
 - 5. **Complete System Continuous Operation Test:** Includes nonstop operation for a minimum of 2 hours, including at least 30 minutes each at ½, ¾, and 1 hour at 100 percent of full load. If unit stops during the 2-hour test, repeat the complete test. Record the following minimum data at the start and end of each load run, at 15-minute intervals between those times, and at 15-minute intervals during the balance of the test:
 - a. Jacket water temperature
 - b. Lubricating oil temperature and pressure
 - c. Generator load current and voltage, each phase
 - d. Generator system gross and net output kW
 - 6. **Complete System Performance Tests:** Include the following to demonstrate conformance to specified performance requirements:

- a. Single-step load pickup
 - b. Transient and steady-state governing
 - c. Transient and steady-state voltage performance
 - d. Safety shutdown devices
 - e. Efficiency Tests: Perform at 50 percent, 75 percent, and 100 percent of rated load.
7. Observation of Test: Provide 2-week advance notice of tests and opportunity for observation of test by Owner's representatives. Do not include any costs associated with owner witness testing.
 8. Provide copy of test result reports to Engineer within 10 days of completion of test.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor generator set and other system components on concrete bases conforming to Division 3 Section "Cast-In-Place Concrete" and as indicated. Provide anchorage according to manufacturer's recommendations.
- B. Maintain minimum working space around components according to manufacturer's shop drawings and NEC.
- C. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to supervise the installing, connecting, pretesting, and adjusting of the unit.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- B. Connect engine exhaust pipe to engine with flexible connector.

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

3.4 IDENTIFICATION/ SIGNAGE

- A. Identify system components and identify circuit numbers serving system components according to Division 23 Section "Mechanical Identification" and Division 26 Section "Electrical Identification."
- B. Generator vendor to provide all NEC and OSHA required signs. Provide sign on all doors "DANGER - THIS EQUIPMENT MAY START AUTOMATICALLY - LOCKOUT PRIOR TO ANY MAINTENANCE." Use ½" high minimum white letters on red background.

3.5 FIELD QUALITY CONTROL

- A. GENERAL: See Section 260500
- B. SUPERVISED ADJUSTING AND PRETESTING:
 - 1. Under supervision of factory-authorized service representative, pretest all system functions, operations, and protective features using steps and methods outlined under final testing. Provide all instruments and equipment required for tests. Adjust to ensure operation is according to Specifications. Pre-testing is intended to identify any problems that are to be corrected prior to Engineer witnessed final testing. Final testing shall be used for final documenting only, not for trouble-shooting the system.
 - 2. In the event that the System fails to function properly during final testing as a result of inadequate pretesting or preparation, the generator vendor shall bear all costs incurred by the necessity for retesting including testing equipment, transportation, subsistence and the Engineer's hourly rate and travel expenses.
- C. FINAL TESTING: After the installation and initial start-up and pre-testing of the engine generator set is complete, a test shall be performed and logged in the presence of the Architect and Engineer. Give two weeks prior notice to commencement. The generator manufacturer shall furnish an engineer to perform testing, operate the engine during the test, to check all details of the installation and to instruct the operators. The engineer will be required for a period of not less than 2 days for instruction and tests and all costs in connection therewith shall be included in the generator vendor's bid. The generator vendor shall furnish all fuel, lubricants, and instruments necessary to conduct the tests and shall connect all devices required to obtain data required below. Use instruments bearing records of calibration within the last 12 months, traceable to NIST standards, and adequate for making positive observation of test results. All field tests, that are to be documented, shall be conducted after completion of the installation of all specified components, (remote annunciator panels, etc.) and installation of all architectural elements that would affect the performance of the engine/generator set. All doors on the weatherproof enclosures shall be closed at all times during tests except to monitor gauges at designated times. All alarm functions shall be field tested after installation. On site testing shall include all items specified in NFPA-110.

- D. **LOAD BANKS:** The generator vendor shall be responsible for providing load bank and cables for on-site testing. Provide portable load bank sized to allow for 100% rated capacity of the generator and shall be **resistive only** type.
1. The load bank(s) shall be connected downstream of the automatic transfer switch(es) at a location designated by the Engineer. The electrical contractor (EC) shall make all necessary temporary connections with the cables provided by the generator vendor. The EC shall provide all lugs as required for those load bank cables as required.
- E. **FIELD TEST REQUIREMENTS:** Refer to Specification Section 26940 for scope of work to be performed by independent testing contractor; all other tests noted herein are to be performed by the generator vendor's engineer, unless otherwise noted. Data and observations shall be recorded every 15 minutes and at the beginning and end of every separate test and shall include all electrical and temperature information. Testing shall be accomplished in the following sequence:
1. **PRE-CHECK/ SYSTEM INTEGRITY TESTS:** Methodically verify the following:
 - a. Check all engine and generator mounting bolts
 - b. Check alignment of engine generator and realign if not within manufacturer's limits
 - c. Proper operation of all controls
 - d. Proper operation of all gages and instruments throughout operation
 - e. Proper operation of all auxiliary and accessory equipment. All valves, including pilot valves and injection pump, shall be checked during the tests to assure proper operation.
 - f. Proper installation, connection, and integrity of each element of engine generator system before and during system operation.
 - g. Check for air, exhaust, and fluid leaks
 2. Perform engine manufacturer's recommended prestarting checks. Include a check of water, fuel and lube oil levels within the engine.
 3. **BATTERY TESTS:** Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
 4. **BATTERY CHARGER TESTS:** Verify specified rates of charge for both equalizing and float-charging conditions.
 5. **EXERCISER TIME CLOCK:** Ensure proper operation of the automatic exercising system by setting system for automatic operation then manually initiating and exercise period of at least 30 minutes.
 6. **VOLTAGE AND FREQUENCY TRANSIENT STABILITY TESTS:** Using recording oscilloscope to measure voltage and frequency transients for 50-percent and 100-percent step-load increases and decreases and verify that performance is as specified.
 7. **START-UP TEST (no load)**
 - a. With prime mover in a "cold start" condition initiate a normal power failure by opening all normal circuit breakers or switches supplying the normal power to the automatic transfer switch(es).

- b. Observe and record the time delay on start.
 - c. Observe and record the cranking time until the prime mover starts and runs.
 - d. Observe and record the time required to come up to operating speed.
 - e. Record voltage and frequency overshoot. This also makes sure the test equipment is set up correctly.
 - f. Perform engine manufacturer's after-starting checks.
 - g. Observe and record time required to achieve steady-state condition with all switches transferred to the emergency position.
 - h. Record voltage, frequency, and amperes for each phase.
 - i. Record prime mover oil pressure, water temperature and battery charge rate at 5-minute intervals for the 15-minutes.
 - j. Return normal power to the automatic transfer switches, record the time delay on retransfer to normal for each automatic transfer switch (set for 30 minutes) and the time delay on prime mover cooldown period (set at 5-minutes) and shutdown.
 - k. After completion of the start-up test the engine/generator set shall be allowed to cool for 5 minutes.
8. LOAD TEST: Load system using load banks simulating kW of total load for which unit is rated. Perform the following tests:
- a. Voltage and Frequency Transient Stability Tests: With load banks preset to 50 percent of generator rated load, initiate a normal power failure by simultaneously opening all normal circuit breakers or switches supplying the normal power to the automatic transfer switch(es). Use recording oscilloscope to measure voltage and frequency transients for 50-percent and 100-percent step-load increases and decreases and verify that performance is as specified.
 - b. Operate engine generator for one hour at 50% of rated load.
 - c. Operate engine generator set for one hour at 75% of rated load.
 - d. Operate engine generator set for two hours at 100% of rated load. Make the 100-percent load run at 80-percent power factor, if reactive type load banks are specified above.
 - e. Record voltage, frequency, output current, battery-charging current, power output (kVA), oil pressure, and coolant temperature using Engineer supplied forms at times indicated during the test.
 - f. After load tests are completed close all switches, or breakers serving the transfer switches to allow an automatic engine/generator cooldown period and shutdown.
 - g. This full load test shall not result in activation of the high temperature pre-alarm or high temperature shutdown.
9. CYCLE CRANK TEST:
- a. A battery starting test shall be performed with the battery charger(s) disconnected. Utilize any method recommended by the manufacturer to prevent the prime mover from starting. Put the control switch into the "RUN" position to cause the prime mover to crank. Verify the three 15-second crank/15 second rest cycles and the subsequent overcrank lockout alarm. After five minutes to allow the starting motor to cool, reset the lockout alarm and repeat the test to verify that the batteries supported the specified six: 15 second crank - 15 second rest periods. (90 seconds of cranking) Record battery DC voltage at beginning and end of test.
 - b. Reconnect battery charger.

10. ALARM/SHUTDOWN SAFETY CHECK:

- a. General: Simulation of malfunctions to verify proper operation of local and remote protective, alarm, and monitoring devices. Verify and record that all alarms, and indicating lights function at both the remote annunciator panel and the control panel. Verify and record proper lockout/resets.
- b. Verification of the following alarms shall be done by manually closing the relay contacts with the engine stopped unless a method is indicated.
 - 1) Low water temperature
 - 2) Pre-high engine water temperature
 - 3) High engine water temperature. Demonstrate or simulate functioning of high temperature coolant circuit. . Record temperatures.
 - 4) Pre-low engine oil pressure
 - 5) Low engine oil pressure. Shutdown engine and observe operation of low oil pressure control. Record pressure at which trip operates.
 - 6) Overspeed: Increase engine speed by manually overriding the governor. Speed shall be measured by a tachometer. Record speed at which overspeed trip operates.
 - 7) Low fuel level
 - 8) Battery charger malfunction. (Current failure alarm relay in the battery charger).
 - 9) Low DC voltage in the batteries. (Disconnect in the battery lead)
 - 10) Fuel leak Test for skid tank rupture.
 - 11) Low Coolant Level
 - 12) Disconnect AC power to battery charger to verify "Battery Charger Malfunction" indicating lights.
 - 13) Place control switch in the "off/reset" position to verify "Not-in-Auto" flashing red indicating lights.
 - 14) Critical Low/Loss of flow in skid
 - 15) Open generator output circuit breaker to verify flashing red "Not-in-Auto" indicating lights. Test all if multiple output breakers.
 - 16) Ground fault alarm indicating lights using the test switch.
- c. Note: If safety conditions of the Safety System are not met during any of the preceding steps, the necessary readjustments shall be made and the step repeated until satisfactory results are obtained.

11. EMERGENCY STOP SAFETY CHECK:

- a. Open generator circuit breaker. Place generator control switch in "Run" position.
- b. After generator is running for 2 minutes press the emergency stop button. Verify and record engine shutdown.
- c. Repeat step a. and b. above for each emergency stop button associated with the generator.
- d. Close the generator output breaker.

12. INSPECTION: Upon completion of the on-site tests, a general inspection shall be made for:
 - a. Leaks in the engine, piping systems, tanks, etc.
 - b. Excessive blow-by
 - c. Any other deficiency which may impair proper operation
 - d. Change oil and oil filter and record hour readings
13. All of the above test results shall be recorded neatly, bound and five copies sent to the Electrical Engineer, within 10 working days, for approval.
14. Owner to refill main and skid fuel tanks to full capacity upon completion of all tests.

3.6 ACCEPTANCE

- A. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- B. Final acceptance shall be made when the generator set has successfully completed the on-site testing, after all defects in material and functionality have been corrected and Maintenance Manuals and training completed.

3.7 CLEANING

- A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.8 DEMONSTRATION

- A. Training: Arrange and pay for the services of a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of the system and to train Owner's personnel.
- B. Conduct a minimum of 8 hours of training as specified under Instructions to Owner's Employees in the Project Closeout Section of these Specifications.
- C. Schedule training with at least 7-day advance notice.

3.9 COMMISSIONING

- A. Battery Equalization: Equalize charging of battery cells according to manufacturer's instructions. Record individual cell voltages.

END OF SECTION 263213

SECTION 26495 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 26 Section, "Basic Electrical Requirements."
 - 2. Division 26 Section, "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less. It includes the following items:
 - 1. Automatic transfer switch (ATS).

1.3 SUBMITTALS

- A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.
 - 1. Shop drawings or published product data for each transfer switch, including dimensioned plans, sections, and elevations showing minimum clearances; conductor entry provisions; gutter space; installed features and devices; and materials lists.
 - 2. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring. Clearly label all terminal numbers used for specified sets of dry contacts to be used for field wiring.
 - 3. Single-line diagrams of transfer switch units showing connections between automatic transfer switch, bypass/isolation switch, power source, and load, plus interlocking provisions.
 - 4. Operation and maintenance data for each type of product, for inclusion in Operating and Maintenance Manual specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions.
 - 5. Manufacturer's certificate of compliance to the referenced standards and tested short-circuit closing and withstand ratings applicable to the protective devices and current ratings used in this Project, as indicated and as specified in paragraph, "Tested Fault Current Ratings."

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms are experienced in manufacturing equipment of the types and capacities indicated and have a record of successful in-service performance.
- B. Emergency Service: Manufacturer maintains a service center capable of providing emergency maintenance and repairs at the Project site with an 8-hour maximum response time.
- C. Comply with NFPA 70, "National Electrical Code," for components and installation.

- D. Comply with NEMA ICS 1, "General Standards for Industrial Control," ICS 2, "Industrial Control Devices, Controllers and Assemblies," and ICS 6, "Enclosures for Industrial Controls and Systems."
- E. UL Listing and Labeling: Items furnished under this Section are listed and labeled by UL for emergency service under UL Standard 1008.
- F. Nationally Recognized Testing Laboratory Listing (NRTL) and Labeling: Items furnished under this Section are listed and labeled by a NRTL for emergency service under UL Standard 1008.
 - 1. Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- G. UL Compliance: Comply with UL Standard 1008, "Automatic Transfer Switches," except where requirements of these Specifications are stricter.
- H. Single-Source Responsibility: Obtain ATs, from a single manufacturer that assumes responsibility for all system components furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Automatic Switch Co. (ASCO)
 - 2. Caterpillar, Inc.
 - 3. Kohler Co.
 - 4. Onan Corp.
 - 5. Russelectric, Inc.
 - 6. Zenith Controls, Inc.

2.2 TRANSFER SWITCH PRODUCTS, GENERAL

- A. Number of Poles, Current, Voltage and Short-Circuit AIC Ratings: As indicated on drawings. If short-circuit withstand ratings are not shown then provide unit with withstand rating equal to or greater than the short-circuit AIC rating of the normal power main switchboard.
- B. Overcurrent devices shall not be used as part of switch and shall not be used to obtain required AIC ratings. Provide oversized units as required to comply with specified withstand/short-circuit AIC ratings.
- C. Tested Fault-Current Ratings: Closing and withstand ratings exceed the indicated available RMS symmetrical fault current at the equipment terminals based on testing according to UL Standard 1008, conducted at full-rated system voltage and 20% power factor. Rate each product for withstand duration time as follows, when tested for rated short circuit, current correlated with the actual type of circuit protective device indicated for transfer switches for this Project:
 - 1. Molded-Case Circuit Breakers, 150 Amperes or Smaller: 1.5 closing and withstand duration cycles.
 - 2. Molded-Case Circuit Breakers, Larger than 150 Amperes: 3 closing and withstand duration cycles.
 - 3. Power Circuit Breakers: 10 closing and withstand duration cycles.
 - 4. Current-Limiting Fuses: 0.5 (nominal) closing and withstand duration cycles.

- D. Annunciation and Control Interface Components: Devices at transfer switches for communicating with remote annunciators or annunciator/control panels have communications capability matched with the remote device.
 - E. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2% or better over an operating temperature range of minus 20°C to 70°C.
 - F. Resistance to Damage by Voltage Transients: Components meet or exceed voltage surge withstand capability requirements when tested according to ANSI C37.90.1, IEEE Guide for Surge Withstand Capability (SWC) Tests. Components meet or exceed voltage impulse withstand test of NEMA ICS 1.
 - G. Neutral Terminal: Where 2- or 3-pole switches are indicated, provide fully rated, solid, unswitched neutral terminal except as indicated.
 - H. Enclosures: General-purpose NEMA 1, conforming to UL Standard 508, "Electric Industrial Control Equipment," except as otherwise indicated.
 - I. Factory Wiring: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.
 - 1. Designated terminals accommodate field wiring.
 - 2. Power Terminals Arrangement and Field Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Terminals: Pressure-type, suitable for copper or aluminum conductors of sizes indicated.
 - 4. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - J. Electrical Operation: Where indicated, accomplish by a non-fused, momentarily energized solenoid or electric motor-operated mechanism, mechanically and electrically interlocked in both directions. Switches using components of molded-case circuit breakers or contactors not designed for continuous duty, repetitive switching between active power sources are not acceptable.
 - K. Switch Action: Mechanically held in both directions for double-throw switches.
 - L. Switch Contacts: Use silver composition for switching load current. Units rated 225 amperes and more have separate arcing contacts.
 - M. Where shown on the Drawings provide busway flange fitting on top of ATS for both normal and emergency power incoming sources and load output.
 - N. All key switches shall be keyed alike. Provide six sets of keys.
 - O. All indicating lights shall be super bright LED type and mounted externally on the front cover of the ATS. Provide push-to-test type lights or provide ATS with single lamp test pushbutton. Incandescent lamps are not acceptable.
 - P. Text on all indicated engraved nameplates shall be a minimum of ¼" in height using white letters on black background.
- 2.3 AUTOMATIC TRANSFER SWITCHES (ATSS)
- A. Comply with Level 1 equipment according to NFPA 110, "Standard for Emergency and Standby Power Systems."

- B. Delayed Neutral Position Operation: Provide switch operator with a programmed neutral position arranged to provide a midpoint between the 2 working switch positions with an intentional, controlled, timed pause during transfer at the midpoint. The midpoint pause is adjustable from 0.5 to 30 seconds minimum, and factory set at 1.0 second, except as indicated. Time delay occurs for both transfer directions.
- C. Manual Switch Operation: Manually operated under load with the door closed with either or both sources energized. Switch must allow operator to go through neutral off position in either direction. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation. Switch handle or separate crank tool only is allowed to protrude through door for manual operation; cables, contacts, etc. shall be behind closed door during operation.
- D. Signal-Before-Transfer Contacts: Normally open/normally closed dry contacts operates in advance of retransfer to normal source, then reset after transfer is complete. Interval is adjustable from 1 to 30 seconds. Provide one set of contacts and control wiring to connect to all elevator controller shown served by the ATS. Provide one spare set of contacts.

2.4 AUTOMATIC TRANSFER SWITCH FEATURES

- A. Voltage sensing for each phase of normal source. Pick-up voltage is adjustable from 85% to 100% nominal, and drop-out voltage is adjustable from 75% to 98% pick-up value. Factory set for pick-up at 91% and drop-out at 89%.
- B. Time-delay override of normal source voltage-sensing delays transfer and engine start signals. Adjustable 0 to 6 seconds, and factory set at 1 second.
- C. Time-delay on transfer to emergency source. Adjustable 0 to 9999 seconds, and factory set at 2 seconds.
- D. Generator Voltage/Frequency Lockout Relay: Prevent premature transfer. Voltage pick-up is adjustable from 85% to 100% nominal. Factory set to pick-up at 90%. Pick-up frequency is adjustable from 90% to 100% nominal. Factory set to pick-up at 95%.
- E. Retransfer Time Delay: Adjustable from 0 to 30 minutes and factory set at 20 minutes. Provides automatic defeat of the delay upon loss of voltage or sustained undervoltage of the emergency source, provided the normal supply has been restored.
- F. Retransfer To Utility Time-Delay Override Pushbutton: Pushbutton to override retransfer time delay noted above, to allow the ATS to return to utility power immediately upon pressing switch only if utility power is available. Provide engraved nameplate with 1/4" high black letters on yellow background, indicating functional description; "PUSH TO OVERRIDE TIME DELAY RETRANSFER TO UTILITY".
- G. Key Operated Test Switch: 3 position ("Test With Load"/ "Automatic"/ "No-Load Test") maintained-contact switch with center Auto position. Switch shall simulate normal source failure, start generator and transfer or not transfer load based on operation of switch. Switch with OFF position is not acceptable.
- H. Switch-Position Indicating Lights: Indicate source to which the load is connected.
 - 1. Normal Power: Green light with nameplate engraved "ATS in Normal Position."
 - 2. Emergency Power: Yellow light with nameplate engraved "ATS in Emergency Position."
- I. Source-Available Indicating Lights: Supervise sources via the transfer switch normal and emergency source-sensing circuits, as defined by actual pick-up and drop-out settings of transfer switch controls.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 2. Emergency Power Supervision: Yellow light with nameplate engraved "Emergency Source Available."
- J. Annunciation and Control Interface Components: Provide indicated number of 10-amp rated at 240 VAC, Form C (SPDT) dry contacts for each of the following items below for communicating with remote annunciators and controls: Contacts shall operate off shaft of ATS transfer mechanism where possible.
1. Normal Power available; provide 3 sets (as defined by actual pick-up and drop-out settings of transfer switch controls).
 2. Emergency Power available; provide 3 sets (as defined by actual pick-up and drop-out settings of transfer switch controls).
 3. ATS in emergency position; provide 4 sets.
 4. ATS in normal position; provide 4 sets.
 5. ATS in neutral position; provide 1 set.
- K. Engine Starting Contacts: One isolated normally closed and 1 isolated normally open. Contacts are gold flashed or gold plated and rated 10-amperes at 32 VDC minimum.
- L. Engine Shut-Down Contacts: Instantaneous, to initiate shutdown sequence at remote engine-generator controls after retransfer of the load to normal or preferred source.
- M. Engine Cool-Down Contacts: Time delay adjustable from 0 to 5 minutes to provide unloaded engine operation after retransfer to normal; factory set at 5 minutes.
- N. Engine-Generator Exerciser: Solid-state programmable time switch starts engine generator, set and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool down period. Initiate exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory set periods are for 14 days and 30 minutes, respectively. Exerciser features include:
1. Exerciser transfer selector switch, which permits selection between exercise with and without load transfer.
 2. Push button programming controls with digital display of settings.
 3. Integral battery operation of time switch when normal control power is not available.

2.5 FINISHES

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

2.6 SOURCE QUALITY CONTROL

- A. Factory test components, assembled switches, and associated equipment to ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for conformance with specified requirements. Perform dielectric strength test conforming to NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install ATS and accessory items in accordance with manufacturers' written installation instructions and the following specifications:
- B. Strength, Spacing, and Placement of Equipment Housekeeping Pads: Provide a concrete housekeeping pad slab under the ATS. Fabricate pads as follows:

1. Coordinate size of equipment bases with actual unit sizes provided. Fabricate base 4" larger in both directions than the overall dimensions of the supported unit.
 2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
 3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units. Anchor or key to floor slab.
 4. Place concrete and allow to cure before installation of units. Use Portland cement that conforms to ASTM C 150, 4000 psi compressive strength, and normal weight aggregate.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from ATS and components.
- D. Identify components according to Division 26 Section, "Electrical Identification."

3.2 WIRING TO REMOTE COMPONENTS

- A. Match the type and number of cables and conductors to the control and communications requirements of the transfer switches used. Increase raceway sizes at no additional cost to the owner if necessary to accommodate required wiring.
- B. Provide control wiring as required to generator remote annunciator for display of each ATS's position and source availability.

3.3 CONNECTIONS

- A. Tighten factory-made connections, including connectors, terminals, bus joints, mountings, and grounding. Tighten field-connected connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values. When manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.

3.4 GROUNDING

- A. Make equipment-grounding connections for transfer switch units as indicated and as required by the NEC.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise field tests.
- B. Preliminary Tests: Perform electrical tests as recommended by the manufacturer and as follows:
1. Measure phase-to-phase and phase-to-ground insulation resistance levels with insulation resistance tester, including external annunciator and control circuits. Use test voltages and procedure recommended by the manufacturer. Meet manufacturer's specified minimum resistance.
 2. Check for electrical continuity of circuits and for short circuits.
- C. Field Tests: Give 7-day advance notice of the tests and perform tests in presence of owner's representative.
- D. Coordinate tests with tests of generator plant and run them concurrently.
- E. Tests: As recommended by the manufacturer and as follows:

1. Contact Resistance Test: Measure resistance of power contacts for ATSS, NATSS, and BP/ISs. Resolve values in excess of 500 micro-ohms, and differences between adjacent poles exceeding 50%.
 2. Ground Fault Tests: Coordinate with testing specified in Division 26 Section, "Overcurrent Protective Devices" to ensure sensors are properly selected and located to optimize ground-fault protection where power is being delivered from either source.
 - a. Verify grounding points and sensor ratings and locations.
 - b. Apply simulated fault current at the sensors and observe reaction of circuit interrupting devices.
 3. Operational Tests: Demonstrate interlock, sequence, and operational function for each switch at least 3 times.
 - a. Simulate power failures of normal source to ATSS and of emergency source with normal source available.
 - b. Simulate low phase-to-ground voltage for each phase of normal source of ATSS.
 - c. Verify time-delay settings and pick-up and drop-out voltages.
- F. Test Failures: Correct deficiencies identified by tests and prepare for retest. Verify that equipment meets the specified requirements.
- G. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected items. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- 3.6 DEMONSTRATION
- A. Training: Furnish the services of a factory-authorized service representative to instruct Owner's personnel in the operation, maintenance, and adjustment of transfer switches and related equipment. Provide a minimum of 1 hour of instruction scheduled 7 days in advance.

END OF SECTION